PB81-216046

Compatibility of Source Separation and Mixed-Waste Processing for Resource Recovery

Gilbert Associates, Inc.
Reading, PA

Prepared for

Municipal Environmental Research Lab.
Cincinnati, OH

Jun 81

U.S. Department of Commerce
National Technical Information Service
NTIS

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-600/2-81-097

2. ORD Report

3. PB81-216046

4. TITLE AND SUBTITLE Compatibility of Source Separation and Mixed-Waste Processing for Resource Recovery

5. REPORT DATE June 1981

6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S) M. C. Klett, W. H. Fischer, B. N. Murthy, H. Fiedler, L. Oliva, R. Crystal

8. PERFORMING ORGANIZATION REPORT NO.

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Gilbert Associates, Inc.
P.O. Box 1498
Reading, Pennsylvania 19603

10. PROGRAM ELEMENT NO. BRD1A

11. CONTRACT/GRANT NO. 68-02-2645

12. SPONSORING AGENCY NAME AND ADDRESS
Municipal Environmental Research Laboratory - Cin., OH
Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268

13. TYPE OF REPORT AND PERIOD COVERED Final

14. SPONSORING AGENCY CODE EPA/600/14

15. SUPPLEMENTARY NOTES

Project Officer - Stephen C. James (513/684-7871)

16. ABSTRACT

Existing source separation programs and mixed-waste processing facilities were analyzed to develop typical options for assessment. Source separation options include high-efficiency multi-material recovery, low-efficiency multi-material recovery, high-efficiency newsprint recovery, low-efficiency newsprint recovery, and beverage container recoveries. Mixed-waste processing alternatives included unprocessed combined waste combustion and ferrous recovery, processed combined waste combustion and ferrous recovery, refuse-derived fuel production and ferrous recovery, and modular incineration.

The analysis considered the viewpoints of the mixed-waste plant operator, the municipality, and the nation. Within four broad areas of concern (energy and materials conservation, environmental impacts, institutional and technological impacts, and economic impacts), issues identified as most important for each viewpoint are assessed for each combination of options and alternatives. Among the issues addressed are changes in production of useful energy from a mixed-waste processing facility, air, land, and water pollution emissions, contractors' employment, operator profitability, total solid waste collection costs, and quantities of recycled materials.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Resource Recovery Source Separation Mixed-Waste Processing Compatibility		

18. DISTRIBUTION STATEMENT Release to Public

19. SECURITY CLASS (This Report) Unclassified

20. SECURITY CLASS (This page) Unclassified

21. NO. OF PAGES 194

22. PRICE

EPA Form 2220-1 (Rev. 4-77)

EPA-600/2-81-097
June 1981

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FOREWORD

The U.S. Environmental Protection Agency was created because of increasing public and government concern about the dangers of pollution to the health and welfare of the American People. Noxious air foul water, and spoiled land are tragic testimonies to the deterioration of our natural environments. The complexity of that environment and the interplay of its components require a concentrated and integrated attack on the problem.

Research and development is that necessary first step in problem solution; it involves defining the problem, measuring its impact, and searching for solutions. The Municipal Environmental Research Laboratory develops new and improved technology and systems to prevent, treat, and manage wastewater and solid and hazardous waste pollutant discharges from municipal and community sources, to preserve and treat public drinking water supplies, and to minimize the adverse economic, social, health, and aesthetic effects of pollution. This publication is one of the products of that research and provides a most vital link between the researcher and the user community.

This report examines the effects of coupling source separation and mixed-waste processing, considering conservation, environmental, institutional/technological, and economic factors.

Francis T. Mayo, Director
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ABSTRACT

This report evaluates whether source separation and mixed-waste processing in municiple solid waste are compatible approaches for recovery of materials and energy in the same community or region.

Existing source separation programs and mixed-waste processing facilities were analyzed to develop typical options for assessment. Source separation options included high-efficiency multi-material recovery, low-efficiency multi-material recovery, high-efficiency newsprint recovery, low-efficiency newprint recovery, and beverage container recovery. Mixed-waste processing alternatives included unprocessed combined waste combustion and ferrous recovery, processed combined waste combustion and ferrous recovery, refuse-derived fuel production and ferrous recovery, and modular incineration.

The analysis considered the viewpoints of the mixed-waste plant operator, the municipality, and the nation. Within four broad areas of concern (energy and materials conservation, environmental impacts, institutional and technological impacts, and economic impacts), issues identified as most important for each viewpoint are assessed for each combination of options and alternatives. Among the issues addressed are changes in production of useful energy from a mixed-waste processing facility, air, and water pollution emissions, residual solid waste, employment, operator profitability, total solid waste collection costs, and quantities of recycled materials.

This report is submitted in fulfillment of Contract No. 68-0?-2645 by Gilbert Associates, Inc., Resource Planning Associates, and Crystal Planning and Communications, Inc. under the sponsorship of the U.S. Environmental Protection Agency.

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ACKNOWLEDGEMENTS

The guidance and advice provided by the EPA Project Officers, Chas. Miller and Steven C. James, are gratefully acknowledged. Many experts in the resource recovery field aided our research by providing helpful information in interviews; the contributions of these individuals (cited in the Reference Section) are much appreciated. We wish to particularly thank Steven Howard of the American Paper Institute, Frank Bernheisl of the National Center for Resource Recovery, and Robert Davis of the Garden State Paper Company for their assistance.

