EPA 910/9-91-008

Decisionmaker's Guide to Recycling Plastics

Prepared for

The Oregon Department of Environmental Quality
Solid Waste Reduction and Recycling Section

and

U.S. Environmental Protection Agency, Region X
Solid Waste Program

December 1990

Printed on Recycled Paper

Table of Contents

Estimating Collection Costs

The Decisionmaker's Guide to Recycling Plastics was prepared under a grant from the U.S. Environmental Protection Agency, Region X , Solid Waste Program. The project was coordinated by the Oregon Department of Environmental Quality.

The document was researched and written by Resource Integration Systems, Ltd., and Waste Matters Consulting, Portland, OR, with design and layout by Becker Projects, Portland, OR.

Introduction

Should your community collect used plastics for recycling? If so, what is the best way to do it?

There are good reasons to collect plastics, but there are important decisions to make. It can become an expensive proposition if program planners take the wrong approach.

Why Recycle Plastics?

- To save resources and reduce the waste stream. Plastics total 7 - 9 percent of the municipal waste stream by weight, and about 25 percent by volume.
- To meet public demand for plastics recycling and to attract other recyclable materials. Collecting plastics can get more people involved in waste reduction programs.
- Even, possibly, to make money. Certain plastics fetch the highest market prices for scrap commodities. Some programs say plastics improve their program finances.

An increasing number of recycling programs in Oregon and across the U.S. collect used plastics. Nationwide, curbside collection of at least one type of plastic is available to as many as 3 million households. Hundreds of drop-off centers and buy-back operations also accept plastics.

But plastics can take up a lot of room on a truck or at a depot without amounting to significant weight. A cubic yard of loose plastic jugs and bottles weighs 5 percent of what newspapers or glass containers occupying the same volume weigh. Transporting loose plastic containers can run up the costs--especially if the program doesn't take steps to avoid unwanted, unsellable items. The light, bulky character of plastics forces program planners to choose approaches that will control the costs of collection and marketing.

This guide is intended to help decisionmakers decide whether and how to collect used plastics from residences. The guide also provides worksheets to estimate collection costs. It includes information on finding markets, preparing plastics for market and lists program development information sources.

Decision Process

Identify Markets *(See pages 9-11)*
- ✓ available, reliable for what resins
- ✓ distance
- ✓ specifications
- ✓ price paid

Identify Target Plastics *(See Worksheet 1)*
- ✓ resin types
- ✓ quantities available
- ✓ quantities likely to be recovered by:
  - Curbside
  - Depot

Identify Space Requirements *(See Worksheet 1)*

Estimate Costs *(See Worksheets 2, 3, 4, 5)*
(model several options for types of packaging collected, methods of collection, costs of capital, operations)
- ✓ Absolute cost to add plastics
- ✓ Increase in average cost/ton for all materials collected

Evaluate Risks/Benefits
- ✓ Which plastics can be sold
- ✓ What costs will be incurred
- ✓ How will plastics recycling fit with other services

Decide
- ✓ Whether to collect
- ✓ What to collect
- ✓ How to collect
- ✓ Program plan and budget

Current Status of Plastic Recycling

Nationwide, curbside recycling collection of at least one type of plastic is available to about 3 million households. Hundreds of drop-off centers and buy-back operations also accept plastics.

- Nationally, markets exist in many urban areas for recycled plastic containers.

Most programs take only one or two types of plastic containers. Milk/water/juice jugs and soft-drink bottles are by far the most common items collected. They are easily recognized, can be accumulated in large quantities. Many areas of the U.S. have established markets nearby. Depending on available markets, some programs accept other scrap plastics.

In Oregon, at least seven curbside programs and more than 20 drop-off depots accept milk jugs. Several drop sites also take dairy tubs and detergent and shampoo bottles. As a result of the Oregon Bottle Bill, citizens have a convenient means to return their plastic soft-drink bottles to stores, retrieving the 5-cents deposit.

- The plastics industry has provided assistance to local recycling programs.

It is estimated that, in 1990, Oregonians recycled as much as 12 million pounds of plastic packaging--9 percent of all plastic used to convey a product to the consumer. More than half of this quantity was soft-drink bottles returned through the deposit system.

Plastic resin manufacturers have begun to put more resources into recycling. In Oregon and elsewhere, they have helped pay for the equipment used to collect and process their products. The plastics industry has also expanded markets for products made with recycled plastic.

- Be sure you can provide what the market wants.

- **Has a reliable market nearby:**
  Don't collect it if you can't find someone who wants it. You'll end up throwing it away and running up costs.

- **Plans for enough space:**
  Light, bulky plastics take up room on collection vehicles and at storage sites. If your plastics are 4 percent of a truckload by weight, they can be 30 percent by volume. You may want to consider shredding or compacting your plastics at the time of collection.

- **Meets market specifications:**
  The public can't always distinguish one plastic from another, and markets want specific types. Often, markets specify "no caps or labels". Be sure you can provide what the market wants, or that the market will take what you collect.

- The less residents have to do to prepare plastics for recycling, the better the participation will be.

- **Educates and promotes:**
  The public has to learn what plastics you want and how to prepare them. Collection staff has to understand the importance of meeting market specifications.

- **Keeps it convenient and consistent:**
  Your list of recyclable plastics and preparation requirements should remain as steady and simple as possible. The less residents have to do to prepare the material--removing labels, for example--the better the participation will be.

Why Collect Plastics?

1. **The public demands it.**
   Recycling is widely perceived as an essential response to solid waste and environmental problems. A great deal of attention has been focused on plastics as one of the least-recycled materials in the waste stream. Information hotlines report that one of the most common calls they get is from citizens asking where to recycle plastics.

2. **Reduce the wastestream.**
   Plastics make up 7 to 9 percent of most municipal wastestreams by weight. Total volume is about 25 percent. Although the plastic containers commonly targeted for recycling may contribute less than 2 percent of garbage by weight, their recovery contributes to waste reduction and the attainment of recycling goals.

- Based on revenue per ton, plastics are the second most valuable recyclable material, after aluminum.

3. **Save non-renewable resources.**
   Plastics are made from petroleum and petroleum by-products. This resource is limited, and there is increasing opposition to its use for one-time, throw-away packaging. Recycling is seen as a way to retain the advantages of plastic while preventing its waste.

4. **Educate the public.**
   Collecting plastics helps make people attend to their consuming and disposing habits. It strengthens participation in recycling programs and can increase recovery of other materials.

5. **It can be done.**
   Active markets exist for several types of plastic. Successful recycling programs have been demonstrated in the Northwest and elsewhere.

What Are Plastics Used For?

- All plastics are not the same.

The word "plastics" covers more than a hundred different resin grades and blends that have varying chemical compositions, physical characteristics and uses. However, a half dozen types make up 70 percent of all plastics--and 95 percent of all packaging.

