NERC

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Managing Pharmaceutical Waste:
Best Management Practices for Plastic Medication Containers from Consumers

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I. Background

The Northeast Recycling Council, Inc. (NERC) was awarded an Innovative Solid Waste grant by the U.S. Environmental Protection Agency (EPA) in order to develop environmentally sound and legal strategies for managing unwanted medication, as well as to develop best management practices (BMP) for the disposal of plastic medication containers.

This report focuses on the BMP for the disposal of plastic medication containers destined for the residential municipal solid waste (MSW) stream, from prescription and over-the-counter (OTC) medications.

The disposition of medication containers, and indeed the availability of containers, is highly dependent on the fate of the medication itself. One of the significant products of the NERC research project was the development of best management practices for the disposal of unwanted medications in order to keep potentially toxic pharmaceutical products from entering the environment through uncontrolled disposition. In addition, the Advisory Committee for the project endorsed a recommendation that unused medications remain in their original container for disposal. See Attachment B.

Thus, the BMPs for plastic containers put forth in this report presume that if medications are collected and disposed of as part of an unwanted medication collection program, that the containers will remain with the medications.

II. Introduction

Information on the quantity, composition, type, and disposition of medication containers in the municipal solid waste stream is limited. This research first set out to fill the information void on the quantity and composition of medication containers generated by consumers, and ultimately, entering the municipal solid waste stream, either empty or with unwanted medication.

This data was then entered into NERC's Environmental Benefits Calculator to assess the relative environmental advantages of different disposition scenarios, including combinations of incineration[1], landfilling, and recycling. Finally, the results of the environmental benefits calculations were evaluated in light of the guidance that unwanted medications remain in their original containers to arrive at recommended BMPs for plastic medication containers.

This report summarizes each of the outputs of this research project, including:

1. Medication container profile
This project developed a profile of the quantity, composition, and type of medication containers through published reports and articles (written or electronic), trade associations, and personal communications. The search for published reports in the public domain yielded sparse data, so industry reports were purchased through a market research firm specializing in pharmaceutical packaging.

2. Characterization of containers at a pilot collection event for unwanted medications
The containers delivered with unwanted medications to a CVS-sponsored pilot collection in South Portland, Maine were characterized to assess first-hand the composition and variability of this waste stream.

3. Analysis of environmental benefits of disposition scenarios using NERC's Environmental Benefits Calculator (EBC)
Using assumptions on the quantity and composition of medication containers in MSW, the EBC was used to compare the environmental benefits of alternative management options for medication containers, including incineration, landfilling, and recycling.

4. Best management practices for medication containers
This report presents recommendations for the best management practices for medication containers based on the above research and analysis.

III. Medication Containers: Types, Quantity and Composition

In order to determine the best management practices for medication containers, this project first had to address a fundamental question. What types and quantities of medication containers are destined for MSW, and of what materials are these made?

Since MSW composition data does not address this specific waste stream, the way in which the pharmaceutical industry packages products was looked at instead. However, this data had its limitations for this research, including:

- The types of packaging included in the industry pharmaceutical packaging reports is much broader than the scope of medication containers considered in this research. Industry data includes packages such as intravenous (IV) containers sent to health

[1] For purposes of this document, all references to incineration shall include waste-to-energy facilities.

care facilities and bulk prescription pill containers sent to pharmacies for repackaging, and secondary packaging, including shipping containers and paperboard boxes.

- Industry data defines "end-use" markets as pharmaceutical manufacturers, contract manufacturers, retail pharmacies, and institutional pharmacies, while the scope of this project research is to determine what types of plastic medication packaging ends up in households. Households most often obtain medications packaged by pharmaceutical manufacturers (e.g., over-the-counter medications) or from retail pharmacies (e.g., prescriptions).

- Much of the industry data is reported by value of shipments, not units. The unit cost of packaging types (e.g., prescription vials vs. blister packs) and materials vary. The value of shipments is not directly proportional to the number of units shipped.

In this report, however, the value of shipments as an approximation of units shipped is used since data is not readily available to normalize the value to better approximate the number of units shipped. Nevertheless, this is the best available data for the purposes of this research, and so the data on pharmaceutical packaging summarized below provides the starting point that was used for the analysis of best management practices for the disposal of medication containers. The industry data is used in a subsequent section to extrapolate the potential quantity and composition of containers entering the residential MSW stream.

Pharmaceutical Packaging

In 2003, manufacturer shipments of pharmaceutical containers in the U.S. totaled 28.8 billion units. Primary containers accounted for approximately 66 percent of total containers, or 19 billion units, while secondary containers made up the remaining 34 percent.[2] Table 1, below, provides examples of the primary and secondary containers for pharmaceutical products.

Primary	Secondary
• Plastic bottles • Blister packaging • Pouches • Pre-fillable inhalers and syringes • Medication tubes • Ampoules • IV containers • Glass bottles and jars	• Prescription containers • Paperboard boxes • Shipping containers • Thermoformed trays and kits • Clamshell packs

Table 1: Examples of Primary and Secondary Pharmaceutical Packaging
Source: The Freedonia Group, Inc., Pharmaceutical Packaging to 2008, Report Number 1779, March 2004.

[2] The Freedonia Group, Inc., "Pharmaceutical Containers Demand by Type: 1993-2013", *Pharmaceutical Packaging to 2008*, Report Number 1779, March 2004.

Eighty-three percent of pharmaceutical containers (by $ value) were destined for use by the pharmaceutical manufacturing industry. The remaining containers were shipped to contract manufacturers (7.7%), retail pharmacies (4.5%), institutional pharmacies (1.8%), and other markets (2.9%).[3] The pharmaceutical manufacturing industry and contract manufacturers ship products (e.g., over-the-counter medication or prescription medications) in their final, ready-to-use packages or in bulk form for subsequent repackaging by retail or institutional pharmacies.

Figure 1, below, shows the relative proportion of primary and secondary packaging by container type. Blister packaging accounts for the largest percentage (24%) of all packaging types, followed by primary plastic bottles at 22 percent.[4] Prescription containers represent roughly five percent of all containers.[5]