T. Robert Holloway, of the Resource Recovery Division of EPA, provided estimates of the costs of operation of mixed-waste processing alternatives. In preparing this report, Gilbert Associates served as the prime contractor and prepared sections dealing with mixed-waste processing alternatives. Resource Planning Associates prepared information and analyses dealing with source separation options. Crystal Planning and Communications prepared the introduction sections on institutional and technological impacts in Sections 4-6, and evaluation of environmental impacts and changes in resource use in Section 3.

SECTION 1

INTRODUCTION

Over the past decade, many methods have been developed for achieving resource recovery, or the productive use of waste materials that would otherwise require disposal. These diverse methods can be divided into two basic approaches: Source separation and mixed-waste processing. Source separation is the segregation of salable materials from wastes at the point of discard for concentrated collection and reprocessing. Mixed-waste processing is the centralized processing of collected, mixed municipal wastes to separate recyclable materials and/or convert the mixed wastes into energy or new forms of salable materials.

Both approaches can vary widely in complexity. Source separation methods include recycling centers, beverage container deposit legislation ("bottle bills"), and systems in which residents or businesses divide their wastes into portions that are collected separately at the curbside. Mixed-waste processing facilities range from small incinerators that burn waste to produce steam for heating, to complex mechanical systems that process the wastes of an entire metropolitan region to produce both energy (either steam, electricity, or solid fuel) and a wide variety of material products. The basic difference between the two approaches is that source separation requires the separation of wastes by the householder or other waste generator, who thus performs much of the work to prepare it for resale, whereas mixed-waste processing relies on machinery to perform this task.

Recently, there has been increasing public debate and political controversy about whether source separation programs are compatible with mixed-waste processing facilities in the same community or region. By "compatibility" we mean whether or not the two alternatives can co-exist with each other. Specifically, to be judged compatible in terms of a particular issue, a mixed-waste processing facility and a source separation program would either have a beneficial effect on one another, no effect, or a small negative effect that does not seriously affect the operation of either. Two alternatives are incompatible when a conflict exists that is large enough to seriously affect the operation of one or the other, for example, by making one of the alternatives economically unprofitable.

The U.S. Environmental Protection Agency (EPA) has extensive statutory responsibilities for studying and reporting on issues concerning resource recovery and solid waste disposal. Through the research, demonstration projects, and studies of its Office of Solid Waste, EPA has contributed to the development of both source separation and mixed-waste processing methods. On the issue of the compatibility of the two approaches, the agency has taken the official position that:

- Both methods will be needed to manage solid waste effectively by 1985.

- Source separation and energy recovery should be investigated simultaneously to achieve the best overall recovery system for a given area.

- Source reduction of solid waste should be undertaken first whenever feasible, followed by recovery of materials and energy from the remaining waste.

The Resource Conservation and Recovery Act (RCRA) of 1976 directed EPA to study the compatibility of the two approaches and to report on the issues. The agency determined that a necessary part of this effort was the preparation of a technical guidance document that would provide background data and a framework for analysis.

This report is intended to assist federal, state, and local decisionmakers in developing policies at the state and federal levels and in carrying out compatibility analyses at the local level.

PROBLEMS TO BE ADDRESSED

In most areas, the quantity of material removed by source separation has, so far, been too small to have a significant effect on the total quantity and quality of solid waste. However, conflicts have been perceived as increasingly likely between source separation and mixed-waste processing methods for several reasons. Both methods may overlap in recovering a single material forming part of the waste stream. For example, metal cans and glass bottles can be separated at the curbside, returned for deposits, or separated by machinery in a mixed-waste processing plant. Also, a single material may be usable for more than one purpose. Wastepaper, for instance, can be either separately collected for its fiber content or burned for its energy content in a mixed-waste processing facility.

Supporters of source separation argue that their approach recovers the highest potential economic value of the paper, avoids the negative effects on the environment of manufacturing paper from virgin materials, and avoids the high capital cost of mixed-waste processing. Planners and operators of mixed-waste processing facilities point to the need for increased energy supplies and argue that separating paper reduces the energy content of solid waste and could jeopardize the financial feasibility of the facility by reducing revenues from energy sales.

The local history of involvement by municipalities and private groups is also a factor in perceived conflicts. Once crucial decisions were made -- such as the capacity of a mixed-waste processing facility, the material and energy products it will produce, and the specific technology to be used -- a community may be locked in to the need to obtain a set tonnage of wastes. Similar situations can occur when financial commitments have been made to a source separation approach, such as the purchase of specialized equipment for separate collection or processing. Municipalities that have put considerable planning and effort into development of a mixed-waste processing facility have, in several cases, passed legislation requiring that all wastes collected within their limits be delivered to the facility. Though apparently intended primarily to limit competition from private waste haulers delivering to private landfills, such legislation could be interpreted as prohibiting source separation programs. An ordinance of this type in Akron, Ohio, is currently being legally challenged in what may become a major test case. The ordinance has been upheld in federal district court, but is currently being appealed. Vendors of mixed-waste processing facilities have frequently requested contractual guarantees that they will be compensated for their loss of revenues if municipalities undertake any form of source separation. Conversely, citizens and private entrepreneurs involved in successful source separation programs in Seattle have expressed concern about a proposed mixed-waste processing facility because they fear their programs would be endangered.

In other regions, however, such as the North Shore of Massachusetts, mutual benefits have been perceived. Operators of a mixed-waste processing facility in Saugus, Massachusetts, have seen source separation as beneficial in allowing them to process a larger amount of waste and in removing glass (which has an abrasive effect on the materials-handling equipment in the facility) from the waste stream. On occasion private companies that have helped to establish community source separation programs have worked on joint marketing efforts with vendors of mixed-waste processing equipment. A number of the cases in which conflicts have been perceived between mixed-waste processing facilities have occurred where each approach was implemented separately.