Over the last 20 years, plastics have replaced glass, metals, paper and wood for many packaging and product applications. Car and plane parts, signs, furniture, pipe, toys, luggage, clothing, handles, inks, paint, appliance casings, personal care products and eyeglasses are only a few of the ever-increasing number of products made from plastic.

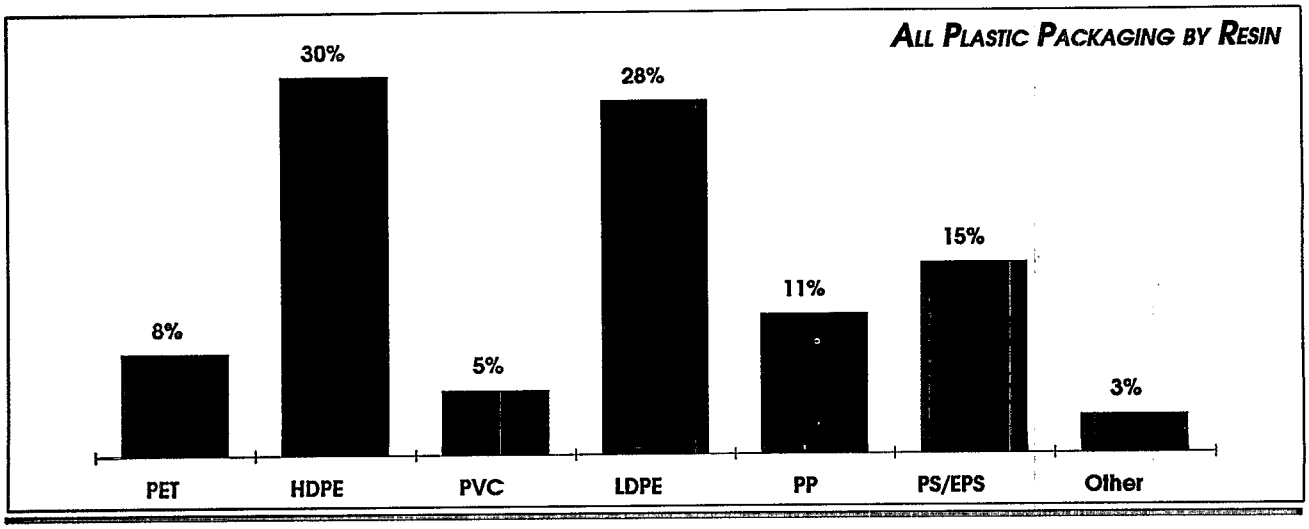
- One-third of all plastics in the wastestream are packaging...two-thirds if disposable dishware, garbage sacks, storage bags and films are included.

As a packaging material, plastic resins offer several cost and marketing advantages: they are light, hard to break, moldable, inexpensive and can be produced in all colors. Some can be as clear as glass.

Because of these advantages, plastic packages and containers have replaced other traditional materials for specific uses, such as:

- glass bottles for milk, shampoo and large-volume soft drinks;
- cardboard-and-metal containers for motor oil;
- paper bags for produce and retail carry-home items.

Even paperboard beverage containers, such as milk cartons, are coated with plastic.



• **Polyethylene Terephthalate (PET or PETe)** -- soft-drink bottles, bottles for liquor, cosmetics, toiletries, food and pharmaceuticals; ovenable trays; boil bags; blister-pack, cups and food trays.

• **High-density polyethylene (HDPE)** -- containers for milk, yogurt, ice cream, cottage cheese, spreads, oil, bleach, antifreeze, automatic transmission fluid, detergent, shampoo, pharmaceuticals, cosmetics, paint and other products; beverage bottle basecups and sacks for goods and garbage.

• **Polyvinyl Chloride (PVC)** -- clear food packaging film and forms, closures, blister-pack, tape, bottles for shampoo and other household items.

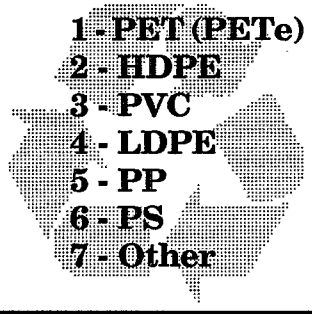
• **Low-density polyethylene (LDPE)** -- usually a film, used for wrap, sacks and bags (garbage, storage, take-out, bakery, frozen food, candy, clothing and meat); can lids and milk bottle caps.

• **Polypropylene (PP)** -- containers, tubs and bottles for yogurt, cream cheese, margarine, medicine, snack foods, confections and condiments; screw-on or snap-on caps; and bags, sacks, film and wrap.

• **Polystyrene (PS)** -- tubs for cottage cheese, yogurt and spreads; also, vending and portion cups, lids, clear containers for dairy, bakery and take-out food.

• **Expanded Polystyrene (EPS)** -- egg cartons, food trays, meat/seafood/poultry trays, single-service plates, hinged containers, cups, packing fill, shapes and containers.

Plastic Container Coding System



Bottles, dairy tubs, sacks and other kinds of packaging can be made with any of several resins. To assist recycling, many packaging manufacturers place an identifying code number, usually on the bottom of the container. The code number appears inside the recycling symbol. Production and lot numbers may appear, but will not be inside the symbol.

What Plastics Are Recycled?

- Almost no programs collect durable plastic products, such as furniture, appliance casings and housewares.

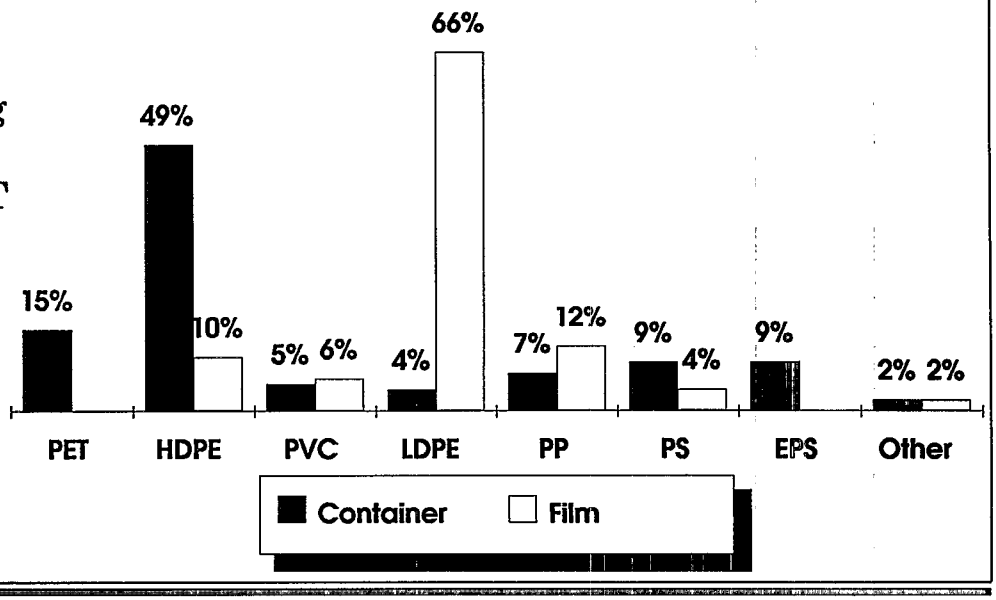
- HDPE, LDPE, PP make up a group of resins-- polyolefins-- that can be blended to make products such as plastic lumber.

