PVC

Bad News Comes in 3s

The Poison Plastic, Health Hazards and the Looming Waste Crisis

CENTER FOR HEALTH, ENVIRONMENT AND JUSTICE

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Authors: Michael Belliveau, Environmental Health Strategy Center (EHSC)
Stephen Lester, Center for Health, Environment and Justice (CHEJ)

Editorial Direction: Lois Gibbs, Anne Rabe and Monica Rohde Buckhorn, CHEJ

Research Interns: Austin Saylor, Alicia Fraser and Jessica Mackow, CHEJ

Editing: Margaret Stemper

Layout and Design: Kieran Daly, KDaddy Design and Barbara Sullivan, CHEJ

The Center for Health, Environment and Justice was founded in 1981 by Lois Gibbs, the community leader at Love Canal. CHEJ empowers local groups to be active, ongoing, democratic forces working to protect people and the environment from health-threatening contaminants. We provide one-on-one organizing and technical assistance, and coordinate nationwide issue-focused campaigns that strengthen and broaden the movement.

www.besafenet.org • www.chej.org

P.O. Box 6806
Falls Church, Virginia 22040
703-237-2249

The Environmental Health Strategy Center is a public health organization that exists to protect human health from exposure to toxic chemicals. The Center promotes safe alternatives and clean industry and builds partnerships that focus on environmental solutions as a public health priority. The Center conducts strategic issue campaigns that help set the pace for national chemicals policy reform.

www.preventharm.org

One Pleasant Street, Fourth Floor
Portland, Maine 04101
207-772-2181

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*Organizations listed for identification purposes.

Keeping the American Promise:

Achieve Safer and Healthier Future By Eliminating PVC, The Poison Plastic

Dear Friends,

This report provides the facts and a plan of action for one of the most important changes society can make to protect the public's health and the environment.

PVC is a poison plastic. It has earned the title after decades of harming our health and environment. PVC's destructive toxic life begins with manufacturing, continues during product use, and then creates devastating pollution problems when it is disposed. I cannot think of another product that is so destructive throughout its entire life cycle as PVC.

In Louisiana, families gather to talk about how growing health problems in their neighborhood are connected to the local plastic chemical plant's emissions. In Massachusetts, families meet to discuss the rising cancer rates in their valley and the nearby incinerators burning large amounts of PVC and releasing dioxin into the air.

I have traveled across the nation visiting neighborhoods that confront the hazards from manufacturing or disposing of PVC plastics every day. These American families find their homes are suddenly worthless and they are trapped in a nightmare of frustration—trying to prove the pollution from the plant or incinerator has caused the damage to their health. Many of these community stories are briefly described in this report.

Our country's fire fighters and first responders are worried about exposures to PVC's toxic fumes every time they encounter a fire. Consumers are concerned about vinyl plastic tablecloths or shower curtains that release toxic fumes, often referred to as "that new smell." Parents are worried about the leaching of toxic chemicals from PVC toys that their children used in the past.

The sad truth behind the destruction and harm caused by PVC, is that in most cases it is not needed. There are plenty of alternatives that are readily available on the market today. On store shelves, consumers can choose shampoo with a PVC bottle (marked with a #3 or V in the recycle symbol triangle) or a safer PVC-free plastic bottle. A growing number of responsible corporations have decided to stop using PVC. Irresponsible corporations, on the other hand, have refused to move to safer plastics.

An important part of this report is the well-documented fact that there is no "away" for PVC. There is no way to get rid of the product once manufactured. It is with us forever—a legacy left to the next generation. You can't burn it—it just changes to dioxin, another very toxic pollutant. You can't bury it—chemicals leak out into the surrounding soil and groundwater. You can't recycle it—it contaminates the recycling process.

This report gives us hope by outlining how we as a society can phase out PVC in the future, with clear models to begin that phase out now. You'll learn in this document about the many safer, affordable alternatives to PVC that are available today.

We need to begin a nationwide conversation, community by community, on how to phase out PVC. As consumers we need to send a strong message to corporations who are resisting the effort to eliminate PVC and let them know we will not purchase their products. We need to encourage companies to use their entrepreneurial ingenuity to develop new products without PVC, the poison plastic. And, we need to enlist all levels of government to pass strong policies to phase-out PVC.

We must move quickly. Generating as much as seven billion pounds of PVC waste each year cannot continue. We can't bury it, burn it or recycle it. PVC wastes will live beyond the lifetime of everybody on this planet—a terrible legacy to leave for future generations.

A road map for how society can eliminate PVC is included in this report. If everyone takes a step down this road we can achieve a phase-out and begin to safeguard public health and the environment. I hope you will join us and help to leave our children a healthier, more sustainable world.

Lois Marie Gibbs
Executive Director
Center for Health, Environment and Justice

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"Billions of pounds of PVC, the 'poison plastic,' are being thrown 'away' in the U.S.— but there is no away for the health threatening chemicals associated with PVC."

The disposal of polyvinyl chloride (PVC) plastic threatens public health and the environment. Although problematic throughout its lifecycle – from production through final use – the discarding of PVC as waste poses perpetual hazards. PVC is widely used in plastic pipes, building materials (e.g., vinyl siding, windows), consumer products, disposable packaging and many everyday products. We can prevent harm from PVC by replacing it with safer, cost-effective alternatives that are available, and by diverting PVC waste away from incineration and open burning. This report summarizes data on PVC production, use and disposal in the United States, though its conclusions about the environmental health hazards of PVC are applicable to every country.

How much PVC do we use?

Billions of Pounds of PVC are Discarded Each Year

Large and growing amounts of PVC are discarded daily in the U.S. As much as 7 billion pounds of PVC is discarded every year in municipal solid waste, medical waste, and construction and demolition debris. PVC disposal is the largest source of dioxin-forming chlorine and hazardous phthalates in solid waste, as well as a major source of lead, cadmium and organotins. Dioxins are a family of highly toxic chemicals that are known to cause cancer, reproductive, developmental and immune problems. More than 2 billion pounds per year of nondurable (short-lived) PVC products are discarded with U.S. household trash, including blister packs and other packaging, plastic bottles and containers, plastic wrap and bags, and more. In fact, nondurable products account for more than 70% of the PVC disposed of in U.S. municipal solid waste. Worldwide, an estimated 300 billion pounds of PVC, which was installed in the last 30 to 40 years in construction and other long lasting uses, will soon reach the end of its useful life and require disposal.

What's so bad about PVC plastic?

PVC: A Truly "Poison" Plastic

Unlike the many plastics made without chlorine, PVC poses serious environmental health threats from the start. The production of PVC requires the manufacture of raw chemicals, including highly polluting chlorine, and cancer-causing vinyl chloride monomer (VCM) and ethylene dichloride (EDC). Communities surrounding U.S. vinyl chloride chemical facilities, half of which are in Louisiana, suffer from serious toxic chemical pollution of their groundwater supplies, surface waters and air. Residents of the town of Mossville, Louisiana had dioxin levels in their blood that were three times higher than normal. PVC plastic also requires large amounts of toxic additives to make it stable and usable. These additives are released during the use (and disposal) of PVC products, resulting in elevated human exposures to phthalates, lead, cadmium, tin and other toxic chemicals. Dioxin emissions from PVC combustion occur regularly due to the 1 million annual fires that burn buildings and vehicles, two sectors that use substantial amounts of PVC.

What are the options for disposing of used PVC?

PVC Products + Waste Incinerators or Open Burning = Dioxin Emissions

Dioxin formation is the Achilles heel of PVC. Burning PVC plastic, which contains 57% chlorine when pure, forms dioxins, a highly toxic group of chemicals that build up in the food chain. PVC is the major contributor of chlorine to four combustion sources—municipal solid waste incinerators, backyard burn barrels, medical waste incinerators and secondary copper smelters—that account for a significant portion of dioxin air emissions. In the most recent USEPA Inventory of Sources of Dioxin in the United States, these four sources accounted for more than 80% of dioxin emissions to air based on data collected in 1995. Since then, the closure of many incinerators and tighter regulations have reduced dioxin air emissions from waste incineration, while increasing the proportion of dioxin disposed of in landfills with incinerator ash. The PVC content in the waste steam fed to incinerators has been linked to elevated levels of dioxins in stack air emissions and incinerator ash.

Incineration and open burning of PVC-laden waste seriously impacts public health and the environment. More than 100 municipal waste incinerators in the U.S. burn 500 to 600 million pounds of PVC each year, forming highly toxic dioxins that are released to the air and disposed of on land as ash. The biggest PVC-burning states include Massachusetts, Connecticut, Maine—which all burn more than half of their waste—Florida, New York, Virginia, Pennsylvania, Maryland, Minnesota, Michigan, New Jersey, Indiana and Washington. The incineration of medical waste, which has the highest PVC content of any waste stream, is finally being replaced across the U.S. by cleaner non-burn technologies after years of community activism and leadership by environmentally-minded hospitals. Backyard burning of PVC-containing household trash is not regulated at the federal level and is poorly regulated by the states. There are no restrictions on backyard burning in Michigan and Pennsylvania. It is partially restricted in 30 states, and banned in 18 states.

PVC Products + Landfill Disposal = Groundwater Contamination

Land disposal of PVC is also problematic. Dumping PVC in landfills poses significant long-term environmental threats due to leaching of toxic additives into groundwater, dioxin-forming landfill fires, and the release of toxic emissions in landfill gases. Land disposal is the final fate of between 2 billion and 4 billion pounds of PVC that are discarded every year at some 1,800 municipal waste landfills in the U.S. Most PVC in construction and demolition debris ends up in landfills, many of which are unlined and cannot capture any contaminants that leak out. An average of 8,400 landfill fires are reported every year in the U.S., contributing further to PVC waste combustion and dioxin pollution.

PVC Products + Recycling = Contamination of the Entire Plastics Recycling Process

Unfortunately, PVC recycling is not the answer. The amount of PVC products that are recycled is negligible, with estimates ranging from only 0.1% to 3%. PVC is very difficult to recycle because of the many different formulations used to make PVC products. Its composition varies because of the many additives used to make PVC products. When these different formulations of PVC are mixed together, they cannot readily be separated which is necessary to recycle the PVC into its original formulation. It's also virtually impossible to create a formulation that can be used for a specific application. PVC can never be truly recycled into the same quality material—it usually ends up being made into lower quality products with less stringent requirements such as park benches or speed bumps.

When PVC products are mixed in with the recycling of non-chlorinated plastics, such as in the "all-bottle" recycling programs favored by the plastics industry, they contaminate the entire recycling process. Although other types of non-chlorine plastics make up more than 95% of all plastic bottles, introducing only one PVC bottle into the recycling process can contaminate 100,000 bottles, rendering the entire stock unusable for making new bottles or products of similar quality. PVC also increases the toxic impacts of other discarded products such as computers, automobiles and corrugated cardboard during the recycling process.

Safer alternatives are available to replace PVC

Safer alternatives to PVC are widely available and effective for almost all major uses in building materials, medical products, packaging, office supplies, toys and consumer goods. PVC is the most environmentally harmful plastic. Many other plastic resins can substitute more safely for PVC when natural materials are not available.

PVC alternatives are affordable and already competitive in the market place. In many cases, the alternatives are only slightly more costly than PVC, and in some cases the costs of the alternative materials are comparable to PVC when measured over the useful life of the product. Phasing out PVC in favor of safer alternatives is economically achievable. A PVC phase-out will likely require the same total employment as PVC production. The current jobs associated with U.S. PVC production (an estimated 9,000 in VCM and PVC resin production, and 126,000 in PVC fabrication) would simply be translated into production of the same products from safer plastic resins.

How can we get rid of PVC?

To end the myriad of problems created by PVC disposal, we recommend the following policies and activities.

- Policymakers at the local, state and federal level should enact and implement laws that steadily reduce the impacts of PVC disposal and lead to a complete phase-out of PVC use and waste incineration within ten years (see box below).
- A new materials policy for PVC that embraces aggressive source reduction of PVC should be adopted to steadily reduce the use of PVC over time.
- Federal and state waste management priorities should be changed to make incineration of PVC waste the least preferable option.
- In the interim, any PVC waste generated should be diverted away from incineration to hazardous waste landfills.
- Consumers should take personal action to buy PVC-free alternatives and to remove PVC from their trash for management as household hazardous waste.
- Communities should continue to organize against PVC-related dioxin sources such as waste incinerators while working to promote safer alternatives.

A PVC-Free Policy Action Agenda

Accomplish Within Three Years

1. Ban all open waste burning.
2. Educate the public about PVC hazards.
3. Ban the incineration of PVC waste.
4. Collect PVC products separately from other waste.
5. In the interim, divert PVC away from incineration to hazardous waste landfills.

Accomplish Within Five Years

6. Establish our Right-to-Know about PVC.
7. Label all PVC products with warnings.
8. Give preference to PVC-free purchasing.
9. Ban PVC use in bottles and disposable packaging.
10. Ban sale of PVC with lead or cadmium.

Accomplish Within Seven Years

11. Phase out other disposable PVC uses.
12. Phase out other high hazard PVC uses.
13. If safer alternatives are not yet available, extend the PVC phase-out deadlines for specific purposes.
14. Fund efforts to reduce the amount of PVC generated through fees on the PVC content of products.

Accomplish Within Ten Years

15. Phase out remaining durable PVC uses.
16. Decommission municipal waste incinerators in favor of zero waste.

INTRODUCTION

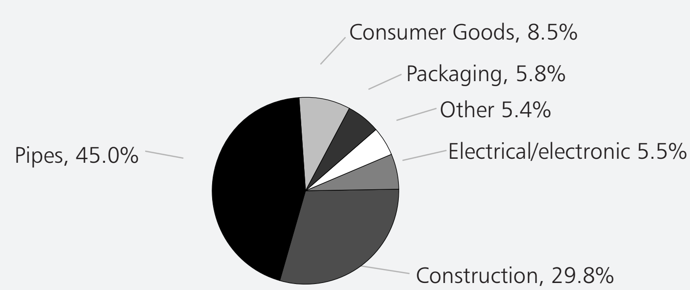
PVC—The Poison Plastic

Polyvinyl chloride, commonly referred to as "PVC" or "vinyl," is the second largest commodity plastic in production in the world today. An estimated 59 billion pounds were produced worldwide in 2002 (CEH 2003). Over 14 billion pounds are produced annually in the U.S. (VI 2004). PVC is used in a wide range of products including pipes and tubing, construction materials, packaging, electrical wiring and thousands of consumer goods (Ackerman 2003). The diverse and widespread use of PVC plastic in disposable and durable goods leads to the many immediate and long-term disposal challenges reviewed in this report.

Figure 1 provides a general breakdown of the many uses of PVC. Because of its low cost and aggressive marketing, PVC is found in hundreds of consumer products that are used everyday, including children's toys, credit cards, clothing, carpeting, furniture, flooring, automotive seats, garden hoses, cellular phones, computer parts, office supplies, siding on our homes, roofing and other building materials. A partial listing of common household products made of PVC can be found in Appendix A.

Plastic pipes and construction uses account for 75% of all PVC consumption in North America. Construction is also the fastest growing PVC sector, with a projected annual average growth rate of 3.5% between 2002 and 2007. Within the construction sector, the fastest growing PVC products are special applications, such as gutters, fencing and decking (growing at 8.1% per year), windows and doors (6.1%), vinyl siding (4.5%) and pipes and tubing (2.5%). PVC use in electrical equipment and electronics is increasing at 2.5% per year. Disposable PVC packaging and transportation-related

Figure 1. Uses of PVC in U.S. and Canada (2002)



Source: Ackerman 2003, CEH 2003

PVC uses will grow by 2.0% every year over the same five-year period (CEH 2003).

This report reviews the many hazards associated with the disposal of PVC in the United States. Although the report relies primarily on U.S. data on PVC production, use and disposal, the information on the environmental health impacts of PVC are applicable to every country. This report is not intended to be a comprehensive review of all the health and environmental risks posed during the lifecycle of PVC throughout its production, use, and disposal. The key impacts of PVC production and use are summarized in order to provide context for assessing the impacts of the disposal of PVC waste.

Throughout the text we have included a number of case studies that illustrate the impact that PVC has on people. In addition, there are a number of sidebars that highlight actions that some organizations have taken to address the public health or environmental impacts of PVC. The following is a brief summary of the report's findings listed by chapter.

Chapter 2, The PVC Generation: Large and Growing Amounts of PVC Waste,
provides an overview of the amount of PVC waste generated in the U.S. each year and estimates how much ends up in different waste streams. This chapter also addresses how PVC increases the toxicity of these waste streams.

Chapter 3, Trouble From The Start: The Production and Use of PVC,
reviews the production and processing of PVC, which involves chlorine and an array of additives that have serious consequences for public health and the environment during PVC use and disposal. The toxic hazards of PVC additives, including phthalates, heavy metals and flame retardants, are described in this chapter.

Chapter 4, The Deadly Connection: PVC, Chlorine and Dioxin,
reviews the relationship between PVC, chlorine and dioxin, which is especially troubling. Dioxin, one of the most toxic chemicals ever tested, is generated when any form of burning is used as a disposal option for PVC.

Chapter 5, Don't Burn It: The Hazards of Burning PVC Waste,
provides a detailed description of the specific hazards of PVC incineration. Open burning of PVC waste in backyard burn barrels or waste piles is especially troubling because of the large amount of dioxins generated.

Chapter 6, No Place Left: Problems with PVC in Landfills,
reviews the specific toxic hazards associated with the land disposal of PVC. Many PVC additives, including phthalates, heavy metals such as lead and cadmium and organotins, slowly leach out of PVC over time when placed in a landfill, eventually contaminating groundwater and surface water. PVC also worsens the impacts of landfill fires and landfill gases that are generated as materials in the landfill decay.

Chapter 7, Recycling Menace: PVC Undermines Recycling Efforts,
reviews efforts to recycle PVC and details its impacts on plastic recycling programs due to its incompatibility with other commonly recyclable plastics. PVC is extremely hard to recycle because of the numerous additives that are used to make a wide range of PVC products. The toxic by-products of PVC also significantly undermine the recycling of other products.

Chapter 8, Don't Buy It: Safer Alternatives to PVC are Available, Effective and Affordable,
looks at the widespread availability of safer alternatives to PVC and provides a summary of an economic analysis conducted by the Global Development and Environment Institute at Tufts University in Medford, MA. This analysis found that cost-competitive alternatives do exist for most uses of PVC. This chapter includes information on resources that can be used to identify alternatives to PVC.

Chapter 9, Take Action: Preventing Harm from PVC Use and Disposal,
describes actions that can be taken by individuals, local grassroots community-based organizations, statewide organizations, and as part of national efforts to prevent harm from the use and disposal of PVC.

In researching this report, we identified a number of important references that we used, and in some cases relied on heavily in writing this report. We appreciate the pioneering work on PVC's hazards and alternatives achieved by the researchers, analysts and authors responsible for these publications. We are especially in debt to these colleagues. We encourage you to consult these resources for more detailed documentation and useful information on the hazards and alternatives to PVC. These and other references are listed at the end of this document.

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THE PVC GENERATION
Large and Growing Amounts of PVC Waste

MAJOR FINDINGS

- As much as 7 billion pounds of PVC are discarded every year in the U.S. in municipal solid waste, medical waste and construction and demolition debris.
- PVC disposal is the largest source of dioxin-forming chlorine and phthalates in solid waste, as well as a major source of lead, cadmium and organotins.
- More than 2 billion pounds per year of non-durable (short-lived) PVC products are discarded in U.S. household trash, including blister packs and other packaging, plastic bottles and containers and plastic wrap and bags.
- Non-durable (short-lived) products account for more than 70% of PVC disposed in municipal solid waste in the U.S.
- Worldwide, an estimated 300 billion pounds of longer-lasting PVC products, such as construction materials that last 30 to 40 years, will soon reach the end of their useful life and require replacement and disposal.

Every day, PVC plastic becomes the problem waste that nobody wants to talk about. Why? Because it enters the waste stream in large amounts as the least recyclable and most environmentally harmful plastic. If there were an honest national dialogue about PVC and dioxin pollution prevention, support for waste incineration would crumble and the government would phase out PVC production and use. Landfills can't contain the toxic components of PVC. PVC contaminates the recycling of so many products that could otherwise be safely reprocessed into useful materials. PVC waste adds daily to a looming waste crisis as more and more long-lasting products made of PVC, such as building materials, are removed from use. And perhaps most of all, because powerful elements of the chemical industry are wedded to promoting PVC use and the chlorine industry involved in its production.

We should care about PVC disposal because that's when the toxic components and by-products of this seemingly benign and ubiquitous plastic are discarded and dispersed throughout the environment. Not everyone lives next to the chemical plant that emits the dangerous raw materials of PVC production. Not everyone experiences the vinyl building fire, the dioxin-spewing burn barrel, or the medical procedure that leaches dangerous chemicals from the intravenous (IV) tubing made of PVC.

Yet all of us generate PVC waste even if we try to avoid doing so. By learning about the harm posed by PVC disposal, we can spur political, business, and consumer action to break the cycle of dependence on this incredibly toxic and problematic material. If we don't burn it, we can reduce the worst impacts of PVC. And if we don't buy it, we can avoid all of the problems associated with PVC production, use, and disposal.

The Quantity of PVC in the Waste Stream

The useful life of a PVC product may come to an end minutes after a purchase in the case of disposable packaging, or a few decades later when PVC building materials must be replaced. Given the widespread use of PVC and its highly variable lifespan across many types of products, it is no wonder that huge amounts of PVC waste are generated on a daily basis in every community.

Table 1 summarizes available information on the PVC content of solid waste in the U.S. The five major waste streams shown in Table 1 account for almost all post-industrial PVC waste: (1) municipal solid waste (MSW); (2) medical waste; (3) construction and demolition (C&D) debris; (4) discarded products collected for recycling; and (5) industrial solid waste generated during manufacturing.

Table 1

Annual PVC Waste Production in the U.S.

Waste Stream Total Quantity Generated	Description of PVC Portion of Waste Stream	PVC Content of Waste Stream Percent	 Amount (tons)
Municipal Solid Waste (MSW) 229 million[1] - 369 million[2] tons	Packaging and other disposable vinyl products	0.62%[1]	1,420,000[1] to 2,290,000[2]*
Medical Waste (Biomedical/Infectious) 3.4 million tons[3]	Mostly medical tubing and bags with some vinyl gloves and supplies	5% to 15% [4]	170,000 to 510,000
Construction & Demolition (C&D) Debris 136 million tons[6]	Vinyl pipes only[5] and vinyl pipes and siding[6] (Does not account for other types of PVC C&D debris)	0.18%[5] to 0.63%[6]	245,000 to 856,000
Discarded Products Collected for Recycling Unknown amount	PVC-contaminated plastics from bottles, electronics, automobiles, scrap wood, cardboard, etc.	Varies	Unknown
Manufacturing Waste Unknown amount	Complete range of PVC products including manufactured homes and plastics fabrication	Varies	Unknown
TOTAL Amount of PVC Discarded Annually in MSW, Medical Waste and C&D Debris			1.8 to 3.6 million tons (3.7 to 7.2 billion pounds) Average = 2.75 million tons (Average = 5.5 billion pounds)

Sources and Notes: 1 - USEPA 2003; 2 - Kaufman 2004; 3 - USEPA 1994; 4 - Marrack 1988, Hasselriis 1993, DTI 1995, USOTA 1988; 5 - Cascadia 2003; and 6 - FA 1998. *These two estimates of total PVC content in MSW are derived using USEPA (2003) and Kaufman (2004) data to generate the low and high estimates, respectively. **Note:** There are many inherent uncertainties in any estimate of the amount of MSW generated. This is reflected in the 140 million ton difference between the USEPA estimate of 229 million tons and the Kaufman estimate of 369 million tons of MSW generated. Part of the reason for this difference is due to the methods used to derive the estimates. The USEPA relied on economic and population data to estimate MSW generated on a per capita basis. Kaufman used a survey sent to state management agencies to collect data on solid waste. The EPA estimate only included household garbage, while Kaufman collected data on a number of solid waste categories and then calculated the MSW portion, which included residential and commercial waste, organics, tires, and "other." In both cases, the MSW estimates included primarily household garbage. A third estimate, not used in this report, was made by the Environmental Research and Education Foundation (EREF 2001) which estimated that 545 million tons of MSW were generated in the U.S. in 1999. This estimate was generated from a survey distributed to both public and private waste disposal companies and included all non-hazardous waste sent off-site for final disposal including household waste, commercial and institutional waste, special waste, C&D waste, regulated medical waste, yard waste, sludge and scrap tires. This estimate clearly includes a much broader universal of waste targeted for recycling or disposal.

Waste versus Discards

This report often refers to PVC in the waste stream. In fact, what we often call 'waste' is actually discarded products that we end up wasting. When products reach the end of their useful life, they should be collected to be taken apart and recycled back into their original materials. This is the concept of 'Zero Waste', which maximizes recycling, minimizes waste, reduces consumption and ensures that products are made to be reused, repaired or recycled back into nature or the marketplace (GRRN 2004). Unfortunately, PVC is very difficult to recycle and when present in discarded products tends to contaminate the recycling process. Therefore, almost all PVC products are wasted sooner or later.

Table 1 shows that three of the five major waste streams—municipal solid waste, biomedical/infectious medical waste and construction and demolition debris—account for on average about 5.5 billion pounds of PVC discarded every year in the U.S. An estimated 7.2 billion pounds are generated annually in the European Union (EU) (AEA 2000). In the U.S., 63% to 77% of the total amount of PVC waste known to be discarded each year ends up in the municipal solid waste stream. Medical waste has the highest PVC content due to the high reliance of hospitals on vinyl medical bags and tubing. PVC also makes up as much as 18% of non-infectious hospital waste (Hasselriis 1993), which is typically disposed of as municipal solid waste. The PVC content of C&D waste is similar to that of MSW but is expected to grow significantly—mirroring the growth in PVC building materials used in the last thirty years as they are replaced because of aging (CEC 2000). Each of these five major waste streams are described in the subsections that follow.