It is important to determine the extent to which perceived conflicts between source separation and mixed-waste processing facilities result from poor coordination as opposed to inherent conflicts between the two approaches. If poor coordination is primarily responsible, well written contractual agreements considering both the distribution of revenues and design of source separation programs and mixed-waste processing systems should prevent most problems from occurring. If, however, there are inherent conflicts (either between particular source separation and mixed-waste processing systems or the economic interests of different parties), then difficult political decisions will have to be made.

APPROACH

To answer these questions, an approach is needed that explicitly recognizes that judgments on the compatibility of source separation and mixed-waste processing may vary, depending on whose viewpoint and interests are being considered. For example, although a given combination of source separation and mixed-waste processing could be the least expensive solid waste disposal system for a municipality, it could be less profitable for the operator of a mixed-waste processing plant than operation of his facility alone. Similarly, although a municipality will be primarily concerned, in terms of environmental impact, with air and water pollution emissions within its boundaries, from the viewpoint of the nation as a whole, this is only one element of an overall comparison of the total environmental impacts of mixed-waste processing and source separation.

This analysis is structured in terms of the viewpoints of the mixed-waste plant operator, the municipality, and the nation. For each of four broad areas of concern (energy and materials conservation, environmental impacts, institutional/technical impacts, and economic impacts), the specific issues that would be most important in terms of each viewpoint are identified. A common set of hypothetical data and reasonable assumptions were used to develop a generalized assessment of how judgments or compatibility could change for the viewpoint and, for that matter, for any other entity, such as a municipality or the nation as a whole.

Several steps were necessary to conduct this generalized assessment. First, a hypothetical community, Baselyn, was defined. The characteristics of this community that are relevant for solid waste management (e.g., its waste generation rate per capita, the composition of its waste, and costs of waste collection and disposal) were given values equal to national averages.

Next, a set of options and scenarios that represented realistic choices for each of the two basic approaches was developed. Five source separation options were chosen (high-efficiency multimaterial recovery, low-efficiency multimaterial recovery, high-efficiency newsprint recovery, low-efficiency newsprint recovery, and beverage container recovery), and four mixed-waste processing options were selected (unprocessed combined waterwall combustion and ferrous recovery, combined processed waterwall combustion and ferrous recovery, refuse-derived fuel and ferrous recovery, and modular incineration without ferrous recovery). Data from the existing programs and facilities most similar to each option were used to define its features in greater detail. The analyses were conducted for three distinct scenarios which specified the size of the service area for solid waste management and the capacity of the mixed-waste processing facility.

Finally, the most important specific issues of concern were identified and impact analyses were conducted that assumed implementation for Baselyn and the surrounding region of each possible combination of source separation and mixed-waste processing options. The result was a judgment on the compatibility of each combination in terms of a specific issue and viewpoint.

An assessment of the compatibility (as defined earlier) of the source separation option and mixed-waste processing alternative was conducted by determining whether the mutual impact was positive, neutral, or negative. If negative, it was determined whether the effects were large enough to affect the viability of the combination.

This generalized assessment, based on national averages, avoids the obscuring effect of unique local circumstances and develops conclusions that should be useful for policy development at the Federal and State levels. However, it is difficult to extrapolate from these conclusions to determine the best choice for a particular community. Such important factors as waste generation rates, waste composition, and the demand for energy and recycled materials vary widely from place to place, making a site-specific analysis necessary before accurate decisions can be made at the local level.

This report has been organized to analyze clearly the viewpoint concept described above. Section 2 presents a summary of the analysis and our conclusions. Section 3 describes the resource recovery alternatives and the data and assumptions used. It documents the characteristics of Baselyn, the definition of the scenarios for solid waste management, the source separation options, and the mixed-waste processing alternatives.

The remaining sections of the report are devoted to each of the three major viewpoints. Section 4 describes the operator's viewpoint, Section 5 discusses that of the municipality, and Section 6 addresses the point of view of the nation as a whole. Within each chapter, the conclusions of our generalized assessment are presented for each of the specific issues within a broad area of concern. Finally, a summary in terms of each specific viewpoint and recommendations for national policy development and further research are presented. Useful supplementary information is included in the appendices.

SECTION 2

SUMMARY AND CONCLUSIONS

SOURCE SEPARATION AND MIXED-WASTE PROCESSING

To identify the most compatible combination of source separation and mixed-waste processing for a community, five source separation options have been considered with four common mixed-waste processing alternatives.

In source separation, the waste generator (e.g., resident, business, or institution) has the primary responsibility for separating recoverable materials from the waste stream. Currently, the major waste materials recoverable through source separation are aluminum, ferrous metals, paper, and glass.

Several common alternatives are used for source separation:

- o Recycling centers
- o Separation of office paper
- o Separation of corrugated paper
- o Separate collection of newsprint and other paper
- o Separate collection of various materials
- o Beverage container deposits.

In this study, a typical option for each type of source separation, except for recycling centers, has been considered for developing and evaluating resource recovery compatibility. Recycling centers were excluded because the total impact of such systems on the waste flow of the community is relatively small, and they require far greater cost and resources per ton recovered than other methods.