Almost all plastics manufacturers recover scrap from their production lines and reuse it. They know exactly what material they are dealing with, and they don't have to worry about contamination that would ruin their products.

Residential recycling programs have to limit the plastic items they collect. If programs collected all the plastic objects available, or even a large portion, the volume and variety would overwhelm them. Much of the material would have to be thrown away. Very few markets accept a mixture of plastic resins. Even experts often cannot readily identify the plastic used to make some products. Different resins may be layered together, and other materials may be bonded to the plastic.

Most residential collection programs focus on one or two types of containers that can be identified easily and accumulated in large quantities. Typically, only milk/juice/water jugs (HDPE) and soft-drink bottles (PET) fit these criteria. However, some programs have found markets for other types of rigid containers and even films. These programs provide the public with clear, illustrated instructions and even brand names. Program staff cull out unacceptable items.

- Nearly two-thirds of all rigid packaging containers are made with PET and HDPE.



Who Buys Used Plastics?

Collection programs typically sell their plastics to brokers, processors or manufacturers Some of these markets accept, but do not pay for, used plastics.

Brokers ship the plastics to processors. A broker may bale or granulate the plastics if needed, but often does little more than handle sales. The granulation process reduces plastics into small pieces usually about one-quarter inch in size.

- Most manufacturers buy recycled resin pellets, not used containers.

Processors clean the material to an extremely high purity, remelt it and form it into pellets for sale to manufacturers. A few processors also make consumer products.

Product manufacturers are the end market for recycled plastics.

What is plastics processing?

Plastics processors usually do not depend solely on post-consumer scrap. They also handle industrial rejects, trimmings and oversupply. Processors often take a fee to clean and return scrap to the manufacturer who generated it.

- Recycled plastics can only compete with virgin resins if their price is kept low and they are extremely pure.

Cleaning is a costly process, involving the removal of glue, paper, metals, dirt, food residues and unwanted resins. Processors must inspect loads, remove unacceptable items, shred the material, wash it and screen out paper fragments. The resulting mixture often contains metal and several resins. Many processors separate out the resin they want by placing the mixture in a water/salt solution that has a controlled density. Resins with lower density, such as HDPE, float and are skimmed away. Heavier materials, such as metals, PET and PVC, sink. The clean flakes are then dried, remelted and extruded as thin strands that are chopped into pellets. Finally, the pellets are shipped to manufacturers.

Contamination can ruin the efforts of processors, which is why they buy only high-quality loads.

Markets for Northwest Plastics

- Information on national markets can be found through sources listed at the back of this document.

Reliable markets exist in the Northwest for post-consumer packages such as:

- **HDPE** "natural" jugs, containers and bottles (used for milk, water, juice and some dairy products) ;
- **HDPE** colored containers (oil, detergent, bleach and margarine) ;
- **PET** soft drink bottles (clear or green) .

There are limited, less established markets for PS, EPS, PVC, PP, and LDPE. One company, Wilsey & Ham Pacific, is attempting to develop a facility in the Portland area that would accept mixed plastics and use them to make products, such as benches and fenceposts.

Some collection programs will accept plastics from smaller collectors. The Oregon Department of Environmental Quality (see listing of information sources at the back of this guide) can provide names of local programs.

Table 1 lists buyers of post-consumer plastics as of December 1990. All are processors or brokers.

Buyers for Post-Consumer Oregon Plastics — TABLE 1

		PET	HDPE	PVC	LDPE	PP	PS
All States Plastics 1109 S. Grace Ave. Battleground, WA	Dan Rohrbach (206) 687-7711	✔	✔		✔	✔	✔
Denton Plastics 4427 NE 158th Ave. Portland, OR	Jeff Walter (503) 257-9945		✔		✔	✔	✔
Hee Company 4555 SE 122nd Ave. Portland, OR	Hee Kwon (503) 760-0361	✔	✔	✔	✔	✔	✔
Wastech 701 N. Hunt Portland, OR	Sam Culpepper (503) 285-5261		✔				
C & M Recovery PO Box 663 Vancouver, WA	Harold Cheeks (206) 737-1646						✔
Interstate Plastic 4300 Columbia Way, Suite B Vancouver, WA	John Kwon (206) 694-1753	✔	✔				✔
Partek Corp. PO Box 1387 Vancouver, WA	Bob Gaudet (206) 695-1777		✔				

Meeting Specifications

Markets specify the quantity, quality and form of delivery for used plastics. These specifications assure that supplies suit their business and technology. Buyers will not accept shipments that do not meet their specifications. On occasion, they may take a substandard load at a lower price, but a collector should not count on this.

A collection program could easily lose money on plastics recycling by shipping unacceptable loads, paying the return freight, and sending the material to a landfill.

- Most buyers insist that the material they accept be separated by resin type prior to purchase.

A common requirement is that material be baled or granulated. Some buyers want only baled material, and they may insist on bales weighing a minimum amount, such as 700 lbs. Collection programs wishing to sell shredded (granulated) material might be required to send a sample to the buyer so it can be checked for quality.

Minimal load requirements are common--such as five tons or more. Many buyers serving Oregon are more flexible about load size. Even so, it can pay to combine your loads with those of other programs, which reduces transportation costs.

Markets Change

Recycling markets change, and a collector must stay informed on market developments. New companies open for business, other companies fold. New materials are accepted, other ones are dropped. Some buyers accept labels and caps, but they could set new standards. Program equipment purchases, operating procedures and success depend on this knowledge.

- Watch your markets and confirm them prior to shipping.

Always confirm the market. Call it, visit it and talk to its other suppliers. Does it accept loads consistently? Does it live by its written standards? Does it pay in a timely fashion?

Whether To Collect

Decisionmakers must weigh the opportunities and challenges of plastics collection. Page 5 of this guide gives five reasons to collect plastics and page 4 lists five criteria for success. But each program must determine whether it can make the commitments that success requires. Here are the special challenges of plastics collection, along with solutions that have enabled programs to succeed.

