

SOURCE SEPARATION: A COST EFFECTIVE  
LOW TECHNOLOGY RESOURCE RECOVERY OPTION

by

Henri-Claude Bailly  
and  
Henry S. Vaccaro  
Resource Planning Associates, Inc.

Introduction

The Massachusetts towns of Somerville and Marblehead initiated weekly curbside collection of paper, glass, and steel and aluminum cans on December 1, 1975, and January 12, 1976, respectively. These innovative recycling programs, called "Somerville Saves" and "Recycle Plus" for the Marblehead program, were aided by a 3-year demonstration grant from the EPA which provided funds for specially designed trucks and for assistance in planning, publicizing, and documenting the programs. This assistance is being provided by Resource Planning Associates, Inc. of Cambridge, Massachusetts and Washington, D.C.

Both programs are designed to collect all recyclable materials from all residents, and to make a profit for the towns' refuse collection operation. Recycle Plus has so far resulted in a profit of \$900/month in Marblehead. However, very substantial cost cuts are currently planned for the program. Assuming a stable material market and several easily made cost cuts, a total profit of \$76,000 should be realized next year. Marblehead has found that it can reduce collection costs because the substantial reduction in refuse load allows the town to eliminate a refuse collection crew, while fewer people are needed to collect recyclables.

Recycling is not a new idea in Marblehead. A monthly (and unprofitable) collection of materials has been available to residents since 1972. This is, however, the first such program in Somerville. The relative newness of recycling in Somerville and some early problems affecting the level of service (e.g. snow storms and municipal employee strikes) has kept the recovery rate from reaching the profitable level. For the first 8-months, the town broke even. However, a profit of about \$150,000 per year could result if Somerville's level of participation were brought up to Marblehead's. It is possible that Somerville's participation will increase significantly in the next year or two.

RPA has extensive experience in source separation and resource recovery programs in Europe and the U. S. Based on this experience and the results in Somerville and Marblehead to date, RPA is convinced that source separation can be a cost-effective low technology supplement to other methods of resource recovery in medium sized cities (up to 100,000

persons). In towns as small as 10,000 persons, it is a viable alternative to conventional disposal. However, to be successful, source separation requires careful planning, a long start-up period, and frequent attention during the initial years of operation. If participation levels similar to those in Marblehead can be attained and if arrangements can be made to market additional recovered materials, 5.44 to 7.26 million metric tons ( 6 to 8 million U.S. tons) of recyclable materials per year could be collected from U.S. cities having populations of less than 100,000. Many of these cities would have no other practical resource recovery opportunity.

#### Towns

The two communities involved in this source separation demonstration represent opposite ends of the municipal spectrum.

TABLE 1

KEY CHARACTERISTICS OF COMMUNITIES\*

	<u>Somerville</u>	<u>Marblehead</u>
Population	90,000	23,000
Land Area (square miles)	4	4.5
Population Density (persons/square mile)	22,500	5,200
Housing		
Single-Family (percentage)	10	70
Multi-Family (percentage)	90	30
Median Income (dollars/year)	9,600	12,600
Median Education (years)	11.6	13.2

\*Conversion factors: 1 square mile = 2.59 square kilometer.

Somerville is an urban, blue-collar community and has a population of 90,000 and a population density of 8,700 persons per square kilometer (22,500 persons per square mile), one of the highest in the nation. The city, which is in the Boston metropolitan area, is governed by a strong

mayor, who was reelected to his fourth consecutive term in November 1975, and a board of aldermen. Single-family homes house 10 percent of the families in Somerville, while most of the remaining population lives in 2-, 3-, and 4-family homes. Sixty-five percent of the families rent their homes or apartments; 35 percent live in their own homes. The median income is \$9,600 per year, and the median education level is 11.6 years. Somerville has a strong, aggressive municipal employees union. Prior to the EPA grant, Somerville had never had a recycling program. The relatively low level of education and the presence of a non-English-speaking minority have hindered communication about the program.