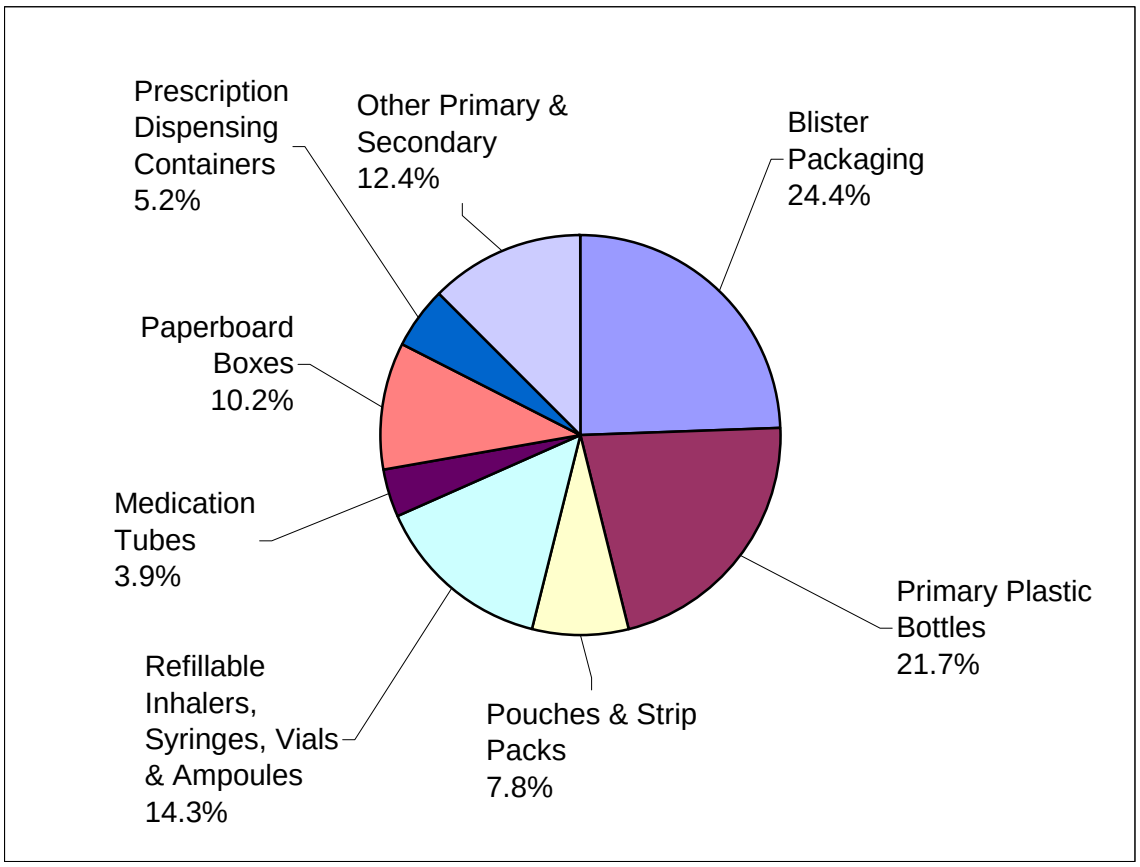

Figure 1: Pharmaceutical Containers by Type (million dollars)
Source: The Freedonia Group, Inc., Pharmaceutical Packaging to 2008, Report Number 1779, March 2004.

[3] The Freedonia Group, Inc., "Pharmaceutical Packaging Demand by End-Use Market: 1993-2013" *Pharmaceutical Packaging to 2008,* Report Number 1779, March 2004.
[4] The Freedonia Group, Inc., "Primary Pharmaceutical Container Demand by Type: 1993-2013," *Pharmaceutical Packaging to 2008*, Report Number 1779, March 2004.
[5] *Id.*

Figure 2, below, provides a breakdown of the raw materials found in primary and secondary pharmaceutical packaging. Plastic resins accounted for almost half (49.5%) of all pharmaceutical packaging materials in 2003. Plastic use as a percentage of all packaging materials has remained relatively constant since 1993 and is predicted to remain at this level through 2013.[6]

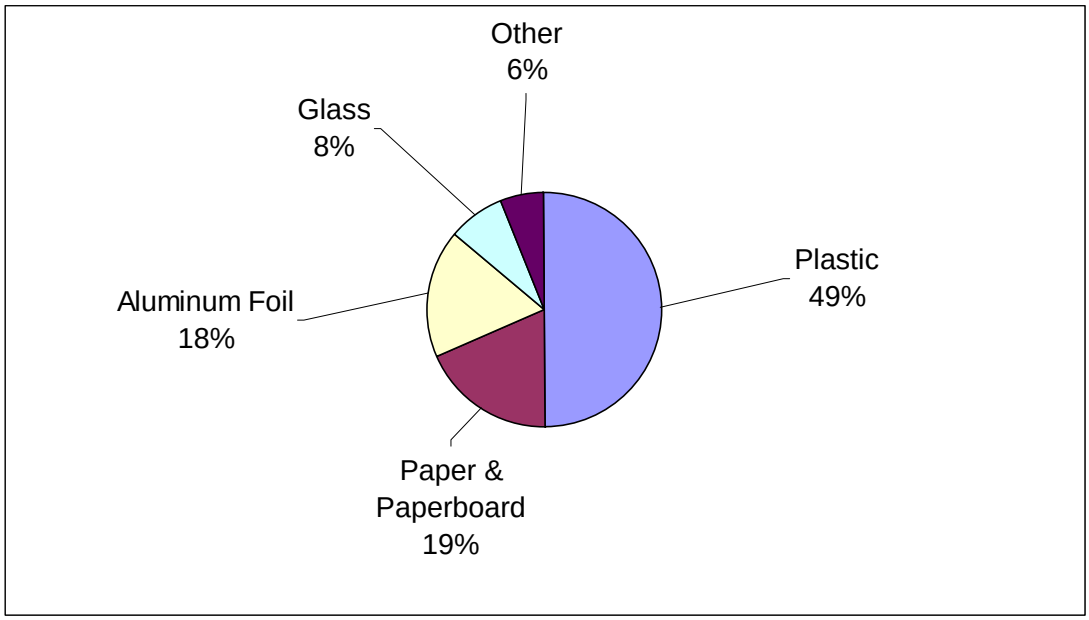

Figure 2: Raw Material by Type, 2003 (million dollars)
Source: The Freedonia Group Inc., Pharmaceutical Packaging to 2008, Report Number 1779, *March 2004.*

Changes in raw material consumption for pharmaceutical packaging are most evident for glass and aluminum foil. Figure 3, below, shows an increase in the percentage of aluminum foil used in packaging from 1993 to 2003, with the trend expected to continue through 2013. This trend is attributed to the growth in the use of blister packaging and foil pouches. At the same time, glass materials are on the decline.[7]

[6] The Freedonia Group, Inc., "Basic Pharmaceutical Packaging Raw Material Consumption by Type: 1993-2013," *Pharmaceutical Packaging to 2008*, Report Number 1779, March 2004.
[7] *Id.*

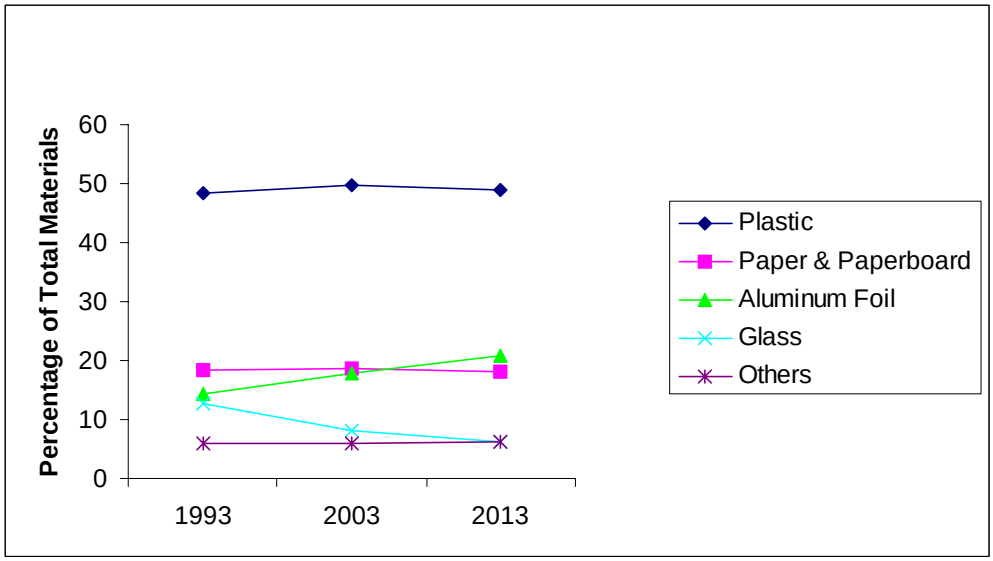

Figure 3: Trend in Materials Use (percentage of shipments, million dollars)
Source: Freedonia Group Inc., Pharmaceutical Packaging to 2008, Report Number 1779. *March 2004.*

Plastic Resins in Pharmaceutical Packaging[8]

In 2003, pharmaceutical packaging consumed 640 million pounds of plastic resins. Applications for plastic that use a significant amount of resin include blister packs, oval, square and round medicine bottles, medication tubes, prescription vials, caps and closures. As shown in Figure 4, below, HDPE dominates the plastic resins used in pharmaceutical packaging with over 40 percent market share, followed by PP at almost 17 percent of the market.[9]

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#1 PET
#2 High Density Polyethylene (HDPE)
#3 Polyvinyl chloride (PVC)
4 Low Density Polyethylene (LDPE)
#5 Polypropylene (PP)
#6 Polystyrene (PS)

[9] The Freedonia Group, Inc., "Plastic Resin Consumption in Pharmaceutical Packaging: 1993-2013, *Pharmaceutical Packaging to 2008*, Report Number 1779, March 2004.