Challenge: There are many different plastic resins which are difficult to tell apart, yet most markets buy only specific types.	**Solution:** Limit the type of items collected to those that can be readily explained and identified. Give clear, repeated instructions and reasons to the public and to collection and sorting crews. Pay close attention to removing unwanted items.
Challenge: Special preparation may be required of the public and the collection program to remove contaminants.	**Solution:** Educate the public in clear, simple terms to "Rinse and Remove Labels." Seek more flexible markets that accept labels, etc.
Challenge: Markets for used plastics are not as well-established as those for glass, metals and paper. Prices, specifications and payment schedules often vary.	**Solution:** Visit the market and confirm its reliability with other suppliers. Stay up-to-date on specifications. Also, increased supplies are likely to strengthen and stabilize buyers. The demand for material and investment in markets are expanding.
Challenge: Plastics are light and bulky. They take up more room per unit of weight than other materials. Plastics that weigh 4 percent of materials collected may occupy 30 percent of the space.	**Solution:** Plan for increased capacity at the beginning of a program and when purchasing new equipment. Inexpensive curbside alternatives include cages and bagholders. Ask the public to "step on it." Also, mechanical densifiers are available for on-route or stationary use.
Challenge: Plastics collection can cost more per ton than other materials. Additional vehicles or other equipment may be needed. Sorting and preparing plastics for market can be labor-intensive.	**Solution:** Seek cooperative processing and marketing arrangements with other programs. Use existing labor, equipment and space. Plan ahead: It costs less to include plastics from the start than to add them later. The relatively few tons of plastic collected won't increase overall program costs significantly. Finally, with markets paying $150 to $300 per ton, plastics are the second most valuable recyclable material, after aluminum.

What To Collect

Until a stable market develops for mixtures of different plastics, it would be wise to limit the selection to one or two items that:

- can be sold or given away;
- the public and sorters can recognize easily;
- will not overwhelm the program's capacity to collect, store and prepare for market.

A drop-off system has lower equipment and operating costs than a curbside program and can afford to accept more resin types. However, the same guidelines apply. Several drop-off centers in Oregon recently discontinued all plastic items except milk jugs, due to market and contamination problems.

- The key factor in choosing to collect any used material is whether it has a market.

The market may or may not pay, but should have a record of reliability and be close to the source of collected material. Payment delays beyond 30-45 days can be a concern.

Some parties insist that there will always be buyers for a clean, plentiful supply of any resin. In practice, the buyers for some resins can be far away and not interested in the quantities generated by an individual program. In addition, it can be too costly to collect, sort, store and ship some resins.

- Look at the types of plastics other collectors in your area are handling.

The place to start in determining what to collect is to look at what most collection programs are handling in the region. As 1990 ends, Oregon programs collect mostly HDPE--usually the translucent containers for milk, water, juice and other liquids. Several also take colored or clear bottles and tubs, such as those used for soap, bleach and dairy products. PET soft-drink bottles are accepted by several collectors and buyers, including those that handle deposit system returns. The odds of recycling these resins are likely to stay good. Several drop-off depots in the Portland area accept LDPE, PS, PP and PVC. Markets should be queried to determine if local programs can meet specifications for these resins and if the costs would be reasonable.

What To Collect

- Collect types you can explain.

Unless told otherwise, repeatedly and in clear terms, the public will donate every worn out plastic item in the house. Toasters, hair dryers, paint brushes and loose packing fill are just a few of the less exotic products that could end up in the bin. And if collection and sorting crews don't understand what is wanted--and why--the buyer can be counted on to turn away shipments.

Start out with a short list that lends itself to good visual illustrations. Product names and description of contents (e.g., milk, soft drinks, margarine) can be helpful. Buyers can be helpful in letting you know if manufacturers have changed the plastic in their containers.

- Collect quantities and types you can handle.

The more container types collected, the more vehicle and storage space needed. More container types will also increase sorting time, marketing costs and contaminated residue. For these reasons, and because of market conditions, most collection programs limit the types of containers they take. Oregon programs typically collect only milk/juice/water jugs.

Participation and recovery rates vary. Based on a national survey, curbside collection of milk jugs will net 4-5 cubic yards each day of weekly service for every 1,000 households on that route. That's a highly efficient route for one truck. The payload would be 120 to 150 lbs. (using 30 lbs. per cubic yard for the jugs). Collecting all types of plastic containers from the same 1,000 households could require 12-15 cubic yards each week--a payload of between between 360 and 450 lbs.

Drop-off depots in Oregon averaged 20 cubic yards of (mostly milk jug) HDPE per week per depot. However, two centers serving a broad population in the Portland area took in between 80 and 120 cubic yards each week--or two to three large roll-off boxes.

- Most programs decide to restrict their target plastics.

Only the program operator can decide whether the markets and resources are available to collect a variety of plastics. **Remember: It is easier to start the flow of plastics than to turn it off. It is easier to add plastics than to take them away.**

How To Collect

Cost and effectiveness are the key factors in choosing a collection method. It is also important to use an approach that fits in with the existing solid waste and recycling system. Some municipal or private curbside programs begin plastics collection by offering drop-off service. This helps develop public awareness and market relationships at a low cost. Curbside collection of plastics is then added when equipment is refitted or purchased.

- Drop-off depots are particularly well-suited to rural settings, disposal sites, or if curbside service is not an option.

Three types of collection are used for plastics: drop-off depots, buy-back centers and curbside service. Each option has relative merits and drawbacks. For example, drop-off centers are least expensive while curbside service usually attains the highest recovery levels. (See the summary in Table 2 on page 17).

DROP-OFF PROGRAMS: The public brings its plastics to a drop-off depot, placing them in bins. About 90 percent of the HDPE collected in Oregon goes to drop-off depots. This type of collection has the advantage of low cost, since the public pays transportation to the depot, and staffing needs are minimal.

- Many local governments operate or assist drop-off depot programs.

It is fairly easy to add plastics to an existing or new drop-off depot. A depot that handles paper may already have an adequate baler. Transportation to market can be done with existing and perhaps under-utilized trucks and staff. Used dumpsters, barrels or even cardboard boxes can serve as collection bins.

Drop-off collection does not offer the same public convenience or financial incentives of other methods, so participation is often lower. But some depots with strong community support capture amounts per household that compare well with curbside collection and buy-back centers. Drop-off depots have been set up on vacant lots, at school or store parking areas, on church grounds, in public maintenance yards, at materials sorting facilities and at transfer stations or landfills. Commercial and industrial generators also have access to depots, whereas curbside collection normally reaches only the residential sector.

How To Collect

BUY-BACK CENTERS: Purchase of plastics from the public is not widespread in Oregon, although several processors pay up to 5 cents per lb. at the door. A portion of the population is motivated to recycle for money but will not bother if the activity doesn't pay. Buy-back centers can recover amounts of material comparable to or greater than drop-off depots. This is especially true if the center is located near low-income areas.