Modern mixed-waste processing facilities are complex and capital-intensive. To reduce amortization costs per unit of municipal solid waste, a long-term commitment from all involved parties is necessary, as well as sophisticated planning, management, and marketing. Many plants that recover energy from waste are in operation. Most systems are equipped to recover ferrous materials, because the technology is simple and relatively inexpensive. However, a strong demand for the ferrous products has not developed because of a frequent lack of local markets and the cost of transportation. Glass recovery by froth-flotation and optical sorting has been demonstrated, but these systems have not reached wide commercialization. The same is true for aluminum recovery by eddy-current devices and other techniques. The processing systems considered in this study recover energy in the form of refuse-derived fuel (RDF) or steam and ferrous metal.

Four mixed-waste processes have been selected as typical commercial alternatives:

- o Unprocessed combined waterwall combustion and ferrous recovery (UWCF)
- o Processed combined waterwall combustion and ferrous recovery (PWCF)
- o Refuse-derived fuel production and ferrous recovery (RDFF)
- o Modular incineration without ferrous recovery (MI).

Options considered also included no source separation and landfill of the remaining mixed-waste. When combined with each other, the two types of options create up to 30 possible combinations, or approaches to resource recovery, for assessment purposes.

BASELYN, A HYPOTHETICAL COMMUNITY

To assess the relative compatibilities of various source separation options with commercially available mixed-waste processing alternatives, we have hypothesized a nationally typical community, Baselyn. Baselyn is assumed to have 108,000 inhabitants and to produce 200 tons per day of mixed municipal solid wastes(1). This waste is collected by the city's sanitation department from all households. Source separation options are based on the characteristics of Baselyn. However, to assess mixed-waste processing alternatives and combinations of the two, further assumptions are necessary, since most mixed-waste processing facilities serve areas generating more than 200 tons per day. Three distinct scenarios were defined for such assessments. In the first scenario, the mixed-waste processing facility is assumed to have a fixed capacity of 1000 tons per day, enough to process the combined waste from a "fixed service area" of Baselyn and four other nearby communities of similar size and characteristics. A second scenario (termed "variable plant size") assumes that a fixed service area generates 1000 tons per day of waste, but varies the plant size to correspond to the amount of waste remaining after the various source separation options are exercised. The third scenario, the "expanded service area", holds the plant capacity constant at 1000 tons per day, but assumes that additional wastes are available from an additional nearby area with characteristics like those of Baselyn.

COMPATIBILITY ANALYSIS

The primary objective of source separation and mixed-waste processing is to achieve solid waste disposal, materials recovery, and energy recovery by environmentally acceptable and economical means.

In this study, the effects of various degrees of source separation on conservation, environmental, and economic areas of concern have been quantitatively assessed for Baselyn. Because the issues associated with the institutional area of concern can not be quantified, they have been treated qualitatively. Although local legislation for source separation of beverage containers has not been widespread or effective, state laws enforcing deposits on beverage containers are becoming more frequent. Hence, our analysis of this source separation option assumes that state, rather than local, legislation is in effect.

CONCLUSIONS

Below, we present the major results of our analysis in the context of the five major areas of concern, explicity, identifying the viewpoints of the operator, the municipality, and the nation.

Conservation

Except for the most efficient source separation option, high multi-material recovery, variations in the amount of energy recovered as steam are small and well within the range expected from mixed municipal solid waste. For the option of high multi-material recovery, energy recovery is reduced by approximately 17 percent. For a fixed service area with an existing MWP plant, this reduced energy recovery could possibly make this option incompatible. However, it is unlikely that in actual practice a large region would have uniform high-efficiency multi-material separation. Among the mixed-waste processes, unprocessed combined waste combustion is the most efficient.

In addition, from the municipal viewpoint, the energy consumed by collection and transportation is an important factor in the selection of the most efficient combination of source separation and mixed-waste processing options. The most favorable source separation option from the municipal viewpoint would be beverage container recovery.

From the national viewpoint, the source separation options that recover metals are most compatible with any mixed-waste processing option. Beverage container source separation combined with mixed-waste processing has the potential to reduce the national energy demand by the equivalent of 200,000 bbl. of oil per day.

Environmental Impacts

From the operator's and municipal viewpoints, one of the important issues is changes in landfill requirements, most of the reduction in landfill requirement is the result of mixed-waste processing. Pollution from leaching of the residues in landfills is slightly decreased by source separation.

Particulate emissions from mixed-waste processing operations are significantly reduced by high efficiency source separation of newsprint.

From the national viewpoint, a combination of multi-material source separation and unprocessed combined waterwall combustion with ferrous recovery is the most appropriate choice for minimizing adverse environmental effects.

Institutional/Technological

Cooperative and contract arrangements between the operator and the municipality can be arranged to ensure adequate flow of solid waste quantities to the mixed-waste facility. Minimum quantity requirements should be included in contracts, compensation, or renegotiation agreements if the composition of waste is changed by source separation. The MWP facility should not be designed with too large a capacity for the waste available.

From the operator's viewpoint, beverage container recovery through source separation is the most compatible option because, by eliminating glass which erodes processing equipment, it reduces maintenance requirements at the mixed-waste facility.

From the municipal viewpoint, source separation programs or legislation may be harder to administer, but are rarely a factor in impeding financing or implementation of mixed-waste processing plants.

From the national viewpoint, short-term price fluctuations for recovered materials and lack of storage capacity make difficult the establishment of long term contracts between municipalities and purchasers of separated materials (particularly wastepaper), which may make communities reluctant to initiate such programs. Federal price supports could alleviate this problem. In addition, mixed-waste processing options may benefit from Federal efforts to support the development of synthetic fuels and other alternative energy sources.