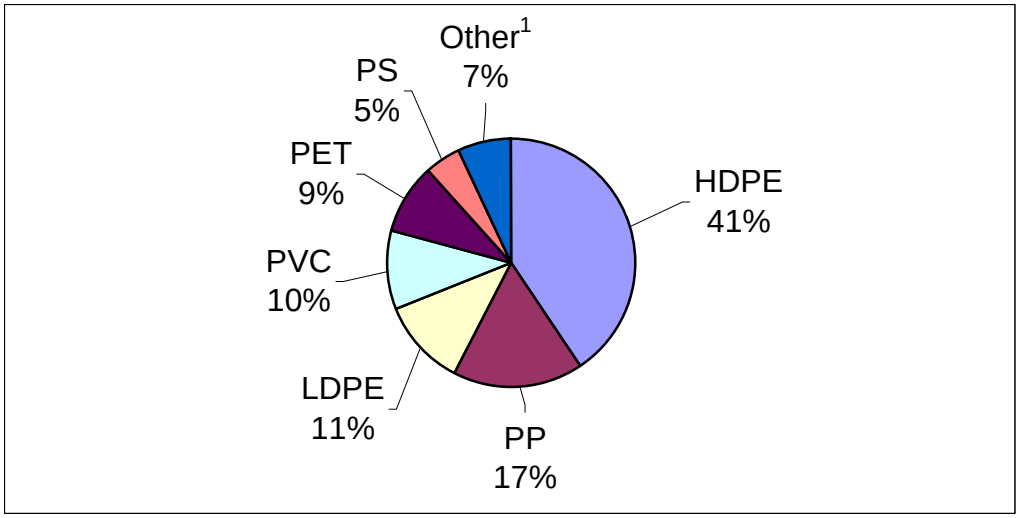

Figure 4: Plastics by Resin Type, 2003 (million lbs)
Source: The Freedonia Group, Inc., Pharmaceutical Packaging to 2008, Report Number 1779, March 2004.
[1]Includes, for example, value-added engineered resins for specialty applications.

Table 2, below, provides examples of pharmaceutical packaging applications for resins.

HDPE (#2)	PP (#5)	LDPE (#4)	PVC (#3)	PET (#1)
• Medicine bottles (oval, squares, rounds) • Dispensing bottles[1] • Medication tubes • Caps/closures	• Prescription vials • Medicine bottles (oval, squares, rounds) • Caps/closures	• Dispensing bottles[1] • Dropper bottles • Caps/closures	• Blister packs • IV containers • Parenteral packaging[2]	• Medicine bottles (ovals, squares, rounds)

Table 2: Sample Applications for Plastics by Major Resin Type
Sources: Multiple sources, including CVS pilot collection event, packaging manufacturer websites; The Freedonia Group Inc., March 2004.
[1]Bottles fitted with an applicator or tip that dispenses the medication. Examples include eye drop and saline solution bottles.
[2] For medications that are administered by routes other than the digestive tract, for example, intravenous or intramuscular injections.

The use of PVC in pharmaceutical packaging is expected to drop by approximately 35 percent from 2003 – 2013, due to safety concerns, leaving it with a 6.5 percent market share. PP and PET are expected to assume this PVC market share in blister and parenteral packaging.[10]

Almost 80 percent of all primary pharmaceutical bottles are oval, square, and round medicine bottles, as shown in Figure 5, below, followed by dispensing bottles (13%). In

[10] *Id.*

2003, approximately 4.72 billion oval, square, and round bottles were shipped. [11] Oval, square, and round bottles are commonly used for over-the-counter medicines (OTC) and nutritional supplements. Pharmacies also receive bulk and single prescription-quantity medication in these bottles. Bulk medications are repackaged by pharmacies into prescription vials. Some pharmacies will also repackage single prescription-quantity medications from the original container into a prescription vial. Dispensing bottles, the second largest category of pharmaceutical bottles, deliver medication directly. Medications found in dispensing bottles include eye drops and nasal sprays.

Prescription vials are considered secondary packaging by the industry, and are not included in Figure 5. This report estimates that approximately 2.74 billion prescription containers are shipped annually.[12]

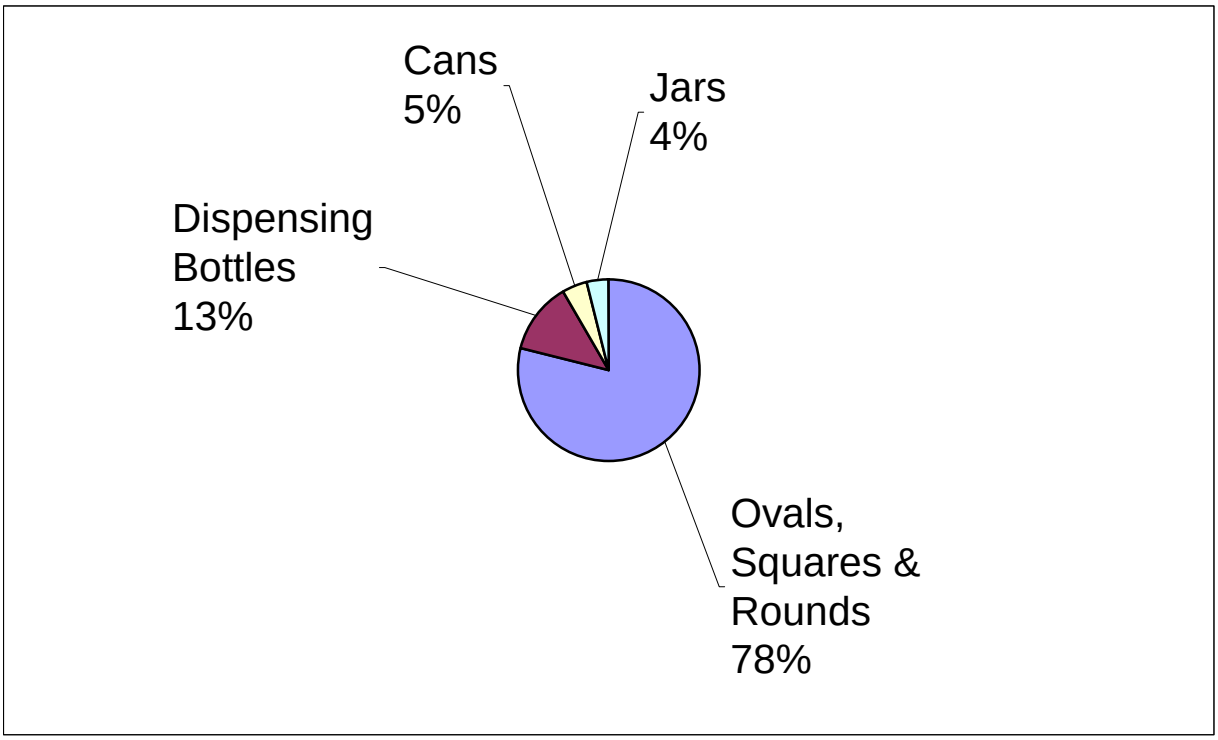

Figure 5: Primary Pharmaceutical Bottles by Type (percentage of units)
Source: The Freedonia Group, Inc., Pharmaceutical Packaging to 2008, Report Number 1779, March 2004.

IV. CVS Pilot Collection – Packaging Data

On February 5, 2005, the research team characterized the types of containers that unwanted medication came in at the CVS Pharmacy collection event held in South Portland, Maine. This data provided a hands-on introduction to the type and composition of packaging that might enter the residential MSW stream. Medication

[11] The Freedonia Group, Inc., "Plastic Pharmaceutical Bottles Demand by Type: 1993-2013", *Pharmaceutical Packaging to 2008*, Report Number 1779, March 2004.
[12] Based on data from The Freedonia Group, Inc., "Secondary Pharmaceutical Containers Demand: 1993-2013", *Pharmaceutical Packaging to 2008*, Report Number 1779, March 2004.

containers were characterized by type, color, size, and material composition, which are the specifications of interest when analyzing disposition options such as incineration and recycling. Attachment A contains the form used to catalogue the containers at that event.