- Buy-back centers incur higher costs per ton than drop-off depots.

Stores that pay the public for return of deposit law containers are not true buy-back operations. They simply pass through monies paid when the container was purchased. However, they resemble buy-backs in that a significant portion of the containers are brought in by people who scavenged them from various sources.

Economics usually require a buy-back center to handle a range of secondary materials, including paper, corrugated cardboard, metals and glass. Paying the public involves more staffing, record-keeping and cash-flow needs than for drop-off collection. Consequently, costs per ton are usually higher for all materials collected.

Local governments do not often operate buy-back businesses. However, they sometimes provide sites and may contract with operators to take materials from or even manage government sponsored drop-off centers.

CURBSIDE COLLECTION is the most convenient, most effective, and most expensive method for collecting plastics. Expenses for vehicles, fuel and skilled labor can easily double or triple the per-ton cost of depot-based or center-based collection. But curbside collection often triples the material diversion rates (7 percent of the wastestream or more compared with 2 percent or less for depots).

- Curbside collection is convenient, effective, expensive.

Curbside collection vehicles generally pick up newspaper, glass containers and cans made of aluminum or tin-plated steel. Some programs collect corrugated cardboard, mixed paper, used oil and other materials--including plastics.

How To Collect

Some programs add vehicles to accomodate new plastic volumes. This is the most expensive solution, as annual costs per vehicle (including labor, fuel, and capital) can easily exceed $60,000. Addition of wire mesh cages on top of vehicles or use of trailers may increase costs no more than a few hundred dollars on an annualized basis. Bag-holders attached to existing vehicles are even less expensive.

Summary of Selected Material Collection — TABLE 2

OPTION	PRINCIPAL FEATURES	ADVANTAGES	DISADVANTAGES
Drop-Off Depots	Drop boxes/bins located in parking lots Materials are self-hauled to depots Often sponsored by community organizations	Easy to implement Low startup costs/budget Available to commercial and industrial sectors	Inconvenient to public Low waste stream reduction Less control over quality of materials
Buy-Back Centers	Purchase materials from public/private sectors ONP, OCC, AL most common materials Materials are self-hauled to centers Require clean and sorted materials Expenses for equipment, site, purchase, labor	Effective collection of AL Collects variety of materials Provides economic incentive Available to commercial and industrial sectors	Good cash flow required Inconvenient to public Low waste stream reduction
Curbside Collection	Most effective method for residential recycling Materials picked up at curb or in alley Typically includes at least ONP, GL, AL, TN Materials may be commingled or separated Service provided by municipality or private firm	Most convenient method Possible high waste reduction City authority over system Possible high disposal savings Garbage system integration	Complex Time-consuming High costs/budget

Product codes ONP (newspapers), OCC (corrugated), AL (aluminum), GL (glass), TN (tin)

Estimating Recovery

This section provides some good rules of thumb and a worksheet for calculating recovery. Based on estimated recovery volumes, you can project program needs for increased collection and storage capacity. This information will help you complete worksheets in the section on "Estimating Collection Costs," including equipment and labor costs (Worksheets 2 and 3, pages 27 and 29) and revenues (Worksheet 4, page 30).

- The amount of plastics a program will recover affects planning for labor, equipment, space needs and revenue.

Worksheet 1, "Plastics Container Collection: Recovery Levels and Space Requirements," allows program planners to estimate tonnage and cubic yards. Each plausible scenario should be modeled separately. The basic steps are:

1. For each plastic collected, multiply the annual lbs. generated per household by the **number of households** the program will serve.

2. For each plastic collected, choose a **recovery level** and multiply the product of Step 1. This will give the lbs. per year that can be expected. The percentage of recovery chosen reflects whether a curbside or depot system is to be used. (See footnote 1 on Worksheet 1).

3. Estimate **recovery volumes** (cubic yards) by following the steps shown under the heading "Cubic Yards" at the bottom of Worksheet 1. These projections of recovery volume can be done for each item collected or for the total items (if more than one type of plastic is to be collected). The cubic yards show the space requirements per month, week and day.

4. Use the cubic yards projected in Step 3 to consider **equipment needs**. Do your vehicles or collection boxes have enough excess capacity to handle the daily volumes? Or will you need to buy new equipment? How often will your storage boxes fill up? If you use curbside collection, will you need new vehicles or will it be enough to add smaller, less expensive cages trailers or bagholders? (See section "Estimating Collection Costs").

Worksheet 1
PLASTICS CONTAINER COLLECTION
RECOVERY LEVELS AND SPACE REQUIREMENTS

Material	Lbs. Generated per Household	X	No. Households Served	X	% Recovery Expected (1)	=	Lbs/Year
HDPE	36.7		_____		_____		_____
milk jugs	10.8		_____		_____		_____
LDPE	3.2		_____		_____		_____
PP	4.9		_____		_____		_____
PS-solid	7.0		_____		_____		_____
PS-foam	8.4		_____		_____		_____
PVC	2.2		_____		_____		_____
PET(2)	10.0		_____		_____		_____
soft drink	7.6		_____		_____		_____

TOTAL WEIGHT _____

Cubic Yards

Per Year: Divide lbs./year by 30: _____

Per Month: Divide cubic yards/year by 12: _____

Per Week: Divide cubic yards/year by 52: _____

Per Day: Divide cubic yards/year by 260: _____

(1) Recovery level is based on collection method. Assume 5-10 percent for depot collection or 20-50 percent for curbside collection.
(2) PET soft drink bottle recovery through curbside or depot collection is not likely to exceed 10% in deposit law states, such as Oregon.

Recovery Assumptions

- Recovery per Household

The table, "Plastic Container Recovery Levels: Sample Estimates," identifies the average quantity of each packaging resin available per capita and per household. It provides two examples of feasible recovery levels: 10 percent (seen in some drop-off depots) and 50 percent (considered a successful rate in curbside programs). Worksheet 1 (page 19) allows planners to model any range of recovery they wish, based on number of households served and extent of promotion/education effort.

The data in Table 3 and on Worksheet 1 were developed for the Oregon Department of Environmental Quality in the study "Current and Target Recovery Rates for Plastics Packaging in Oregon." It is based on U.S. consumption averages compiled by the Society of the Plastics Industry and published in Modern Plastics magazine.