Economic

With a fixed service area, the only source separation scheme that has a favorable economic impact on net mixed waste processing costs is beverage container recovery. Relatively large processing cost increases ($5-$6 per ton) occur with the high efficiency multi-material option assuming a fixed service area and plant size. However, these increases can be readily eliminated by a reduced plant size or expanded service area. Other source separation options have a lesser impact on net processing costs (less than $2 per ton). With proper planning, all source separation and mixed-waste processing options should be economically compatible.

The primary economic issues from the municipal viewpoint involve the total collection, distribution and disposal (including landfill) costs. From this viewpoint, source separation of any type is less costly than using landfill entirely. An expanded service area with source separation, in combination with unprocessed or processed combined waterwall combustion, is most economical.

From the national viewpoint, the major economic issue is the potential of source separation and mixed-waste processing to reduce fuel import needs. A combination of high multi-material source separation and unprocessed combined waterwall combustion with ferrous recovery could reduce the fuel import costs by up to $2.6 billion/yr.

Summary

Analyses showed that any of the source separation options can be combined with any of the mixed-waste processing alternatives. However, some combinations are more compatible than others depending on which issues are judged most important and the specific circumstances of a particular project. If environmental impacts are considered most important, the high-efficiency multi-material recovery option would be the most compatible source separation option. If, however, the MWP facility has a fixed capacity, the service area cannot be expanded and the primary concern of a municipality is the disposal of solid wastes at the lowest overall cost, high multi-material might not be compatible with the MWP facility. While the choice of a particular combination depends upon local circumstances, in all cases combinations are available which results in a greater net benefit than implementing either separately.

SECTION 3

RESOURCE RECOVERY OPTIONS

A hypothetical community, Baselyn, has been established as a vehicle for determining whether a community can increase its net benefits by conducting both source separation and mixed-waste processing simultaneously. Baselyn is typical of many communities in which such programs are now being conducted.

In the following sections, Baselyn is described, the features of the mixed-waste processing and source separation options, and scenarios for their implementation, are presented.

BASELYN, A HYPOTHETICAL COMMUNITY

Baselyn is a community of 108,000 that produces 181.4 Mg (200 tons) of solid waste per day and is located in a major metropolitan area. The city has affluent areas of single family homes as well as more densely populated areas of multifamily dwellings. The average population density is 1,930 inhabitants per square kilometer or 5,000 inhabitants per square mile. Real cities whose population and density are similar to Baselyn's include Pasedena, California; Lakewood, Colorado; Waterbury, Connecticut; Hollywood, Florida; New Bedford, Massachusetts; Ann Arbor, Michigan; Woodbridge, New Jersey; Albany, New York; and Canton, Ohio. There is no heavy industry, but a number of light manufacturing plants and service businesses are located in the core of the city and in two outlying industrial parks.

There are approximately 24,000 single family homes in Baselyn; approximately 60 percent of the families own their homes. The median income is $12,000 per year and the median education level is 12.4 years, which is the national median educational level

The city's Sanitation Department collects solid waste from all households in Baselyn. Collection and disposal costs are approximately $5 per household per month. Before the source separation program, the department employed 60 people and 10 packer trucks with a capacity of 15 m^3 (20 yd^3) each to collect waste. Each truck was operated by a crew of three. The department also employed 60 people for administration, maintenance, and other duties, or a total of 1.11 employees per 1,000 inhabitants. The national average is 1.13 sanitation department employees per 1,000 inhabitants. The department's employees are members of a strong union.

Waste is collected at curbside once a week. Each resident generates 1.7 Kg (3.7 lb) of waste per day (the national average). Therefore, before the source separation program began, the department collected a total of approximately 181 Mg per day (200 tons per day) (Table 1).

The collection trucks unload at a transfer station located within the city limits. This station, operated by two people, has a compactor that loads the waste into 60 m^3 (80 yd^3) trailers. From the transfer station, waste is hauled to a sanitary landfill that the county maintains in a rural area 40 km (25 mi) away. The landfill has a six meter (20 ft) depth and a capacity of 22,500 Mg per hectare (10,000 tons per acre). Baselyn uses approximately three hectares (seven acres) per year, and over 60 hectares (150 acres) are available for landfill.

Commercial establishments must contract with private companies for collection of their waste, which is delivered directly to the county landfill. The county charges the city and private companies a tipping fee of $14.35 per Mg ($13 per ton).

There is a materials processor willing to buy paper, glass, and cans. Current prices (FOB) are:

Newspaper	$33/Mg ($30/ton)
Corrugated paper	$33/Mg ($30/ton)
High grade paper	$65/Mg ($60/ton)
Mixed glass and cans	$11/Mg ($10/ton)

TABLE 1. COMPOSITION OF SOLID WASTE IN BASELYN*

Component	Percentage**	Quantity Collected Daily in Mg (tons)
Paper	38.9	70.6 (77.8)
Newsprint	7.5	13.6 (15.0)
Office	3.5	6.4 (7.0)
Corrugated	11.0	20.0 (22.0)
Other	16.9	30.6 (33.8)
Glass	9.8	17.8 (19.6)
Beer and soft drink	5.0	9.1 (10.0)
Other	4.8	8.7 (9.6)
Metal	4.9	8.9 (9.8)
Ferrous	4.1	7.4 (8.2)
Beer and soft drink	1.0	1.8 (2.0)
Other	3.1	5.6 (6.2)
Nonferrous	0.8	1.5 (1.6)
Beer and soft drink	0.5	0.9 (1.0)
Other	0.3	0.5 (0.6)
Remaining Waste***	46.4	84.2 (92.8)
Total	100.0	181.4 (200.0)

* Based on national figures for distribution of waste - U.S. EPA Resource Recovery Division.(3)

** Percentage of total waste stream excluding durable goods.

*** Includes organic materials, wood, plastics, clothing, and other nondurable goods.

There are markets approximately 320 kilometers (200 miles) from Baselyn for glass cullet, sorted and crushed ferrous and aluminum cans, and baled paper.