Packaging collected at the CVS collection event included both primary and secondary packaging as defined in the industry data above. Packaging types included over-the-counter and prescription medications in the following containers: oval, square and round bottles; prescription vials; medication tubes; dispenser bottles; inhalers; blister packs; foil pouches; and paperboard boxes.

Table 3 and Figure 6, below, provide a breakdown of the containers received by material type. Data was collected only on the container that directly held the medication; for example, a prescription vial, plastic bottle, medication tube, or inhaler. (Note: the terms "primary" and "secondary" packages are not used in this context since the pharmaceutical industry considers a prescription vial a "secondary" package since it is used to repackage medication sold to retail or institutional pharmacies.) Data was not collected on other secondary containers such as paperboard boxes (e.g., holding multiple packages of medications) or clamshell packaging (e.g., containing medication and a delivery device).

Material Type	Number of Packages Collected	Percentage of Containers[1]	Characterization
Plastic	511	78.3%	See detailed breakdown below
Glass	56	8.6%	Over 1/2 brown (36), others clear
Metal	23	3.5%	Predominantly aluminum tubes[13]
Mixed	63	9.6%	Includes inhalers, epi-pens, monthly dispensers, etc.
Blister Packs	758	Not included in %	Usually multi-dose cards
Foil Pouches	1,307	Not included in %	Unit dose samples

Table 3: CVS Pilot Collection - Medication Containers by Material Type

In South Portland, Maine, plastic containers accounted for approximately 78 percent of the unwanted medication packaging by unit, followed by "mixed" packaging (9.6%) made of more than one material type, glass packaging (8.5%), and metal packaging (3.5%). Plastic made up a greater percentage of packaging at the collection event (Figure 6) compared to the industry data presented in Figure 3 above, in part because the collection event did not quantify paperboard containers or unit dose packaging, which often uses aluminum foil in the percentage calculations.

[13] Such as for topical ointments

At other unwanted medication collection events, NERC has found approximately a 1:2 ratio of paperboard to medication by volume when paperboard is removed.

The percentage of mixed and metal packaging would have been greater if blister packages and foil pouches were included in this category. The number of unit dose packages (blister packages and foil pouches) were counted as shown in Figure 6, below, but were not included in percentage calculations in order not to skew the data. Most of the foil pouches were single-dose samples and the blister packs generally held from 1 - 6 doses, while other packaging types generally held a greater number of doses.

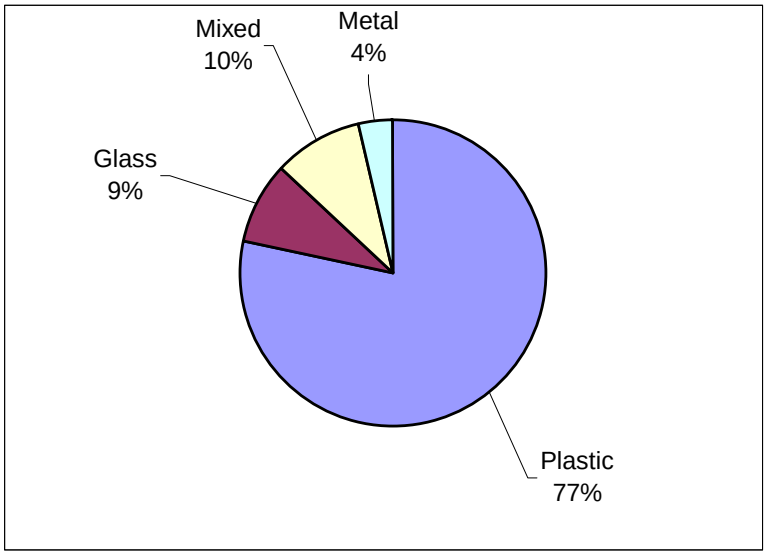

Figure 6: CVS Pilot Collection - Medication Containers by Material Type (Not including unit dose packaging)

Table 4 and Figure 7, below, further characterize the plastic containers by resin type. At the CVS collection event, PP containers accounted for almost 45 percent of containers, while HDPE made up about 28 percent. PET containers were a distant third place with slightly more than 4 percent of containers. Over 20 percent of containers were unmarked. Plastic eye drop and nasal sprays were often unmarked.

Examples of HDPE over-the counter pharmaceutical containers (left)

Examples of prescription containers. All amber vials are PP. The unpigmented container is not marked with a resin identification symbol (above).

Resin Type	Percentage	Characterization
#5 Polypropylene (PP)	44.8%	• 97% of prescription vials were PP (#5) • Only veterinary prescriptions and old vials were unmarked
#2 High Density Polyethylene (HDPE)	28.2%	• OTC medication dominated but could include prescription medications if not repackaged by pharmacy • White resin dominated (90%) but sample included natural, brown, and a few other colors (red, pink, blue, green)
#1 PET	4.3%	• Some nutritional supplements
# 4 Low Density Polyethylene (LDPE)	0.8%	• Very limited and miscellaneous uses
#6 Polystyrene (PS)	0.8%	• Very limited and miscellaneous uses
Unmarked	21.1%	• Eye drops & nasal spray dominated unmarked bottles; includes tubes

Table 4: CVS Pilot Collection - Characterization of Plastic Containers

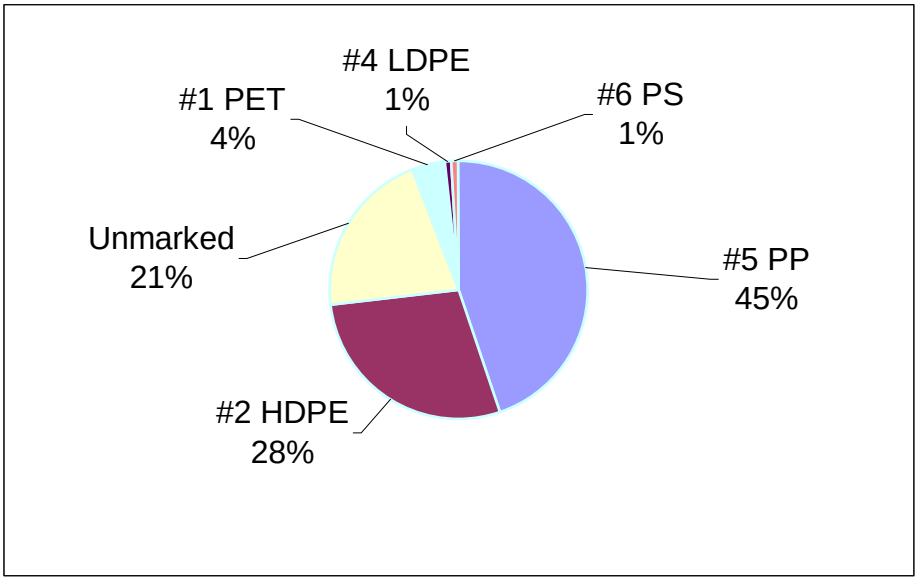

Figure 7: CVS Pilot Collection - Plastic Containers by Resin Type

The PP and HDPE streams were characterized further by homogeneity. PP containers were predominantly amber prescription vials and ninety-seven percent of prescription containers were PP. OTC medications (with the exception of eye drops and nasal sprays) were largely HDPE, and approximately 90% of the HDPE containers were white.