Although PVC generally contributes only a modest amount to the total volume of a waste stream, as shown in Table 1, there are exceptions such as hospital waste (Marrack 1988, Hasselriis 1993, DTI 1995, USOTA 1988) and consumer electronics waste (MCTC 1996) that have particularly high PVC content. Furthermore, the amount of PVC waste generated which requires disposal appears to be growing due to the expiration of products placed in use 20 to 30 years ago when PVC materials were introduced (CEC 2000). This adds to concerns about the toxic impacts of PVC disposal due to dioxin formation when burned (see Chapter 5) and the leaching of lead, cadmium, tin, and other toxic additives from the plastic when landfilled (see Chapter 6).

PVC in Municipal Solid Waste

In the U.S., about 79% of PVC in the municipal solid waste (MSW), or about 2.2 billion pounds of PVC, ends up in landfills every year (USEPA 2003). About 21% or about 600 million pounds of PVC in MSW is incinerated every year, leading to the formation of dioxins in air emissions and ash. EPA estimated that a "negligible" amount of PVC is collected for municipal solid waste recycling. MSW includes solid waste generated by households as well as commercial and institutional sources. These figures are based on 2001 data (USEPA 2003).

Non-durable goods (materials with a relatively short useful life) make up 71% of the PVC found in municipal solid waste as shown in Table 2. Over one million tons (2 billion pounds) of these materials were discarded in the U.S. in 2001 (USEPA 2003). The largest portion of these materials was PVC Blister packs (hard plastic packaging often used for toys or computer supplies) and other vinyl packaging that accounted for more than 250,000 tons (500 million pounds). About 500,000 tons (one billion pounds) of these short-lived PVC products are tossed in household trash every year from disposable plastic blister packs, other packaging, film wrap, bags, bottles and other containers. Even more PVC is discarded annually as other non-durable goods, such as shower curtains, beach balls, credit cards and checkbook covers.

The third major category of PVC waste in household trash is durable goods, accounting for 411,000 tons (822 million pounds) per year. "Durable" trash containing PVC could include building materials such as piping, siding, windows and flooring, and consumer electronics and appliances.

PVC in Medical Waste

Until recently, the majority of medical waste was incinerated and much of that was burned on-site at hospitals. By 1990, about 60% to 70% of all medical waste was incinerated (USEPA 1994, USOTA 1990). This included biomedical waste produced by hospitals, labs,

Table 2

PVC Products Disposed in U.S. Municipal Solid Waste (MSW) in 2001

Type of PVC Product		Amount of PVC (tons)	(%)
Non-durable Goods (Short useful life)	Blister packs and other packaging	255,000	18%
	Plastic bottles and containers	147,000	10%
	Plastic wrap and bags	68,000	5%
	Other nondurable goods	539,000	38%
	SUBTOTAL - Nondurables	1,009,000	71%
Durable Goods	SUBTOTAL - Durables	411,000	29%
TOTAL Amount of PVC in MSW (tons)		1,420,000	100%

Source: USEPA 2003

clinics, physician offices and other sources. Since then, the amount of medical waste burned and the number of operating incinerators have dramatically declined due to overwhelming evidence of enormous dioxin emissions, leading to government regulation and powerful community opposition.

As the health care industry continues its transition to non-incineration methods for disinfecting medical waste, the problems caused by vinyl medical products in the waste stream may not be solved. For example, until recently almost all of the medical waste generated in the state of Maine was sent to an out-of-state commercial incinerator. After local community opposition, this regional incinerator was closed and Maine's medical waste was shipped to a microwave disinfection treatment facility. However, the disinfected residue after treatment is now sent to a municipal solid waste incinerator in Massachusetts. The Maine Hospital Association (MHA) is in the process of siting an autoclave facility in the state to disinfect medical waste (see Chapter 5). Due to concerns raised about dioxin emissions, the MHA has pledged to dispose of disinfected PVC-rich residue in a landfill rather than a municipal waste incinerator (Belliveau 2002, Huang 2004).

In states like Maine that are highly dependent on incineration to handle municipal waste, the closure of medical waste facilities may not prevent PVC medical waste from being burned elsewhere, releasing toxic additives and by-products to the environment. Efforts to phase out PVC by the health care industry will prevent such a dilemma.

PVC in Construction and Demolition Debris

More PVC ends up in construction and demolition (C&D) waste each year than in medical waste (See Table 1). About 850,000 tons (1.7 billion pounds) of PVC is disposed of every year in nearly 2,000 C&D landfills across the U.S. (Kaufman 2004). Very little C&D waste is incinerated, except for a portion that enters municipal solid waste when generated by households or small businesses. However, many if not most C&D landfills are unlined or poorly lined compared to municipal solid waste landfills. Thus, there are even fewer barriers to keep chemicals from leaking out than those provided by MSW landfills. This is a serious problem that will likely result in more contaminants from PVC entering the environment.

The amount of PVC in C&D waste may be seriously underestimated. The available waste characterization data included in Table 1 only accounts for PVC pipes (Cascadia 2003) or pipes and vinyl siding (FA 1998). There are many other applications of PVC in building materials and furnishings that may become C&D waste, including vinyl window frames, flooring, roofing foils and carpet backing (Thornton 2002).

Also, the growth in the installation of durable PVC building products over the last twenty to thirty years has built up a stockpile of PVC still in use. As these materials reach the end of their useful life, the amount of PVC in the construction and demolition debris will inevitably and rapidly increase in content and amount. An estimated 300 million pounds of PVC materials will require disposal worldwide in the coming years (van der Naald 1998).

PVC as a Contaminant in the Recycling of Other Products

Another poorly quantified PVC waste stream is the discarded products and materials that are collected for recycling. PVC is very difficult to recycle because of the many different formulations used to make PVC products. Its composition varies widely due to the many additives used to make PVC products. When these different formulations are mixed together, they cannot readily be separated which is necessary to recycle the PVC into its original formulation. It is also virtually impossible to create a formulation that can be used for any application. At best, only about 3% of PVC products and materials are recycled in the U.S.

Two additional problems are created by the presence of PVC in the waste stream targeted for recycling. The first is the difficulty in separating PVC from other plastics, such as PET bottles or nylon carpet facing. This makes it extremely difficult, if not impossible, to recycle these otherwise recyclable materials. Second, the presence of PVC impedes the successful recycling of other valuable commodities such as copper from wiring and cable used in electronics such as computers, steel from scrapped automobiles and corrugated cardboard containers sealed with PVC tape. PVC increases the toxic impacts of recycling these materials. Each of these problems is discussed in more detail in Chapter 7.

PVC as a Manufacturing Waste

In addition to the health care industry, other industrial, commercial and institutional facilities generate PVC waste. Two manufacturing industries are known users of large volumes of PVC—plastics fabricators where PVC consumer products are manufactured from PVC resin (see Chapter 3) and makers of pre-manufactured homes. Fabricators blend PVC resin with additives to form a variety of rigid and flexible PVC products. Manufacturers of modular and pre-made homes use a large proportion of PVC building materials and furnishings. Some amount of pre-consumer PVC waste should be recycled by these industries. Recycling rates for PVC waste from these types of industries are not readily available.

PVC Increases the Toxicity of Solid Waste

PVC contributes a disproportionate share of toxic contaminants to solid waste relative to its modest weight and volume in the waste stream. The different components of PVC add significantly to the hazardous constituents of solid waste as shown in Table 3. The Table shows that PVC contributes from 38 to 67% of the total chlorine found in solid waste, from 90 to 98% of phthalates, from 1 to 28% of the lead and about 10% of the cadmium. Phthalates, lead and cadmium are all added to the PVC resin to achieve different product features. The toxicity of these and other additives is discussed in Chapter 3.

Chlorine is the primary component of PVC making up 57% by weight of the raw material used to make the pure PVC resin (VI 2004). There have been several efforts to estimate the contribution of PVC to total chlorine found in municipal solid waste (MSW). In MSW, at least 80% of the organically bound chlorine, which is thought to be more conducive to dioxin formation than inorganic chlorine, is from PVC (Thornton 2000). In medical waste, PVC's contribution of chlorine is even higher, accounting for more than 90% of organic chlorine and more than 80% of total chlorine (Thornton 2000, Green 1993). Based on these estimates, PVC could reasonably account for as much as 50% of all chlorine found in MSW.

About 90% of all phthalates consumed in the U.S. are used in PVC products (Thornton 2000). In England, an estimated 98% of phthalates are used in PVC products (OECD 2004). Thus, the disposal of PVC in landfills can be expected to account for a substantial portion of the phthalates found in landfills. Phthalates are a group of chemicals used as plasticizers to make the otherwise brittle PVC resin soft and flexible. The proportion of phthalates leaching from PVC in medical waste could be even higher given the prevalence of pliable vinyl medical products, such as tubing and bags, that are disposed of as infectious medical waste (see Chapter 5).

PVC disposal contributes several toxic metals to the solid waste stream, including compounds of lead, cadmium and tin. These metals are added to PVC as stabilizers to help inhibit the plastic's tendency to degrade in the presence of sunlight or heat. Lead is still commonly used in the plastic vinyl sheathing of wires and cables. Older vinyl mini-blinds also contain lead. Estimates of the amount of lead in solid waste attributable to PVC ranges widely from a low of 1% to a high of 28% (CEC 2000). One study found that 10% of the lead stabilizer from one type of flexible PVC cable containing a mixture of additives was released from the PVC (Mersiowski 1999). Lead in rigid PVC is expected to

Table 3

PVC Increases the Toxicity of Municipal Solid Waste (MSW)

Toxic Substance Present in PVC	Use in PVC	PVC's Contribution of Toxic Chemicals in MSW
Chlorine	Part of polymer; pure PVC is 57% chlorine	38% - 67% of total chlorine[1,2] and at least 80% of organic chlorine[2]
Phthalates	Added as plasticizer to make PVC soft and flexible	From 90 to 98%[3]
Lead	Added as a heat stabilizer to slow degradation	1% - 28%[1]
Cadmium	Added as a heat stabilizer to slow degradation	About 10%[4]
Tin (organotins)[5]	Added as a heat stabilizer to slow degradation	Unknown
Antimony[6]	Added to enhance flame retardant effect of chlorine in PVC	Unknown
Organochlorines[6]	Added as a flame retardant to reduce risk of ignition and retard combustion	Unknown

Sources and Notes: 1 - CEC 2000; 2 - Thornton 2000 reports PVC makes up 50% to 67% of total chlorine and at least 80% of organically bound chlorine; 3 - Thornton 2002, OECD 2004; since from 90 to 98% of phthalates consumed are used in PVC products, we assume an equal amount will end up in the waste stream; 4 - Bertin 2000; 5 - Organotin compounds represent about 9.3% of European consumption of stabilizers (CEC 2000); and 6 - UBA 2001.

stay encapsulated in the PVC waste (CEC 2000). Various organotin additives have replaced some use of lead and cadmium as a stabilizer in PVC. Organotin stabilizers are added to rigid packaging film, bottles, roofing and clear rigid construction sheeting and account for 9.3% of the stabilizers on the market (CEC 2000). These estimates are based on European formulations of PVC that may differ slightly from those used in the U.S.

Certain flexible PVC products are a source of the toxic metal antimony in solid waste. Antimony trioxide (ATO) is added to PVC used in flexible electrical cables and roofing foils (an alternative to roofing felt on flat roofs) to inhibit the formation and spread of flames during a fire (UBA 2001, DEPA 1999). Antimony from PVC would show up in electronic waste (cables) and construction and demolition debris (foils).

Other toxic and persistent organochlorine flame retardants are present in solid waste as a result of their use in PVC. These include chlorinated flame retardants such as chloroparaffins and phosphate esters, which are organic phosphorus compounds that may also contain chlorine in their chemical structure (UBA 2001). Chlorinated paraffins and antimony are added as a flame retardant formulation for some PVC textile fibers that are resistant to soaking and weather (UBA 2001).

TROUBLE FROM THE START
The Production and Use of PVC

MAJOR FINDINGS

- The production of PVC poses serious environmental health threats due to the manufacture of raw chemicals, including chlorine, cancer-causing vinyl chloride monomer (VCM) and ethylene dichloride (EDC).
- U.S. communities surrounding vinyl chloride chemical facilities, half of which are in Louisiana, suffer from serious toxic chemical pollution of their groundwater supplies, surface waters and air. Residents of the town of Mossville, LA had dioxin levels in their blood that were three times higher than normal.
- PVC includes high amounts of toxic additives, which are released during the use (and disposal) of the product, resulting in elevated human exposures to phthalates, lead, cadmium, tin and other chemicals.
- The use of PVC results in dioxin emissions from PVC combustion which occurs regularly in the U.S due to 1 million annual fires that burn buildings and vehicles—two sectors that consume large amounts of PVC in construction materials.

The Life Cycle of PVC

The ‘life cycle’ of a product describes the stages that a material goes through from production to disposal. The general life cycle for PVC is shown in Figure 2.

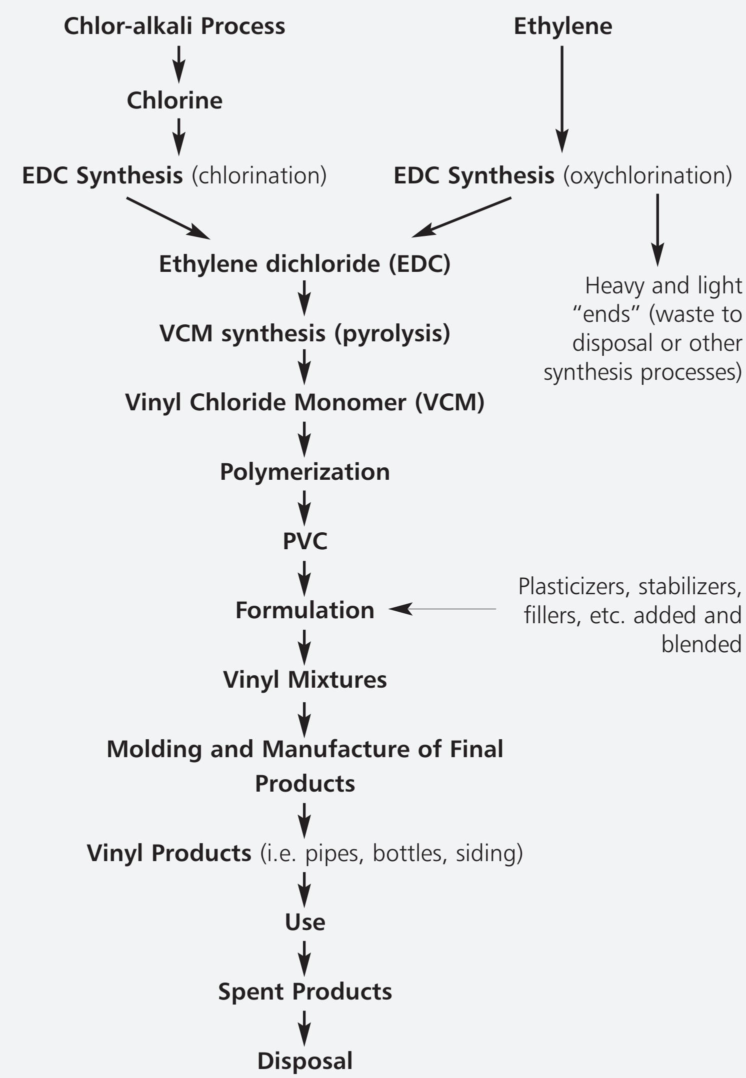
PVC poses environmental and health threats throughout its life cycle, from the production of feedstock chemicals to the final disposal of PVC products. Though some PVC products can pose direct health risks to consumers, most of the hazards associated with PVC occur during production and disposal. An overview of the hazards associated with PVC production, use, and disposal is shown in Table 4.

The major reason why PVC poses so many environmental and health threats throughout its life cycle is because it contains large amounts of chlorine (Thornton 2000). Chlorine is a highly reactive substance that readily combines with carbon molecules, the building block of life in people and animals. Carbon is the most important element in living things because it combines with oxygen, nitrogen and hydrogen to produce stable molecules such as DNA, proteins, hormones, sugars, starches and fats that are essential for life. Chlorine reacts readily with carbon, altering the original molecules and their functions (Thornton 2000).

The chlorine in PVC and its feedstocks (ethylene dichloride and vinyl chloride monomer) results in the generation of very large amounts of chlorine-containing by-products during the manufacture of PVC and the burning of vinyl-containing products and waste. These chemicals include the extraordinarily hazardous chlorinated dioxins and furans, PCBs, hexachlorobenzene, hexachloroethane and hexachlorobutadiene (Papp 1996). Because of the chemical properties of chlorine, these by-products tend to be far more toxic, more persistent in the environment, and more likely to build up in the food supply and the bodies of people than otherwise similar chemicals that do not contain chlorine (Thornton 2000). PVC is the only major plastic that contains chlorine, so it is unique in the hazards it creates.

The chemicals used in the production of PVC (ethylene dichloride and vinyl chloride monomer) are also extremely hazardous. Vinyl chloride is a known human carcinogen that affects the central nervous system and damages the liver (Kielhorn 2000). Ethylene dichloride is a suspected human carcinogen that also affects the central nervous system and damages the liver (USEPA 2003a). Chlorine is a highly irritating gas that damages the upper respiratory system (USEPA 2003b). Hydrogen chloride is a corrosive gas that also affects the upper respiratory system (NAS 2004). These substances pose considerable threats to human health and the environment as a result of PVC production and processing.

Figure 2. The Life Cycle of PVC Plastic



Source: Adapted from Thornton 2002

PVC Production

PVC production begins with the conversion of salt to chlorine using huge amounts of electricity and the purification of ethylene from natural gas (See Figure 2). Chlorine and ethylene are then combined in a chemical reaction to form ethylene dichloride (EDC) in a process generally described as "feedstock production." EDC (considered a "feedstock" chemical) is converted in another chemical reaction to vinyl chloride monomer (VCM), the basic building block of PVC. Vinyl products are then produced in three additional steps. First, polymerization converts the single vinyl chloride monomer into a long chain of vinyl chloride molecules, the PVC polymer or resin. Second, through compounding (or formulation), additives are mixed in with the PVC resin to produce a vinyl formula with desired characteristics such as plasticity, color or resistance to degradation. The ability to change the properties of PVC (making it hard or making it soft or flexible) is what makes it possible to produce a wide range of PVC products. Third, during fabrication (or molding) the product is melted and then molded into its final shape such as a pipe, floor tile or window casing. A more

Table 4
Overview of Hazards Associated with PVC Production, Use and Disposal

Production

- Dioxin and mercury emissions and asbestos waste from chlorine production.
- Air emissions and wastewater releases from Ethylene Dichloride/Vinyl Chloride Monomer (VCM) production facilities.
- Dioxins and other organochlorines released as by-products of Ethylene Dichloride/Vinyl Chloride Monomer (VCM) production.
- Worker exposures to VCM.
- Incineration of production wastes.

Use

- Additives leach and otherwise migrate from PVC products (plasticizers/metal stabilizers).
- Accidental structure and vehicle fires release dioxins.

Disposal

Landfill

- Accidental landfill fires release dioxins.
- Additives, heavy metals and dioxins leach into groundwater.
- Gaseous emissions from additives.

Incineration

- Dioxins form when PVC is burned.
- Hydrochloric acid, toxic metals and dioxins are emitted to air.
- Ash, later stored in landfills, contains high levels of heavy metals and dioxins.

Recycling

- Diversity of additives prevents effective recycling of mixed PVC products and materials resulting in poor quality products (downcycling).
- Low recycling rates (currently <1%).
- Contaminates other plastics during recycling as well as other valuable commodities that are targeted for recycling.
- Does not reduce the overall demand for raw materials to make plastics (virgin resin) and has no effect on the amount of vinyl produced each year.

detailed description of the production and manufacturing process for PVC can been found in numerous references (Thornton 2002, Thornton 2000).

In 2000, there were 12 facilities in the U.S. that produced VCM (CEH 2000). Seven of these plants also produced PVC. As of 2003, there were 24 facilities operated by 12 companies that produced PVC resin in the U.S. (CEH 2003) and an estimated 2,332 PVC fabricating facilities (ARCC 2003). These PVC production facilities released 811,000 pounds of VCM and 670,000 pounds of EDC into the environment in 2002 (USEPA 2004). In addition, 6.5 million pounds of VCM and 2.5 million pounds of EDC were sent off-site to sewage treatment plants or waste treatment facilities (USEPA 2004). It should be noted that these are self-reported numbers that represent an absolute minimum. The actual releases are likely to be greater.

During production, most vinyl chloride releases are to the air since it is a volatile gas. A smaller amount of vinyl chloride monomer is released into groundwater or into wastewater discharged to nearby rivers and streams. The wastes and emissions from production facilities are not limited to vinyl chloride. Dioxins are formed during the oxychlorination process, where chlorine is combined with ethylene gas (or ethylene, oxygen and hydrochloric acid) to form ethylene dichloride (EDC), the primary building block of the vinyl chloride monomer (Evers 1989). Dioxins are also formed when production wastes are incinerated. Incinerators, boilers and acid furnaces burn waste from the oxychlorination process (especially relevant are wastes such as "heavy ends" and distillation tars) and are responsible for the greatest proportion of dioxin releases during PVC production (Thornton 2002). Using data provided by the Vinyl Institute, the USEPA estimates that PVC-only production facilities were a documented source of dioxin air emissions (see Table 6) (USEPA 2001).

Mercury is used in the oldest and most energy intensive process for producing chlorine (Thornton 2002). There are nine chlor-alkali facilities in the U.S. that still use mercury in their process, a 50-year-old technology (Steingraber 2004). Most of this mercury is reused at the plant, but there are still significant air emissions, waste water releases and waste sludge generated (Thornton 2000). Only about 10% of chlorine production in the U.S. still uses mercury, though very little of the mercury-produced chlorine goes to the production of ethylene dichloride or vinyl chloride monomer. The chlorine industry is the largest consumer of mercury in the country (Thornton 2000).

Mercury emissions at these plants are another environmental and public health concern (Steingraber 2004, USEPA 2003c) as mercury causes reproductive and neurological damage (NAS 2000). Mercury is a potent neurotoxin that accumulates primarily as methyl mercury, in aquatic food chains. The highest levels are found in large predatory fish, such as tuna and swordfish. Air emissions of mercury are transported through the atmosphere and eventually settle on land or surface water where natural bacterial processes transform some of the mercury into methyl mercury. Ingestion of mercury-contaminated fish is the primary route of exposure to methyl mercury. Neurodevelopmental toxicity can result from the exposure of pregnant women and young children to mercury, leading to learning disabilities in children (USEPA 2003c, NAS 2000).

Plants that manufacture ethylene dichloride and vinyl chloride monomer are a risk to workers and residents of surrounding areas. In the early 1970's, plants that manufactured vinyl chloride were found to be exposing workers to levels of the chemical high enough to put them at risk of developing a rare form of liver cancer—angiosarcoma. In 1974, the industry finally admitted that workers exposed to vinyl chloride did develop this rare form of liver cancer (Creech 1974). Residents of communities near vinyl chloride production plants are also affected by plant emissions. These plants discharge pollutants into nearby communities, contaminating drinking water and releasing dioxins into the air from on-site incinerators. Besides cancer, workers and residents alike are vulnerable to a range of ailments associated with vinyl chloride exposure, including damage to the liver, lungs, blood, nervous system, immune system, cardiovascular system, skin, bones and reproductive system (Kielhorn 2000, ATSDR 1997). More detailed analyses of the human health and environmental impact of PVC production processes can be found in numerous references (Steingraber 2004, USEPA 2002, Kielhorn 2000, ATSDR 1997).

Although the levels of vinyl chloride and ethylene dichloride released from these facilities are lower today than in the past, exposure to these substances is still a concern. There appears to be no safe level of exposure for these substances, especially vinyl chloride. Both of these substances are considered to be "genotoxic" meaning that they cause irreversible damage to DNA (Kielhorn 2000). A generally accepted scientific theory is that mutation in a single cell can result in cancer (Pitot 1991). Similarly, exposure to a genotoxic substance can lead to DNA damage. This means there is no safe level of exposure to these substances and any exposure increases the risk of developing cancer, a birth defect or a genetic disorder. Thus, lower emissions from vinyl chloride and ethylene dichloride facilities reduce, but do not eliminate, health and environmental risks.

The production and disposal of PVC poses dangers relevant to everyone, but often, particular groups of people are especially at risk. Plants that manufacture the ethylene dichloride and vinyl chloride monomer are often located in low-income areas or communities of color, as are incinerators that burn PVC waste and landfills that store PVC waste (Thornton 1997). These types of sites pose a threat. Community-based groups understand the threat these facilities pose to their communities. The urgency of their opposition to these facilities speaks to the intensity of the danger that they feel these facilities pose.