Environmental standards require that wastewater discharges to bodies of water in Baselyn not exceed 30 mg per liter in average monthly concentrations of suspended solids or in biological oxygen demand. These standards do not apply to wastewater discharged to municipal sewers.(2) The Baselyn area meets the national ambient air quality standards.

SERVICE AREA AND PLANT SIZE SCENARIOS

The size and characteristics of Baselyn are typical of communities where source separation options have been implemented. However, most existing mixed-waste processing facilities serve areas generating more than 200 tons per day of mixed-waste, the level assumed for Baselyn. To correspond with the typical sizes of such facilities, and to study the impacts of varying the sizes of the plant and service area, we defined several scenarios. The first scenario, termed the "fixed service area", assumes five communities like Baselyn, which together generate 905 Mg (1000 tons) per day of waste and a corresponding capacity of the MWP plant. It is assumed in this scenario that both the MWP capacity and the area delivering waste cannot be altered (as, for instance, when an MWP facility already exists and political conditions make it difficult to expand the service area).

Source separation reduces the quantities of waste entering the mixed-waste processing plant, therefore, it may be economical to either reduce the plant size to correspond to the amount of remaining mixed-waste, or make up the shortage with mixed-waste collected in an area outside the five communities. Our second scenario, termed "variable plant size", assumes that a fixed service area generates 905 Mg (1000 tons) per day of waste but alters the plant size to correspond to the amount of waste remaining after source separation. The third scenario, the "expanded service area", holds the plant capacity constant at 905 Mg (1000 tons) per day, but assumes that additional wastes are available from an area with characteristics like those of Baselyn.

The effects on waste disposal of maintaining a fixed service area and expanding it are displayed in Figures 1 and 2.

SOURCE SEPARATION OPTIONS

This section first describes the general concept and methods of source separation, including: recycling centers, separation of office paper, separation of corrugated paper, separate collection of newsprint and other paper, separate collection of various materials, and beverage container deposits. Five source separation options are then identified and discussed for Baselyn. They are:

- High efficiency multimaterial source separation (papers, cans and bottles) and separation of high grade office and corrugated paper
- Low efficiency multimaterial source separation (paper, cans, and bottles)
- High efficiency separate collection of newsprint (mandatory program)
- Low efficiency separate collection of newsprint (voluntary program)
- Recovery of beverage containers through a beverage container deposit system.

The general characteristics and economics, energy use, and environmental impacts of each option are described in more detail in Appendix A.

Source Separation General Description

In source separation, the primary responsibility for sorting materials lies with the residential or commercial waste generator.

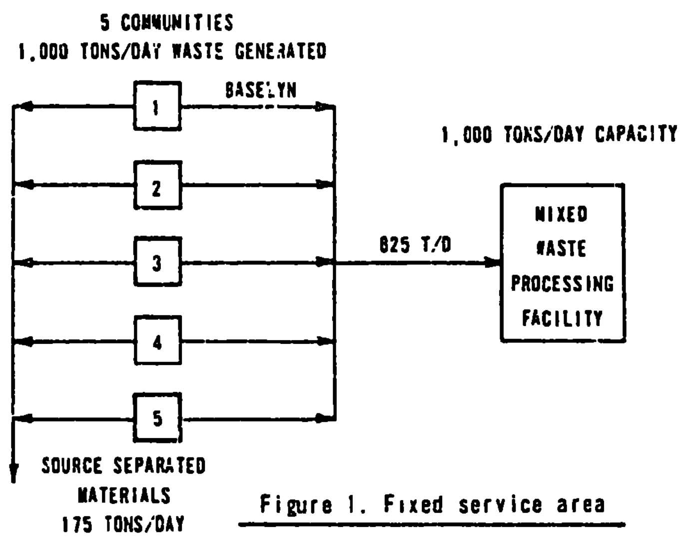

Figure 1. Fixed service area

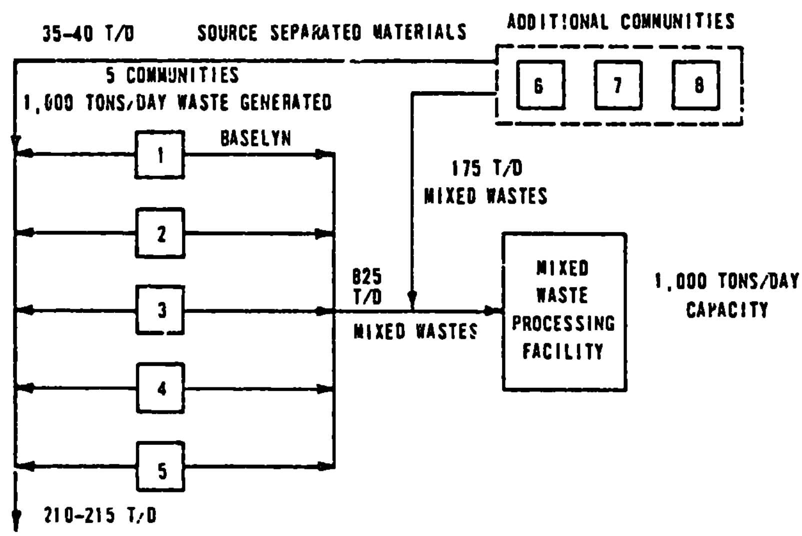

Figure 2. Expanded service area

Source separation programs are generally designed to recover materials that can replace virgin materials in manufacturing. The waste materials most appropriate for separation are aluminum, ferrous metal, paper fiber, and glass cullet (crushed glass). Other reusable wastes, such as plastics and textiles, are not being separated on a regular basis in the United States. Organic food waste was often separated for animal feed in the United States until the 1950's. However, because of tighter health regulations and cheaper sources of animal protein, this practice has been nearly abandoned. Food processing and restaurant wastes are sometimes recycled, for feeding pigs, but most residential food waste in the United States is not.