The relative volume of HDPE medication packaging could increase and PP decrease in the future if retail pharmacies stop repackaging medication from original containers (typically white HDPE) into prescription vials. In some cases, medications must be repackaged since they are distributed in bulk containers (also known as stock bottles). In other cases, pharmacists repackage medication into prescription vials for appearance (e.g., to look like a prescription, avoid affixing a prescription label over the manufacturer's label.) Innovation in retail pharmaceutical packaging could also change the resin mix in the future. The Target Corporation, for example, recently introduced a new package for its retail prescriptions (photo, right). The bottle is primarily red with a choice of colored bands to allow family members easily to distinguish their medications. This package is a significant departure from current practice, where pill and tablet prescriptions, if repackaged by the retail pharmacy, are predominantly delivered to consumers in amber vials. Upon examination of the new packaging design, another departure from the status quo was noted. The Target prescription container examined was not coded by plastic type (i.e., plastics 1-7), a practice that will hinder its recycling.[14]

[14] Amber prescription vials are typically coded, even though they usually fall below the weight threshold established by state legislation requiring coding on a container. According to the Society of the Plastics Industry, legislation in 39 states (as of January 1995) requires resin identification codes on bottles of 16

V. Environmental Benefits of Alternative Disposition Scenarios

As demonstrated by industry data and the CVS collection event, plastic containers make up a significant portion of original and recovered medication packaging. As such, plastic medication containers are the logical container type to target for best management practices for disposal. Plastic containers are also an appropriate topic because existing residential MSW programs often provide recycling alternatives for plastic containers. Such opportunities are not available for other major types of medication packaging (e.g., blister packaging).

To develop best management practice recommendations, the environmental benefits of alternative disposition scenarios (incineration, landfilling, and recycling) for plastic containers were calculated using NERC's Environmental Benefit Calculator (EBC)[15]. NERC's EBC generates estimates of the environmental benefits for a study area, based on the tonnage of materials that are source reduced, reused, recycled, landfilled, and incinerated (including waste-to-energy). The Calculator is based on several life cycle analyses and their estimates of energy use and emissions per ton of solid waste. The estimates are average figures based on "typical" facilities in the U.S.[16] The results of the EBC calculations are then tailored to the MSW disposition patterns in the study area.

The EBC calculations for medication containers in this report focus on the Northeast States. The analysis indicates the preferred disposition alternative(s) for plastic containers based on the relative environmental impacts of resource conservation, energy conservation, avoided greenhouse gas and acid rain emissions, and avoided water pollution. In the final section of this report, technical, economic, infrastructure, and practical consideration will be taken into account, or superimposed, on the environmentally preferred disposition alternative(s), to arrive at overall best management practice recommendations.

Assumptions Used in Environmental Benefits Calculations

Calculating environmental benefits using the NERC Environmental Benefits Calculator requires several data inputs and assumptions. The data presented in previous sections of this report were used to derive values for the following data inputs:

1) Amount of resin generated in Northeast states
2) Resins targeted for recycling
3) Resin recycling rate(s)
4) Disposition scenarios for non-recycled containers

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ounces or more and rigid containers of 8 ounces or more. (Wisconsin requires use of the code on bottles of 8 ounces or more.) (http://www.plasticsindustry.org/outreach/recycling/2124.htm)

[15] The Calculator can be downloaded at http://www.nerc.org/documents/Blank_NERC_EB_Calculator.xls

[16] *Id.* On the worksheet tab entitled "Data Inputs", the algorithm and references underlying the calculator are detailed.

1) Amount of Resin Generated in Northeast States[17]

Table 5, below, shows the amount of resins used in pharmaceutical packaging by resin type in the U.S. and the estimated consumption in the Northeast states. The Northeast states consumption rate assumes that 19% of all pharmaceutical packaging is consumed in this region, based upon the percentage of retail sales of prescriptions (19.5%) and over-the-counter medications (18.5%).[18] This also mirrors the percentage of the U.S. population (19%) that resides in this region, according the 2000 US Census.

Resin	U.S.	Estimated Consumption by NE States
HDPE	260	49.4
PP	108	20.5
LDPE	73	13.9
PVC	65	12.4
PET	59	11.2
PS	30	5.7
Other	45	8.5
Total	**640**	**121.6**

Table 5: Resins Used in Pharmaceutical Packaging in U.S. in 2003 and Estimated Consumption by Northeast States (mil lbs)

Source of US data: The Freedonia Group, Inc., "Plastic Resin Consumption in Pharmaceutical Packaging: 1993-2013, Pharmaceutical Packaging to 2008, Report Number 1779, March 2004.

2) Resins Targeted for Recycling

The EBC requires the user to input the amount of material recycled (in tons). For plastics, the amount of specific resins (HDPE, LDPE and/or PET) can be specified and/or the amount of mixed resins.

It is logical to begin the discussion of which resins to target for recycling with HDPE and PP, given their dominant use by the industry (Table 5, above) and their prevalence among plastic bottles at the CVS pilot collection (Figure 7, above).

HDPE has a strong presence in U.S. MSW municipal recycling programs as well as being widely used in medication containers. By contrast, PP is not regularly collected in municipal recycling programs and represents only a very small percentage of medicine containers. This analysis will therefore focus on HDPE medication container recycling.

3) Resin Recycling Rates

The calculation of the environmental benefits used an input figure of a 20 percent recycling rate for HDPE containers. This rate was chosen as a conservative estimate based on industry data. The overall recycling rate for post-consumer pigmented HDPE

[17] Connecticut, Delaware, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont

[18] Calculated based on data in Center for Medicare and Medicaid Services, Department of Health and Human Services, State Health Accounts, State of Provider: Type of Service, 1980-2000.

bottles as a percentage of resin sales was 24.3% in 2004, while all bottles were recycled at a rate of 22.6 percent.[19]

As was discussed in previous sections, data was not available on the specific use of HDPE for medicine containers. For the purposes of the EBC calculations, it was assumed that the use of HDPE for specific packaging applications mirrors the distribution of primary plastic bottles.[20] This report, therefore, assumes that 78 percent of all HDPE consumed in pharmaceutical packaging is used in the manufacture of oval, square and round bottles.

Table 6, below, summarizes the data and assumptions used to generate the estimate of the amount of HDPE recycled, which was used in the EBC calculations.

Resin	U.S. Consumption 2003	Estimated Consumption by NE States	Estimated NE Consumption in Medication Bottles	20% Recycling Rate
HDPE	260 million lbs	49.4 million lbs	38.5 million lbs	7.7 million lbs (3,850 tons)

Table 6: HDPE Data and Assumptions

4) Disposition Scenarios for Non-Recycled Containers

The NERC environmental benefits calculator utilizes state-specific data for calculations. To demonstrate the environmental benefits of recycling compared to landfilling and incineration of plastic medication containers, several states with different municipal solid waste disposition routes and rates were selected for the analysis. Table 7, below, shows the percentage of MSW destined for landfilling and incineration, after recycling, in each of the Northeast states. The environmental benefits calculator was run for three different scenarios, based on the states of Connecticut, Massachusetts, and Rhode Island.

The total volume of resins destined for recycling was entered into the calculations for each of the state scenarios. The results illustrate the *total* potential benefit for Northeast States for recycling HDPE medication containers. Since the calculations were run using the entire amount of material available for recycling the results DO NOT illustrate the potential benefits for individual states. The results also demonstrate the variation in environmental benefits as a function of the disposition route for materials not recycled.

[19] American Plastics Council, 2004 National Post-Consumer Plastics Recycling Report, available at http://www.plasticsresource.com/s_plasticsresource/docs/1700/1646.pdf.

[20] Assumption is based on data provided in Figures 5 and Table 2.

	% Landfilled	% Incinerated
Connecticut	5%	95%
Delaware	100%	0%
Massachusetts	52%	48%
Maine	56%	44%
New Hampshire	74%	26%
New Jersey	79%	21%
New York	67%	33%
Pennsylvania	73%	27%
Rhode Island	100%	0%
Vermont	86%	14%

Table 7: Disposition of MSW after Recycling for Northeast States
Source: Northeast Recycling Council, Inc., 2004. State data from 2002 or 2003.

Environmental Benefits of Alternative Disposition Scenarios for Plastic Containers

Each of the environmental benefit calculation scenarios, reflecting different proportions of landfilling and incineration of the solid waste stream, indicated that recycling HDPE medication containers is the preferred management practice as opposed to solid waste disposal. Table 8, below, provides estimates of the environmental benefits of recycling 20 percent of HDPE medication bottles. Recycling results in environmental benefits across all benefits categories as well as all disposition scenarios.