Marblehead is an affluent suburban community, also within the Boston metropolitan area, with a population of 23,000 and a population density of 2,000 persons per square kilometer (5,200 persons per square mile). The town is governed by a board of selectmen, and has a nearly autonomous board of health in charge of all public health matters, including refuse collection and disposal. Seventy percent of the families live in single-family homes. Fifteen percent of the families rent their homes or apartments, 85 percent own their residences. The median income is \$12,600 per year, and the median education level 13.2 years. The municipal employees are unionized, but the union is relatively inactive. The town had a relatively successful but unprofitable municipally operated, multi-material, curbside source separation program for several years prior to the start of the new program, although with less frequent pickups than the new program. Participation in Recycle Plus is currently more than twice that in the old Marblehead recycling program and three times that in Somerville. Between 60 and 80 percent of the residents participate weekly in the new program which currently recovers about 25 percent of the town's residential waste stream. Resident participation in the recycling program is mandatory in Marblehead but not in Somerville. The Marblehead Board of Health has publicly announced that a 50-dollar fine will be imposed on residents who do not separate recyclables from their household refuse, however, the fine has thus far not been imposed. RPA has not yet concluded whether the advantages of a mandatory program outweigh those of a voluntary program.

### Collection Procedures

The operations in Somerville and Marblehead are very similar, so this report will focus solely on the more successful Marblehead project. In Marblehead the residents accumulate paper, glass and cans during the week. Clear glass must be separated from colored glass, but cans may be combined with either type of glass. Therefore, most families need three containers: one for refuse, one for clear glass and cans, and one for colored glass and cans. They also need some place to store paper. On their regular refuse collection day, residents put their refuse and recyclables at the curb. If they use durable container or even a cardboard box, it is left behind for them to reuse. However, many residents find it most convenient to put their recyclables in paper bags. Plastic bags are not permitted.

On a normal day, about 8.2 metric tons (9 U.S. tons) of recyclables are deposited in this fashion and collected by two three-man crews. Collection and delivery take an average of only 5 1/2 hours per day. Clearly, collection costs could be reduced, and RPA is working toward that end. The current Marblehead collection operation ends up costing about \$38 per ton of recyclables; refuse costs only \$27.5 a metric ton (\$25 a U.S. ton) to collect.

Materials collected are sold to a processor in the neighboring town of Salem. The processor separates and cleans the glass and cans before shipping them to final markets. The paper is shredded and baled before transporting.

### Collection Vehicles

One of the innovations in the Somerville/Marblehead program is the collection vehicle. Other programs to collect source separated materials typically use racks or trailers attached to regular refuse trucks, or surplus trucks such as flat-beds, pick-ups, rack trucks, dump trucks, and packer trucks. None of these vehicles is well suited to the simultaneous collection of several different materials. The racks and trailers have low capacity and interfere with the safety and efficiency of refuse collection. Non-packing vehicles can be divided to permit separation of materials, but they are either too small or have such high loading levels that an additional man is needed to dump and return containers to the collectors working on the ground. A two-compartment vehicle combining a paper baler on one side with a modest size non-compacting section on the other has been marketed in Canada, but the vehicle is expensive and has not been used in the U. S.

The EPA/RPA team selected an open-top rear-bucket-loading vehicle commonly used for waste disposal in the rendering industry. RPA worked with the manufacturer to modify the vehicles for these recycling programs. Somerville's two vehicles are 15 cubic meters (20 cubic yards) each; Marblehead required smaller vehicles, 12 cubic meters (16 cubic yards) each, to negotiate its narrow New England streets. Although the vehicles are non-packing, the nature of the materials collected results in densities of about 237 kilograms per cubic meter (400 pounds per cubic yard), or 2.95 metric tons (3.25 U.S. tons) per load. Thus, the recyclables of 1500 to 2000 persons can be collected in a single load in Marblehead.

The operation of the vehicles is relatively simple. Collectors load the separated materials into a full-width rear bucket which has three compartments. The bucket has a capacity of about 0.76 cubic meter (1.0 cubic yard). When the bucket compartment is full, a lever-actuated hydraulic system lifts the bucket over the truck and drops the contents into three lengthwise body compartments. The dumping cycle requires about 20 to 30 seconds of operator time. Naturally, caution must be used to avoid overhead power lines and branches.

As soon as any compartment of the vehicle is full, the entire load is driven to the discharge point. The compartments are emptied one at a time by opening a series of narrow top-hinged rear doors corresponding to the compartment widths. Materials are discharged by hydraulically lifting the truck body. Weighing and unloading of all three compartments takes about 10 minutes.

A particular advantage of this vehicle is its flexibility. Any of the interior partitions can be removed to combine two compartments, and provisions have been made so that partitions can be relocated to increase the size of one compartment or another. Furthermore, the vehicle, which costs approximately \$22-25,000 including the chassis, is much less expensive than a packing vehicle.