EPA estimates that the quantity of recyclable materials separated at the source is likely to increase from about eight million Mg (nine million tons) in 1974, of which over 90 percent was waste paper and paperboard, to about 13.5 million Mg (15 million tons) per year by 1985 without any federal incentive programs. However, the potential supply of materials for recovery through source separation is far greater: an aggressive federal program to promote source separation could increase the level of recovery 32-45 million Mg (35-50 million tons) of material per year by 1985. Such a high level of recovery would require expanded industrial markets for recovered material and better techniques for segregating materials for collection and processing.

At present, source separation programs probably recover, at most, five percent of this country's residential and commercial waste. It should, however, be possible to recover over 10 percent of that waste. There are three reasons for this gap:

- The waste generator currently has few or no incentives to participate in source separation programs.

- The market for recovered materials (particularly paper) fluctuates widely, in the short term.

- Recovered materials have a relatively low value and therefore materials must be collected and handled very efficiently.

Source separation should, however, increase greatly over the next decade because of its growing economic and environmental benefits.

There are six common methods of source separation excluding collection of waste tires, oil, and household appliances.

- o Recycling centers
- o Separation of office paper
- o Separation of corrugated paper
- o Separate collection of newsprint and other paper
- o Separate collection of various materials
- o Beverage container deposits.

Recycling Centers--

Recycling centers rely upon the waste generator to separate and deliver materials to a central location where each material is stored separately. At one such center in Nottingham, New Hampshire, glass is hand-sorted by color, aluminum and ferrous cans are separated magnetically, and paper is baled. At most recycling centers, however, materials are simply accumulated until there is enough to sell to a processor or middleman.

Recycling centers are operated municipally, privately, or by nonprofit service organizations. Many have failed because of high operating costs, even though the centers do not pay collection costs. Most successful centers have been convenient to a large population, and have survived by maintaining high throughput and managing costs carefully.

Strong public interest and cooperation are critical to the success of a recycling center, because the residents themselves must bring the materials to the center. Recycling centers have not succeeded in recovering much waste in cities because other means of waste disposal are readily available. Recycling centers can be effective in rural environments, however, where no collection service is provided and residents must deliver their household waste to the local landfill.

Separation of Office Paper--

Separation of high-quality office paper (commonly referred to as "white ledger") is a relatively new type of source separation that has received considerable impetus from mandatory programs in Federal office buildings. There are numerous office-paper separation techniques; perhaps the most effective, however, is a desk-top waste paper holder. Office workers are expected to separate the marketable, high value white paper (for example, letterhead, dry copy paper, and computer printout) from lower grade papers and place them in a desk top container. When full, each desk top container is emptied by the office worker into a nearby, larger container. These larger containers are then periodically emptied and the contents taken to a central storage area (where the paper may be baled) until a sufficient quantity has accumulated for transportation to a buyer. Typically, paper ready for shipment is stored in a large roll-off container or bin for each pick-up and delivery.

The economics of high grade office paper separation vary, but the method has relatively good prospects for large commercial establishments for three reasons: it is relatively easy to gain the cooperation of office workers (voluntary participation in programs studied by EPA averages 80 percent); office waste contains a high percentage of high grade paper (average 35 percent by weight in 12 programs studied by EPA); and the price paid for high grade office paper is attractive--$95-132 per Mg ($90-120 per ton) in 1979.

There are at least 500 Federal and private programs for the separation of high grade office paper. EPA estimates that its mandatory program for separation of high grade office paper in Federal office buildings that employ 100 or more people will recover approximately 200,000 Mg (220,000 tons) of high grade paper fiber each year. Total savings are estimated at $7.4 million per year. Private companies have also implemented office paper recovery programs.

Separation of Corrugated Paper--

Many commercial establishments generate large quantities of waste corrugated and paperboard packaging materials. Rather than dispose of these salable products, they are kept separate from other refuse, baled onsite, and sold. Many commercial establishments own their own baling and storage equipment. Contracts for at least one year are set up with local waste paper dealers for transport and sale of the materials.

An estimated 30 percent of the corrugated waste and paperboard generated in the United States is recycled, much of it in this manner. Recovery rates are relatively high for two reasons. separating corrugated materials from other waste is relatively easy; and it reduces mixed-waste collection costs to the commercial establishments.

Separate Collection of Newsprint and Other Paper--

Separate curbside collection of newsprint and other paper is an innovation in solid waste management in the United States. EPA reports that in 1968 there were only two such collection systems; by 1978, there were 218. These programs generally depend upon voluntary participation by residents, who place newspaper and other suitable waste papers at the curbside on a scheduled collection day.