PLASTIC CONTAINER RECOVERY LEVELS
SAMPLE ANNUAL ESTIMATES
RESIDENTIAL COLLECTION PROGRAMS
TABLE 3

Resin Type	Weight Generated (lbs./yr.)(1) *Per capita*	*Per household*	Recovery (Lbs/Household/Yr) 10%	50%
HDPE	13.6	36.7	3.7	18.4
milk jugs	4.0	10.8	1.1	5.4
LDPE	1.2	3.2	0.3	1.6
PP	1.8	4.9	0.5	2.4
PS-solid	2.6	7.0	0.7	3.5
PS-foam	3.1	8.4	0.8	4.2
PVC	0.8	2.2	0.2	1.1
PET(2)	3.7	10.0	1.0	5.0
soft drink	2.8	7.6	0.8	3.8

(1) Based on U.S. resin consumption data, Modern Plastics, January 1990. Per capita generation derived by using U.S. population of 250 million. Household generation assumes 2.7 persons per household.
(2) PET recovery would be much lower where there is deposit legislation.

Recovery Assumptions

- Recovery Level by Method

Recovery levels vary with the collection method, the extent and effectiveness of promotion and education and the types of packaging targeted. No two programs operate under the same conditions or attain the same results. Some people will not participate in even the most convenient and efficient collection program. Many people who participate will not contribute all the material they have.

Curbside programs seldom top 70 to 80 percent participation, and more people set out newspaper than glass, metal and plastic containers. People also separate a higher percentage of their newspaper than their plastics. Drop-off depots and buy-back centers typically attract only a small portion of the public. Continuing promotion and education can increase recovery levels, but the following diversion rates are common for plastics.

Curbside collection:	20 to 50 percent of quantity generated
Depot collection:	5 to 10 percent of quantity generated

- Weight and Volume Equivalents

Bottles & Jugs:	about 7 items per pound
All containers:	30 lbs. per cubic yard (loose)
40 cubic yard box:	1,100 lbs. loose containers
Standard Bale:	700 to 1,000 lbs.
Gaylord, shredded:	500 to 700 lbs.

A national survey of collection programs shows an average of one milk jug per eligible household per week, or 7.3 lbs. per eligible household, recycled annually. Oregon curbside programs averaged about 6 lbs. of HDPE recycled (not all of it beverage jugs). "Eligible" refers to all households that could set out, not all the ones that do. Mixed plastics collection programs, including film, have generated more than 2.5 lbs. per eligible household weekly, or 130 lbs. annually.

Estimating Collection Costs

Introduction

This section provides information and worksheets to help estimate costs of collecting plastics. Costs are calculated per ton and per household for the addition of plastics only or for the entire program--that is, for all materials collected by the program.

Identifying the impact on total program costs is the most useful way to look at the cost of plastics collection. Considered alone, curbside plastics collection may cost several times more per ton than other items, but could add only pennies per household or a few dollars per ton overall. Plastics collection typically has even less impact on the costs of depot collection.

Four worksheets are provided:

- Worksheet 2: Capital/Start-Up Costs
- Worksheet 3: Annual Operating Costs
- Worksheet 4: Cost Offsets
- Worksheet 5: Summary Worksheet

● Making multiple copies of the worksheets will allow development of several scenarios.

Program planners need Worksheet 1 (page 19) and previous data to decide the following:

- the collection and processing methods they will employ;
- the equipment they will use, and its cost;
- the materials to be collected;
- estimated recovery tonnages and cubic yards;
- the staff levels and labor rates involved.

The worksheets can be used to estimate costs for all materials and households in a multi-material program, as well as to calculate the costs of adding plastics.

Cost Factors

Each program will have different equipment, labor rates, productivity and operating procedures. One program may have higher costs per ton than another, but lower costs per household. Several program characteristics affect the costs of adding plastics to a collection program:

1. Existing capacity. If the truck fleet has spare capacity, plastics may not add much cost. In fact, they may lower overall costs by improving utilization. But if plastics collection requires more vehicles, higher costs result. This is especially true for smaller programs: the impact of increasing from two trucks to three trucks is much greater than going from ten trucks to twelve.

2. Collection efficiency. Efficiency is the amount of time and money needed to collect a given amount of material.

Higher costs may be observed with:

- inefficient collection vehicles (more time per pick-up due to drivers walking around vehicles, slow loading system);
- inefficient collection routes (fewer stops per route, fewer hours on route, fewer households per day collected--due to low participation, low population density, distance from the central yard, poor route design, short work day);
- higher labor costs (more crew per vehicle, higher salaries);
- more curbside sorts (more time per stop, fewer stops per day).

The lowest curbside costs are attained by one-person collection crews serving a route of more than 800 households per day and collecting material that is commingled to some degree. Depot collection typically requires lower capital, labor and operating costs because transportation is minimized.

3. Materials collected. Collection of mixed plastics or collecting a variety of containers will result in higher space requirements, more expensive handling, increased disposal of unacceptable plastics and more load rejection by markets.

Cost Factors

4. Quantities recovered. Higher recovery can reduce costs per ton and increase revenues, but may also increase equipment and labor requirements. Low recovery coupled with expensive equipment purchases will drive up costs.

5. Cost of equipment. Less expensive options for curbside programs may include used vehicles and bins or expanded vehicle capacity (cages, bag holders, trailers) rather than new trucks. But more expensive, high-capacity vehicles may be justified if plastics are included in planning a new program. Depot collection may be able to rely entirely on existing boxes and balers. New drop-boxes or dumpsters still cost less than vehicles.

6. Sorting efficiency. An efficient sorting system (high sorting rates per worker, low costs per lb.) reduces overall collection system costs. However, high quantities--several hundred lbs. per hour--may be needed to justify the investment in expensive processing equipment. Most programs do not generate this quantity of material.

7. Transportation costs. Distance to market is a major factor, with truck operation (including labor) often costing $40 per hour or more. Undensified material is too expensive to haul farther than a few miles.

- Representative costs of programs nationwide

Table 4 on page 25 provides average costs and ranges observed nationally. It is offered for general interest only. A multitude of labor costs, equipment types, sociodemographics, efficiency and recovery levels are represented by the programs included in these averages. Comparison with your own program should be undertaken cautiously.

TABLE 4

SUMMARY OF PLASTICS RECOVERY COSTS FOR MULTI-MATERIAL COLLECTION PROGRAMS

Based on surveys and program models

	Per Ton		Per Household	
	Average	*Range*	*Average*	*Range(1)*
Curbside Collection				
All materials	$100	$35-$283	$1.23	$0.61 - $4.02
To add plastics	$14	$1 - $50	$0.25	$0.04 - $0.73
Plastic $ only	$473	$200 - $1,225	$0.25	$0.04 - $0.73
Drop-off Collection				
All materials	$34	$25 - $44	Not Available	Not Available
To add plastics	$5	$2 - $6	Not Available	Not Available
Plastic $ only	$223	$70 - $588	Not Available	Not Available
Sorting Plastics				
Manual only	$240	$100 - $600	Not Available	Not Available
Mechanical/Manual	$40	$10 - $106	Not Available	Not Available
Densification				
Bale	$35	$20 - $80	Not Available	Not Available
Granulate	$25	$20 - $80	Not Available	Not Available
Transportation	$40	$20 - $66	Not Available	Not Available
Recycled Resin Mfr.				
Cleaning	N.A.	$200 - $300	Not Available	Not Available
Pelletization	N.A.	$100 - $140	Not Available	Not Available

(1) Per household cost ranges are the same for adding plastics and for plastics only, because the number of households and total added cost are the same.