### The Market

The marketing arrangements for these programs are also unusual. One of the most important factors in the success of any materials recovery program is a good market for recovered materials. A good market for a municipality is quite different from one which would be good for private industry. Some of the more important characteristics that a municipality's market for source separated materials should have are:

- The ability to handle all materials from the municipality
- Minimal administrative requirements
- A tolerance of fluctuations in the quantity and quality of materials
- A tolerance of wide variations in moisture content
- The capability of screening and, if necessary, rejecting materials, and perhaps most importantly,
- A commitment to work with the town that includes long term agreements.

The highest market prices are not necessarily the best deal. For example, municipalities find it more important to maintain a minimum floor price, especially during times of adverse regional market conditions, than to obtain peak prices that may be available only during good times. The supply of materials from a town simply cannot be turned on and off. The quickest way to ruin a recycling program is to landfill unmarketable materials after they have been carefully separated by residents. Somerville and Marblehead sell all their materials to one buyer at prices keyed to the current open market for scrap materials, subject to guaranteed floor prices. Thus, the towns are assured of a market at all times.

TABLE 2

MATERIALS PRICES  
(Dollars per ton)\*

	FOB Somerville			Marblehead (FOB Salem)		
	Floor	Current	Anticipated Year's Average	Floor	Current	Anticipated Year's Average
Paper	2	21	15	5	27	21
Clear or Colored Glass	10	10	12	12	12	12
Cans	5	27	22	10	29	25
Average* Mixture	4.75	19.75	16.00	8.80	21.40	18.20

\* Conversion factor: 1 Dollar/U.S.Ton = 1.1 Dollar/metric ton

In Somerville and Marblehead, an additional marketing concept, that of combining glass and cans, is being tested. This option substantially improves collection efficiency and reduces the inconvenience to households. The processing cost for the combined materials is increased only slightly. The materials from both programs are sold to Recor, Inc. of Salem, Massachusetts. Recor shreds and bales the paper before transporting it to a Massachusetts boxboard mill. The mixture of cans and glass is run through a combined system for size sorting, magnetic separation, cleaning and shredding. Aluminum cans are separated by hand on a conveyor carrying large non-magnetic items. Cans are hauled by rail to various eastern locations and glass cullet is transported by tractor to Glass Container Corporation in Dayville, Connecticut where it undergoes a final cleaning process before reuse as a raw material.

Recor has had some difficulty with the contamination of materials from Somerville and Marblehead. Cans and glass, for example, are sometimes mixed in with the paper, and large items such as bicycles occasionally appear with the cans and glass. However, most problems have been overcome by more careful preprocessing, increased screening by collectors, and improvements to the partitioning system in the vehicles.

\* Assuming the refuse collected is 50% paper, 25% cans, 25% glass in Somerville and 40% paper, 20% cans, 40% glass in Marblehead.

## The Public Education Program

Of course special trucks and guaranteed markets are useless the residents cooperate by separating materials. Public relations and public education (PR/PE) are not new techniques in refuse disposal, but they have probably never been used so extensively as in this program.

Recycling is not like refuse collection. Salesmanship and careful instruction are necessary to obtain high levels of participation. Residents have to be convinced that source separation is a good idea -- but even that is not enough. Until source separation becomes a habit most people would just as soon forget that it exists in their town.

The role of public education and public relations in source separation programs then is to inform residents of the economic and environmental merits of source separation, instruct them in separation and collection procedures, and then to make sure they don't forget to participate. Forming the recycling habit seems to take a long time. One technique used in Marblehead is to keep residents informed of the program's progress, both in terms of economics and of materials recovery. Therefore, a public education program must be continued at a moderately high level for several years. In Marblehead, we expect to funnel up to 10 percent of annual program revenues each year (about \$4000) back into public education and public relations.

The PR/PE program in Marblehead so far has been quite extensive. Conducted by two residents of the town working for token salaries under the direction of RPA, this program consists of a multi-media approach including newspapers, posters, letters, bulletins, radio spots, and personal contact. Information was aimed at the general public, as well as at specific citizen groups, religious groups, and at all levels of the school system. The most successful media so far have been the two town newspapers, which have and run articles and editorials nearly every week. Direct mailings have also been effective, and were in fact responsible for the successful start of the program. Local radio interviews and advertising spots seem to have been less effective, but it is difficult to assess the impact of any single method. In just about any community, contact with the numerous community organizations is an effective mechanism for arousing interest. Community groups such as garden clubs or the League of Women Voters are excellent sources of free labor to help conduct a PR program. However, RPA suspects that many of its community group audiences were already "hard core" recyclers and that the time would have been better spent in missionary work.\*

## Results

After 8 months of operation, the 23,000 residents of Marblehead have

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\*Audience response at predominantly male group meetings was much less enthusiastic.

recycled more than 1.36 million kilograms (3 million pounds) or about 56.7 kilograms (125 pounds) apiece. This represents more than 25 percent of total residential waste flow from January to August. Participation has remained stable since the start of Recycle Plus (Exhibit 3). The program has saved the town more than \$22,000 to date.