C A S E   S T U D Y

Mossville, Louisiana:
PVC Production in the New "Cancer Alley"

In Calcasieu Parish, Louisiana, residents of Mossville, a small unincorporated community of about 1,500 African Americans, are confronting numerous toxic industries including four vinyl production facilities that include two major vinyl chloride manufacturers. Louisiana is home to more than half of the 12 vinyl chloride plants in the U.S., and Calcasieu Parish produces more vinyl than any other county in the country making it the unofficial PVC capitol of America. At the urging of Mossville residents, air monitoring conducted by the U.S. Environmental Protection Agency (USEPA) in June 1999 showed vinyl manufacturing facilities emitted concentrations of vinyl chloride, a potent human carcinogen, that were more than 120 times higher than the ambient air standard—making the air in Mossville unhealthy to breathe. PPG Industries and Condea Vista in Mossville leaked hundreds of thousands of pounds of ethylene dichloride, a feedstock for PVC, and contaminated the groundwater. As a result of this contamination and a lawsuit settlement with two companies, a significant portion of Mossville families have relocated. This has transformed a once highly populated neighborhood into a virtual ghost town. The Condea Vista facility has changed ownership, but has not improved. The portion of the facility now owned by Sasol Ltd. continues to be ranked in the top 10% of industrial companies that create the highest cancer risk from air and water pollution according to the USEPA 2002 Toxic Release Inventory. This data shows that in 2002 vinyl production facilities in Mossville generated 238,458,615 pounds of toxic waste that were dumped on the community or transferred to disposal facilities. Over 30 million pounds of this waste wound up in landfills and incinerators located in other communities.

In 1998, Mossville Environmental Action Now, Inc. (MEAN) appealed to the U.S. Agency for Toxic Substances and Disease Registry (ATSDR) to test residents for exposure to dioxin, a highly toxic compound that is a byproduct of vinyl manufacturing and other industrial processes. In 1999, ATSDR reported dioxin test results showed the average Mossville resident has three times more dioxin in their blood than the average U.S. citizen. Furthermore, testing of breast milk from local mothers found elevated levels of dioxins as high as 30% above the national average. Cancer mortality rates for Calcasieu Parish are 1.6 times the national average and many women suffer from endometriosis, a condition linked to dioxin exposure.

The citizens of Mossville are determined in their search for justice. As descendants of African Americans who proudly settled the community in the late 1800's, they have inherited not only the land, but also the fighting spirit to survive and demand what is rightfully theirs. Working through MEAN, they have lobbied successfully for government action. Through use of a Bucket Brigade program, which allows residents to test their own air, they have caused industry to be fined as much as $300,000 when testing showed benzene levels 231 times greater than the state standard. In 2001, Sasol Ltd., a South African company with chemical and fuel operations in 20 countries, acquired Condea Vista. Working in solidarity with communities in South Africa, SasolWatch.com was created to expose the company's record of violations and toxic dumping on poor communities. MEAN is working with a local health care provider to develop necessary environmental health services for Mossville residents. The organization is educating the public about the dangers of PVC production, use and disposal. MEAN is also demanding significant pollution reduction, the clean-up of industrial contamination in the local estuary, and the just and fair relocation of consenting residents to a healthier environment (Sources: MEAN 2000, Ermler 2001, LBB 2004, SasolWatch 2004, Greenpeace 2004a, Greenpeace 2004b).

PVC Use

PVC plastic used in consumer products is not a pure material. By the time a product containing PVC reaches your home, a wide range of chemicals have been added in order to change its properties to meet a wide range of product needs. These additives include stabilizers, plasticizers and fillers that are mixed in with, but are not chemically bound to the PVC. A list of common additives found in PVC products is shown in Table 5.

The most important of these chemical additives are the plasticizers known as phthalates (pronounced 'thal - eights') and the metal stabilizers. Plasticizers are added

Table 5
Common Additives Found in PVC

Stabilizers
Lead • Cadmium • Antimony • Organotins • Zinc
Plasticizers
Diethylhexylphthalate (DEHP) • Diisononylphthalate (DINP) Diisodecylphthalate (DIDP)

Source: CEC 2000, DEPA 1995

to PVC to "soften" the plastic and make it pliable for certain applications. About 90% of all phthalates consumed in the U.S. (and about 98% in England) are used in PVC products (Thornton 2002, OECD 2004). These plasticizers can make up a large portion, in some cases up to 60% by weight, of the vinyl product (DTI 1995). Because these additives are not chemically bound to the PVC, they will leach out over time (Thornton 2002).

Studies have shown plasticizers such as diethylhexylphthalate (DEHP) and diisononylphthalate (DINP) have migrated out of PVC containers used to store food (CR 1998, DTI 1995); IV bags used to hold blood (Pearson 1993, Tickner 1999); toys (NET 1999, Stringer 1997); and numerous other products, exposing people to these toxic additives (DEPA 2001, Harmon 2001, HCWH 2002).

In some cases, these additives will evaporate or "off-gas" from PVC materials like flooring, wall covering or carpeting, contaminating indoor air (CARB 1999, Rudell 2000, Uhde 2001). A study by the California Air Resources Board measured forty target compounds off-gassing from PVC flooring. Phenol was found in the air off-gassing from all the vinyl sheets evaluated. Tetrahydofuran, cyclohexanone, toluene and n-tridecane were also found (CARB 1999). Another study found the degradation of plasticizers from PVC flooring was likely responsible for an increase in adult asthma as well as eye and skin symptoms in workers. The prevalence of these symptoms decreased when the PVC flooring was removed (Tuomainen 2003). A Swedish study estimated that 42,000 tons of phthalates are released from PVC products worldwide each year (DTI 1995). The familiar "new car" smell or the odor from a newly opened shower curtain represents the release of phthalates evaporating from a PVC product (Thornton 2000).

Components of PVC have also been found to leach from PVC pipes. Vinyl chloride has been found to leach from PVC pipes made prior to 1977 (Yaw 1999). PVC pipes made prior to this time had a high residue of vinyl chloride that failed to bond when the vinyl chloride monomer was polymerized into polyvinyl chloride. In a study of unplasticized PVC pipe, vinyl chloride was detected in water after 30 days at 2.5 parts per billion (ppb), a level that exceeds the USEPA drinking water standard of 1 ppb (Al-Malack 2000). Smaller pipe size, longer line length, and warm temperatures all increase the likelihood of vinyl chloride leaching from PVC pipes. Additional studies have found organotin stabilizers also leach from PVC pipes (Sadiki 1999, Sadiki 1996, Wu 1989, Forsyth 1997).

Phthalates have been shown to cause developmental and reproductive damage (NTP 2000), altered liver (Woodward 1990) and kidney function (Seth 1982) and have been linked to the development of respiratory problems in children (Jaakkola 1999, Oie 1997). More detailed information on the health and environmental impact of phthalates used in PVC products are available from many resources (ATSDR 1997, HCWH 2002, Rossi 2001).

Metal stabilizers are used in PVC to prevent degradation from heat during processing and from exposure to ultraviolet light during the useful life of a product (Pless 2002). They include lead, cadmium, zinc, antimony and the organotins (see Table 5). These metals will leach out of PVC products. Lead and cadmium were found to leach out of children's toys made with PVC (DiGangi 1997). Lead migrated out of PVC window blinds (CT 1996) and into water carried in PVC pipes (DTI 1995). Lead is a known cause of neurodevelopmental problems (USEPA 2004a). Cadmium causes cancer and kidney damage (USEPA 2003d).

Organotin stabilizers (tributyltin, tetrabutyltin, monooctyltin, dioctyltin) were introduced to replace toxic metal stabilizers like lead and cadmium, but they have also been found to leach from PVC products (Sadiki 1999, Harmon 2001). The organotins are also toxic. They affect the central nervous system, skin, liver, immune system and reproductive system (WHO 1980, Pless 2002). The diorganotins, such as dioctyltin, are potent developmental toxins (Ema 1995, Pless

2002) and potent teratogens (Noda 1993, Pless 2002). Tributyltin affects the nervous system, and has caused reproductive and developmental problems in animal studies (Boyer 1989, ATSDR 1992).

Antimony trioxide (ATO) is added to PVC used in flexible electrical cables and roofing foils (an alternative to roofing felt on flat roofs) to inhibit the formation and spread of flames during a fire (UBA 2001, DEPA 1999). For flame retardant applications, PVC accounted for 32% of the European market for antimony trioxide in 1998 (UBA 2001). The antimony, which is a synergist rather than a flame retardant, acts to enhance the flame retarding properties of chlorine in PVC. Antimony trioxide is a suspect human carcinogen when inhaled and is toxic to the lungs, heart, eyes and skin (UBA 2001, NAS 2000a). During fires and waste incineration, antimony dust and toxic antimony halides are released. Antimony also catalyzes the formation of dioxins and furans (UBA 2001).

Other flame retardants added to PVC include chlorinated paraffins, phosphate esters (organic phosphorus compounds some of which also contain chlorine or bromine) and aluminum trihydroxide (UBA 2001). These additives are used in high volumes but are also used in many other polymer applications in addition to PVC. Chlorinated paraffins and antimony are added as a flame retardant formulation for some PVC textile fibers that are resistant to soaking and weather (UBA 2001). Chlorinated paraffins are complex mixtures of short-chain and long-chain hydrocarbons containing up to 70% chlorine. Chlorinated paraffins cause liver and kidney toxicity in animals while the short-chain mixture is an animal carcinogen and possible human carcinogen (NAS 2000a). Chlorinated paraffins and phosphate esters in PVC also function as secondary plasticizers (UBA 2001).

The phosphate ester flame retardants used in PVC include tris (2-chloroethyl) phosphate, tris (chloropropyl) phosphate [TCCP], and tris (dichloropropyl) phosphate [TDCPP]. These compounds are added to PVC floor covering and are released as off-gassing occurs from the vinyl (Marklund 2003). TDCPP was widely used as a flame retardant in children's sleepwear until May 1977, when it was withdrawn from the market after published reports that it was mutagenic in bacteria (Sanders 1978). The use of TDCPP as a flame retardant may pose significant cancer risks and reproductive harm (testicular atrophy and decreased seminal vesicle secretions), according to a committee of top U.S. scientists (NAS 2000a). The German Federal Environmental Agency has recommended a reduction in the use of TCCP in favor of safer substitutes, since it has high environmental persistence with some evidence of carcinogenicity. (UBA 2001).

Structural and Vehicle Fires

Another hazard associated with the use of PVC products arises when PVC is burned in an accidental fire. Not only are many building materials made from PVC but it was once standard practice to use PVC to insulate wiring in buildings. In 1995, there were an estimated 574,000 structural fires and another 406,000 vehicle fires in the U.S. (USEPA 2001). When the PVC in buildings and vehicles burns, a variety of toxic substances are formed that pose major public health risks. The primary combustion products are hydrogen chloride gas, carbon dioxide and carbon monoxide (OFM 1997). Hydrogen chloride gas is a corrosive and highly toxic gas that can burn the skin and cause severe damage to the eyes and lungs. When hydrogen chloride comes in contact with the mucous lining of the lungs, it is converted into hydrochloric acid that can cause severe and permanent respiratory damage (IAFF 1995).

Accidental fires that burn PVC also generate phosgene gas, benzene, toluene, xylenes, dioxins, furans and other products of incomplete combustion (IAFF 1995). The poor combustion conditions that are typical of these fires are ideal for the formation of dioxins and furans (TNO 1996). Dioxins were found in the air, water, surface soil and nearby vegetation following the burning of a plastics recycling plant in Hamilton, Ontario (OMEE 1997). In the World Trade Center fires, dioxins and furans were identified as significant components of the smoke given off by the smoldering buildings (Landrigan 2004). In Germany, dioxin levels in indoor soot remaining after a house fire were found to be as high as 45,000 parts per trillion (ppt) TEQ—more than 300 times the German government's health standard (Fiedler 1993). After a fire at a plastics warehouse in Binghamton, NY, dioxin levels in soils were found to be more than 100 times higher than other areas of the community not impacted by the fire (Schecter 1996).

Firefighters and emergency responders are especially at risk from smoke and gases generated by fires burning PVC. Exposure to combustion gases from building fires has been linked to a high incidence of leukemia and laryngeal and colon cancers in firefighters at young ages (Wallace 1990) and to other adverse health problems including pulmonary hemorrhage and edema due to chemical pneumonitis (Schreiber 2003, Dyer 1976). This is one of the reasons why the International

Association of Fire Fighters supports the use of alternative building materials that do not pose as high a risk as PVC (Duffy 1998).

The toxic gases generated when PVC is burned in accidental fires have resulted in deaths and injuries, including workers exposed to toxic gases from burning electrical wires coated with PVC (Colardyn 1978); residents exposed to airborne toxics from a Hamilton, Ontario plastics recycling plant fire (Upshur 2001); and guests who died in the MGM Grand Hotel fire in Las Vegas (Buerk 1982). A summary of the public health hazards associated with accidental fires that burn PVC has been published elsewhere (Schreiber 2003).

PVC's use to insulate wiring has raised concerns not only for its use in buildings, but also in airplanes. The use of PVC insulation around wiring was once standard practice in airplanes. A typical airplane, for example, could contain more than 100 miles of PVC coated wiring (Ackerman 2003). Insulation of the wires is critical to air safety, but defects in the insulation can lead to short circuits and sparks that could potentially start a fire or spark an explosion. If PVC wiring overheats and starts to smolder, large amounts of smoke are generated and, if moisture is present, hydrochloric acid can be produced. Although there is no proof that PVC insulation has ever caused an airplane crash, concerns have been raised about older airplanes that still contain PVC-insulated wires. Use of PVC wiring is now prohibited on new planes since PVC insulation failed Federal Aviation Administration flammability tests (Ackerman 2003).

Accidental fires are unexpected, and thus difficult to regulate, but phasing out PVC could reduce the harm they cause. If PVC was not so widely used as a building material, accidental fires would not produce the toxic combustion products that are specifically caused by the burning of PVC. Both immediate and long-term impacts would be lessened: firefighters and victims alike would avoid exposure to the toxic gases and smoke caused by the fire, and the leftover ash would be largely free of these toxins as well.

CASE STUDY

Illiopolis, Illinois: PVC Plant Explodes

On April 23, 2004, a PVC plant operated by Formosa Plastics in Illiopolis, Illinois exploded. A towering plume of smoke containing dioxins, hydrochloric acid, vinyl chloride and vinyl acetate could be seen for miles around. The explosion caused both power and water to be cut off and over 900 people were evacuated from the community. People were stationed in makeshift shelters including the local shopping mall. The U.S. Chemical Safety and Hazard Investigation Board called the explosion the most serious the agency has investigated since it was founded in 1998. Four workers were killed instantly and one died shortly after being hospitalized.

Nearly three months after the disaster, the Illinois Environmental Protection Agency (IEPA) reported elevated levels of dioxin were found in the soil at 12 of 13 sites sampled. Some samples reached levels of 50 ppt—10 times higher than normal. Some areas tested were as far as 3 miles from the explosion. Residents are concerned about the constant health risks posed by these hazardous sites. More testing is planned. (Sources: Antonacci 2004, IEPA 2004, Steingraber 2004a).

CASE STUDY

Montreal, Canada: PVC Fire and Firefighter Exposure

A 1993 fire in St. Terese, Canada at a plastics plant called Plastibec, Ltd consumed more than 15 tons of PVC. The plant manufactured vinyl blinds and vinyl window frames. After burning for 18 hours and forcing 250 people from their homes, the smoldering structure continued to emit thick black smoke. In the end, the fire produced between 40-85 grams of dioxins and furans, equal to the amount released by the pulp and paper industry in an entire year. Of the 50 firefighters called out to the blaze, 6 were treated for smoke inhalation and more than 30 required medical treatment after being exposed to the fumes (Source: Greenpeace 1994).

IV

THE DEADLY CONNECTION

PVC, Chlorine and Dioxin

MAJOR FINDINGS

- When burned, PVC plastic, which contains 57% chlorine when pure, forms dioxins, a highly toxic group of chemicals that build up in the food chain.
- The PVC content in the waste stream fed to incinerators has been linked to elevated levels of dioxins in stack air emissions and incinerator ash.
- PVC is the major contributor of chlorine to four combustion sources— municipal solid waste incinerators, backyard burn barrels, medical waste incinerators and secondary copper smelters—that account for a significant portion of dioxin air emissions. In the most recent USEPA Inventory of Sources of Dioxin in the United States, these four sources accounted for more than 80% of dioxin emissions to air (based on 1995 data).

The Formation of Dioxin

A major concern about PVC is the formation of dioxin during production and during disposal through incineration. The term 'dioxin' refers to a family of chemical compounds that are not intentionally made. They are generated as by-products during production and disposal of chlorinated compounds including PVC. There are many forms ("congeners") of dioxin, each with a different toxicity. The most toxic form is 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), and is the standard against which the toxicity of all other forms of dioxin is measured. TCDD is a known human carcinogen according to the U.S. National Toxicology Program (USHHS 2002), World Health Organization (WHO 1997) and U.S. Environmental Protection Agency (USEPA) (USEPA 2000). Dioxin is fat-soluble, which means it will bioaccumulate in increasing concentrations as it moves up the food chain. Exposure to dioxins is associated with reproductive and developmental health problems, and has been shown to impair immune system response and interfere with normal hormone function (Birnbaum 2003).

The PVC-Dioxin Connection

The relationship between PVC and the formation of dioxins in incinerators is clear: PVC is a significant chlorine donor in the incineration process, spurring the formation of dioxins. The strongest evidence of this comes from laboratory studies. The German EPA found that burning waste that includes PVC or other organochlorines produced dioxins, while burning waste without PVC did not (Theisen 1991). Two Danish studies found similar results (Vikelsoe 2000, Christmann 1989). In Japan, researchers found that adding 4% PVC to a mixture of PVC-free material increased dioxin emissions ten fold (Ishibashi 2000). When PVC was added to a mixture of newspapers or to chlorine-free paper and burned, dioxin emissions increased significantly with chlorine and PVC content (Yasuhara 2001). In a similar study, dioxin levels in fly ash were 200 to 1,200 times higher when PVC was added to a mixture of newspaper or chlorine-free plastics (Takasuga 2000). Several other studies found increased dioxin levels in fly ash or unburned residue were correlated with increased PVC levels in the waste stream burned (Kopponen 1992, Kolenda 1994, Wunderli 2000).

When elemental chlorine was added to a mixture of coal and salt, dioxin levels were 130 times higher than when the same mixture was burned without the chlorine (Mahle 1980). Adding PVC or chlorine gas to chloride-containing vegetable matter resulted in increased dioxin formation (Liberti 1983). In another study, as the level of organochlorines in a waste stream increased, so too did the amount of dioxins formed (Altwicker 1993). A study in Finland found that burning perchloroethylene in a laboratory produced more dioxins, chlorobenzenes and chlorophenols than burning sodium chloride (Halonen 1995).

There is also evidence from small-scale incinerators that support a relationship between burning organochlorine compounds like PVC and dioxin formation. The Danish EPA found that doubling the PVC content of an incinerator's waste feed increases dioxin emissions by 32% (DEPA 1995). Conversely, reducing the PVC feed results in a reduction in dioxin emissions. Researchers in Japan found that burning a mixture of PVC and polyethylene produced large amounts of dioxins (Tamade 2000, Yoneda 2000). A study conducted for the Dutch Environment Ministry found that PVC levels in the waste stream increased dioxin levels in the air emissions (Kanters 1996). Other studies in both the U.S. (Wagner 1993) and Europe (Christmann 1989, Vesterinen 1996, Halonen 1993, Hutari 1996, Manninen 1996, Hatanaka 2000) have found a positive correlation between PVC content in a waste stream and dioxin emissions.

An excellent review of the evidence linking chlorine content in the waste stream and dioxin emissions has been published (Costner 2001). This paper identified 47 studies involving laboratory and pilot scale combustion system/processes; 12 studies involving small-scale and other combustion systems/processes; and 31 studies involving full-scale combustors that are relevant to the relationship of chlorine content and dioxin emissions. The author found that reduced chlorine content was correlated with reduced dioxin formation in all three study groups and concluded that there is "a compelling body of evidence that dioxin formation in waste incinerators decreases when chlorine input is reduced."

The USEPA confirmed that PVC is a dioxin precursor in 1997 (USEPA 1997). They also acknowledged that, "several studies have identified strong correlations between chlorine content and CDD/CDF [dioxin/furan] emissions during combustion tests." As part of the Inventory of Sources of Dioxin developed by the USEPA, the agency acknowledged that a "review of experimental data clearly indicates an association between chlorine content of feed/fuels and … synthesis of CDDs and CDFs" (USEPA 2001). However, the agency concluded that the results on whether a relationship between chlorine input and dioxin emissions exists were not "unequivocal" and left it at that.

Additional insight into the relationship between PVC and dioxin emissions can be found by examining the USEPA Inventory of Sources of Dioxin. Table 6 summarizes dioxin emissions from sources that include PVC. The table shows facilities that burn PVC are responsible for most of the dioxin sources identified. Eight quantified air sources and eight non-quantified air sources are identified that include PVC as a chlorine contributor in the waste stream. There are also quantified releases to water and land from sources that clearly contain PVC as a chlorine donor. In addition, quantified sources such as tire burning and asphalt mixing plants may contain PVC when household garbage is burned with tires, or when PVC is added as "filler" in producing asphalt. In fact, any process that burns household garbage—including gasification or pyrolysis (systems that burn waste in the absence of oxygen) — can be expected to generate dioxin emissions in large part due to the presence of PVC in the waste (BREDL 2002). The table also shows a number of other unquantified sources that may include PVC as a contributor to dioxin emissions. The data used to generate these estimates were collected in 1995 and represent the most recent data available on dioxin emissions in the U.S. (USEPA 2001).

The top four quantified sources alone—municipal solid waste incinerators, backyard barrel burning, medical

Table 6

Dioxin Emissions in the U.S. from Sources that Include PVC

Sources with Chlorine from PVC	Dioxin Releases (grams/year TEQ*)
Quantified Air Sources	
Municipal solid waste incinerators	1,250 [see note below]
Backyard barrel burning	628
Medical waste incinerators	488
Secondary copper smelters	271
Cement kilns burning hazardous waste	156
Cement kilns not burning hazardous waste	17.8
EDC/VCM production	11.2
Hazardous waste incineration	5.8
Non-Quantified Air Sources	
Landfill fires	
Landfill gas	
Accidental fires	
Scrap electrical wire recovery	
Secondary ferrous metal smelting	
Ferrous foundries	
Manufacturing chlorine and chlorine derivatives	
PVC manufacturing	
Other Possible Air Sources	
Sewage sludge	14.8
Asphalt mixing plants	7
Secondary lead smelters	1.72
Tire burning	0.11
Total Dioxin Releases to Air	**3,125**
Quantified Releases to Water	
Ethylene dichloride/vinyl chloride	0.43
Quantified Releases to Land	
Ethylene dichloride/vinyl chloride	0.73
Municipal waste water sludge	76.6

Sources and Notes: All data are from the USEPA Inventory of Sources of Dioxin (USEPA 2001) which reflects data generated in 1995, the most recent year for which data are available. Since the 2001 Inventory was published, dioxin air emissions from municipal waste incinerators have declined for two reasons related to a December 2000 compliance deadline for new federal regulations on toxic air emissions: (1) the closure of 25 waste combustion plants, nearly 20% of the total number, between 2000 and 2002 (Kaufman 2004); and (2) added air pollution controls that shifted much of the total amount of dioxin formed to incinerator ash, which requires land disposal. The USEPA now estimates that dioxin air emissions from large municipal waste incinerators are 12.0 grams of dioxin per year (TEQ) from 66 large incineration facilities in 24 states (USEPA 2002a). Dioxin air emissions from 39 small incinerators were estimated at 50 grams per year TEQ in 2000 and are projected to decline to 1.8 grams per year in response to a December 2005 compliance deadline for new federal toxic air emission regulations (ERG 2002). These more recent estimates have not yet been peer reviewed or published according to USEPA.

* TEQ = toxic equivalents; a measure of the total amount of all forms of dioxins, furans, and dioxin-like PCBs found in a sample.

waste incinerators and secondary copper smelters—account for 2,637 grams TEQ, which is equivalent to 84% of the annual total estimated dioxin emissions to air. Clearly, not all of these emissions are attributable to PVC. Dioxin can be generated when other chlorine donors are present. The fraction attributable to PVC is not known.

It is clear from this evidence that without PVC, there would be considerably less chlorine in the incinerator feed and hence less dioxins formed. This is not to say that chlorine content is the only factor determining dioxin production. It is not. Facility design, operating conditions and the presence of catalysts also matter, but numerous studies support the conclusion that without chlorine, dioxin cannot be formed and that PVC is the predominant source of chlorine in the waste stream (Costner 2001).

It is misleading to focus only on stack air emissions when assessing chlorine's contribution to dioxin formation. Fly ash, bottom ash and other residues contain dioxin as well. Two studies on municipal waste incinerators provide evidence that only from 0.0004 to 1% of total dioxins formed remain in the stack gases (Fabrellas 1999, Sakai 1997). Other research has shown that there is a positive correlation between dioxin concentrations in ash and the amount of PVC in the waste feed. In one study, when PVC was burned with wood, dioxin levels increased in the ash (Wilken 1994). In another study, higher dioxin concentrations were observed in ash residue from chlorinated plastics than in ash from chlorine-free paper, wood, cotton or wool (Theisen 1991). In general, as more PVC is added, dioxin levels rise.

Nonetheless, most studies focus on dioxin concentrations in stack gas as a means of assessing the relationship between chlorine and dioxin. The fact that many studies examining miniscule dioxin concentrations in this hard-to-measure source still find a positive correlation between chlorine and dioxin testifies to the strength of the relationship.