Estimating Collection Costs

Capital / Start-Up Costs

Use Worksheet 2 on page 27 to examine several options for providing service. Based on the space needs identified in Worksheet 1 (page 19), estimate costs for equipment and other capital improvements. Interest rates of 10 percent may be used. Compounded interest should be added to the cost of equipment over the useful life of the item. Equipment life is often estimated at seven years.

Table 5 provides estimated capital costs for equipment needed to collect, sort and process plastics. Local planners will be able to identify opportunities to reduce costs.

Equipment Costs — Table 5

Curbside Collection	
Vehicles	
Pick-up truck	$5,000-$20,000
Manual loader	$60,000-$85,000
Front-loader	$100,000
Automated pickup	$100,000
Packer	$100,000
Customer storage containers	
Burlap sacks @	$0.25-$0.50
60 gal. roll-carts	$45

Supplemental vehicle capacity	
Wire-mesh cage	$2,000
Trailer	$3,000-$10,000
1.5 cu. yd. sacks @	$200
Sack holders @	$500
Customer storage containers	
14 gal. boxes @	$7
90 gal. roll-carts	$60

Drop-off Collection (and Site Storage)	
Storage/collection	
30 cu. yd. roll-off box	$3,000
4 cu. yd. bin	$450
Gaylord box @	$7
55-gal barrel, used	$7
20-gal. fiber barrel	$5

Site preparation	
8' chainlink fence	$13/linear ft.
Plastic or snow fencing	$2/linear ft.

Processing equipment			
Densification		**Sorting**	
On-board compactor	$5,000-$15,000	Conveyors	$7,000-$10,000
Granulator	$2,500-$20,000	Air classifier	$9,000
Shredder	$3,000-$6,000	Eddy current	$100,000
Baler	$10,000-$500,000	Trommel screen	$20,000
Perforator	$10,000	Sorting table	$500-$40,000

Materials handling	
Forklift	$15,000-$60,000
Roll-off truck	$75,000
Front-end loader	$90,000

Worksheet 2

Capital/Start-Up Costs

		Number	X	Unit Cost	=	Total Cost	Annual Cost(1)
Equipment							
Collection -	Trucks		X	$	=	$	$
	Trailers		X	$	=	$	$
	Cages		X	$	=	$	$
	Bag Systems		X	$	=	$	$
	Other		X	$	=	$	$
Handling -	Forklift		X	$	=	$	$
	Other		X	$	=	$	$
Processing -	Conveyor		X	$	=	$	$
	Sorting table		X	$	=	$	$
	Granulator		X	$	=	$	$
	Baler		X	$	=	$	$
	Other		X	$	=	$	$
Storage -	Drop boxes		X	$	=	$	$
	Bins		X	$	=	$	$
	Gaylords		X	$	=	$	$
	Barrels		X	$	=	$	$
	Other		X	$	=	$	$
Household storage units							
	Boxes, bags		X	$	=	$	$
	Carts		X	$	=	$	$
Promotion (one-time, start-up costs)							
	Signs			$	=	$	$
TOTAL CAPITAL COSTS						**$**	**$**

(1) Some programs depreciate an item over its useful life. Others account for all of the cost in the year of purchase.

Annual Operating Costs

Worksheet 3 on page 29 requires local solid waste planners to use their knowledge of salaries and operating costs. Several programs can be modeled. For example, a single sorter may be able to remove contaminants from one ton of plastic containers daily. Only a few hours may be needed for smaller quantities. Baling or shredding may proceed at different rates, depending on the equipment. It should be possible to densify a ton of material in two hours with commonly available equipment.

Table 6 provides a broad estimate of vehicle costs seen in other programs. Information available to local decisionmakers will be more specific and useful. However, the categories need to be considered.

Representative Vehicle Operating Expenses Other Than Labor (1) — TABLE 6

Category	Cost (1990)
Vehicle license/insurance	$4,000/year
Tires, parts (per vehicle)	$1,500 - $4,500/yr.
Fuel ($/gallon)	$1.50
Miles/gallon	5 - 10
Miles/hour	12
Maintenance ($/hr of operation)	.03 - .06

(1) Larger vehicles with more hydraulic equipment have higher costs for maintenance, parts, fuel.

Worksheet 3

Annual Operating Costs

		Number	X	Unit Cost	=	Annual Cost
Labor (wages, taxes, benefits)						
Collection:	Drivers		X	$	=	$
	Laborers		X	$	=	$
Process/Market:	Sorters		X	$	=	$
	Equipment Operator		X	$	=	$
Maintenance:	Mechanic		X	$	=	$
Administration:	Manager		X	$	=	$
	Clerical		X	$	=	$
Other Operating Expenses						
Collection:	License/Insurance		X	$	=	$
	Fuel, oil		X	$	=	$
	Tires/Parts		X	$	=	$
	Maintenance		X	$	=	$
Process/Market:	Utilities		X	$	=	$
	License/Insurance		X	$	=	$
	Fuel, oil		X	$	=	$
	Tires/Parts		X	$	=	$
	Phone, mail		X	$	=	$
	Maintenance		X	$	=	$
Promotion:	Design, printing		X	$	=	$
	Distribute/mail		X	$	=	$
	Supplies		X	$	=	$
	Advertising		X	$	=	$
TOTAL ANNUAL OPERATING COST						$

Cost Offsets

Program costs will be reduced by revenues from sale of materials and by savings on disposal. Worksheet 4 allows planners to estimate revenues and disposal savings. These projections can be incorporated into Worksheet 5, "Summary Worksheet." Tonnages developed on Worksheet 1 (page 19) are needed to complete Worksheet 4.

Prices vary considerably from one buyer to the next. A low price estimate paid by Northwest markets for any type of plastic is $.02 - $.04 per lb. A high estimate for HDPE is $.10 - $.15 per lb. Other materials seldom exceed $.08 per lb. These prices can be applied to recovery estimates in order to project revenues (see Worksheet 1). Multiply total estimated tonnage recovered by the local cost of disposal to calculate disposal savings.