However, this figure may not be representative of that which can be expected in other towns for two reasons. The revenues included an \$20.89 disposal credit for every metric ton (\$18.95 for every U.S. ton) recycled.\* Other communities may soon have such high disposal costs, but for the present this figure is unusually high. Communities which operate their own landfills may realize only small real disposal savings. Secondly, these costs are based on a comparison with Marblehead's previous mixed refuse collection operations. Labor costs attributed to the program included only additional personnel hired. If all personnel actually working on the program were included in costs, the net profit so far would be only about \$7,000 or \$10,500 per year (Exhibit 4). Whether the incremental program economics (more than \$22,000 profit) or the full cost economics (only \$7000 profit) are more important is a difficult question. Certainly the town itself has realized the former. By conducting the program, Marblehead was able to utilize spare labor capacity already on the payroll, provide jobs for several additional men, improve its public image, yet still reduce overall waste collection and disposal system costs by \$22,000 in eight months. Many towns are in the same situation that Marblehead was in before beginning its program; that is, they have extra personnel on their staff who can not easily be cut from the payroll. Other towns have ignored potential collection system efficiency improvements because they could not or did not or did not want to lay off personnel freed by such improvements. A source separation program is an excellent way to utilize such excess capacity. Thus, for many cities and towns, the incremental program economics will be most important.

On the bright side is the fact that these figures do not include contemplated cost reductions that are scheduled to take place over the next 6 months. These cost reductions include reducing manpower on the recycling trucks to two men per vehicle and eliminating one unnecessary refuse collection route. Additional savings will result from the elimination of the town's little used recycling bins. The net effect will be a reduction of \$66,000 per year in the cost of Recycle Plus. Thus, if next year's market and recovery conditions are similar to this year's, we project net savings, of \$99,000 over the former refuse collection system without recycling. This represents more than \$4 per person. However, the town must eliminate 5 collection staff members. Of these savings,

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\*Refuse from Marblehead is delivered to a privately operated transfer station. Marblehead pays the operator \$20.89 per metric ton (\$18.95 per U.S. ton) delivered. Since the transfer station is used by several towns in the area, Marblehead's 25 percent tonnage drop has little effect on the operator and no effect on the disposal fee per ton paid by Marblehead.

approximately \$47,000 will be disposal savings. Even without a disposal credit and without using spare personnel the system would be profitable.

The potential in Somerville is nearly as great, except that system improvements are constrained by difficult labor/management relations. Such problems may be the rule rather than the exception in higher density urbanized communities. If these labor issues could be satisfactorily resolved in Somerville, the high residential density would result in an even more efficient collection operation than in Marblehead and reduce collection costs as much as 15 to 20 percent below Marblehead's projected collection costs. At this time Somerville's collection costs are still higher than Marblehead's.