Despite this compelling body of evidence, the Chlorine Chemistry Council (CCC) has aggressively argued that there is no relationship between PVC content and dioxin emissions from incinerators. The industry's prime support for this claim is a study funded by the Vinyl Institute, a member of the CCC, conducted by an industry consultant and published by the American Society of Mechanical Engineers (ASME). This study examined data from 169 facilities and concluded that there was "little or no correlation between chlorine input and dioxin emissions from incinerators" (Rigo 1995). This study has been critiqued and its methodology shown to be invalid (Thornton 2002, Costner 2000, Costner 1997, Chien 2003). In addition, the conclusions of the ASME study were refuted at a workshop held by the USEPA in 1996 on Dioxin Formation Processes and Sources (Costner 2000).

Furthermore, a memo prepared prior to the release of the ASME study by the public relations firm Nichols-Desenhall Communications (under contract to the Vinyl Institute) calls into question the derivation and perhaps the integrity of the ASME study. This memo laid out a strategy to diffuse any connection between chlorine content/PVC and dioxin emissions made by the USEPA as part of their Dioxin Reassessment effort. The memo recommends the Vinyl Institute fund an "independent" scientific study to "debunk" the USEPA's claim about the positive relationship between PVC and dioxin emissions (Burnett 1994). This study turned out to be the one conducted under contract with the consulting firm of Rigo & Rigo Associates under the auspices of ASME. An internal Vinyl Institute memo described the role of the ASME, "The purpose of the ASME as the contractor is to provide unassailable objectivity to the study …" (Goodman 1994). In this same memo, Rigo was described as "… willing to set his priorities to our needs, and he appears sympathetic to Plastics, Vinyl, PVC and Cl2 ..." Additional details on these memos have been described elsewhere (Thornton 2002).

PVC is the primary source of chlorine in the waste stream. Eliminating PVC would dramatically reduce the amount of chlorine being burned, and thereby limit dioxin formation. Given the abundant evidence implicating chlorine as an essential precursor to dioxin formation, it is important to reduce if not eliminate the levels of PVC in the waste stream. Banning PVC would be the most effective means of achieving this goal.

V

DON'T BURN IT
The Hazards of Burning PVC Waste

MAJOR FINDINGS

- More than 100 municipal waste incinerators in the U.S. burn 500 to 600 million pounds of PVC each year, forming highly toxic dioxins and releasing toxic additives to the air and in ash disposed of on land.
- The largest PVC-burning states include Massachusetts, Connecticut, Maine—which all burn more than half of their waste—Florida, New York, Virginia, Pennsylvania, Maryland, Minnesota, Michigan, New Jersey, Indiana and Washington.
- The incineration of medical waste, which has the highest PVC content of any waste stream, is being steadily replaced by cleaner non-burn technologies.
- Open burning of solid waste, which contains PVC, is a major source of dioxin air emissions and dioxin-laden ash, as well as other dangerous pollutants.
- Backyard burning of PVC-containing household trash is not regulated at the federal level and is poorly regulated by the states—it is completely unrestricted in Michigan and Pennsylvania, partially restricted in 30 states and banned in 18.

When PVC is burned in municipal and medical waste incinerators, dioxins and other toxic gases are formed and heavy metals present in the waste are released into the air and residual ash. Dioxins are also released when residents in rural areas dispose of their trash by burning it in small furnaces or barrels behind their homes, and when PVC products or waste are burned in building, vehicle and landfill fires.

Municipal Waste Incinerators

Incineration, or high-temperature burning, is frequently used to dispose of municipal, hazardous and medical wastes. Because PVC is a widely used plastic (especially in medical applications), the waste burned in these incinerators inevitably contains PVC. As discussed earlier, the chlorine in PVC facilitates the formation of dioxins and other chlorinated organic compounds that are subsequently released to the environment (Costner 2001). Thus, incinerators are a major source of dioxins released to the air and land, and PVC is largely responsible for this situation.

Municipal waste or household trash incinerators are considered the largest source of dioxin emissions in air (USEPA 2001). The most recent inventory of dioxin sources in the U.S. estimated municipal and medical waste incinerators together account for 55% of all dioxin releases to air (40% and 15%, respectively) (USEPA 2001). Dioxin air emissions have since declined as

Table 7

States with the Heaviest Reliance on Municipal Waste Incineration

State	Percent Incinerated (After Recycling)	Number of Incinerators	Amount of PVC Incinerated (tons)
Maine	66.2%	4	5,448
Connecticut	55.4%	6	16,257
Massachusetts	54.6%	7	28,145
Minnesota	46.1%	15	14,432
Florida	37.1%	13	45,364
Hawaii	32.7%	1	3,454
Virginia	27.9%	5	18,806
New York	24.4%	10	37,517
Maryland	22.6%	3	12,486
Pennsylvania	22.6%	6	17,746
New Hampshire	22.2%	2	1,675
Remaining States*	Varies	32	49,075
Total	10.5%	104	250,405

Sources and Notes: Estimates derived from Kaufman (2004) for 2002. The amount of PVC incinerated by each state was calculated by: (1) assuming that the percent PVC content of municipal solid waste (0.62%) estimated by the USEPA (2003) is representative of the typical percentage of PVC in the waste stream; (2) assuming that post-consumer recycling of PVC in MSW is zero; (3) multiplying the average percent PVC in the waste (0.62%) by the total waste generated in that state according to Table 4 in Kaufman (2004); and (4) multiplying this value (the total PVC disposed in the state) by the percent of waste incinerated after recycling as shown in column 2 above. The percent of PVC incinerated after recycling was determined by dividing the total amount of waste incinerated in a state (provided in Table 4 of Kaufman 2004) by the total waste disposed of (after recycling).

* 19 states did not burn any MSW according to Kaufman 2004 and AL, AK, and MT did not report any data (see Appendix B).

incinerators have closed or added pollution controls to meet new standards (USEPA 2002a, ERG 2002). Now much of the dioxins formed from incinerators are released to the land through landfilling of incinerator ash.

Table 7 lists those states that rely heavily on incineration as a disposal option for municipal solid waste. Maine, Connecticut, and Massachusetts incinerate more than 50% of their municipal solid waste destined for disposal (not counting the amount of waste recycled). Minnesota has the largest number of municipal waste incinerators (15) followed by Florida (13) and New York (10). These states have been dependent on waste incineration since the late 1980's and early 1990's. This trend may have been motivated by zealous protection of abundant groundwater and surface water supplies; limited potential for new landfill capacity; subsidies for generating electricity from waste burning; and state policies which favor incineration over land disposal. A complete listing of the amount of PVC burned in each state is shown in Appendix B.

As shown in Table 7, an estimated 250,000 tons (500 million pounds) of PVC is burned in trash incinerators in the U.S. each year (Kaufman 2004). This estimate is even higher if you use the municipal solid waste data generated by the USEPA. Using the USEPA data for the year 2001, the amount of PVC burned is estimated to be about 600 million pounds (USEPA 2003). These values are consistent with other estimates (Thornton 2002). As discussed earlier, PVC waste contributes substantially to the chlorine content of the waste and to the formation of dioxins in trash incinerator emissions. Estimates of how much PVC waste contributes to the chlorine content in waste streams vary from 35 to 66% (CEC 2000, ECC 1994). Other minor chlorine sources include food waste and paper. Another source estimates that, on average, about 50 to 67% of the chlorine input in an incinerator can be attributed to PVC (Thornton 2002). However, as much as 80% of the organically bound chlorine, which is thought to be more conducive to dioxin formation than inorganic chlorine, is from PVC (Thornton 2000).

In addition to dioxins, PVC waste contributes to the formation of hydrochloric acid (HCl) in the flue gases of incinerators. This gas must be neutralized (primarily by lime) and removed by scrubbers. HCl damages the air pollution control equipment because it is so corrosive and requires additional maintenance. In addition, the metal stabilizers in PVC (lead and cadmium) do not break down during incineration but are released either as hazardous air emissions or remain in the ash and cinders (ECC 1994). Older PVC products that used cadmium as a metal stabilizer will contribute cadmium when burned (ECC 1994). Consequently, the more PVC in the waste stream the greater the operating cost of the incinerator due to: (1) the use of more agents to neutralize the acids and flue gases; (2) additional operating and repair costs; and (3) additional waste management costs to dispose of the residual ash (CEC 2000).

Waste incineration has been linked to a number of serious health problems in plant workers, as well as in surrounding communities. Many of these troubles implicate PVC as the root source of contamination. For instance, workers in incinerator plants have increased levels of chlorinated phenols and lead in their body tissues, which may result from PVC, as well as mercury and arsenic (Allsopp 2001). The USEPA has reported that metals emissions in incinerators rise when the chlorine content of the waste rises. In one study, metals were up to seven times higher when the chlorine content of the waste was increased from 0 to 8.3% (Carroll 1989). Elevated chlorine content levels also impair the efficiency of the scrubber (an air pollution control device) to remove metals from stack gases (Carroll 1989). Incinerator operators are not the only exposed group. Populations living near incinerators are particularly vulnerable to elevated levels of dioxins and heavy metals in tissue and blood, as well as to respiratory ailments and cancers (Allsopp 2001). Elevated levels of congenital abnormalities have also been observed in newborns in areas in the immediate vicinity of incineration plants (ten Tusscher 2000).

Even distant populations are at risk, as toxic air releases settle on crops and these crops are transported to other areas and/or eaten by livestock which, in turn, are consumed by people (Cohen 1998, Cohen 1995). A study by Barry Commoner and researchers at Queens College in New York found Inuit Native peoples living in the northern reaches of Canada, miles from any sources of dioxin, had high levels of dioxin in their bodies (Commoner 2000). These researchers also found dioxins released from incinerators and other dioxin sources hundreds of miles away in the U.S. and lower Canada were transported by wind currents to the far reaches of the globe.

A common argument in favor of incinerators is that they significantly reduce the weight and volume of waste going to landfills. While waste volume is reduced by about 45 to 50%, this statement only tells part of the story. The fly ash captured by the air pollution control equipment and the residual ash left in the burner must be disposed of in landfills and is often more toxic than the original raw waste. This is the result of burning metal-containing materials (including PVC), chlorine-containing PVC waste that generates dioxins, and other difficult to burn waste. This ash is stored in landfills, and often leaches into surrounding soil and water. Incineration may indeed reduce the volume of waste going to landfills, but in doing so, this practice shifts the waste burden to air releases and increases the toxicity of the waste that will eventually be landfilled in the form of ash. Incineration is not a solution to waste disposal, especially not for PVC-containing waste.

Medical Waste Incinerators

Incineration of medical waste involves the burning of solid waste generated primarily by hospitals and research facilities. PVC accounts for 5 to 15% of medical waste (DTI 1995, Hasselriis 1993, Marrack 1988, USOTA 1988). Medical products made of, or containing, PVC include surgical gloves, dialysis tubing, blister packs, inhalation masks, IV bags/tubing, mattress covers and blood bags. Even non-medical products containing PVC (e.g., office supplies) are often burned along with medical trash.

As the overall volume of waste generated by hospitals has increased over the past 50 years, so has the proportion of that waste containing PVC. In 1996, PVC accounted for 27% of all plastic used in durable and disposable medical products (Rossi 2000). This growth in the use and disposal of vinyl medical products has led to increased chlorine input to medical waste incinerators and thus greater dioxin formation. In 2001, the USEPA cited medical waste incinerators as the 3rd largest source of dioxin releases to the environment in the U.S (USEPA 2001).

In 1990, roughly 70% of U.S. hospitals used on-site incinerators (USOTA 1990). According to the USEPA, the number of medical waste incinerators operating in the U.S. dropped roughly in half from 1987 to 1995 (USEPA 2001). Similarly, the amount of medical waste burned in these incinerators dropped from an estimated 1.43 billion kilograms (kg) in 1987 to 0.77 billion kg in 1995. Today there are substantially fewer medical waste incinerators operating (USEPA 2004b). Some of this drop is due to new regulations that have gone into effect, which increased operating costs (USEPA 2000a). But the work of activist grassroots citizen organizations and national groups like Health Care Without Harm have played a major role in shutting down medical waste incinerators and encouraging the use of non-incineration treatment technologies (HCWH 2001, Lester 2003).

Hospital waste primarily consists of general solid waste (70%), medical waste (17%), patient waste (9%) and a small amount of hazardous waste (2%). Approximately 15% of this waste is considered to be infectious waste (HCWH 2001), which requires treatment to disinfect the waste but not necessarily incineration. Viable alternatives to incineration exist for the disposal of the remaining 98% of medical waste that is non-pathological. Much of this waste is paper, cardboard, plastic, metals and general solid waste that does not need to be burned.

The most prominent alternative for treating hospital waste is autoclaving—a process that disinfects the biological waste component. Other treatment methods include microwaving, electro-thermal deactivation, gasification, chemical disinfection and thermal treatment (HCWH 2001). Yet even these alternatives do not address the underlying problem, the initial use and generation of PVC wastes. A better solution is to replace PVC products with non-chlorinated plastics.

Given the finding in recent studies that flexible PVC products used in hospitals (like dialysis tubing) leach toxic additives into patients' bodies (USFDA 2001, NTP 2000), the imperative to employ alternatives is stronger than ever. Additives mixed in with PVC to make it flexible or rigid are not chemically bound to the plastic and are thus prone to leach from the material. One such additive, a phthalate called 2-diethylhexyl phthalate (DEHP), has been found to leach from soft plastic, and has been documented to have a significant impact on the development of the male reproductive system and the production of normal sperm in young animals (Moore 2001). Also linked with DEHP exposure is respiratory distress, changes in kidney and liver function, ovarian dysfunction and decreased hormone production in females (Rossi 2001).

Open Burning

Perhaps the most under appreciated source of dioxin emissions is the open burning of household trash.

C A S E S T U D Y

Detroit, Michigan:

Henry Ford Hospital Medical Waste Incinerator

In February 2000, residents of a predominately African-American community in Detroit, Michigan succeeded in their efforts to shut down Henry Ford Hospital's medical waste incinerator. Since it began operating in 1980, the facility had been burning approximately 6 million pounds of waste annually. As of 1998, Henry Ford was the only hospital (of 25 surveyed) still burning medical waste in an on-site incinerator. Environmental justice was a primary concern: the Henry Ford Hospital System owns two other hospitals located in predominately white suburbs that send their waste to a commercial autoclave facility in Toledo, Ohio rather than burn it. This inconsistency fueled local activists.

The Henry Ford Hospital incinerator was a major, chronic polluter. For instance, the only emission controls in place were opacity limits, which do not involve emissions testing, but use a visual estimate of how 'opaque' a cloud of smoke emitted from the stack is. And even those limits had been violated on a number of occasions. Federal pollution controls on emissions of mercury, dioxins and heavy metals had not yet been implemented in Michigan, so the facility burned medical and other waste largely without regulation. The impact on public health was consequently severe. A five year long Michigan Department of Community Health study found the rate of children hospitalized for asthma in the zip codes immediately surrounding the incinerator to be three times that of neighboring Wayne County. Moreover, a report commissioned by the New York University Research Program focusing on Ambulatory Care Sensitive Conditions in Michigan from 1983 through 1994 found that in the four zip codes surrounding the incinerator, the average hospital admissions of children aged zero to four were four times the state average.

A coalition of more than a dozen organizations including Detroiters Working for Environmental Justice, Virginia Park Citizen's District Council, a local Sierra Club chapter, and the Sugar Law Center for Economic and Social Justice worked together for four years before successfully closing the incinerator in the spring of 2000. Strategies included civil disobedience, media attention and coalition building. Yard signs helped draw attention to the fight, and a constant barrage of phone calls and postcards to hospital officials ensured residents' concerns would not be ignored. Steady, targeted pressure on executives within Henry Ford Hospital System was a major factor in the eventual shutdown of the incinerator (Sources: Lott 2004, Holden 1999, Bates-Rudd 2000).

CASE STUDY

Oakland, California: IES Medical Waste Incinerator

On December 10, 2001, after a 4-year struggle, Integrated Environmental Systems (IES) was forced to shut down its commercial medical waste incinerator in Oakland, California. Even under "perfect" operating conditions, the incinerator was known to emit dioxins, mercury and other toxic pollutants. The facility was also notorious for all kinds of permit violations including excess emissions, broken monitors, odors, uncontrolled bypasses of the pollution control devices and worker safety violations.

The Coalition for Healthy Communities and Environmental Justice, consisting of Oakland residents and community, health, and environmental justice organizations, formed to bring an end to the IES incinerator. After having ignored emissions and permit violations for years, the Bay Area Air Quality Management District finally took action by declining to renew the facility's operating permit in 2001. When IES insisted on its intentions to keep burning millions of pounds of medical and non-medical waste every year, a powerful direct action was planned and executed by the Coalition. Community protesters blocked the entrance to the IES incinerator for eight hours nonviolently putting their bodies in front of trucks carrying waste.

Owing largely to the community's powerful voices and actions, IES sold its company to competitor Stericycle in December 2001 who is reportedly planning to tear down the incinerators and close the facility (Sources: Greenaction 2001, Greenaction 2001a).

CASE STUDY

Gila River Indian Reservation, Arizona: Stericycle Medical Waste Incinerator

Members of the Gila River Indian community near Chandler, Arizona organized as the Gila River Alliance for a Clean Environment and succeeded in forcing Stericycle to shut down a medical waste incinerator operating on tribal land in 2002. The incinerator had been burning medical and non-medical waste from several states for about 10 years, and was among the largest in the U.S. Waste from hospitals, medical and dental offices, mortuaries and research institutes was among the waste being burned. When Stericycle's lease for the facility came up for renegotiation, activists seized the opportunity to push for cleaner technologies like autoclaving. The renegotiated lease will allow only an autoclave on the site. With the closure of this facility, there are now no commercial medical waste incinerators in Arizona, Nevada, or California (Source: Greenaction 2002).

Open burning, also called uncontrolled burning or backyard burning, involves the burning of household trash by residents on their property. Burning typically occurs in a burn barrel, open fireplace or furnace, homemade burn box, wood stove, outdoor boiler or open pit (USEPA 2003e). Most backyard burning occurs in rural areas where there is no curbside trash pickup. According to government surveys, an estimated 20 million people in rural areas burn trash in their backyards (MDEQ 2003).

The smoke and vapors from the open burning of household trash contain many toxic chemicals that can affect people's health and the environment, including dioxins and furans; carbon monoxide; heavy metals such as mercury, lead, arsenic, and cyanide; volatile organic compounds (VOCs) such as benzene, styrene, and formaldehyde; particulates; polycyclic aromatic hydrocarbons (PAHs); and hexachlorobenzene (USEPA 2003f, MDEQ 2003). Exposure to these chemicals have been linked to adverse health problems including, but not limited to asthma, lung cancer, and other respiratory ailments, kidney and liver damage, and nervous system, reproductive and developmental disorders (USEPA 2003g). One study found emissions were highest for VOCs such as benzene and styrene, formaldehyde, hydrogen cyanide and hydrochloric acid, followed by polychlorinated biphenyls (PCBs) and arsenic (MDEQ 2003).

Among the toxic byproducts of backyard waste burning, dioxins and furans may pose the greatest public health threat. Dioxins are highly toxic even at low levels and have been linked to serious health problems in people that include cancer and adverse developmental and reproductive effects (USEPA

2003g, Birnbaum 2003). Dioxins are formed primarily because of low combustion temperatures, poor air distribution, and the presence of chlorine (USEPA 2003h). The majority of chlorine in household trash comes from PVC plastic. Because the emissions from open burning are released close to the ground, they are particularly dangerous to people and animals located nearby. There are also no pollution control devices on these burners.

The backyard burning of household trash also produces residual ash that contains toxic metals such as lead, chromium, mercury and arsenic, as well as PCBs and dioxins (USEPA 2003f, Lemieux 1998). The ash left over from the burning is often used by homeowners in gardens or placed in areas where children may play and come in contact with these toxic substances. In gardens, vegetables can absorb and accumulate the metals (USEPA 2003f).

Open burning was not initially identified by the USEPA as a source of dioxin (USEPA 1998). Now the agency has identified open burning as a major source of dioxins. The USEPA's most recent Inventory of Sources of Dioxin estimated open burning may account for as much as 628 grams TEQ dioxin, making it the second largest source of dioxin emissions in the U.S. (USEPA 2001). The USEPA found a single household burn barrel may release more toxic chemicals into the air than a municipal waste incinerator burning 200 tons of household trash a day that is equipped with state-of-the-art air pollution control devices (Lemieux 1998).

C A S E   S T U D Y

Maine Bans Backyard Burning; Warns Public About PVC Hazards

Reducing dioxin emissions and protecting the health of Maine residents was a high priority when the Maine legislature voted to prohibit backyard trash burning in 2001. This new law and PVC educational outreach followed a citizen advocacy campaign led by the Natural Resources Council of Maine which focused on reducing the use and disposal of PVC because of its role as a dioxin-forming consumer product. A 1997 study found 10,000 backyard burn barrels across rural Maine and documented the high levels of dioxin emissions and exposures that resulted. The law also required the Maine Department of Environmental Protection (DEP) to educate people about dioxin-forming PVC products and their alternatives.

An educational bulletin, poster and flyer prepared and distributed by the Maine DEP contain clear and compelling messages about PVC.

> "We can make a difference by RETHINKING our purchasing habits to avoid putting PVC products in the waste stream."
>
> "You can help to reduce dioxin pollution from municipal trash incineration by: REPLACING #3 PVC Products with 'less polluting' natural materials OR safer plastic alternatives #1 PETE, #2 HDPE, #4 LDPE, #5 PP."
>
> "PVC plastics waste is a major source of our dioxin pollution in Maine. It is the only plastic that forms significant amounts of dioxin when burned and has very low recycling rates. It is even preferable to avoid burning PVC in municipal incinerators to reduce air pollutant levels and toxic ash disposal. Safe alternatives exist for virtually every use of PVC plastic."

Maine's educational materials also give clear consumer guidance on safer alternatives to typical uses of PVC plastic. The Maine DEP established the link between open burning and PVC as follows: "In addition to eliminating backyard trash burning, we need to reduce the toxic nature of our waste stream that goes to incineration because of the potential for serious health effects and contamination of our food supply" (Sources: MDEP 2001, MDEP 2001a, MDEP 1997).

A key study used by the USEPA to estimate the amount of dioxins generated by open burning of household trash was published in 1998 by a New York researcher (Lemieux 1998). The author burned two sets of simulated household garbage in separate metal burn barrels in a controlled laboratory setting and measured emissions from each barrel. One barrel contained simulated waste from a household that did not recycle and the other contained waste remaining after "avid recycling." This study reported high emissions of volatile organic compounds (VOCs) including benzene, polynuclear aromatic hydrocarbons (PAHs), chlorinated benzenes and dioxins and furans. Surprisingly, higher levels of dioxins and furans were found in the emissions from the avid recycling household sample compared to the non-recycler.

A likely explanation for this difference may be the higher proportion of PVC plastic which is not recycled that ends up in the trash of the avid recycling household (4.5% versus 0.2%). According to the author of the study, "the higher proportion of PVC plastic in the avid recycler's waste stream could potentially increase the formation of chlorinated organic compounds." Other factors such as time, temperature history, mixing patterns, oxygen availability, as well as the mixture of carbon with chlorine in the presence of metal catalysts are also important factors in the formation of PCDDs (dioxins) and PCDFs (furans) (Lemieux, 2000).

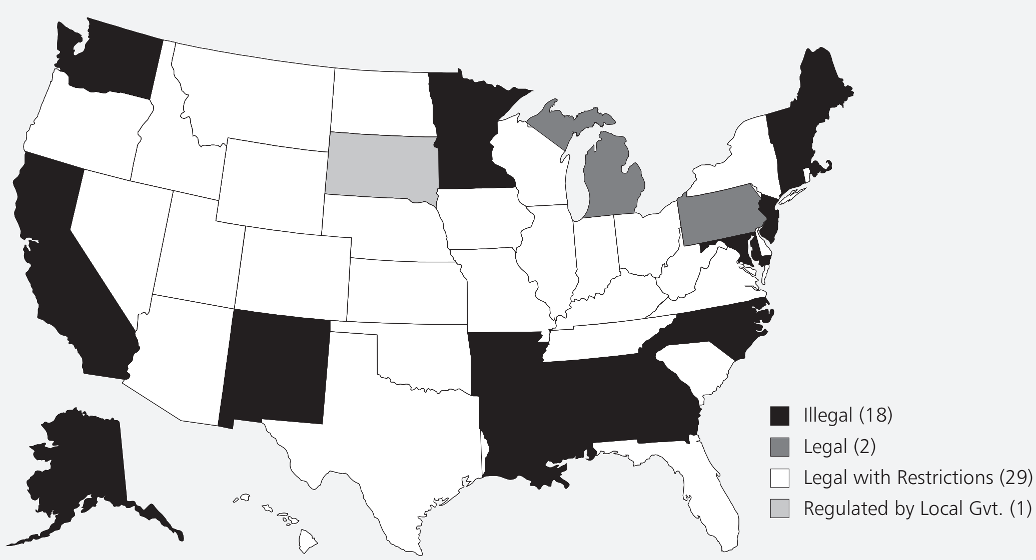
Initially, USEPA considered that PVC content in the waste might be a key determinant of dioxin emissions during open burning (Lemieix 1997, Gullett 1999). They conducted several experiments to evaluate the effect of PVC and chlorine input on dioxin emissions (Gullett 1999, Gullett 2000, Gullett 2001). The latest study concluded that the chlorine in the waste does appear to influence dioxin emissions, but only at high levels not typically found in household trash, and dioxin emissions were independent of the source of chlorine (Lemieux 2003).

A recent reanalysis of this same data found a very strong correlation between PVC and dioxin emissions in the USEPA burn barrel experiments (Neurath 2004). This study found that the percent chlorine, especially the percent PVC, were "the most important predictors of dioxin emissions"—not combustion variables such as carbon monoxide, temperature, or air input levels as claimed by the USEPA (Neurath 2004). Backyard burning is not like an incinerator where you can control these variables. By definition, uncontrolled burning is uncontrolled. What can be controlled is the type of waste, such as PVC, that is burned.