20% HDPE Recycling Rate			
Environmental Benefit	**5% Landfill/ 95% Incineration**	**52% Landfill/ 48% Incineration**	**100% Landfill**
Net Greenhouse Gas Emissions (MTCE[21])	-2,324	-1,924	-1,515
Net Energy Consumption (mil BTU)	-171,814	-184,760	-198,011
Net Emissions of CO_2 from Recycling as Compared to Disposal (Metric Tons[22])	-6,016	-5,475	-4,920
Net Emissions of SOx from Recycling as Compared to Disposal (Metric Tons)	-9.6	-14.4	-19.3
Net Emissions of NOx from Recycling as Compared to Disposal (Metric Tons)	-16.2	-17.3	-18.3

Table 8: Environmental Benefits of Recycling Medication Containers in Northeast – Comparison of Three (3) Scenarios

The method of handling the materials that are not recycled influences the environmental benefits. The reduction in greenhouse gas emissions and carbon dioxide (CO^2) emissions is greater with higher levels of incineration than landfilling, while the environmental benefits of recycling are greater for net energy consumption and sulfur

[21]Metric tons of carbon equivalent (MTCE) are a unit of measurement that expresses the heat-trapping effects of various greenhouse gas emissions in carbon equivalent. Another unit sometimes used is metric tons of carbon dioxide equivalent ($MTCO^2$).
[22] A metric ton equals 2,204 pounds

oxide (SOx) and nitrous oxide (NOx) emissions when combined with higher landfilling rates. Figures 8 through 10, below, illustrate these trends with graphs comparing greenhouse gas emission reduction, energy savings, and SOx and NOx emission reduction for the three disposition scenarios.