Worksheet 4

Cost Offsets

Revenues from Sale of Materials

Annual Lbs. of Material		Avg. Price/Lb.		Revenue
HDPE	X		=	
PET	X		=	
Other	X		=	
	X		=	
	X		=	

TOTAL ANNUAL SALES REVENUE
(total of revenue column) $ _____

TOTAL ANNUAL DISPOSAL SAVINGS

Annual Tons Recycled		Disposal Cost/Ton		
	X		=	$

TOTAL ANNUAL COST OFFSETS
(add total sales revenue and disposal savings) $ _____

Sumrnary Worksheet

Worksheet 5

Summary Worksheet

Annualized Capital Costs (from Worksheet 2)	$	
Annual Operating Costs (from Worksheet 3)	$	
TOTAL ANNUAL COSTS		$
Annual Revenues (from Worksheet 4)	$	
Annual Disposal Savings (From Worksheet 4)	$	
TOTAL ANNUAL COST OFFSETS (from Worksheet 4)		$
NET PROGRAM COST (Subtract total annual cost offsets from total annual costs)		$
Cost per Ton - divide net program cost by total tons of material recovered		$
Cost per Household per Month - divide net program costs by number of houses offered service. Divide result by 12.		$

Costs of Adding Plastics

To estimate the costs of adding plastics to the program, you must calculate current costs for all materials collected and processed. Then add-in the total costs for including plastics and divide the new total cost by total tons and by all households.

For example, if a program serves 50,000 households and collects 6,000 tons of all materials at a total annual cost of $600,000, it costs $100 per ton and $1 per household per month. If this program adds 500 tons of plastics annually, at a total annual cost of $150,000, the entire program now collects 6,500 tons for $115 per ton and $1.25 per household per month.

Policy Issues

Decisionmakers need to resolve a number of issues surrounding plastics collection. Most of these issues are the same for all recyclable materials. Whether and how to collect are discussed above. Other questions include:

- **Who collects?** Will the local jurisdiction require plastics collection as part of garbage franchise or contract agreements? Will collection be assigned by bid?

- **Who markets?** Government is seldom equipped for the daily decisions involved in selling secondary materials.

- **Cost and Revenue sharing.** What formula will be used to distribute expenses and revenues? Markets may decline or increase, and an equitable arrangement may involve sharing of both risks and benefits. The simplest plan administratively may be to assign all revenues to the collector/seller.

- **How will collection costs be paid?** Will they be billed directly to customers as part of solid waste collection charges? If so, as a separate line item? Will they be paid out of general tax funds? Can the plastics industry be enlisted to contribute equipment costs?

- **How much can be spent?** What limits will be set on increased expenditure for plastics collection? What period of time is allowed to bring costs down? Is the community willing to landfill as much as 20 percent of collected plastics if they are not marketable?

- **Will participation be mandatory?** Higher recovery will result, but strong opposition may also emerge. Additional equipment could be needed to handle the added tonnage.

- **What education and promotion methods will be used?** Programs that do not encourage and inform the public on a regular basis risk wasting their investment in collection.

- **Are zoning issues involved?** Storage of milk jugs and other food containers can conflict with health codes, particularly in certain neighborhoods. Will special permits be required? Will these requirements restrict a plastics recycling operation?

- **Monitoring and evaluation.** How will program results be reported and assessed? Over what period? Who will be responsible for maintaining and reviewing records? What standards will be set for intervening?

- **Procurement of recycled products.** Will the local jurisdiction make an effort to purchase recycled plastic products, such as car-stops, pallets, park benches, traffic cones and road markers? Such efforts "close the recycling loop" and are important in creating demand for the collected material. The local jurisdiction should publicize its efforts in this area.

- **Interjurisdictional cooperation.** Costs can be lowered by pooling collected materials for processing and shipment to market. Will this be done, and if so, who will be responsible for it? Should it be required of the collector?

- **Will bans on certain packaging be employed?** Some communities, such as Portland, Oregon and Minneapolis, Minnesota, have ordinances banning non-recycled packaging. These local actions reduce non-recyclable plastics in the waste stream. They also educate the public and put pressure on industry to assist recycling. They may encourage use of more recyclable resins and packaging, but they can be cumbersome to enforce. New state laws may supercede local initiatives. Municipalities that have enacted bans should be contacted to find out the pros and cons of such actions.

On MARKETS

Eaglebrook Plastics, Inc.	2600 West Roosevelt Chicago, IL 60608 (312) 523-1366
Oregon Department of Environmental Quality	811 S.W. Sixth Portland, OR 97204 (503) 229-5913
Plastic Recycling Alliance	(215) 774-1942
Plastics Recycling Update Guidebook	Resource Recycling, Inc. P.O. Box 10540 Portland, OR 97210 (503) 227-1319
Plastics Recycling Compendium	Christiansen Associates P.O. Box 7364 Toledo, OH 43615 (419) 389-1799
Resource Integration Systems	425 N.W. 18th Ave. Portland, OR 97209 (503) 227-1326
Society of the Plastics Industry	1275 K Street NW, Suite 400 Washington, DC 20005 (202) 371-5319
Wellman, Inc.	P.O. Box 188 Johnsonville, SC 29555 (803) 386-2011

On PROGRAM PLANNING

Association of Oregon Recyclers	P.O. Box 15279 Portland, OR 97215 (503) 233-7770
Council for Solid Waste Solutions	1275 K Street NW, Suite 400 Washington, DC 20005 (202) 371-5319
EPA National Peer Match Program	GRCDA Attn: EPA Peer Match Program P.O. Box 7219 Silver Springs, MD 20910 1-800-456-GRCD
EPA Region X Peer Match Program (Available in 1991)	1200 6th Ave. Seattle, WA 98101 (206) 553-6640
Oregon Department of Environmental Quality	811 S.W. Sixth Portland, OR 97204 (503) 229-5913
Resource Integration Systems	425 N.W. 18th Ave. Portland, OR 97209 (503) 227-1326
Solid Waste Information Clearinghouse (SWICH)	1-800-67-SWICH FAX: 1-301-585-0297
Waste Matters Consulting	800 NW 6th Ave., Suite 210 Portland, OR 97209 (503) 294-0911

On NEW DEVELOPMENTS

Council on Plastics Packaging and the Environment	1275 K Street NW, Suite 400 Washington, DC 20005 (202) 371-5228
Garbage (magazine)	Old-House Journal Corp. 435 Ninth Street Brooklyn, NY 11215 (718) 788-1700
Modern Plastics (magazine)	P.O. Box 602 Hightstown, NY 08520 1-800-257-9402, ext. 81
Plastics News	965 E. Jefferson Detroit, MI 48207-3185
Resource Recycling (magazine) and Plastics Recycling Update	Resource Recycling, Inc. P.O. Box 10540 Portland, OR 97210 (503) 227-1319
Waste Age (magazine)	1730 Rhode Island Ave, NW Suite 1000 Washington, DC 20036 (202) 861-0708

☆ U.S. GOVERNMENT PRINTING OFFICE: 1991—592-754