Open burning of household trash is thought to account for a considerable share of dioxin air emissions in many states including Maine (26%) (MDEP 2004) and New Hampshire (17%) (NHDES 2001). Some states including Massachusetts, Maine, Vermont, Connecticut, North Carolina, New Mexico, and Washington (USEPA 2003i), recognize the threat to public health and have adopted regulations completely banning open burning of household trash. Others, such as Alaska (AKDEC 2004) and California (CARB 2003), while allowing the burning of paper, cardboard and yard waste, have specifically banned the burning of plastic, rubber and other hazardous materials.

Figure 3 includes data originally developed by the New Hampshire Department of Environmental Services and updated in 2004. The figure shows open or backyard burning is illegal in 18 states, restricted in 29 states, completely unrestricted in two states (Michigan and Pennsylvania) and left to local government in one state

Figure 3. Current State Regulations on Backyard Burning of Household Waste in the U.S.



Source: Adapted from NHDES 2001

(South Dakota) (NHDES 2001, NHDES, 2003, NMED 2004, CARB, 2003a, MRSA 2004). Several states that have yet to enact proper legislation (e.g., Rhode Island, New York, Pennsylvania) have issued public health statements and developed pamphlets warning of the dangers associated with burning plastic, specifically the release of dioxins. The USEPA currently has no regulations that apply to open burning even though they estimate that it is one of the largest sources of dioxin in air (USEPA 2001). To assist in finding current regulations for each state, the USEPA has constructed a virtual map on their Website with links to each state's rules and regulations (USEPA 2003i).

Regulations on open burning typically vary between rural and urban/suburban areas. While generally prohibited in highly populated areas and municipalities, open burning is seldom stringently regulated in rural areas. One reason given for this has been that decisions on whether to restrict or ban open burning of household trash has been driven by citizen complaints (Lighthall 1998). Thus, those communities with enough people to generate a substantial number of complaints are the ones that enact or adopt policies to restrict or ban the open burning of household trash.

Every state has distinct laws though, and even within states, rules are far from uniform. Even in those states and areas where rules and regulations exist, enforcement is extremely difficult. This lack of coherence tends to stifle efforts to curb open burning in general and PVC burning in particular. Unless open burning can be curtailed or even adequately controlled, it is unrealistic to expect PVC will not be burned. PVC will continue to harm human and environmental health as long as open burning continues to be used to dispose of trash.

In addition to open burning of household trash, vehicle fires, structure fires, construction site burning and landfill fires all represent significant types of uncontrolled PVC combustion. Because PVC is so ubiquitous, the chance that it will be burned in intentional or accidental fires is high.

The cost of waste disposal has risen in recent years, and many rural residents are unable or unwilling to pay these increased costs. Otherwise laudable "pay-as-you-throw" (variable rate pricing) programs in communities across the nation aim to reduce waste, but in rural areas accustomed to paying a fixed rate regardless of the amount of waste they generate, such programs actually tend to trigger an increase in burning and illegal dumping. Rather than reduce the amount of waste generated, the more appealing option for some is illegal dumping and/or open burning. Moreover, proper disposal is often less convenient in rural areas. Burning trash may be a more appealing option than driving long distances to pay for and legally dispose of trash. State and local governments must address matters of affordability and convenience in these areas in order to help bring an end to open burning (MEDEP 1997). In the long term though, replacing PVC with safer alternatives is the only way to eliminate PVC from the waste stream.

NO PLACE LEFT
Problems with PVC in Landfills

VI

MAJOR FINDINGS

- Dumping of PVC in landfills poses significant long-term environmental threats due to leaching of toxic additives into groundwater, dioxin-forming landfill fires and toxic emissions in landfill gases.
- Land disposal is the final fate of between 2 billion and 4 billion pounds of PVC that is discarded every year in some 1,800 municipal waste landfills.
- Many of the more than 1,900 landfills used for disposal of construction and demolition (C&D) debris are unlined and can not capture any contaminants that leak out of PVC building material waste.
- An average of 8,400 landfill fires are reported every year in the U.S., contributing further to PVC waste combustion and dioxin pollution.

Landfilling is the most common disposal option for PVC and thus is a significant part of the disposal stage of the PVC life cycle. The majority of PVC that is discarded as waste ends up in a landfill. However, landfills do not solve the PVC disposal dilemma. They eventually leak, routinely emit toxic gases and occasionally catch on fire. Landfills merely represent a temporary, polluting alternative to burning PVC and creating dioxins. As an interim strategy, land disposal of PVC is preferable to incineration, but it does not provide a long-term secure solution to PVC waste management.

Municipal Waste Landfills

In 2001, about 79% of U.S. municipal solid waste destined for disposal was landfilled (USEPA 2003). According to data made available by the USEPA, about 1.42 million tons of PVC was in U.S. municipal solid waste in 2001 (USEPA 2003). This represents less than one percent of the 163 million tons of municipal solid waste disposed of in landfills and incinerators. (This total does not include an additional 49 millions tons of municipal discards that were recycled or composted and contained negligible amounts of PVC).

The USEPA data establishes a low-end estimate of about 1.12 million tons of PVC (more than 2.2 billion pounds) that was dumped in landfills in 2001 (USEPA 2003). Using another source of data on municipal waste generation for 2002, the amount of PVC dumped in landfills was estimated at 2.04 million tons, or more than 4 billion pounds (Kaufman 2004), nearly twice the USEPA amount. This latter estimate assumes the same percent PVC content in the municipal solid waste stream as reported by the USEPA.

The estimated number of active landfills in the U.S. that accept PVC for disposal in municipal solid waste varies. Citing 2002 data reported by 47 states, Kaufman lists a total of 1,767 municipal solid waste landfills (Kaufman 2004). USEPA concluded that 1,858 landfills received municipal solid waste in 2001 (USEPA 2004c). Yet another source estimates that there are 3,200 municipal solid waste landfills (EREF 2004).

Table 8 lists those states that rely heavily on landfilling as a disposal option for municipal solid waste in the U.S. California, Texas and Michigan landfill the most waste. Texas has the largest number of landfills (175), followed by California (161) and Florida (100). A total of 19 states including Texas, Ohio, and Illinois landfill 100% of their waste. A complete listing of the amount of PVC landfilled in each state is show in Appendix B.

Table 8

Estimated Amounts of PVC Discarded in Landfills According to States that Landfill the Most Municipal Solid Waste (MSW)

State	Number of Landfills	Amount of PVC Landfilled (tons)
California	161	328,260
Texas	175	176,896
New York	26	116,088
Ohio	44	100,509
Illinois	51	98,896
Michigan	52	96,241
Florida	100	76,817
Georgia	60	69,177
Pennsylvania	49	60,844
New Jersey	60	56,166
North Carolina	41	54,842
Indiana	35	52,986
Washington	21	49,128
Virginia	67	48,636
Maryland	20	42,722
Remaining States*	805	610,553
Total	**1,767**	**2,038,761**

Sources and Notes: Estimates derived from Kaufman (2004) for 2002. The amount of PVC landfilled by each state was calculated by (1) assuming that the percent PVC content of municipal solid waste (0.62%) estimated by the USEPA (2003) is representative of the typical percentage of PVC in the waste stream; (2) assuming that post-consumer recycling of PVC in MSW is zero; (3) multiplying the average percent PVC in the waste (0.62%) by the total waste generated in that state according to Table 4 in Kaufman (2004); and (4) multiplying this value (the total PVC disposed in the state) by the percent of waste landfilled after recycling as shown in column 2 above. The percent of PVC landfilled after recycling was determined by dividing the total amount of waste landfilled in a state (provided in Table 4 of Kaufman 2004) by the total waste disposed of (after recycling).

* AL, AK, and MT did not report any data (see Appendix B).

The amount of PVC waste going to landfills is expected to increase substantially over the next 20 years. A study in Europe found the amount of PVC waste generated in the 15 European Union countries will increase from 3.6 million tons per year in 2000 to 4.7 million tons in 2010 and to 6.4 million tons per year by 2020 (AEA 2000, ARGUS 2000). This is an increase of more than 75% over 20 years. This is because most PVC products were put into commercial use during the 1970's and their useful service life is ending. Components in cars, construction materials, and electrical, household and industrial goods typically last from 5 to 15 years (AEA 2000). Building materials such as pipes, flooring, and siding may last for decades before being replaced (AEA 2000). As production of these PVC materials has been on going for more than 30 years, the PVC waste that is entering the waste stream today is a reflection of the products put in use years ago. An estimated 300 billion pounds of this PVC will require disposal worldwide in the coming years (van der Naald 1998).

Construction and Demolition Waste Landfills

PVC is also found in construction and demolition (C&D) waste. C&D waste is generated from the construction, renovation, repair and demolition of structures such as residential and commercial buildings, roads, and bridges (ICF 1995). Franklin Associates (under contract to the USEPA) estimated that 136 million tons of building-related C&D debris was generated in 1996 (FA 1998). This figure did not include road, bridge and land clearing debris. C&D waste consists mainly of wood products, asphalt, drywall and masonry waste with lesser quantities of metals, plastics including PVC, dirt, shingles, insulation, paper and cardboard (ICF 1995). The percentage of PVC in C&D waste is hard to estimate. One report specifically identified and estimated the percent of vinyl siding and PVC pipes in C&D waste to be 0.63% for the two materials combined (FA 1998). Other types of PVC plastic waste were not considered.

In 2002, forty-two states reported that 1,931 landfills were dedicated for disposal of C&D waste (Kaufman 2004). Many if not most of these landfills are unlined, offering groundwater supplies even less protection from contaminants that may leach from PVC and other C&D waste components.

The Hazards of Landfill Disposal of PVC

There are significant dangers associated with the dumping of PVC in landfills. Although there appears to be little degradation of the PVC polymer (ARGUS 2000, Mersiowski 1999), the additives present in PVC products are not chemically bound to the PVC and they will seep out into the environment over time (CEC 2000). These additives include plasticizers, stabilizers, pigments, fillers and other chemicals that are added to PVC depending on the final product's intended purpose (see Chapter 3). Many of these additives leach out in the disposal phase (Mersiowski 1999). This is especially true of flexible PVC products. In the case of the rigid PVC products, stabilizers are generally thought to be encapsulated in the matrix of the PVC polymer and thus migration is expected to be less than what occurs with the plasticizers (ARGUS 2000, AEA 2000, Mersiowski 1999).

In landfills, PVC (as well as all waste) is subject to different reactive conditions such as moisture, changing temperatures, the presence (or absence) of oxygen, and the activity of microorganisms (CEC 2000). These factors will interact with the waste at different stages of the aging process. Recent studies evaluating the behavior of PVC in landfills found that microorganisms and/or corrosive liquids common to landfill environments act to accelerate the release of additives in PVC products (Mersiowski 1999, Hjertberg 1995).

Cadmium, lead, organotins and phthalates (which account for over 90% of plasticizers) are commonly released from PVC waste in landfills (Mersiowski 1999, Hjertberg 1995). In studies evaluating the leaching of bisphenol A (BPA), an additive used in many plastics, PVC was found to release the highest concentrations of BPA (Yamamoto 1999). These additives will mix with water and other substances in the waste and generate "leachate" which will contaminate local groundwater in the vicinity of the landfill.

Leachate generated by waste in landfills has been detected in groundwater monitoring wells at numerous garbage landfills (Lee 1996). One study in California reported that 72% of 528 landfills had polluted the nearby groundwater (Lee 1996). The USEPA passed regulations in 1991 to control landfill leachate (USEPA 1991). These regulations have been criticized for relying on a "fundamentally flawed technological approach for MSW management that at best only postpones when significant environmental problems will occur as a result of the landfilled waste" (Lee 2003).

Estimates have been made of the amount of lead present in landfills that are attributable to lead additives in discarded PVC products. These estimates range from 1 to 28% (CEC 2000). In 1998, an estimated 51,000 tons of lead were used as stabilizers in plastic in Europe (CEC 2000) and an estimated 6 billion tons were used worldwide in 2000 (Tukker 2001). Much of this lead will end up in landfills and can be expected to be a significant source of lead being released into the environment (NCM 2003). The key question is how much of the lead will be mobilized and released into the environment and when. Although the mobility of lead is generally thought to be low, small amounts will slowly leak out. Over time, this could lead to substantial amounts of lead being released into the environment. One study in Europe reported that an estimated 8 kilotons of lead from PVC entered the waste stream and that 0.5 kilotons was released into the environment in 2000 (Tukker 2001). Given the longevity of PVC products, it can be expected that lead leaching from discarded PVC products in landfills will continue to be a health and environmental threat for many years to come.

The lack of adequate liners and/or leachate treatment in many old landfills (and even some new ones) ensures that these releases have an easy route into surrounding groundwater and soil. Many construction and demolition debris landfills are completely unlined. Most old landfills contain no liner or collection system to prevent leachate generated in the landfill from mixing with and contaminating local groundwater. This leachate will seep down through the waste and eventually contaminate groundwater with hazardous and toxic chemicals (Lee 1994).

Even landfills equipped with the best liners and most up-to-date treatment methods cannot ensure long-term safety. In instances where liners or collection systems have been installed, leachate is still generated. When it reaches the bottom of the landfill, it is collected by a system of pipes and treated. The treated leachate is often sprayed back onto the waste and eventually collected again. If these pipes clog up, the leachate will accumulate in the landfill and create pressure on the liner. Eventually, this pressure will force the leachate out at the point of least resistance, usually the bottom of the landfill when the bottom liner fails.

These collection systems can be clogged by silt or mud, the growth of microorganisms in the pipes, or chemical reactions leading to the precipitation of minerals in the pipes. The pipes may also become weakened by chemical attack (acids, solvents, oxidizing agents or corrosion) and may be crushed by the tons of garbage piled on them (ERF 1989)

The liners used in landfills are generally made from high-density polyethylene (HDPE). These liners can be degraded by a number of household chemicals that can cause them to either lose strength, soften or become brittle and crack. Liners will also tear during installation or as a result of pressure from the weight of the waste. There may also be defects in the liners such as cracks, holes and faulty seams that allow leachate to pass through the liner (ERF 1992). One study found certain organic chemicals, such as chlorinated solvents, benzene, trichloroethylene (TCE) and vinyl chloride, can readily pass through an intact liner (i.e., a liner with no holes) in a short period of time (Haxo 1988). This finding has been confirmed in separate studies (Sakti 1991, Buss 1995, Lee 1996). Eventually, all landfills will leak whether they have a liner or not (ERF 1992, Bonaparte 1990, Lee 1992) and threaten the health of residents living nearby (ERF 1998). Landfills cannot guarantee safe, long-term disposal of PVC wastes and their by-products.

Landfill fires present another cause for concern. These fires generate a range of hazardous gases including carbon dioxide, carbon monoxide and hydrogen chloride. Dioxins and furan are also formed (USEPA 2001). Such fires are not uncommon. An average of 8,400 landfill fires are reported each year in the U.S. (FEMA 2002) and their ignition can be traced to a number of causes. Though over half of reported fires have no information available as to the initial cause, 40% of reported fires are classified as deliberate or suspicious, 20% are attributable to smoldering waste, and 5% ignite spontaneously. Highly flammable methane gas, released by landfilled waste as it decays is a primary factor in many cases.

PVC products disposed of in landfills contribute to the formation of dioxins and furans in the event of a fire. Four PVC products—pipes, rigid foils, floorings and cable wires—contribute about 40% of the chlorine content in landfills (Mersiowsky 1999). As previously discussed, the chlorine in PVC contributes to the formation of dioxins. Other factors that influence the amount of chlorinated dioxins and furans formed include fire temperature, and the availability of oxygen and catalysts (e.g., copper). Lower oxygen concentrations and lower temperatures (500-700° C) correspond with elevated dioxin formation (Moeller 1996). Both these conditions occur frequently at landfill fires.

Measured concentrations of dioxins and furans in the air of landfill fires are generally high and consistent with evidence gathered from test fires (Ruokojärvi 1995). As is the case with open burning, these air emissions are unfiltered and largely uncontrolled (see Chapter 3).

Another concern with landfills is the generation of landfill gases. All municipal waste landfills generate gases that result from the degradation of materials in the waste (USEPA 1995). The most common landfill gas is methane that results from the degradation of biological matter in the waste stream. Other common landfill gases include vinyl chloride, benzene, toluene and dichloroethane (ATSDR 2001). These volatile gases result from the breakdown of waste components present in the landfill. When PVC degrades, plasticizers and other additives leach out, and some of these evaporate and contribute to the landfill gases (ARGUS 2000).

Older landfills made no attempt to vent or control these gases. As a result, there were many explosions in homes and buildings located near solid waste landfills caused by the migration of methane gas, a highly explosive substance (USEPA 1990, Lee 1994). More modern landfills attempt to capture these gases using a gas collection system. These systems consist of a series of wells installed throughout the landfill that are used to pull out the gas. A series of pipes connect the wells and carry the gas to either a flare where it is burned or to an energy recovery system where the gases are converted into electricity (USEPA 1990). The flares can be a source of dioxins if chlorinated chemicals such as vinyl chloride are present in the landfill gases (USEPA 2001, Eden 1993).

Since 1996, large landfills have been required to have gas collection systems, which, the USEPA maintains, capture 75% of the gases (USEPA 2002b). However, there is no factual basis for this number. There are no studies that define the collection efficiency of these systems. Instead, this estimate is intended to reflect the best achievable efficiency while the systems are operating. The flaws in EPA's estimate are two fold. First, more of the gases are emitted both before the systems are installed and after they are removed from service, than during the time they are functional. Second, most landfills do not achieve best practices, especially because there is no way to measure emissions that might disclose poor efficiency, other than by detecting odor problems, which is just the manifestation of the worst fugitive emissions. A study that includes these factors found that there is no factual basis to conclude that, in practice and on a lifetime basis, more than 20% of the landfill gases generated are actually captured and either flared or used to recover energy (Anderson 2004a).

Landfills are also used to discard the residual ash generated when PVC products are incinerated. This ash contains dioxins and many heavy metals that will eventually cause many of the same leaching problems and threats to groundwater discussed earlier (USEPA 1994a, ERF 1990, Denison 1988). Clearly, landfills do not solve the disposal dilemma. They merely present a temporary, polluting alternative to burning PVC and creating dioxins. As an interim strategy, land disposal of PVC in a hazardous waste landfill may be preferable to incineration, but it poses its own environmental and public health threats and does not provide a long term secure solution to PVC waste management. Avoiding the generation of PVC-containing waste is the only sure way to prevent the problems associated with either landfill disposal or incineration of PVC waste.

VII RECYCLING MENACE
PVC Undermines Recycling Efforts

MAJOR FINDINGS

- Contrary to popular belief, recycling of PVC is negligible, with estimates ranging from 0.1% to 3% of post-consumer PVC waste being recycled.
- PVC is very difficult to recycle because the many additives used in PVC products make it impossible to retain the unique properties of the original formulation from a batch of mixed PVC products collected for recycling.
- PVC severely impacts the recycling of PET plastic bottles due to difficulty in separating these plastics when they are mixed together, and because of the contamination caused by the chlorine in PVC when they are processed together for recycling.
- The vinyl industry has inflated its PVC recycling rate by failing to account for all PVC waste generated and by redefining PVC waste incineration as recycling.
- PVC increases the toxic impacts of the recycling process for other discarded products such as nylon carpet, computers, automobiles and corrugated cardboard.

The ability to recycle used PVC products into new products is not feasible as a practical matter (Plinke 2000). While the vinyl industry has argued that PVC can be recycled (VI 2004a, PP 1999), in reality, a negligible amount of PVC is actually recycled. Estimates of how much post-consumer PVC (PVC that was used by a consumer for its intended purpose) is recycled vary from a high of about 3% (Plinke 2000, PP 1999) to a low of less than 1% (Denison 1997, Beck 1996). USEPA reports that less than 0.1% of PVC in post-consumer municipal solid waste was recycled in 2001, the most recent year for which data are available (USEPA 2003). As discussed below, at most 0.3% of PVC bottles were recycled in 2001 (Anderson 2004).

The primary reason for these poor recycling rates is the lack of uniformity in the composition of PVC products. Vinyl products are made using various formulations that are designed to achieve certain properties and create specific products. To achieve these features, additives such as lead, cadmium and phthalates that enhance properties such as durability and plasticity are mixed together with PVC. For example, vinyl siding and windows are made with lead to make them more durable, whereas infant chew toys contain phthalates to make them more soft and pliable. Table 9 shows what portion of the PVC is made up of these additives.

When these different formulations of PVC are mixed together, such as when they are collected as part of a recycling effort, they cannot be readily separated which

Table 9

Typical Composition of PVC Products and Materials

Application	Share of the Components (weight - %) PVC Polymer	Plasticizer	Stabilizer	Filler	Others
Rigid PVC Applications					
Pipes	98	—	1-2	—	—
Window Profiles (lead stabilized)	85	—	3	4	8
Other profiles	90	—	3	6	1
Rigid film	95	—	—	—	5
Flexible (soft) PVC Applications					
Cable installation	42	23	2	33	—
Flooring (calander)	42	15	2	41	0
Flooring (paste, upper layer)	65	32	1	—	2
Flooring (paste, inside material)	35	25	1	40	—
Synthetic leather	53	40	1	5	1
Furniture films	75	10	2	5	8
Leisure articles	60	30	2	5	3

Source: Prognos 1994, Prognos 1999, Totsch 1990 as cited in Plinke, 2000.

is necessary to reprocess the PVC back into its original formulation and to retain the unique properties of the original formulation (Plinke 2000, Thornton 2000). This problem is further complicated because PVC formulations for the same materials have changed over time.

There are other problems with mixing PVC with other plastics. One difficulty is color. Recycled products must be separated by color, which in most cases is not practical (Plinke 2000). Another difficulty is that soft PVC cannot be used in rigid PVC applications, and rigid PVC cannot be used in soft PVC applications since the material has to be reformulated (i.e., new additives need to be added). Thus, when different formulations of PVC are mixed together, it becomes virtually impossible to create a formulation that can be used for any application that requires specific properties.

As a result, a lower quality PVC plastic is produced which cannot be used for the same purpose as the original product (Plinke 2000). Thus, PVC can never be truly recycled into the same quality material. It usually ends up being made into lower quality products with less stringent requirements such as speed bumps, parking bumpers, or park benches. The loss of quality in a material during recycling is called "downcycling." The downcycling of plastics is common because of the difficulties in separating out the components with different additives (Plinke 2000). PVC that is downcycled does not reduce the overall demand for the raw materials (virgin resin) used in making plastic, and has no effect on the amount of vinyl produced each year (Denison 1997).

In Europe, where PVC recycling has received greater attention, the vinyl industry has claimed greater progress in PVC recycling than is actually the case. Instead of measuring recycling progress against the total amount of PVC waste generated, the industry instead limited its recycling goals to the much smaller fraction of PVC waste that they deem to be economically "collectable" and "available." With this distortion the European industry claimed that they achieved their goal of recycling 25% of PVC waste window frames, pipes and fittings, and roofing membranes by 2003. In fact, actual PVC recycling rates were less than 5% for pipes and fittings, 6% for roofing waste and 16% for window frames (ENDS 2004).

The PVC industry's distortion of its recycling progress can't hide the facts. Throughout Europe, the total amount of PVC recycled in 2003 was 2% to 3%, matching only one-fifth of the industry's modest goal of recycling 10% to 15% of all PVC (not just what's collectable and available) by 2010 (ENDS 2003). These modest gains are being rapidly overshadowed by the projected 50% to 80% increase in PVC waste generation over the next twenty years (ENDS 2003, ENDS 2004).

Compare the 2% to 3% PVC recycling rate in Europe (which far outpaces the 0.1% to 3% U.S. PVC recycling rate) with the recycling rates for other commonly discarded products in the United States in 2001: auto batteries (94%), yard trimmings (57%), steel cans (50%), aluminum beer and soft drink cans (49%), paper and paperboard (45%), PET #1 plastic soft drink bottles (36%), tires (31%) and glass containers (21%) (USEPA 2004c).

To further cover its poor recycling record, the vinyl industry has taken to re-labeling PVC waste incineration as recycling. For example, the European Council of Vinyl Manufacturers describes trials of several new PVC "recycling" technologies. These include PVC waste incineration at a Dow Chemical plant in Leipzig, Germany to recover hydrochloric acid, and the chemical processing of waste PVC and mixed plastics to help fuel a steel plant in the Netherlands (ENDS 2003). They also included a proposed PVC waste gasification plant to make hydrochloric acid and a fuel gas, which was later abandoned by Solvay in France due to costs and technical problems (ENDS 2003). High temperature processing of PVC waste will form chlorinated dioxins and furans and other toxic byproducts and can only be properly classified as incineration or waste treatment, not recycling.

Impacts on the Recycling of Other Materials

The difficulty in separating PVC from other plastics, such as polyethylene terephthalate (PET) bottles or nylon carpet facing, makes it extremely difficult, if not impossible, to recycle those otherwise recyclable materials. PVC also increases the toxic impacts of recycling of other valuable commodities such as copper from wiring and cable used in electronics like computers, steel from the scrapped automobiles and corrugated cardboard containers sealed with PVC tape. These examples are summarized in Table 10 and discussed below.