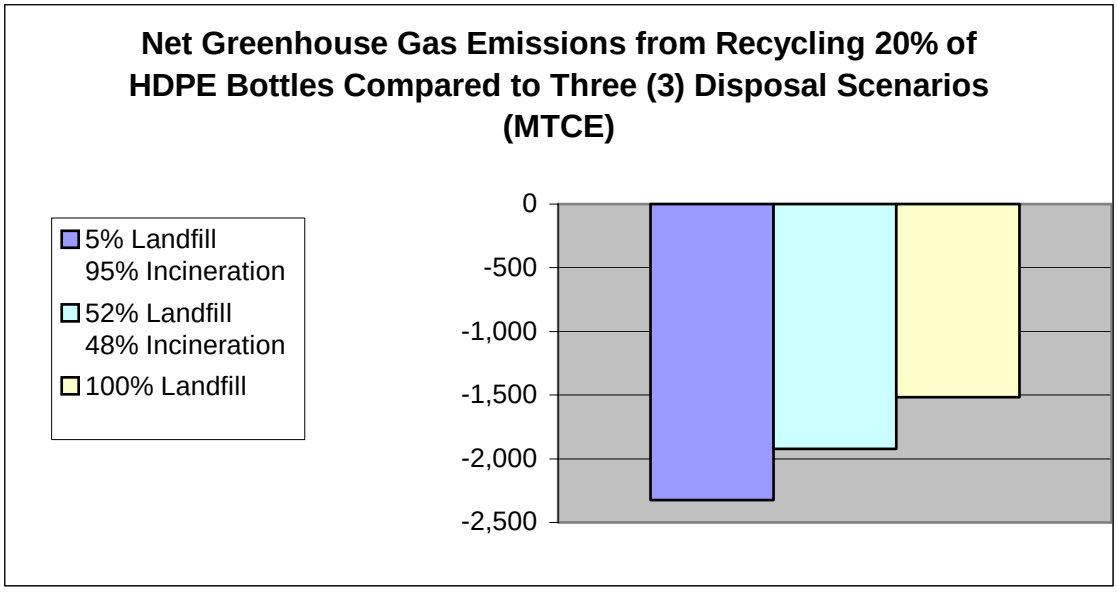

Figure 8

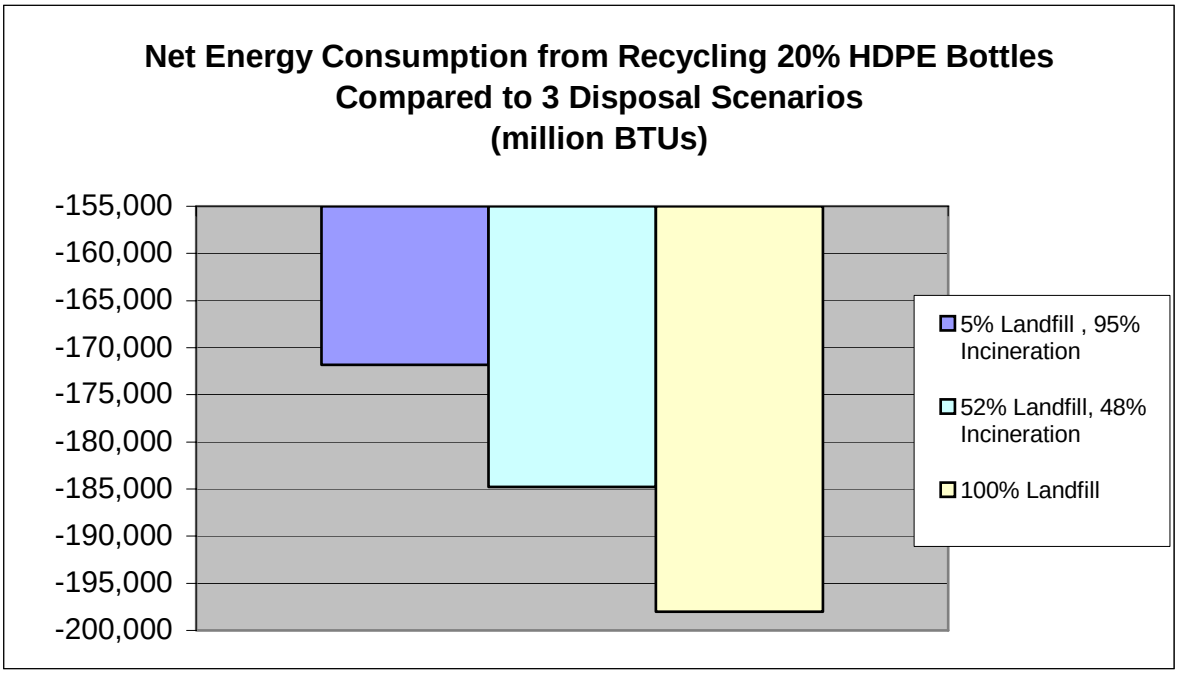

Figure 9

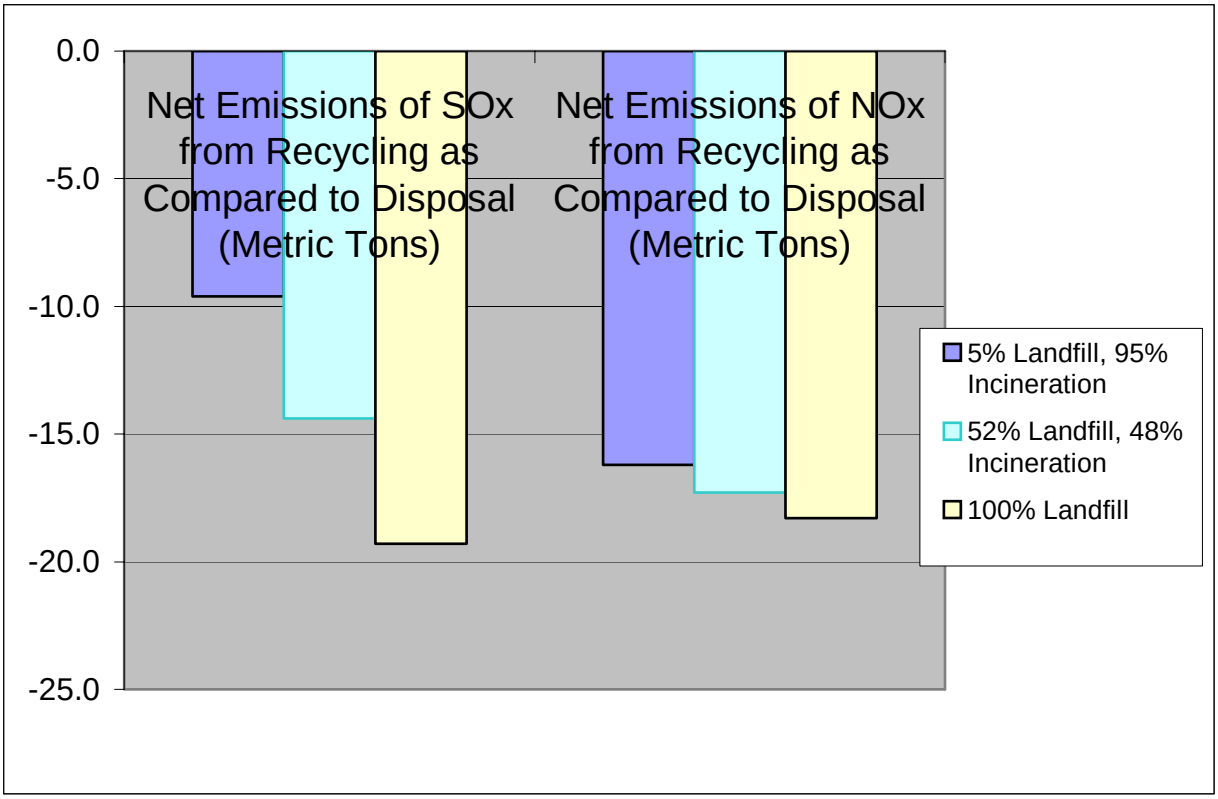

Figure 10

Table 9, below, converts energy savings from recycling 20 percent of HDPE medication containers into equivalent environmental benefits. For example, this level of recycling would be equivalent to removing over 2,500 passenger cars from the roads in the Northeast annually, no matter which disposition scenario is used.

20% HDPE Bottle Recycling Rate			
Environmental Benefit	**5% Landfill/95% Incineration**	**52% Landfill/48% Incineration**	**100% Landfill**
Net Energy Consumption (mil BTU)	-171,814	-184,760	-198,011
Oil Saved (barrels)	-29,623	-29,623	-34,140
Gas Saved (gallons)	-1,386,132	-1,490,572	-1,597,476
Reduction of "Average" Passenger Cars on the Road/Year	-2,516	-2,705	-2,899
Reduction of Car Emissions (CO_2 Tons/Year)	-12,805	-13,770	-14,757

Table 9: Translating Energy Savings into Equivalent Environmental Benefit

VI. Best Management Practices for Plastic Containers

Viewed exclusively from the environmental standpoint, the previous section of this report demonstrated that recycling plastic medication containers is the preferred management option. Best management practices, however, need to consider additional factors such as collection infrastructure, processing technology, and end markets.

Material volume, contamination, and available market applications are additional considerations when analyzing end markets. The contamination of containers by potentially toxic medication is a concern as well.

Table 10, below, identifies opportunities and limitations related to recycling the largest volume of plastic medication containers by plastic type: HDPE oval, rounds and squares; and PP prescription vials. The greatest unknown is the number of plastic medication containers potentially available for recycling. From a material processing perspective, for both HDPE and PP, the small size of the containers used to package medications may limit recyclability.

As a general statement, plastic medication containers are made from commodity-grade resins and, as such, could be suitable for recycling within the existing recycling infrastructure. PP, however, has neither a large market share of overall U.S. container production nor a strong recycling presence. In 2004, for example, 41 percent of all bottles manufactured in the U.S. were HDPE, and 55 percent were PET. All other resins, including PP, represented just 4% of all plastic bottle production. For post consumer bottles, PET soft drink bottles had the highest recycling rate at 33.7 percent, followed by natural HDPE (27.8 %) and pigmented HDPE (24.3%). The recycling rate for PP bottles was just 3.2 percent, while all post-consumer bottles were recycled at a rate of 22.6 percent.[23] The small amount of PP medication containers that might be available for recycling is not enough to affect overall PP recycling markets, and is likely inadequate to provide market incentives on its own. While, the possibly significant volume of HDPE medication bottles represents a potential recycling market strength.

Table 11, below, provides a quick snapshot of U.S. resin sales and recycling rates for selected resins, including pigmented HDPE and PP.

Resin	Resin Sales (Mil lbs)	Resin Recycled (Mil lbs)	Recycling Rate
PET Soft Drink Bottles	1,722	579.4	33.7%
Natural HDPE	1,621	450.3	27.8%
Pigmented HDPE	1,865	453.9	24.3%
PP	190	6.0	3.2%
Total Bottles	8,489	1,914.8	22.6%

Table 11: Post-Consumer Plastic Bottle Recycling – Selected Resins
Source: American Plastics Council, *2004 National Post-Consumer Plastics Recycling Report*, available at http://www.plasticsresource.com/s_plasticsresource/docs/1700/1646.pdf

Finally, PP medication vials may be incompatible with the bottle stream since they are usually manufactured by injection molding, rather than blow molding techniques used in bottle manufacturing. The end use application for the recovered materials, therefore, may limit the acceptance of PP medication vials by MSW recycling programs.

[23] American Plastics Council, *2004 National Post-Consumer Plastics Recycling Report*, available at http://www.plasticsresource.com/s_plasticsresource/docs/1700/1646.pdf.

	Opportunities & Limitations	HDPE	PP
Collection Infrastructure	**Opportunity**	• Commonly collected in recycling programs.	
	Limitation	• Some recycling programs exclude medication containers due to their small size.	• Resin not typically collected in recycling programs, except those accepting #1 - 7 plastics. • Some recycling programs exclude medication containers due to their small size.
Material Processing	**Opportunity**	• Opaque medication containers are predominantly white HDPE, making them easy to identify & separate by resin type. • Compatible with other pigmented #2 plastics from households, such as laundry detergent bottles, providing opportunity to "ride the coat-tails" of a major, existing recycling stream.	• PP prescription containers are easily identifiable given their unique appearance & separable given their homogeneity.
	Limitation	• Small size of containers is a concern to material processors (e.g., MRFs). Small containers can cause operational difficulties when they slip off belts & conveyors, jamming machinery. • Potential for public health risk from loose pills at recycling facility, unwanted medications diverted for illegal use or sale, or personal information stolen from labels.	• Small size of containers is a concern to material processors (e.g., MRFs). Small containers can cause operational difficulties when they slip off belts & conveyors, jamming machinery. • Potential for public health risk from loose pills at recycling facility, or unwanted medications diverted for illegal use or sale, or personal information stolen from labels.
Material Volume	**Opportunity**	• HDPE market share & recycling rates are high compared to resins such as PP.	
	Limitation		• PP market share & recycling rates are low.
Market Applications	**Opportunity**	• Mature recycling markets.	• Injection molded PP vials may be incompatible with the bottle stream.
Material Contamination	**Opportunity**	• Containers relatively homogeneous, reducing potential resin contamination.	• Containers relatively homogeneous, reducing potential resin contamination.
	Limitation	• Concern that packaging is contaminated with medication.	• Concern that packaging is contaminated with medication.