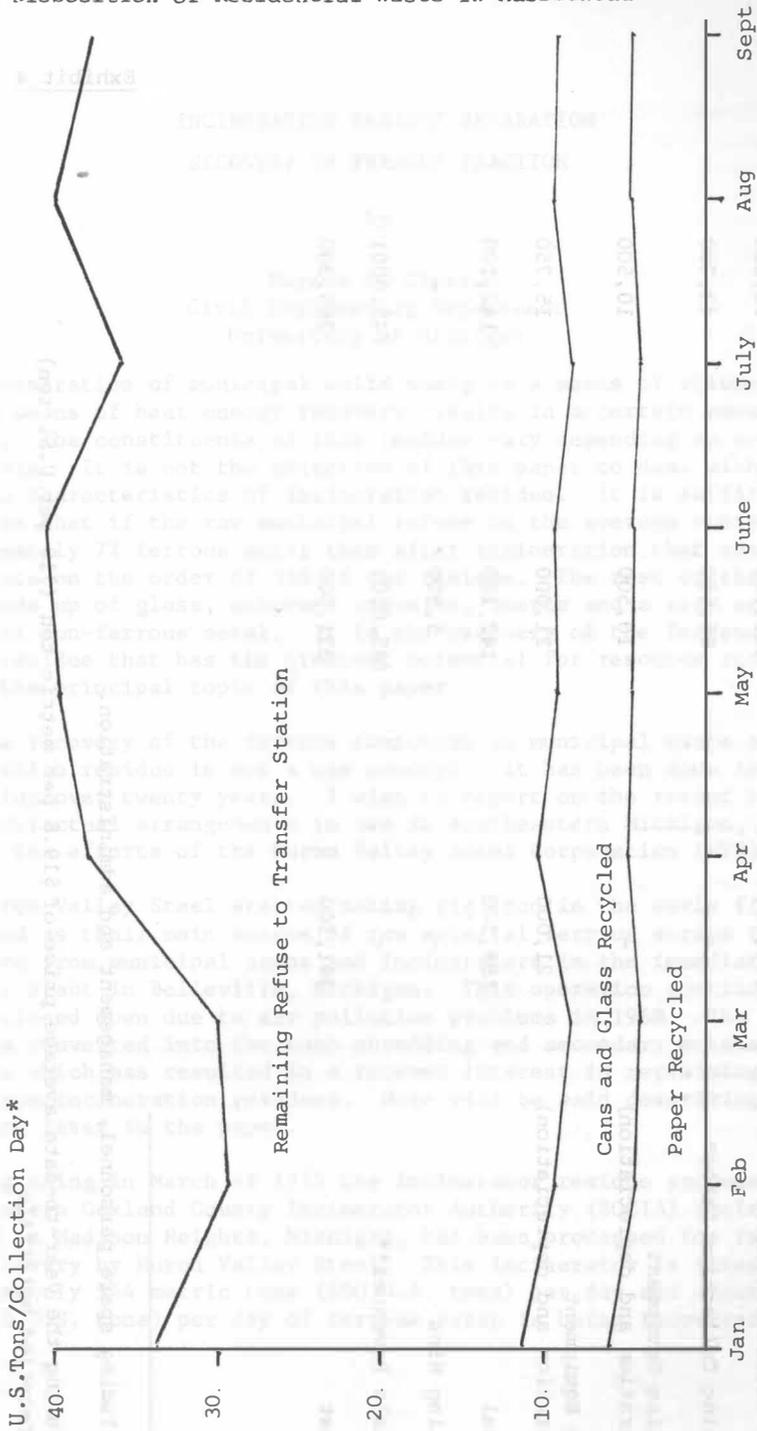
### Conclusions

Source separation is a cost effective resource recovery option. The major requirements are good, local markets for materials; expertise and resources to plan and maintain an efficient collection system; and the commitment to a well-organized, extensive and long-lasting public relations and public education program. A significant constraint in some communities is the deteriorating relationship between collection labor and management which makes innovation and efficiency difficult to achieve. Assuming that only 50 percent of all cities and towns with a population between 10,000 and 100,000 were able to overcome these obstacles, the U.S. could be recovering 2.7 to 3.6 million metric tons (3 to 4 million U.S. tons) of paper, cans and glass per year through source separation alone. Although collection system costs and market conditions would vary widely, our experience in Somerville and Marblehead shows that the majority of these towns could do so at a profit.

### Next Steps

RPA's commitment to the two towns extends through June 1978. During that time program improvement, monitoring and reporting will continue. The second major report on the program will be produced by February 1977. It is also anticipated that some additional worthwhile information will be gathered during the remainder of the program. Items of particular interest include the impact of Marblehead's recycling program on the fuel value of the remaining municipal refuse and the overall energy balance of Recycle Plus versus Marblehead's refuse collection and disposal system. Other areas that RPA hopes to explore are the impact and severity of paper scavenging, motivating factors for the participants, and the effectiveness of alternative lower-cost collection vehicles.

Disposition of Residential Waste in Marblehead



\*Conversion factor: 1(U.S. ton) = 0.907 (metric ton)

MARBLEHEAD  
ANNUAL COSTS AND REVENUES  
(Dollars)

	Initial System	Current System	Planned System
Refuse Collection Labor*	131,000	131,000	98,250
Recycling Collection Labor*	-	65,500	43,700
Recycling Equipment (operation and depreciation)	-	10,500	10,500
Refuse Equipment (operation and depreciation)	21,000	21,000	15,750
Disposal	189,500	142,100	142,100
Recycling Bins	-	5,900	-
Materials Revenues**	-	(45,000)	(45,000)
Net Cost	341,500	331,000	265,300

\* Excluding spare personnel, management and administration.

\*\* Assuming the year-to-date average price of \$19.8 per metric ton (\$18 per U.S. ton) of recycled materials

Exhibit 4