Plastic Bottles

PVC severely impacts the recyclability of other plastics such as polyethylene terephthalate (PET or sometimes PETE). Bottles made of PET and high density polyeth-

Table 10

PVC Contaminates the Recycling of Many Materials and Products

Material and Product	PVC Use	PVC as Contaminant
Polyester from PET plastic (#1) bottles[1]	PVC and PET bottles are commingled in all bottle recycling efforts	Due to similar densities, it is difficult and expensive to separate PVC from PET; the presence of even a little PVC ruins PET recycling during processing.
Nylon facing from carpets[1]	Backing of carpet	PVC can't be readily separated from nylon; it contaminates it and results in "down-cycling."
Copper from wires and cables of electronics[2]	Plastic sheathing of wires and cables	The PVC on wires and cables with low copper content are burned at secondary copper smelters releasing dioxins and toxic additives and by-products.
Steel from automobiles[3]	Undercoating, wiring, interior and exterior trim, other plastics in autos	After shredding, most non-metal "fluff" is landfilled, but some PVC mixed with the steel is burned in electric arc furnaces.
Cardboard from boxes[4]	Tape and other binders used to seal boxes	After separation from corrugated cardboard, PVC plastic is burned at the paper mill.
Scrap wood from C&D[5]	Siding, pipes, window frames, flooring and other building materials	PVC scraps contaminate the waste wood extracted from C&D waste which is chipped to burn as a cheap fuel in "biomass" boilers.

Sources: 1 - Anderson 2004; 2 - SVTC 2004; 3 - CCC 2004; 4 - SCC 1988; and 5 - MDEP 2004a.

ylene (HDPE) make up 95% of all plastic bottles compared to only about 2.3% for PVC bottles (Anderson 2004). PET bottles (recycling code #1) are commonly used to contain water, soda, vegetable oil and many other products (Anderson 2004) and are highly recyclable. Lower quality recycled PET (which has greater tolerance for contaminants such as PVC) is often used to make a polyester fabric known as "fiberfill" that is used in coats, sleeping bags, pillows and carpeting. However, higher quality recycled PET (containing very little PVC) is increasingly being recycled directly back into bottles. It also has an economic benefit as it is sold for fiber at seven times the price of PET contaminated with PVC (Anderson 2004).

When PVC is mixed together with PET or other highly recyclable plastic, such as in the "all-bottle" recycling programs favored by the plastics industry, the few PVC bottles likely to be collected will be virtually indistinguishable from PET containers due to their similar appearance and density. Sophisticated separation technology that uses optical systems is available to identify and remove unwanted plastic bottles, such as PVC (USEPA 1993). However, the effectiveness of these systems is greatly reduced when the bottles are damaged or dirty. This makes accurate readings difficult to achieve and as a practical matter separation of PVC almost impossible (USEPA 1993, Anderson 2004).

If the PVC cannot be separated from the PET, it will severely effect the processing of the PET bottles into reusable plastic resin. This is because PET and PVC behave very differently when they are processed for recycling. PVC burns at a lower temperature than PET. It burns at the temperature that simply melts PET (Anderson 2004, EAF 1993). When this occurs, "black spots" get into the PET resin contaminating the batch and ruining or seriously downgrading the quality of recycled PET residue (Anderson 2004). According to one plastics recycler, "introducing one PVC bottle into the recycling process can contaminate 100,000 PET bottles" (Anderson 2004, EAF 1993). In addition, when PVC is melted, it generates hydrochloric acid, which will damage the processing equipment (OSWM 1993).

Despite these difficulties, the vinyl industry partially subsidized PVC bottle recycling in the mid-1990s (Anderson 2004). This effort failed miserably. At best, barely 2% of the bottles were recovered (Anderson 2004). Instead, truckloads of PVC plastic waste were landfilled (Denison 1997) leading the Association of Post-Consumer Plastic Recyclers (APR), a recycling industry trade group, to declare that vinyl products are "unrecyclable contaminants" in the recycling of PET and HDPE bottles (PMF 2003). APR later abandoned its efforts to establish viable markets to recycle PVC (RT 2001). A report on the recycling of PVC waste prepared for the European Union similarly concluded "mechanical recycling is not qualified to contribute significantly to the management of PVC post-consumer wastes in the next decades…" (Plinke 2000).

More recently, a report released by the GrassRoots Recycling Network (a group of community activists and recycling professionals advocating for zero waste and sustainable communities) concluded that PVC bottle recycling is negligible today and that at most 0.3% of PVC bottles were recycled in 2001 (Anderson 2004). The report provides details of how PVC recycling of bottles does not exist, cannot exist, and is not wanted even by the plastics recycling industry. The only solution is a total phase-out of PVC and a rejection of programs encouraging curbside pickup of PVC that ultimately cause more harm than good.

Electronics

An estimated 26% of the plastic used in electrical and electronic equipment is made of PVC (MCTC 1996). The cabling of computers and other electronics is currently a major application of PVC in electronics, although it can be found in the housings of older computers that may still enter the waste stream (SVTC 2004).

When these consumer products reach the end of their useful life, components can be recovered and reused. Recyclers strive to recover valuable metals, such as copper from the wiring of these electronics. This is done by mechanical removal of the plastic sheathing, but it is only economical when the copper content is high. Most PVC cables from consumer electronics do not contain enough copper and so are bundled and shipped to a secondary copper smelter. Once there, the PVC plastic is burned off from the copper, a known catalyst of dioxin formation. Thus, recovery of copper wire results in toxic emissions including dioxins and furans to air and ash (SVTC 2004, USEPA 2001).

Smelting can present dangers similar to incineration. A report on the recycling of computer parts raised concerns that the Noranda Smelter in Quebec, Canada, where much of the North American "electroscrap" is sent, is "producing dioxins due to the residual presence of PVC or other plastics in the scrap" (SVTC 2004). Noranda has denied that this facility presents a "pollution hazard." Secondary copper smelters, such as the one operated by Noranda, have been identified as one of the highest sources of dioxin emissions in the U.S. (USEPA 2001).

Automobiles

Cars currently produced in North America average about twenty-four pounds of PVC per vehicle, according to plastics manufacturers (APC 2004). When the hulks of old cars are shredded, some of the PVC plastic mixes with the scrap metal which is melted down to make recycled steel. The high temperature and possible metal catalysts trigger formation of dioxins and furans. The vinyl industry advocates burning the plastics-rich automotive shredder residue (ASR or "fluff") either with municipal solid waste or in a cement kiln (VI 2004b). This will further contribute to dioxin formation from the chlorine present in automotive vinyl materials and formation of toxic PVC by-products (Singhofen 1997, CCC 2004).

The main uses of PVC in automobiles include underbody coatings and sealants, wire harnesses, dash boards, door panels, arm and head rests, upholstery, heating and cooling ducts, floor mats, spray-on sound deadener, seat belt latches, seat covers, mud flaps, and exterior trim such as body side protection strips, weather strips and window sealing profiles (APC 2004, VI 2004c, CCC 2004). PVC is the second largest volume plastic for automotive use in North America (APC 2004).

Carpets

The disposal of carpets in municipal and construction and demolition waste adds PVC from carpet backing to the solid waste stream. Two progressive companies controlling just ten percent of the market have achieved a modest 22% recycling rate for PVC carpet backing. But mechanical separation used by companies such as Interface Fabrics leaves too much PVC contaminant in with the nylon. PVC burns at the same temperature that nylon begins to soften and destroys the separated nylon fibers (Anderson 2004). Another company that uses recycling (Collins & Aikman) must downcycle the entire carpet to a lower value carpet backing, losing the nylon fibers for reuse and requiring virgin materials for new carpet facing (Anderson 2004).

Truly closed loop recycling for carpets, in which the facing and the backing fibers are recycled back into their original uses, remains elusive (Anderson 2004). And the modest success earned by recycling of PVC carpet backing can't be readily translated to other uses of PVC. The carpet makers enjoy a large volume, steady supply of discards with a relatively standard formula of PVC, unlike the variable PVC mixtures used in so many other far-flung products that are difficult to collect and recycle for a high end use (Anderson 2004).

Old Corrugated Cardboard (OCC)

Another use of PVC is to make packing tape that binds corrugated cardboard boxes. After this cardboard is used, it is broken down and returned to a paper mill for recycling. Any tape or plastic binding used to seal the cardboard is removed and separated from the cardboard, and then burned in the mill's industrial boilers. When this tape or binding is made of PVC and burned, another source of dioxin is created (SCC 1988). The Smurfit-Stone Container cardboard recycling facility in Missoula, MT processes up to 525 tons of old corrugated cardboard (OCC) per day. This mill generates about 15 to 25 tons per day of "OCC rejects" that consist of plastic packing tape, plastic twine and other non-cardboard contaminants, some of which is made of PVC (WVE 2002). Dioxins and furans have been identified in the air emissions of pulp and paper mills (USEPA 2004d).

Scrap Wood

Pressures are increasing to burn more scrap wood for fuel and power in so-called "biomass" boilers that are a proven source of dioxin emissions (MDEP 2004). Yet it is increasingly likely that PVC siding, window frames, roofing foils and other vinyl building materials will become mixed with scrap wood recovered from construction and demolition debris. When chipped and burned, this PVC-contaminated wood scrap is likely to add to the amount of dioxins formed.

VIII

DON'T BUY IT

Safer Alternatives to PVC are Available, Effective and Affordable

MAJOR FINDINGS

- PVC is the most environmentally harmful plastic; many other plastic resins can substitute more safely for PVC when natural materials are not available.
- Safer alternatives to PVC are widely available and effective for almost all major uses in building materials, medical products, packaging, office supplies, toys and consumer goods.
- PVC alternatives are affordable and already competitive in the market place.
- In many cases, the alternatives are only marginally more costly than PVC, and in some cases the costs of the alternative materials are comparable to PVC when measured over the useful life of the product.
- Phasing out PVC in favor of safer alternatives is economically achievable.
- A PVC phase-out will likely require the same total employment as PVC production (an estimated 9,000 jobs in VCM/PVC resin production, and 126,000 jobs in PVC fabrication) by making the same types of products from safer plastic resins.

Safer alternatives to the use of PVC plastic are widely available, effective and affordable. These alternatives pose fewer toxic chemical hazards than those associated with the manufacturing, use and disposal of PVC. In many cases, they completely avoid the formation of chlorinated by-products of combustion, e.g., dioxins, because they are chlorine-free; they also prevent the release of other harmful chemicals because they do not contain additives such as phthalates, lead, cadmium or tin, which are commonly found in PVC formulations.

Safer alternatives to PVC come in several forms including natural materials, as well as other synthetic plastics that are cleaner than PVC. For instance, instead of a vinyl shower curtain, a cloth shower curtain, wood clapboard siding or glass door easily does the job. For some people, the perceived aesthetic value of these natural materials further outweighs the comparative appearance of the PVC products. For others, the perceived convenience of lower maintenance tips the balance in favor of synthetic materials.

Even so, other cleaner plastics will do the same job as PVC without the high degree of toxic impacts throughout their life cycle. For example, a polyurethane-coated nylon shower curtain will repel water as well as one made of vinyl. The newly marketed polyethylene-based plastic siding avoids the toxic impacts associated with vinyl siding.

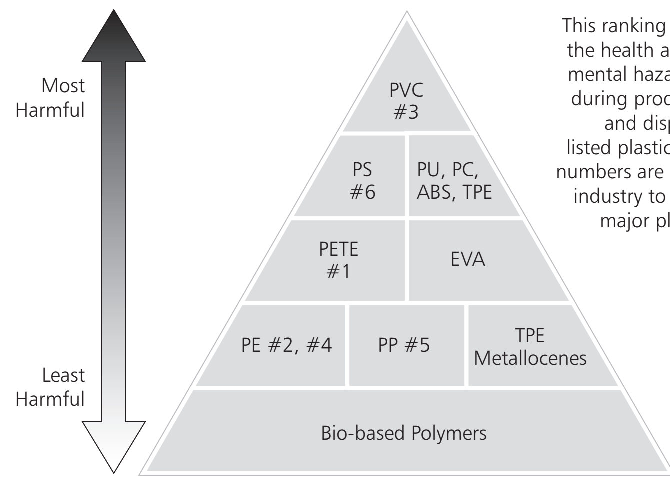
Many Other Plastic Resins are Safer Than PVC

Not all plastics or synthetic polymers are created equal. In a study of all major packaging materials conducted for the Council of State Governments in the U.S., PVC was found to be the most damaging of all plastics (Tellus 1992). A life cycle analysis conducted by the Danish EPA found that common plastics, such as polyethylene, polypropylene, polystyrene, PET and ethylene-propylene synthetic rubber, were all clearly preferable to PVC in terms of resource and energy consumption, accident risk and occupational and environmental hazards (Christiansen 1990).

This ranking of the major plastic resins from most harmful to least harmful is reflected in a revision of the Plastics Pyramid, originally developed by Greenpeace, shown in Figure 4 (DEPA 1995, van der Naald 1998, Tickner 1999a). The ranking qualitatively accounts for the toxic chemical hazards associated with the manufacture, use and disposal of plastics. Similar in concept to the federal government's Food Pyramid, the most harmful items at the narrow top of the pyramid should be avoided or used sparingly, while liberal advantage should be taken of the least harmful items listed at the broad base of the pyramid.

PVC clearly ranks as the most harmful plastic due to its high chlorine content, the toxic intermediate compounds used to produce PVC, the many toxic additives routinely added and its toxic by-products of combustion. PVC products, especially bottles and packaging, are sometimes labeled with the code number "3" (or the letter "V") based on a system used by the plastics industry to distinguish among the major plastic resins.

Figure 4. A Plastics Pyramid



This ranking is based on the health and environmental hazards created during production, use and disposal of the listed plastics. The code numbers are used by the industry to identify the major plastic resins.

A key to the plastics and some hazards associated with production, use and disposal

Level 1	PVC = Polyvinyl chloride	Chlorine, intermediates, many additives, byproducts
Level 2	PS = Polystyrene	Intermediates, fewer additives, some byproducts
	PU = Polyurethane	Some chlorine used, intermediates, waste byproducts
	ABS = AcrylonitrileButadieneStyrene	Hazardous intermediates, difficult to recycle
	PC = Polycarbonate	Some chlorine used, intermediates, toxic solvents, BPA
	TPE = Thermoplastic Elastomer	A copolymer or alloy of conventional plastic
Level 3	PETE = Polyethylene terephthalate	Some hazardous chemicals, high recycling rate
	EVA = Ethyl vinyl acetate	Chloride catalyst, some byproducts
Level 4	PE = Polyethylene	Fewer additives, some byproducts, high recycling rate
	PP = Polypropylene	Fewer additives, some byproducts
Level 5	Bio-based Polymers	Naturally based, e.g. starch, cellulose; compostable

Sources: DEPA 1993, van der Naald 1998, Tickner 1999a.

The next level of the pyramid lists plastics that are still harmful but less so than PVC. These include polystyrene (PS), used for plastic cups and utensils and to make Styrofoam, and polycarbonate (PC), used to make compact discs and most reusable water bottles. PC releases a chemical known as bisphenol A (BPA) which is known to interfere with the functioning of the hormone system in lab animals and, as an endocrine disruptor, may pose a hazard to human health (Colborn, 1996). Acrylonitrile Butadiene Styrene (ABS) and polyurethane (PU) are also hazardous, but they are less toxic, persistent, and bioaccumulative than PVC.

The plastics in the middle of the ranking are even less hazardous than PVC and the other plastics higher on the pyramid. These include the polymer most often found in plastic beverage bottles, including bottled drinking water, known as polyethylene terephthalate (PET or PETE) (code # 1). Although hazardous chemicals are involved in the production of PET, it is recycled at a relatively high rate for plastics (19%) (USEPA 2003), especially in the eleven states that have a returnable deposit on the sale of bottles of beer, wine, soda and other beverages.

Two high volume synthetic plastics are found near the base of the pyramid because they are far cleaner than PVC. These are polyethylene and polypropylene. Although these are both synthetic resins derived from nonrenewable fossil fuels, they are produced without toxic intermediates and far fewer additives or toxic by-products. Polyethylene, which ranks first in production among all resins, comes in two major versions: high density (HDPE or # 2), which is widely used in many applications, and low density (LDPE or # 4), which is commonly used in plastic bags. Both types are highly recyclable. Polypropylene (PP or # 5), often used for containers for products such as yogurt and prescription drugs, can readily be recycled but few recycling markets have been developed.

Even more environmentally preferable are the bio-based polymers, which are derived from natural renewable materials such as cornstarch or cellulose and which can be composted into beneficial organic matter to enrich soils rather than landfilled or incinerated. The Interface Fabrics company, among others, is pilot testing textile fibers made from bio-based polymers. An even higher standard would give preference to bio-based plastics developed from sustainable agricultural practices (e.g., without the use of pesticides and minimal fossil fuel inputs) that do not rely on genetically modified organisms or displace food products from serving the marketplace. Genetically engineered products should not be used in making bio-plastics.

Minimizing the disposal impacts of PVC favors the use of natural organic-based materials whenever practical because they biodegrade and represent a renewable resource. In many cases, however, a durable man-made plastic offers unique advantages to alternatives made of organic matter, minerals or metals.

Fortunately, as Figure 4 shows, many other synthetic plastic resins are widely available for product manufacturers to choose from to avoid the harmful impacts of PVC. And the emergence of bio-based plastics in the commercial marketplace gives an even greater boost to the success of sustainable production and environmentally preferable purchasing.

Safer Alternatives to PVC are Widely Available and Effective

PVC-free alternatives are already widely available for many applications. Several extensive reports have identified available and affordable alternatives to PVC (Ackerman 2003, Thornton 2002, Greenpeace 2001). Table 11 provides a few examples of available PVC-Free alternatives for several common PVC products. The sources reviewed below provide specific guidance on which vendors currently provide alternatives to specific products representing some of the most common uses of PVC. Several of these resources are searchable online databases of PVC-free products. The alternatives described can be currently found in the marketplace and are functionally equivalent, i.e., are as effective as a PVC product for the specified end use.

Building Materials

Effective alternatives are available now for most construction-related uses of PVC. Several databases, such as those offered by the Healthy Building Network (HBN 2004: http://www.healthybuilding.net/pvc/alternatives.html) and Greenpeace (Greenpeace 2004: http://archive.greenpeace.org/toxics/pvcdatabase), list these alternatives. A large number of construction projects, including the Sydney 2000 Olympic Stadium and the new EPA headquarters in Washington, DC have been constructed with little or no PVC (Greenpeace 2001, Greenpeace 2004b).

Medical Products

The Sustainable Hospitals Project is an excellent resource for healthy medical products, including PVC-free alternatives for gloves, bags and tubing. They operate a Website that includes extensive listings of products by category, by "hazard" or by manufacturer (SHP 2000: http://www.sustainablehospitals.org/cgi-bin/DB_Index.cgi).

Office Supplies

The Lowell Center for Sustainable Production has identified alternatives to the use of PVC in office supplies (SHP 2000: http://www.sustainablehospitals.org/cgi-bin/DB_Index.cgi). For example, instead of the common vinyl-coated three-ring binder, you can purchase an equivalent binder made of polypropylene with recycled content.

Packaging

The Grassroots Recycling Network has identified specific brand products that are currently packaged in PVC

Table 11

PVC-Free Alternatives to Common Materials

PVC Product	Available Alternatives	Affordability
Automobile Components	Polyolefins[1]	Competitive for most uses[1,2]
Blinds	Wood[3], Aluminum[3]	Varies
Bottles	High Density Polyethylene (HDPE)[4] polypropylene (PP) Polyethylene Terephthalate (PET)[4]	Slightly more expensive. Costs expected to go down with increased market share.
Flooring (Hard)	Bamboo[5], Ceramic Tile[5] Recycled Glass Tile[5]	Bamboo is comparable to vinyl.[5] Ceramic and recycled glass are more expensive.[5]
Flooring (Resilient)	Cork[6], Stratica[6], Linoleum[6]	Alternatives cost more up front but last nearly twice as long. Savings of 30-50% over 20 years.[6]
Gloves	Nitrile[7]	Cost competitive when purchased in large quantities.[7]
Medical Bags, Tubing, Etc.	Polyurethane[7,8], Silicon[7,8] Polypropylene[7,8], Polyethylene[7,8]	Prices vary but most hospitals are able to negotiate comparable rates through high volume purchasing.[8] Prices will fall as market increases.[8]
Pipes	High Density Polyethylene[5,6,9] Copper[6,9], Cast Iron[5,9] Vitrified Clay[5], Concrete[9]	Decreased labor cost for installation reduces importance of price.[6,9] Pipe selection rarely determined by material cost differences in this industry[6,9]
Roofing (For Flat Roofs)	TPO- Thermoplastic Polyolefin[5] EPDM- Ethylene Propylene Diene Monomer[5]	Comparable to similar vinyl roofing[5]
Siding	Wood[6], Fiber Cement[6], Aluminum[5]	Varies - High quality, longer lasting materials can cost less than PVC if you shop wisely.[6] Aluminum is more expensive but very durable and maintenance free.[5]
Wallpaper	Natural Fiber[6]	More expensive[5]
Windows	Wood[6], Aluminum[6]	Varies widely[6]

Sources and Notes: 1 - Greenpeace 2001; 2 - Singhofen 1997; 3 - Dickey 2002; 4 - GRRN -2004; 5 - CEC 2004; 6 - Ackerman 2003; 7 - Ruzickova 2004; 8- SHP 2000; 9 - Harvie 2002. **Note:** This table is not meant to be exhaustive, as there are endless uses of PVC. Rather, it is provided to offer a few concrete examples of available and affordable alternatives to PVC. In choosing alternative materials for this table, an effort was made to exclude those having significant environmental and/or health concerns of their own. This does not imply an endorsement by CHEJ or EHSC of any materials listed. We do believe, however, that the materials listed offer an improvement over PVC. For any material, there are advantages and disadvantages and we would encourage you to thoroughly research all purchasing decisions.

bottles (GRRN 2004a: To view their list online, go to http://www.grrn.org/pvc). The market share of PVC for containers has steadily declined to about 2% of all bottles sold (Anderson 2004). The mostly widely used PVC-free alternatives for plastic bottles are high density polyethylene (used for milk products and almost all personal and household care products) and PET (used for most beverages and vegetables oils, for example).

Toys and Other Consumer Products

Greenpeace has established a Website that provides information on PVC alternatives for more general consumer items, including toys. This site includes a toy-company report card that rates companies on a scale of 1 to 5, from being completely PVC-free to refusing to change policies or provide information (Greenpeace 2003, Greenpeace 1997: http://archive.greenpeace.org/comms/pvctoys; a more recent 2003 version can be found at http://www.greenpeaceusa.org/features/details?item_id=526899). It is worth visiting each site as they both contain unique information. Greenpeace also has issued a report on worldwide PVC restrictions that includes a list of companies, by country, that have made a decision to phase out the use of PVC in their products (Greenpeace 2001: http://archive.greenpeace.org/toxics/reports/restrictions.pdf).

Automobiles

Many automobile makers are beginning to find and implement alternatives to PVC. General Motors, the world's largest auto manufacturer, was the first to make a public statement of its intention to stop using vinyl. GM planned to end the use of PVC in car interiors by 2004, cutting total PVC use by 30% (CCC 2004: http://www.cleancarcampaign.org/pvc_elvbackground.shtml). Also, other automakers, while remaining less public, have taken similar steps. Daimler Benz has not used PVC for interiors or undercoating in Mercedes autos since 1995 and Honda said they would gradually replace PVC in interiors by 2003 (Greenpeace 2001). Pontiac has found a unique way of applying polyolefin skin for full instrument panel design, instead of PVC. Likewise, Mitsubishi has substituted polyolefins in its instrument panels and door trimmings (Greenpeace 2001). According to the Clean Car Campaign—a national campaign coordinated by state, regional and national environmental organizations promoting a clean revolution in the motor vehicle industry—Volvo, Nissan, Toyota, and BMW are all using alternative materials to PVC in various applications and to varying degrees (Singhofen 1997). And according to the Greenpeace Review of Restrictions and PVC-Free Policies Worldwide, "Ford world-wide has set itself and its suppliers the ambitious target to eliminate applications of PVC by the 2006 model year" (Greenpeace 2001).

Appendix A to this report lists some common products available on the market that may contain PVC, including which products are bottled or packaged in PVC containers. Used with the resources reviewed above, consumers can easily leverage this knowledge to identify and replaced their purchases of PVC with safer alternatives. Also available is a list of specific products packaged with PVC (GRRN 2004a: http://www.grrn.org/pvc).

PVC Alternatives are Affordable

The following section on the affordability of replacing PVC with safer alternatives was derived primarily from the report "The Economics of Phasing Out PVC," written by Frank Ackerman and Rachel Massey of the Global Development and Environmental Institute, Tufts University, December 2003 (Ackerman 2003). This section was adapted from the above report with permission of the authors. The references used by the authors are cited in the original report which can be found in its entirety at www.ase.tufts.edu/gdae/Pubs/rp/Economics_of_PVC.pdf.

The serious health and environmental impacts caused by the production, use and disposal of PVC raise two important economic policy questions.

1) Are there affordable alternatives to replace most uses of PVC?
2) What would be the economic impact on society if PVC were phased out?

The Tufts University Global Development and Environment Institute addressed both of these questions in their recent report *The Economics of Phasing Out PVC* (Ackerman 2003). This report found that alternatives to PVC do exist and that PVC does not offer enormous economic advantages over other materials.

PVC-free alternatives are already competitive in the market place. The Tufts researchers found affordable alternatives available in every commercial and institutional PVC market they evaluated, including pipes, roofing materials, flooring, medical gloves, siding and windows (Ackerman 2003). Because PVC is found in so many products, the alternatives also widely differ depending on the product. The estimated costs of phasing out specific PVC products will likewise differ from one product market to the next. Many manufacturers and suppliers have been identified who currently sell cost-comparable alternatives to PVC used in medical bags and tubing, office supplies and building and construction materials.