Table 10: Opportunities and Limitations for Plastic Medication Container Recycling

Best Management Practice Recommendations for Plastic Consumer Medication Containers

Plastic medicine containers are a valuable resource that should be recycled, if possible. The results of the environmental benefits calculations clearly indicated that recycling plastic medication containers results in net environmental benefits compared to landfilling or incineration. Overlying the realities of collection, processing, and end-use markets, and considering the recommendation that unwanted medications should be destroyed in their containers, the following best management practices are recommended:

1. Containers with medication remaining should *not* be recycled. If unwanted medication remains in the container, it should be disposed along with the medication. Unwanted medication should **never be flushed down the drain or toilet.**

2. HDPE and PP plastic containers can add incremental volume to existing recycling programs but alone do not justify initiation of a recycling program. Municipal recycling programs should try to encourage recycling of empty medication containers where possible within the guidelines of existing recycling programs. For example, collection of HDPE medicine bottles should be encouraged if approved by the community's MRF or recycling broker. PP vials, however, if injection molded, are not compatible with the traditional bottle stream. Some MRFs and recycling brokers may have markets that accept PP amber medicine vials. Prior to collecting PP vials recycling programs should check with the MRF or recycling broker to make sure that these resins are acceptable for the end market application.

These two resin types constitute the majority of plastic medication containers in the residential stream. Retail pharmacies should also be encouraged to promote the recycling of appropriate containers both by their customers, through municipal recycling programs, and within the pharmacy itself, especially for stock bottles with no patient information.

3. Be sure that MRF and/or plastics broker can manage small-sized containers. Prior to advertising the collection of these containers, municipal programs should confer with the material processing entity or plastics broker to ensure that the small size of the containers will not cause unreasonable operational difficulties. For example, at least two MRF operators complained that medication containers slip through the belts on the conveyors and can become stuck in machinery.

4. Remove labels from prescription medications before recycling. Residents should be encouraged to remove identification labels to protect confidentiality and against the potential of theft of prescription numbers. Patient confidentiality does not present a legal issue since municipal recycling programs are not covered by health information protection requirements.

Other Recommendations

Several recommendations emerged from this study that goes beyond the disposition of plastic containers from consumers.

Pharmaceutical Supply Chain

There appear to be untapped opportunities for source reduction and recycling within the pharmaceutical supply chain.

- Conversations with several pharmacists during this project revealed that prescriptions are sometimes repackaged for aesthetic reasons, rather than affixing a label over the generic white pill bottle provided by the manufacturer. For example, some medications come in standard prescription quantities (e.g., one-month supply) yet are repackaged into a prescription vial. Why? Answers included:

    - Repackaging is the "value-added" by retail pharmacies;
    - Amber vials are what customers expect; and
    - Amber vials provide a consistent image for the retail pharmacy.

This study recommends that pharmacies discontinue the wasteful practice of transferring a prescription from one bottle to another for aesthetic reasons. This might require working with the supply chain to deliver a more aesthetically pleasing package (once the prescription label is affixed) to the retail pharmacy.

- Prescription medications generally are delivered to retail pharmacies in various size HDPE containers. The containers may be "stock" bottles that contain bulk quantities of medications to fill multiple prescriptions, or standard prescription quantities (e.g., one-month supply). Conversations with pharmacists revealed that recycling of these containers might not be a priority at many retail pharmacies. While further study is needed on the rate of recycling by retail pharmacies, this may be an opportunity to expand pharmaceutical container recycling.

- This study found that some plastic medication containers are not labeled with the standard resin identification and recycling logo. Packaging manufacturers must be encouraged to utilize this long-accepted industry practice on all plastic medication containers. The absence of these markings hinders recycling, since most MRFs, plastics brokers, and processors will only accept plastics with these resin identification symbols (e.g., #1, #2). And, as a result, MSW recycling programs will only accept plastics with appropriate resin identification symbols. Without resin identification, it is highly unlikely that consumers will recycle these containers, that municipalities will accept them, or that processors will recycle them.

VII. Conclusions

Plastic medicine containers represent a resource that should not be wasted in the trash. Recycling is the preferred best management practice for plastic medication containers, provided, however, that the container is empty of medication, that the material processor can handle small-size containers, and that the end markets will accept this

material. These containers can add incremental volume to existing municipal recycling programs but alone do not justify the initiation of a recycling program.

Additional recycling, as well as source reduction, opportunities may exist in the pharmaceutical supply chain. Further study of the pharmaceutical packaging industry and retail pharmacy practices and disposition is warranted to refine further these recommendations.

Acknowledgements

The authors thank the Unwanted Medications Advisory Committee for its insights and perspectives on the potential for and risks inherent in the recovery of medication containers. Special thanks go to Judith Dunbar of the American Plastics Council and Charlotte Smith of PharmEcology Associates LLC for their thoughtful review and comments on the draft report, and Jessica Wozniak of NERC for instruction on use of the Environmental Benefits Calculator. Finally, thanks to the staff at the CVS Pharmacy in South Portland, Maine for insights on retail pharmaceutical packaging, and a very informative day. And, to Mary Dever of the U.S. Environmental Protection Agency, grant administrator for this project.

Attachment A
NERC Medication Collection
CVS Collection Pilot, February 5, 2005 – South Portland, Maine
Sample Form for Characterization of Containers

Material & Quantity

Type	**Color**	**Size**[1]	**#1 PET**	**#2 HDPE**	**#5 PP**	**Other**	**Unmarked**
PLASTIC							
Vial	Amber	Small (5–8/9DR)					
		Medium (13, 16 DR)					
		Large (20, 30DR)					
		X-Large 40-60DR)					
	Other:						
Bottle (Oval)	Amber	Small <3.5oz)					
		Medium (4-8oz)					
		Large (16 oz+)					
	Other:						
Bottle (Round)	Natural/ Clear	Small (<3.5oz)					
		Medium (4-8oz.)					
		Large (8.5 oz+)-					
	White	Small (<3.5oz)					
		Medium (4-8oz.)					
		Large (8.5 oz+)-					
	Amber	Small (<3.5oz)					
		Medium (4-8oz.)					
		Large (8.5 oz+)-					
	Other:						
Ointment Jar	White	Small (½ - 4oz)					
		Medium (4-8oz)					
		Large (16oz+)					
	Other:						
Tube		Small					
		Medium					
		Large					
Pump/ Aerosol)							
Syringe (no needle_							
Dropper							
Bag							
Other:							

			Material Type, Color & Quantity				
Type		Size[1]					
GLASS			Clear	Brown	Other:	Other:	Other:
Bottle		Small <3.5oz)					
		Medium (4-8oz)					
		Large (16 oz+)					
Vial		Small					
		Medium					
		Large					
Ampoule		Small					
		Medium					
		Large					
METAL CONTAINERS			Aluminum	Steel	Unknown		
Tube		Small					
		Medium					
		Large					
Aerosol container							
Gas Cylinder							
Other							
Other							
MIXED CONTAINERS							
Blister pack							
Syringe w/needle							
Other:							
Other:							
OTHER							

Attachment B

RECOMMENDATION:
Medications Should Stay in their Original Containers for Disposal

Primarily due to the wasted space that medication containers take-up in disposal drums, the question has arisen "why not dump the medications out and dispose of the containers separately?" The Advisory Committee for this project has concluded that the medications should stay in their original containers for disposal. There are many reasons for this decision, but they include:

1. If there is a loose bunch of unlabeled pills in a container and they are diverted or someone chooses to help themselves, you have no idea what they are and no way to treat a potential poisoning. Some folks are stupid enough to scoop up a bunch and try to sell them on the street. It is not good medication management policy under any circumstances.

2. Encouraging consumers to combine them at home and then bring them in is even more fraught with risk. You only need one case of accidental poisoning to give the program a black eye.

3. Some states, like Maine, regulate household generated waste as hazardous (if it meets RCRA criteria) if returned to a facility. The drum would need to be manifested with waste codes, such as P, U, and D. If the medications were co-mingled it would be very hard to verify that if the barrel is inspected at the incinerator which could cause the load to be rejected.

4. Some medications are hazardous waste and even those that aren't can have hazardous properties. Handling of loose pills, especially broken pills, present a risk to individuals handling them. In addition, the dust and fumes that can be released through the "dropping" of loose pills into a container may present additional worker exposure concerns.

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5. Anytime you remove drugs from the identifying labels there are worker exposure and public safety risks. Part of the decision whether to consolidate the medications should be a risk benefit analysis of what are the inherent risks with a bucket full of unmarked drugs vs. the cost savings of co-mingling the materials.