The Tufts report concluded that a PVC phase-out is achievable and affordable and that it would not place a large burden on the economy. The study finds that the advantages of PVC are often overstated, that PVC is not substantially cheaper than many alternatives, and that alternatives providing equal or better performance are available for almost every use of PVC. In some cases, the costs of the alternative materials are already comparable to PVC when costs are measured over the useful life of the product. In other cases, the alternatives are slightly more costly in today's market, though they are likely to come down in cost as their market share expands. There are "good reasons to expect the costs of alternatives to decline over time." The report also found that the continued use of PVC offers small short-term gains in some areas, and none at all in others.

The Costs of Replacing PVC: Three Studies

The Tufts report identified three detailed studies, all published in the mid-1990's, which estimated the costs of phasing out PVC. All three studies found PVC to be only modestly cheaper than the alternatives. The first study, conducted by the U.S.-Canada International Joint Commission (IJC) for the Great Lakes, examined the cost of phasing out PVC as part of its 1993 "Strategy for Virtual Elimination of Persistent Toxic Substances." This report was written for the IJC by a Canadian consulting firm, the Hickling Corporation, and updated in 1994. Charles River Associates (CRA), a U.S. consulting firm under contract to the Chlorine Institute, conducted the second study. This report, which was prepared in response to the IJC report, provided an economic analysis of the benefits of chlorine and related chemicals and included an analysis of PVC. The third study, conducted by Environment Canada in 1997, evaluated the options for replacing chlorine-based products and included a detailed look at the alternatives to PVC (Ackerman 20003a).

Each of these studies evaluated many specific uses of PVC and compared the prices of PVC products to their PVC-free alternatives. Environment Canada created two sets of price comparisons: a low cost case based on the least expensive available alternative and a high cost case based on higher-priced alternatives. Table 12 provides a summary of the estimated costs of replacing PVC made in each of these three studies. The table shows the cost increase that would result from switching to PVC-free alternatives, expressed in dollars per pound of PVC produced (updated to 2002 prices) for each study. Cost estimates are shown separately for pipes and for all other products since pipes represent about half of all PVC use. The pipe and non-pipe figures in Table 12 were averaged to obtain a rough estimate of the total cost of replacing PVC.

According to the Tufts report, this table shows that there was a remarkable degree of agreement between the Hickling and CRA studies. These studies found nearly identical average costs for replacing PVC—$1.07 to $1.15 per pound. The Environment Canada low estimate had an average cost of about half this much, due to its lower estimate for pipe costs. For the non-pipe uses of PVC, there also was fairly good agreement between CRA, Hickling and the Environment Canada low estimate ($0.87 to $1.10 per pound). The data shows that PVC is only modestly cheaper than the alternatives. The Environment Canada study, which included the full cost of installation, found alternative materials would cost just 6% more than vinyl, and building a PVC-free home would increase the cost of a home by just 0.4 percent—increasing the cost of a $150,000 home to $150,600 (CIS 1997, Thornton 2000).

Factors Favoring Phase-Out of PVC

According to the Tufts report, cost estimates such as those made by Environment Canada, based on current market prices, tend to overstate the economic benefits of PVC. Four reasons were given for this conclusion.

1) Life Cycle Costs Often Favor Alternatives.

Some of the alternatives have higher initial purchase prices than PVC products, but are actually less expensive over the useful life of the product. The total cost

Table 12

The Cost of Replacing PVC

US dollars per pound of PVC (2002 prices)

	CRA (industry)	Hickling (for IJC)	Environment Canada Low	Environment Canada High
Pipes	$1.43	$1.03	$0.15	$0.33
All other uses	$0.87	$1.10	$0.94	$3.84
Average	$1.15	$1.07	$0.55	$2.08

Average is the unweighted average of pipes and "all other uses."
Hickling data excludes windows.

Source: Ackerman 2003

over a product's life cycle is the cost that ultimately matters to the user. For example, the maintenance and repair costs for some building materials, such as flooring, can be the largest cost of a product's life cycle. In such cases, the lowest maintenance product is often the cheapest on a life cycle basis, regardless if it has the lowest purchase price. In this example, PVC or vinyl flooring is the cheapest option for commercial and institutional flooring on an initial cost basis, but among the most expensive options on a life cycle basis. When full life cycle costs are taken into account, PVC flooring loses out to alternatives that may have a higher initial price but last longer and are more easily maintained (Ackerman 2003).

2) Mass Production Reduces Costs.

Most products are cheaper when they are produced in large quantities. Costs typically drop as production volume increases. Currently, the advantages to mass production favor PVC, as many PVC products are produced in huge volumes. However, the production of the alternatives could likewise grow in volume in the future, making them less expensive and more competitive than they are at present. There are also learning curves that affect costs over time. As an industry gains experience with a production line, "bugs" are worked out, process improvements develop, and maintenance procedures and schedules are improved. All of these factors help to reduce costs.

3) PVC Products Endanger Their Users.

As previously discussed, the harmful effects of PVC are sometimes felt by the users of the products. For example, plasticizers in flexible PVC products such as children's toys can leach out of the product during use posing health hazards to users (see Chapter 3).

The Impact of a PVC Phase-Out on Jobs

The Tufts report examined the impact that phasing out PVC would have on jobs. Using data provided by the Alliance for Responsible Use of Chlorine Chemistry (ARCC), they estimated that there are approximately 126,000 workers in PVC fabrication plants and approximately 170,000 workers at chlorine-producing and chlorine-using chemical plants in the U.S. However, most of the chlorine workers are in non-PVC related chlorine sectors such as paper mills, pesticides, and solvents. The Tufts researchers estimated that only about 9,000 of the 170,000 workers were employed in the production of vinyl chloride monomer (VCM) and PVC resin.

The Tufts report identified 12 operating VCM plants in the U.S. as of 2000, with a capacity to produce 17.4 billion pounds of VCM. According to the report, seven of the facilities that account for more than half the capacity were jointly located with PVC plants owned by the same company. The report also showed that as of mid-2003, ten companies produced 15.8 billion pounds of PVC resin at twenty locations in the U.S. Three other plants were idled by the recession with an additional capacity of 1.2 billion pounds.

The Tufts report suggested that replacing PVC with safer alternatives will change some of these jobs: from fabricating PVC products to fabricating the same products from other materials, most often other plastics; or from making vinyl chloride and PVC resin to making safer substitutes. However, the alternatives are likely to require about the same total employment as production of PVC. In some cases, the same workers who currently make PVC products will be employed making products from PVC alternatives
(Sources: Ackerman 2003 and Ackerman 2003c).

4) Environmental Protection Costs Are Routinely Less than Anticipated.

History has shown that the actual costs of compliance with environmental standards are often lower than the originally predicted costs. One of the best examples of this occurred in the PVC industry in 1974 when the Occupational Safety and Health Administration (OSHA) established a strict standard for workplace exposure to vinyl chloride, the raw material used to produce PVC. When this standard was proposed, the vinyl industry claimed that the costs of compliance would be in the "billions" and that the industry might shut down. Instead, actual costs were only a fraction of the original estimates primarily because the industry developed new cost effective technologies to comply with the regulation. Other studies have confirmed this pattern of overestimating compliance costs (Ackerman 2003b).

In summary, the Tufts report concluded that a "PVC phase-out is achievable and affordable. The alternatives are increasingly well known and well developed, and in many cases are already cost-competitive with PVC. It is realistic and practical to build health and environmental considerations into materials choices for municipal infrastructure, commercial and residential buildings, medical supplies and consumer products. The cost impacts of substitution will be modest and will grow smaller over time" (Ackerman 2003).

IX

TAKE ACTION
Preventing Harm from PVC Use and Disposal

RECOMMENDATIONS

- Policy makers at the local, state and federal level should enact and implement laws that steadily reduce the impacts of PVC disposal and lead to a complete phase-out of PVC use and waste incineration within ten years.
- A new materials policy that embraces aggressive source reduction of PVC should be adopted to steadily reduce the use of PVC over time.
- Federal and state waste management priorities should be changed to make incineration of PVC waste the least preferable disposal option.
- In the interim, any PVC waste generated should be diverted away from incineration to hazardous waste landfills.
- Consumers should take personal action to buy PVC-free alternatives and to remove PVC from their trash for management as household hazardous waste.
- Communities should continue to organize against PVC-related dioxin sources such as waste incinerators while working to promote safer alternatives.

Personal and political actions must be taken to prevent harm to human health and the environment from the use and disposal of PVC. If we don't burn PVC, the formation of dioxins and other toxic by-products of combustion will be prevented. If we can reduce the flow of PVC to landfills, leaching of toxic additives will be avoided. If we promote and purchase safer alternatives to PVC whenever they are available, then toxic pollution will be prevented throughout the PVC life cycle.

Making Choices: A New Materials Policy for PVC

When solid waste experts in the U.S. first established meaningful management goals about fifteen years ago, there was universal support for source reduction as the top priority (USEPA 1989). Table 13 shows the priorities established by the USEPA for the most environmentally sound strategies for managing solid waste. Source reduction is the top choice. It means taking action to avoid or prevent waste from being generated in the first place. In keeping with this philosophy, the first priority in managing PVC waste should be to avoid making it or using it in the first place.

We should adopt a universal policy and practice across the country to avoid the purchase or use of PVC whenever possible in order to prevent waste management problems before they start. We need to dramatically

Table 13

National Priorities for Solid Waste Management

Highest Priority	SOURCE REDUCTION	Includes Reuse
Middle Priority	RECYCLING	Includes Composting
Lowest Priority	DISPOSAL	Includes both Combustion and Land Disposal

Source: USEPA 2004d, USEPA 1989

By favoring waste incineration, such policies encourage the continuous formation of dioxins and other toxic air emissions, and the generation of toxic ash requiring land disposal. The burning of PVC in municipal solid waste releases dioxins and toxic additives. Land disposal, on the other hand, minimizes dioxin formation by avoiding intentional combustion, although some highly polluting landfill fires are unavoidable. Land disposal additives in PVC will leach and eventually contaminate groundwater. However, this is also true for incineration, since a large amount of dioxin and metal-laden incinerator ash also requires land disposal.

and steadily reduce the amount of PVC waste produced through a source reduction strategy that targets PVC-containing products.

The second best option, if generating waste can't be avoided in the first place, is to reuse, recycle and compost the wastes. With PVC waste, this is not an option. Most PVC products cannot be reused or recycled, and definitely will not compost. What is the best option for PVC waste after source reduction and recycling? The answer lies in defining what ultimate disposal strategy is preferred once PVC waste has unavoidably been generated.

Federal solid waste policy fails to express a preference between waste disposal in incinerators or in landfills, treating each as equally usable options (See Table 13). Consistent with this lack of judgment, the USEPA has failed for over 12 years to finalize its reassessment of the health risks from exposure to dioxins. In addition, the USEPA has failed to take aggressive action to prevent dioxins and other toxic pollutant releases at their source, such as working to reduce PVC use and disposal.

Some states have chosen incineration as their top waste management option, favoring even dirty mass burn facilities over landfill disposal. For example, as shown in Table 14, under Maine state law, waste incineration is preferred over landfill disposal (MRSA 2004a). The State of Maine, in turn, burns the highest proportion of its waste (after recycling) of any state in the country (see Table 7 in Chapter 5).

We believe that a new health-based materials policy is needed to reorder current federal and state priorities for waste management. Such a health-based policy should be designed so that the greatest effort is invested in the highest priority options as shown in Table 15. We propose a new set of priorities for PVC waste management that are based first and foremost on targeted source reduction steps that will prevent the creation of PVC waste in the first place. This strategy aims to aggressively and continuously replace the most hazardous uses of PVC with safer alternatives whenever available.

These source reduction steps include immediate action

Table 14

The State of Maine's Waste Management Policy Favors Incineration Over Landfill Disposal

Highest Priority	SOURCE REDUCTION	Includes reducing both the amount and toxicity of the waste
2nd Priority	REUSE	
3rd Priority	RECYCLING	
4th Priority	COMPOSTING	Of biodegradable waste
5th Priority	INCINERATION	And other waste processing which reduces waste volume
Lowest Priority	LAND DISPOSAL	

Source: MRSA 2004a

Table 15

Proposed Priorities for PVC Waste Management

Highest Priorities	Step # 1 - SOURCE REDUCTION	Ban disposable PVC bottles, containers and packaging.
	Step # 2 - SOURCE REDUCTION	End the use of lead and cadmium in all PVC products.
	Step # 3 - SOURCE REDUCTION	Phase out all disposable, non-durable uses of PVC.
	Step # 4 - SOURCE REDUCTION	End the use of PVC products containing phthalates.
	Step # 5 - SOURCE REDUCTION	Phase out PVC uses that are vulnerable to fire hazards, e.g., in building materials and cars.
2nd Highest Priority	EXTENDED PRODUCER RESPONSIBILITY	Require manufacturers to finance the "take-back" and safe management of PVC products at the end of their useful life.
3rd Priority	REUSE AND RECYCLING	Achieve the low potential to recycle bulk PVC waste into the same type products.
4th Priority	LAND DISPOSAL	In the interim, divert any unavoidable PVC waste away from incineration for disposal in hazardous waste landfills.
Last Option	INCINERATION	Ban open burning and incineration of any waste containing PVC

to end the use of PVC bottles and packaging. Other source reduction targets would include short-lived disposable PVC products and those that contain lead, cadmium and phthalates. Fire-vulnerable uses of PVC in buildings and vehicles should be replaced with safer alternatives. To avoid toxic by-products generated during structural fires, vinyl siding, roofing and window frames among other uses, should be replaced with safer alternatives.

This health-based materials policy would favor land disposal over incineration only temporarily and only for legacy waste from the stock of current PVC in use and any other unavoidable PVC waste. This waste would be managed by land disposal in a hazardous waste landfill.

A new materials policy for PVC defines incineration as the least favorable waste disposal option. We need to create effective systems to collect and divert PVC in the waste stream away from incineration. PVC should be actively managed as a serious problem waste akin to handling household hazardous waste (or other non-hazardous problem wastes like propane tanks or latex paint). This would mean educating consumers to identify PVC waste and separate it from the waste stream. As an interim practice, PVC should be diverted away from incineration for collection and transfer to a triple-lined "secure" hazardous waste landfill. With time, after PVC has been replaced with safer materials, the need to divert PVC to landfills would diminish.

Our vision for managing PVC waste is positive. We promote safer alternatives to PVC that are effective, affordable and available now. Alternatives that exist for most uses of PVC are able to do the job well at a cost that is comparable to PVC. Substituting safer materials for PVC is consistent with principles of clean, sustainable production (see Chapter 8).

To realize steady progress on the path to a PVC–Free Future, many personal and political actions by many people will be necessary.

Personal Steps

Taking personal responsibility for preventing harm from PVC is an important place to begin. Here are some key actions you can take as a consumer and contributor to generating household PVC waste.

1. Identify PVC Products.

Look for the "# 3" or the letter "V" inside the plastic recycling symbol (or sometimes beneath the recycling symbol) on the bottom of bottles and on clear plastic packaging such as blister packs. The # 3 and the letter V indicate that the plastic is made from PVC. Also, look for the words "PVC" or "vinyl" on the product (e.g., plastic pipe) or on its packaging. You will need to use other strategies to identify PVC products that are not labeled. Does the unlabeled soft plastic, such as the skin on a 3-ring office binder or a shower curtain, have that "new car smell" of chemicals? If so, it's probably vinyl and you're breathing phthalates, a PVC additive. Check the PVC product listing in Appendix A for likely suspects. You can also call the company and ask them whether they use PVC. If they do, ask them to switch. If they don't, thank them for being environmentally conscientious.

2. Buy and Promote Safer Alternatives.

Search for and purchase non-PVC alternatives (see Chapter 8). Always avoid PVC bottles and plastic wrap (e.g., Saran Wrap). Consult Internet resources on PVC-free alternatives for office supplies, medical supplies, toys and building materials (see Chapter 8). Educate others about PVC hazards. Promote safer alternatives in your homes and business, with your friends and neighbors. If the best alternative is a plastic, look for the cleaner plastics, such as polyethylene (# 4 or # 2) or polypropylene (# 5) (See Figure 4).

3. Start Collecting PVC.

Don't toss PVC in the household trash, especially if your garbage is incinerated (see Table 7 to see if your state relies heavily on burning its waste). Put the PVC aside in an enclosed cardboard box and/or garbage bag away from the sun and possible ignition sources. See how much PVC you can salvage and segregate from the waste stream. Every bit of PVC diverted away from incineration will prevent some dioxin formation.

4. Ask the Manufacturer to Take it Back.

If you can identify who made the product containing PVC, bundle it up in a secure cardboard box and mail it back to the Chief Executive Officer of the product manufacturer (search the Internet for the address of the corporate headquarters and the CEO's name). Enclose a polite note asking that they take personal and corporate responsibility for safely managing this problem material at the end of its life. Tell them you won't buy any more of their products until they make the switch to PVC-free manufacturing. Warn them not to burn it. Ask them to dispose of it at a hazardous waste landfill or to securely store the PVC unless they can recycle it for high value uses. Ask for a written response.

5. Dispose of Your Collected PVC as You Would Household Hazardous Waste.

If you have too much PVC waste to mail back, ask that your community household hazardous waste collection program accept PVC plastic for secure hazardous waste land disposal, not for incineration. Explain the reasons why PVC is a serious problem waste. Encourage others to separate and divert PVC away from incineration.

Community Action: People, Voices and Communities

Being a PVC-free consumer is not enough. The real power needed to adopt a new health-based materials policy for PVC lies in the number of people involved. When friends and neighbors work together to organize their community to take action, major changes can occur. Grassroots action by community groups around the country has already stemmed the damage from PVC use and disposal. Medical waste incinerators are rapidly being replaced due to community-based campaigns that promote non-incineration alternatives (see case studies in Chapter 5). Few new municipal waste incinerators have been sited in the last ten years due to environmental health concerns and community opposition.

C A S E   S T U D Y

Intimate Brands Responds to 6,000 Consumers and Stops Using PVC

Greenpeace and the Center for Health, Environment and Justice (CHEJ) teamed up in 2001 to launch a consumer campaign against a major beauty supply company who distributed products packaged in PVC containers. The Victoria's Dirty Little Secret campaign successfully targeted Intimate Brands, the parent company of Victoria's Secret and Bath & Body Works, who agreed to phase-out PVC containers from their product line by the end of 2003 after receiving 6,000 faxes, phone calls, and postcards in one month.

Organizers launched the campaign at an Eco-Conference held annually on college campuses, distributed flyers and postcards, and posted an action alert allowing Website visitors to fax a letter or send a postcard directly to Intimate Brands. The company initially responded by sending defensive letters to the individuals that wrote to them. However, as more letters continued to come in, they took the demand more seriously. In February 2002, they met with representatives from CHEJ and Greenpeace and presented a plan to phase out the use of PVC bottles in both their Victoria's Secret and Bath & Body Work's line. PVC bottle production would stop by 2003 and by 2005 all PVC bottles would be out of circulation. The effectiveness of this campaign is a testimony to the positive changes that can be made when people come together and pressure companies to put safety first (Source: Lester 2003).

Community action has also repeatedly changed national waste policy from the grassroots up. Join with your friends and neighbors to make a difference. Join a local group or start a new one to take action against dioxin sources such as incinerators, backyard burning, landfills, biomass plants or building fires where PVC use and disposal release toxic chemicals into the environment. For referrals and how-to tips, contact the Center for Health, Environment and Justice (www.chej.org).

Organizing To Win Around Issues on PVC

Every day, people facing threats to their health and environment speak out about PVC problems. They look for proof that a landfill leaks, or seek to undertake a health study to link emissions from an incinerator to cancer, or find evidence that a polluting company has a bad environmental record. However, simply speaking the truth about landfills, incinerators, toxic products or previous violations won't stop the poisoning of our bodies and the environment.

The truth is only a start. In order for things to change, the truth has to be understood by a large group of people who then use this knowledge to fuel their efforts to win justice. The truth won't stop the poisoning, but mobilizing and organizing will.

According to Webster's dictionary, organizing is "uniting in a body or becoming systematically arranged." Organizing to protect our communities from environmental harm means pulling together a large enough, diverse enough, active enough group of people to convince corporations and the government that they have to stop making people sick with toxic chemicals.

Organizing is how we restore the balance between the rights of people to safe products and healthy communities, and the rights of corporations to profit. We will never have as much money as the corporate polluters. We will never be able to afford their Madison Avenue media campaigns or their twenty-four hour access to elected officials. But we can build our own power to overcome their influence. We can do this by organizing to demonstrate the strength of our numbers and the righteousness of our demands.

Successful organizing happens when a group of people find visible ways to use the truth to wake up the conscience of a larger group. In an era when politics is defined by scandals and sound bytes, organizing can remind the American people that political life is supposed to be about self-government, justice and the common good.

After years of doing it, we've come to the conclusion that organizing is more of an art than a science. At the same time, there are some basic rules for organizing that usually hold true. These rules aren't always applicable, but they are right often enough that you should consider them if you start to get organized around an environmental issue in your community.

Basic Organizing Rules

Power determines the outcome.

If two or more groups care about an issue, and one of them has a lot more power, that group will get what it wants, no matter what the facts are or who will be hurt.

Our power comes from people, while corporations and government's power comes from money.

Communities need to use strategies that depend on people's creativity, courage and caring. The corporations and government will use strategies that depend on things that can be paid for, like experts and lawyers.

Polluters and government agencies write the rules so they can win using experts and lawyers, which are their strength.

You can assume going in that if you play exactly according to the rules of their game, you will lose most of the time, whether you are at the slot machines in Atlantic City or the hearing process of your state environmental agency. Create your own rules instead.

To win, communities will have to work harder than polluters and government agencies do.

Polluters and agencies are doing what they do because they are paid to. They've done it before, and they know most of the facts before the fight even starts. You are opposing them because you believe your health and your community are at risk. This gives you an unmatched motivation for working harder than they do.

These rules may seem harsh and they are. And sometimes things turn out to be easier than these rules would lead you to expect. But when your community is at stake, it's important to start out vigilant, alert and ready to face the challenges ahead.

Experience has taught us that organizing isn't easy. Recognizing this should help you to be forgiving of each other and ourselves. We are trying to build a democratic society without adequate blueprints and models, so our trial-and-error method has to leave room for experimentation and mistakes. And recognizing how necessary organizing is should help you to be inclusive and persistent. There are no magic facts. There are no perfect heroes to give perfect speeches that will convince the polluters to stop polluting. There is only the dogged determination of people working together to protect their own health, their families' health and the health of their communities. This is why we organize. (See below for "Ten Simple Steps To Organizing.")

Mobilizing vs. Organizing

What is the difference between mobilizing and organizing? Take the 2004 protests in New York City around the Republican Convention. There was a large mobilization—demonstrations that brought out over 800,000 people—and various targeted actions. The main goal was to influence the results on Election Day and get people to understand the issues.

Mobilization is a thing that good organizers do. Mobilization is getting people together, moving people out. It's bringing people in to do an action. It's using everything including phone calls, personal visits and handing out fliers to bring a certain level of consciousness to the community. When trying to change policy and public opinion and purchasing choices, you need to use both organizing and mobilizing.

As a result of a mobilizing initiative, you will likely find people who will join your organization and build your organization's base. However, most people who are mobilized are not likely to join but their voice/presence in an activity increases your power for that moment. You are not likely to know how folks got to the mobilizing activity. Maybe they saw it listed on the internet at MoveOn.org or received an e-mail flyer, or a friend agreed to have dinner with them afterwards if they met at an event.

In organizing, leaders understand how people got there. For an organizer it would be important to have 100 people at a demonstration and to know exactly how those people got there. You know which leaders talked to people and can talk to them again, not just for this one event, but maybe for another campaign. Think about how to use mobilization opportunities to move your issues and to identify new members for your organization.

Ten Simple Steps To Organizing

1. Talk and Listen

If you are one, two or three individuals without an organization, you'll need to talk with other people in your community to build a group. If you are already part of an organization, then your next step is to talk to the people in your organization about initiating a campaign around a PVC issue in your community. Brainstorm a list of groups and individuals whose interests are most directly affected by PVC, then determine who you need to talk with first. Who are the people that are most directly affected? Who are the leaders in that neighborhood? What other organizations are involved in protecting the community's health? You can work out the answers to these questions in a brainstorming exercise at an early meeting of your group. Brainstorm a list of the groups of people whose self-interests are most directly affected, then figure out who has contacts with these groups or individuals.

2. Create and Distribute Fact Sheets

Create an attractive, easy-to-read and accurate fact sheet to educate the community about the problems and how these problems relate directly to their lives. A simple one-page fact sheet will serve the purpose.

3. Recruit Hundreds, One At A Time

Recruiting will help you build the relationships, resources and critical mass to act effectively for change. Reach out to a wide range of local groups to build the broadest possible coalition. It will be much more difficult for decision-makers to ignore your concerns if your campaign represents a wide cross-section of your community. All recruiting is a form of door knocking. If you are trying to organize a neighborhood, the doors line the streets. If you are trying to build a different kind of group or coalition, the doors may spread all over town and you may need appointments to open them. There are several ways to make knocking on doors easier. First come up with a 'rap'— "I am..." "We are..." "This is..." "We want..." "You can..." Also, consider circulating a petition. Not only will the petition help you get the names and addresses of community supporters and show community support to those in power, it also begins the process of getting the people you're talking with involved in the issue. Make sure to listen closely to the concerns of the people you are talking with and link the PVC problem to their interests and concerns.

4. Hold Meetings That Make People Want to Come Back and Bring Their Friends

People will come to a meeting if:

- They have made a commitment to come
- They have a role or responsibility in the meeting
- They have an immediate and specific self-interest in the work of the organization
- They have past, positive experiences with similar meetings

To have a successful meeting, your recruitment efforts must satisfy the first and third of these conditions. The second and fourth conditions will depend on how you run the meeting. There are several different kinds of meetings to suit different purposes.

House Meetings - This is the kind of meeting many groups hold when they are first forming. The meeting is held at a member's house and the style is informal. One of the biggest benefits of this kind of meeting is the greater comfort level among members.

Planning Meetings - Leaders or other key decision makers within the group get together to set their agenda, review the work that's been done and plan activities. Planning meetings should not be decision-making meetings, but rather they should establish the agenda and process by which decisions will be made at a general membership meeting or define a plan to carry out an activity that has already been decided upon by the membership.

General Membership Meetings - These meetings are important to ensure that all members of the organization share the responsibility for decision making and carrying out the activities of the organization. The time and location should always be chosen to accommodate the maximum number of people. The meeting should always start with an agenda and when possible, get the agenda out to people prior to the meeting in the form of a flier (this will also serve as a reminder for the meeting). Make sure you pass around a sign up sheet to collect names and addresses to contact people who attended in the future.

People will come to the next meeting if they enjoyed the first one, if it started and ended on time and wasn't a bore, if it produced concrete results, if it was lively and exciting, and if it delivered what was promised.

5. Set Goals

It is critically important to have long-term, intermediate and short-term goals to help members understand where they are going and the steps they have mastered along the way. Ask yourselves: What do we want? What is your bottom line? Do you want to pass a local or state law that bans PVC products where alternatives are available? This could be your long-term goal.

Next identify different strategies and tactics that will lead you to your goal such as getting your city or county council to pass a resolution to phase out all PVC products where alternatives are readily available. This could be your intermediate or short-term goal.

6. Identify Your Targets

Once you've identified what it is that you want, the next step is to identify who can give it to you. Pinpoint the actions and the people that have the power to help you reach your goal. The people who impede the achievement of your goal are often referred to as the targets of the campaign. This does not mean that they are evil or bad. It simply means that because they have the power to give you what you want, it makes sense to focus your attention and actions on them. The target of your campaign must always be a person or persons. You can't fight City Hall because City Hall is a building, but you can target the person with the power at City Hall to get them to act.

To help your group identify your targets, answer these three questions.

- Who is responsible for the situation you want to change?
- Who can make the changes you want to happen?
- How can you convince them to act on your issue?

7. Research Is An Essential Tool

Research is a tool, not an end product. You need to do research to gather enough information to achieve your goals, not to know absolutely everything there is to know. Research should tell you who has the power to give you what you want and should help you figure out what arguments your targets will probably use against you. Once you know this, you can create counter arguments. This report will give you some of the information you need, but you need to undertake the local research related to the problem that you want to address.

8. Take Direct Action

An action is any step you take to advance your group's goals. Petitions, letter-writing campaigns and educational meetings are all actions that advance your group's goals. A direct action is the most dramatic type of action, involving confrontation and demands. Direct action begins after your efforts at education, information sharing and persuasion are ignored. Use direct action when your group is ready to confront a decision-maker with its frustrations and to make specific demands. Direct actions move your organization outside the established rules for meetings and discussion. It takes your group into a forum in which you make the rules and where elected representatives and corporate executives are less sure of themselves and how to handle the situation. A direct action often provides the necessary pressure to force your target to act on your group's issue.

9. Target The Media

Who are the media decision-makers who need to be convinced that your story should be covered? What will it take to convince them? In most media outlets, the decision-makers are the editors, and the way you get to them is to spoon-feed them a story they can use without much work. It is important to develop a media strategy for your campaign that you can constantly refine and develop. But don't be fooled into believing that the media is the only way to get your story out. Keep creating your own media through fact sheets, cable access television programs, newsletters, call-ins to radio talk shows, letters to the editor, statements at public hearings, barbecues, rallies, auctions, concerts and videotapes.

10. Celebrate The Victories And Keep Applying Pressure

Savor the victories no matter how large or small. A meeting with the City Council is a small victory and a resolution to stop purchasing PVC is a larger victory. Celebrate all victories because it helps members to see that you are moving forward and are winning. No one wants to join a loser organization.

Policy Action

While personal steps are critically important, community action is a must. But neither are enough. The personal should also be political. Unless the system that unduly relies on hazardous materials like PVC is changed, then green consumerism and green behavior will remain a minor movement of the privileged few. Unless many community-based organizations join forces, large-scale systemic change will be slow in coming.

Table 16

A PVC-Free Policy Action Agenda

Accomplish Within Three Years

1. Ban all open waste burning.
2. Educate the public about PVC hazards.
3. Ban the incineration of PVC waste.
4. Collect PVC products separately from other waste.
5. In the interim, divert PVC away from incineration to hazardous waste landfills.

Accomplish Within Five Years

6. Establish our Right-to-Know about PVC.
7. Label all PVC products with warnings.
8. Give preference to PVC-free purchasing.
9. Ban use of PVC in bottles and disposable packaging.
10. Ban sale of PVC with lead or cadmium.

Accomplish Within Seven Years

11. Phase out other disposable PVC uses.
12. Phase out other high hazard PVC uses.
13. If safer alternatives are not yet available, extend the PVC phase-out deadlines for specific uses.
14. Fund Efforts to reduce the amount of PVC generated through fees on the PVC content of products.

Accomplish Within Ten Years

15. Phase out remaining durable PVC uses.
16. Decommission municipal waste incinerators in favor of zero waste plans.

Here are a number of action steps that government at the state, local and national levels must take to phase-out PVC in a timely and orderly manner. Actions that may be successful early on and that establish a foundation for future PVC reductions are listed first in order on the timeline below. These policy actions also give guidance to other decision makers in industry, commerce and institutions about policies that they should embrace to help prevent harm from PVC use. This PVC-free action agenda is summarized in Table 16.

Accomplish Within Three Years

1. Ban All Open Waste Burning. Backyard burning of household trash and other open burning should be strictly prohibited everywhere as the country's major uncontrolled source of dioxin pollution. However, a statutory ban will not be effective without educating people about the hazards of PVC and simultaneously working aggressively to reduce the toxicity of the waste stream. People burn their waste to avoid real costs and inconvenience, and out of cultural habit and practice. People need to know the truth about PVC and waste burning in order to overcome their resistance to change.

2. Educate the Public About PVC Hazards. Conduct a well-funded public education campaign that targets PVC as a serious problem waste that especially threatens public health when burned, but also creates health and environmental risks when disposed of in a landfill. Use a hard-hitting approach that holds the chemical industry responsible for the impacts of open burning and for selling a material that releases toxic additives and by-products. Model the campaign along the same lines as the anti-tobacco industry ads that work to reduce teenage and adult smoking. The educational campaign should sell PVC-free solutions as it persuades people to halt the backyard burning of trash.

3. Ban the Incineration of PVC Waste. All forms of incineration of PVC waste should be phased out by a certain date. Designate PVC waste as hazardous waste. Develop educational programs and incentives to remove PVC from waste streams destined for incineration. Replace all medical waste incinerators with non-burn technologies for waste that needs to be disinfected and send the disinfected residue to a "secure" landfill. Develop a workable timeline to ban the incineration of PVC in municipal solid waste.

4. Collect PVC Products Separately from Other Wastes. Award grants and publicize new programs to support PVC waste separation and collection. Identify

C A S E   S T U D Y

PVC Identified as Household Hazardous Waste

In its Plan for the Statewide Collection of Household Hazardous Waste, the State of Maine identified PVC as a problem waste that should be separately collected and, if not recycled, then diverted away from incineration to landfill disposal. Although household hazardous waste remains exempt from regulation, collection programs are being expanded in Maine and elsewhere to encourage residents to turn in old hazardous products for safe management rather than tossing them in the trash. In addition to spent paint thinner, old pesticides, mercury products and other toxic household waste, the Plan targets PVC, latex paint and old propane tanks as problem wastes requiring special collection and management. Efforts are underway to establish a reliable means of funding the operational costs of household hazardous waste collection so that this plan can be fully implemented in Maine (Source: MDEP 2001b).

C A S E   S T U D Y

San Francisco Bay Area Adopts Dioxin-Free Purchasing Policies

The San Francisco Bay Area is leading the nation in preventing dioxin pollution by passing Dioxin Resolutions in Oakland and San Francisco and establishing dioxin-free purchasing requirements for local governments. The resolutions grew out of a grassroots campaign to shut down the last commercial medical waste incinerator in Oakland, one of the largest sources of dioxin in the Bay Area. A diverse coalition of environmental, environmental justice, health-impacted groups, labor representatives, and local government officials worked together to shut down the incinerator in 2001. In the process, they convinced local governments to pass dioxin resolutions and establish a Bay Area Government Task Force to implement resolutions that will:

- Promote dioxin pollution prevention practices;
- Use less toxic, non-chlorinated products and processes, such as chlorine-free paper and PVC-free plastics;
- Urge health care institutions to phase out PVC products;
- Work with other local governments to convene a Regional Task Force to identify sources of regional dioxin pollution and develop prevention strategies; and
- Pursue dioxin reduction practices that do not cause workers to become unemployed (Sources: Greenaction 2001a, CO 1999, CSF 1999).

PVC as a hazardous waste and add PVC waste products to existing programs that collect household hazardous waste, mercury products and other problem wastes for safer management.

5. In the Interim, Divert PVC Away from Incineration to Hazardous Waste Landfills. Clarify waste management priorities for PVC to establish preference for land disposal over incineration due to the formation of dioxin and other toxic by-products. Make the institutional arrangements needed to ensure that PVC waste is disposed of in “secure” triple-lined hazardous waste landfills and diverted away from incineration. Identify opportunities for operators of waste incinerators to remove more PVC waste from the floor of the incinerator prior to waste combustion.

Accomplish Within Five Years

6. Establish Our Right-To-Know About PVC. Require product manufacturers that sell products containing PVC to notify the state of the amount of PVC and the specific chemical name of additives used in individual products, identified by brand name, model and type of PVC use. This information should be made available on-line in a searchable database on PVC products that allows consumers and business people to identify PVC and its ingredients in consumer products and materials. This provides people with the knowledge they need to ask questions and make decisions about safer PVC-free alternatives.

7. Label All PVC Products with Warnings. A meaningful education and PVC diversion program will run head long into the current limits on identifying PVC in the waste stream. By requiring all PVC products to be labeled, PVC can be more readily separated from other waste and diverted away from incineration. Warnings should encourage consumers to avoid burning PVC products. Labeling will also encourage product manufacturers to switch to safer non-PVC materials to avoid labeling requirements.

8. Give Preference to PVC-free Purchasing. A government procurement policy that establishes as a priority the purchasing of safer alternatives to PVC will harness institutional buying power. Changing the buying habits of various levels of government will help drive the market for PVC alternatives and begin to affect the practices of other institutions in the supply chain that supports government operations.

U.S. Companies Stop Using PVC in Products

Dozens of U.S. companies have stopped using PVC in their products. Some examples are as follows.

- General Motors announced it would phase out the use of PVC for auto interior panels by 2004, informing its suppliers to use alternatives for all new products (CCC 2004).
- Nine toy manufacturers, including International Playthings, Gerber and Brio are phasing out all the PVC in their products (Greenpeace 2003).
- Mattel, Inc., the world's largest toy manufacturer, is planning to phase in plant-based plastics to replace PVC in company products (Greenpeace 2001).
- NIKE, the shoe and sports equipment manufacturer, is phasing out PVC in its products (Greenpeace 2001).
- Helene Curtis eliminated PVC bottles for packaging Suave, and Intimate Brands, a major beauty supply company, is phasing out PVC containers by 2005 (Lester 2003).

9. Ban the Use of PVC in Bottles and Disposable Packaging. These two uses of PVC are the easiest and most compelling to ban outright in the near term. Both represent short-lived uses that become PVC waste soon after purchase. The PVC in bottles contaminates the recycling of the more plentiful and safer PET bottles (# 1 plastic) (see Chapter 7). The market in PVC bottles has already been declining steadily. The growing use of PVC for packaging, such as in clear plastic blister packs, adds disproportionately to the problem of PVC in municipal solid waste. Safer alternatives for both uses are readily available and already in the market place.

10. Ban the Sale of Any PVC Containing Lead and Cadmium. The continued use of these two highly toxic PVC additives presents a serious hazard that has long been recognized by progressive governments. Even the PVC industry has moved to replace some uses of lead and cadmium as stabilizers in their products. For example, the European vinyl industry has set a voluntary goal to phase out the sale of lead stabilizers by 2015 with a 15% reduction by 2005 and 50% by 2010 (ENDS 2004). However, by 2003 only a 5.3 % reduction in lead had been achieved (ENDS 2004). We think the global PVC industry needs to move away from lead much faster. By banning the sale of any new PVC product containing lead or cadmium, policy makers will be acting on strong public health science. Such a ban will further clean up PVC and raise questions about the other additives used in PVC and the hazards of the material itself.

Accomplish Within Seven Years

Priorities for Replacing Specific PVC Uses

1. PVC bottles and disposable packaging
2. PVC containing lead or cadmium
3. Other non-durable disposable PVC uses
4. Other higher hazard PVC uses
5. Other PVC used in durable goods

11. Phase Out Other Disposable Uses of PVC. Non-durable products made with PVC become waste in short order, steadily adding PVC to the municipal waste stream. Separating PVC from the waste stream after it is generated will never be 100% effective. Nor can these collected non-durable PVC products be readily recycled. Therefore, the next phase in directing reductions in PVC usage should focus on replacing the remaining non-durable disposable uses of PVC with safer alternatives whenever they are available, effective and affordable.

12. Phase Out Other High Hazard Uses of PVC. A further priority should target replacement of PVC uses that expose sensitive groups of people to toxic additives and other uses that are vulnerable to dioxin-forming fires. The continued use of vinyl in medical products

Health Care Institutions Move to Phase Out PVC

- Health Care Purchasing: Four top group purchasing organizations that buy supplies for more than 70% of U.S. health care facilities, such as Premier, Inc., established initiatives to reduce the purchasing of medical products containing PVC, mercury and the chemical plasticizer diethylhexyl phthalate (DEHP) (HCWH 2002a).
- Baxter International, Inc., one of the world's largest medical supply manufacturers, is phasing out PVC in its intravenous (IV) solutions containers (Baxter 1999).
- Abbott Laboratories has committed to move toward PVC- and DEHP-free alternatives (Abbott 2003).
- The thirty-seven members of the Maine Hospital Association agreed to continuously reduce the use and disposal of PVC plastic in hospitals as part of a statewide pollution prevention agreement (MHA 2001)

CASE STUDY

Model Policy Action Taken to Phase Out PBTs and PVC

In 2000, the Washington State Department of Ecology (Ecology) developed a groundbreaking strategy to phase out some of the deadliest toxic chemicals in Washington—persistent, bioaccumulative and toxic chemicals (PBTs). Ecology's program has a goal of reducing PBTs such as mercury, dioxin, PBDEs (toxic flame retardants) and PCBs by the year 2020.

Under Washington's PBT strategy, chemical action plans are developed for high priority chemicals. In 2003, Ecology developed a plan to reduce and phase out mercury and the legislature passed a bill to ban certain mercury consumer products. Right now, Ecology is working on a chemical action plan to reduce and eliminate toxic flame retardants (PBDEs), chemical cousins of PCBs that are rapidly rising in the environment, breast milk, orcas and other wildlife.

The Toxic Free Legacy Coalition, led by Washington Toxics Coalition, Washington Physicians for Social Responsibility, Healthy Building Network, WashPIRG, Breast Cancer Fund and People for Puget Sound, is working to ensure the meaningful implementation of legislation and Ecology's PBT strategy.

On a local level, the Toxic Free Legacy Coalition was successful in getting the City of Seattle to adopt a first in the nation purchasing policy to reduce and eliminate the purchasing of products that contain or generate PBTs, including PVC. The hazards of PVC continue to be central to the debate surrounding successful implementation of the Resolution (Source: WTC 2004).

represents a prime example of unnecessary exposure to the additives in PVC products. DEHP, a type of phthalate additive, leaches out of vinyl medical bags and tubing. An infant boy in neonatal intensive care may be exposed to enough phthalates from PVC to pose harm to his developing reproductive organs (Rossi 2001). Examples of PVC uses particularly vulnerable to dioxin-forming fires include automotive applications and building materials such as vinyl siding. High fire hazard uses of PVC should be replaced with safer alternatives.

13. If Safer Alternatives are Not Yet Available, Extend the Phase-Out Deadlines for Specific PVC Uses. A reasonable PVC phase-out policy would make allowance for those few cases where acceptable alternatives are not readily available. In such a case, a temporary exemption could be granted for a scheduled PVC phase-out deadline upon a satisfactory demonstration by a product manufacturer. Further criteria for granting interim relief should consider whether the specific use of PVC is essential to public health and safety or if the available alternative does not work effectively or is much more expensive.

14. Fund Efforts to Reduce the Amount of PVC Waste Generated Through Fees on the PVC Content of Products. Funding will be needed for public education, developing diversion and labeling programs, and to administer an orderly phase-out of PVC products. PVC products should be assessed fees to pay for these PVC reduction programs. That's the fairest approach. Fees should be collected at the product distribution level to avoid the administrative burden of retail fee collection.

Accomplish Within Ten Years

15. Phase Out Remaining Uses of Durable PVC Products. The remaining uses of PVC should be relatively lower hazard uses in longer-lived products that have less chance of accidental combustion or public exposure to toxic additives. These uses should be replaced with safer alternatives as the final priority for the orderly phase-out of PVC. By ending all uses of PVC, the toxic impacts across the life cycle from production to disposal will be prevented.

16. Decommission Municipal Waste Incinerators in Favor of 'Zero Waste' Plans. Within ten years, we should replace the inherently dirty and obsolete strategy of needlessly burning valuable resources disguised as discarded materials and products. Zero waste strategies involving much more aggressive source reduction (including product redesign), reuse, recycling and composting can reduce waste volumes even more than incineration, and without generating toxic by-products. As the contracts expire on the current inventory of more than 100 municipal solid waste incinerators, these plants should be safely decommissioned. Waste incineration should be relegated to the dustbin of history.

Conclusion

Within ten years, we can bring a virtual halt to the toxic life cycle of PVC. Through persistent organized action at all levels, discarding harm from PVC disposal will become a practice of the past. Safer alternatives will serve the same purposes filled by PVC now through the use of clean materials and the sustainable production of clean products. The health and environmental problems created by PVC can be solved through two profoundly simple actions—don't buy it, don't burn it!

APPENDIX A
Common Household Products and Packaging That May Contain PVC

Thousands of consumer products and packaging are made from PVC. The following is a general list of some common products that are typically made of PVC This list is meant to be a starting point for identifying what common products are packaged in or made from PVC. In creating this list, we recognize that companies are always changing their products, including the materials they use to package them. In some cases, you may find that a product listed is no longer made from PVC. If this happens, you may want to contact the company and congratulate them for being environmentally conscientious.

While this list may help get you started, not all containers and products are labeled. If you suspect that a product or its packaging is made of PVC, we suggest you contact the product manufacturer and ask them directly about the materials used in the product or its packaging. One way to be sure if the packaging of a product is made from PVC is to look for the number "3" or for the letter "V" inside the universal recycling symbol. This means that the product is made of PVC. Soft flexible plastic products that are made with PVC often have a distinct odor. What you smell is the plasticizer that was added to the PVC material to make it soft and flexible.

In addition, a list of specific products identified by brand name that are packaged in PVC bottles, was generated by the Grassroots Recycling Network (GRRN 2004a). This list can be accessed on the GRRN web site at http://www.grrn.org/pvc.

Apparel:
Boots
Aprons
T-shirts with PVC prints (shiny)
Raincoats
Rain pants
Skirts
Lingerie
Shoes
Bags
Luggage
Bibs
Backpacks (PVC coating for waterproofing)
Watchbands
Diaper covers

Personal Care Items (packaging):
Shampoo
Hair gel
Lotion
Suntan lotion
Baby oil
Mouthwash
Face Wash
Aloe Vera Gel
Massage oil
Liquid soap

Household Items:

Cleaning product containers
Waterbeds
Shelving
Checkbook covers
Photo album sheets
Self-adhesive labels and stickers
Shower curtains
Imitation leather furniture
Mattress covers
Textiles
Toys
Clothes racks (covers metal to prevent rusting)
Pet care product containers
Strollers

Kitchen Items:

Drinking straws
Tablecloths
Beverage containers
Plastic utensils
Dishwasher, refrigerator and freezer racks
Dish drying racks (covers metal to prevent rusting)
Appliance casings
Food wrap
Food containers

Outdoor Items:

Pond liners
Tarps
Greenhouses
Children's swimming pools
Inflatable furniture
Outdoor furniture
Garden hoses
Balls

Automotive:

Upholstery
Dashboards
Door panels
Underbody coating
Car seats for children
Traffic cones
Wire coating
Auto-related product containers

Building Materials:

Pipes
Siding
Tiles
Wall coverings
Window frames
Door frames
Door gaskets
Gutters
Fencing
Plastic lumber
Shutters
Flooring
Wire/cable insulation
Molding
Cavity closure insulation

Medical Supplies:

Colostomy bags
Catheters
Blood bags
Bed liners
Tubing
Gloves
Mattress covers

Office Supplies:

Computer keyboards
Computer monitor housing
Cellular phones
Floppy disks
Binders
Clipboards
Paper clips
Tape
Mouse pads

Miscellaneous:

Credit cards
Slide holders
Landfill liners and leachate pipes

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APPENDIX B
Amount of PVC Generated, Incinerated and Landfilled in Each State

State	Total MSW Generated (tons)	Total Amount of PVC Disposed (tons)[1]	Amount of PVC Incinerated (tons)[2]	Amount of PVC Landfilled (tons)[2]
Alabama	*	*	*	*
Alaska	*	*	*	*
Arizona	6,012,359	37,277	0	37,277
Arkansas	3,838,217	23,797	545	23,252
California	54,429,851	337,465	9,205	328,260
Colorado	5,051,132	31,317	0	31,317
Connecticut	4,734,132	29,352	16,257	13,095
Delaware	1,069,042	6,628	0	6,628
Florida	19,706,584	122,181	45,364	76,817
Georgia	11,214,006	69,527	350	69,177
Hawaii	1,706,018	10,577	3,454	7,123
Idaho	1,090,000	6,758	0	6,758
Illinois	15,951,037	98,896	0	98,896
Indiana	9,542,378	59,163	6,177	52,986
Iowa	3,416,268	21,181	366	20,815
Kansas	4,698,338	29,130	0	29,130
Kentucky	5,465,608	33,887	16	33,871
Louisiana	4,952,900	30,708	0	30,708
Maine	1,327,164	8,228	5,448	2,780
Maryland	8,904,464	55,208	12,486	42,722
Massachusetts	8,307,387	51,506	28,145	23,361
Michigan	16,916,076	104,880	8,639	96,241
Minnesota	5,043,752	31,271	14,432	16,839
Mississippi	2,918,407	18,094	0	18,094
Missouri	7,256,744	44,992	207	44,785
Montana	*	*	*	*
Nebraska	2,395,100	14,849	0	14,849

State	Total MSW Generated (tons)	Total Amount of PVC Disposed (tons)[1]	Amount of PVC Incinerated (tons)[2]	Amount of PVC Landfilled (tons)[2]
Nevada	3,365,570	20,867	0	20,867
New Hampshire	1,214,777	7,532	1,675	5,857
New Jersey	10,606,326	65,759	9,593	56,166
New Mexico	2,095,052	12,989	0	12,989
New York	24,775,000	153,605	37,517	116,088
North Carolina	8,981,349	55,684	842	54,842
North Dakota	638,804	3,961	0	3,961
Ohio	16,211,198	100,509	0	100,509
Oklahoma	4,489,028	27,823	0	27,832
Oregon	4,074,945	25,265	2,434	22,831
Pennsylvania	12,675,854	78,590	17,746	60,844
Rhode Island	1,248,745	7,742	0	7,742
South Carolina	5,973,059	37,033	2,004	35,029
South Dakota	518,493	3,215	0	3,215
Tennessee	7,365,920	45,669	1,266	44,403
Texas	28,531,660	176,896	0	176,896
Utah	2,471,404	15,323	782	14,541
Vermont	611,617	3,792	498	3,294
Virginia	10,877,723	67,442	18,806	48,636
Washington	8,666,755	53,734	4,606	49,128
West Virginia	1,754,523	10,878	0	10,878
Wisconsin	5,592,862	34,676	1,545	33,131
Wyoming	693,783	3,301	0	3,301
Totals	**369,381,411**	**2,289,166**	**250,405**	**2,038,761**

Sources and Notes: Estimates derived from Kaufman (2004) for 2002. (1) The amount of PVC generated in each state is derived by multiplying the total Municipal Solid Waste (MSW) generated in that state by the percent of PVC (0.62%) estimated from USEPA (2003). We assumed the percent of PVC estimated from the USEPA data was representative of the PVC content in a typical municipal solid waste stream and that none of the PVC was recycled. (2) The amount of PVC incinerated (or landfilled) in each state was calculated by multiplying the total PVC disposed of in the state by the percent of waste incinerated (or landfilled) after recycling. The percent of PVC incinerated (or landfilled) after recycling was determined by dividing the total amount of waste incinerated (or landfilled) in a state (provided in Table 4 of Kaufman 2004) by the total waste disposed of (after recycling).

* These states did not participate in the survey conducted by Biocycle magazine (Kaufman 2004).

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