Weekly, biweekly, and monthly collections are most common. The materials are collected either in a separate truck, in racks suspended from the regular refuse collection truck, or in a container towed behind the regular refuse collection truck. The resident's task is relatively simple: newspapers are easy to separate, and preparation is minimal (i.e., tying the newspapers in bundles or placing them in paper bags). Many of these programs have been well received by residents. However, few of the programs have been mandatory, and aggressive public education and public awareness programs to encourage participation have been rare. Consequently, only an estimated 28 percent of newsprint discarded in 1978 was recovered through this and other newsprint recovery methods. Most of the recovered newsprint was from commercial sources.

Separate Collection of Various Materials--

Many communities have collected more than one material via source separation, but such programs are less common than single material programs. Two separate collection programs for various materials in Somerville and Marblehead, Massachusetts, have received national attention through EPA grants. These programs provide weekly collection of separated paper, glass, and cans. They use the town collection crews and special compartmentalized vehicles to collect the separated materials.

One of the problems with the multimaterial program is that the burden of separating and storing several different materials until collection day reduces the resident's willingness to participate. In Somerville, this problem was alleviated by permitting residents to store glass and cans together in a single container. Because residents are not required to separate the glass by color, only two containers (i.e., one for paper, one for glass and cans) and two levels of separation were required.

In Marblehead, residents separate their materials in nearly the same way. However, in that program, clear glass and cans must be kept separate from colored glass and cans. Neither program requires residents to remove labels, crush cans, or wash containers.

Both communities have sought to increase participation through aggressive and continuing public awareness programs. As a result, nearly 25 percent of municipal waste in Marblehead and about eight percent in Somerville was recycled. The Marblehead program has continued since the demonstration program until the present. However, the Somerville program has since been discontinued because of inefficient collection and marketing difficulties.

The materials were sold to a local processor who separated the cans and glass by a relatively simple mechanical and magnetic process. This processor purchased materials from other communities in the same area, several of which rely on private contractors to collect and deliver the materials.

The profitability of these multimaterial programs depends on favorable prices, efficient collection techniques, and high participation rates. Somerville's program was not profitable during the latest period for which cost data were available (1977); Marblehead's was.

Beverage Container Deposits--

Beverage container deposits have been in use for a long time. However, deposits in the United States had nearly disappeared, in favor of "no-deposit, no-return" containers, by 1970. In an effort to conserve materials and energy and to reduce roadside litter, seven states (Maine, Vermont, Connecticut, Oregon, Iowa, Delaware, and Michigan) have instituted mandatory deposit systems for beverage containers, including bottles and cans. Retailers are required to pay customers between five and ten cents for each returned container.

As in the case of the recycling center, the resident himself is responsible for transporting the glass and cans. In Oregon and Vermont, the program has achieved return rates of 90 percent or more for returnable bottles and cans: residents find it convenient to return these materials to supermarkets or grocery stores on a regular trip, and the refund is substantial. The deposit system is maintained by the beverage container retailers and distributors, and no municipal involvement is necessary.

Early experience with mandatory state-wide deposit systems has been favorable and other states may pass similar legislation. However, in 1976, the U.S. Senate voted against an attempt to institute mandatory deposits nationwide. Nevertheless, since beer and soft drink containers represent about five percent of the net postconsumer and commercial solid waste stream, interest in mandatory deposit systems continues to be high.

Description of Source Separation Options--

Five source separation options are considered for Baselyn. Each is a feasible, tested option, and together they cover the spectrum of possible source separation programs. The options described in the following paragraphs include:

a. Multimaterial Recovery, High: Multimaterial source separation (newsprint, cans, and bottles) at a high recovery efficiency and separation of high grade office and corrugated paper

b. Multimaterial Recovery, Low: Multimaterial source separation at a low recovery efficiency without separation of office and corrugated papers

c. Newsprint Recovery, High: Separate collection of newsprint (mandatory program)

d. Newsprint Recovery, Low: Separate collection of newsprint (voluntary program)

e. Beverage Container Recovery: Recovery of beverage containers (only glass and metal cans) through a beverage container deposit system.

The only source separation method excluded is the recycling center. This method has been excluded because the total impact of such a system on the waste flow of the community is relatively small (less than five percent recovery), and the cost and resources invested (including residents' trips to the recycling center) are much greater than for the other methods.

The profiles for the source separation cases are based, wherever possible, on ongoing or recent programs. In all cases, the source of information is documented, and assumptions or judgment are noted. The profiles of the two multimaterial source separation programs are based mainly on the programs in Somerville and Marblehead, Massachusetts; separate collection of newsprint, on EPA case studies of several newsprint recovery programs; and the beverage container recovery system, on the experience of Oregon and Vermont.

Multimaterial Recovery, High - Case No. 1--

This case represents the maximum poss[illegible] separation by residents. The profile is based primarily on [illegible], Massachusetts. West Orange, New Jersey and Nottingham, New Hampshire are other communities where more than one waste material is separated by residents. [illegible]sumes that residents separate their wastes into four categories: (1) mixed paper, such as newsprint, books, corrugated containers; (2) clear glass and cans mixed; (3) colored glass and cans mixed; and (4) remaining mixed waste, such as organic and food waste and plastics. Wastes in the first three categories are picked up at curbside by municipal crews and sold to an intermediate materials processor who sorts and packages them for direct resale to manufacturers

There is also a privately operated program for separation of commercial office and corrugated paper wastes. Commercial establishments separate paper wastes, using desk top collectors, and sell them directly to the intermediate materials processor. Remaining mixed wastes from both residences and commercial establishments are used for landfill or delivered to a mixed-waste processing facility.

Program Description--Separated materials are collected by the municipality once a week at each residence by three person crews using special compartmentalized trucks with a capacity of 3.6 Mg (4 tons). Four crews and trucks operate each day, collecting an average of approximately six Mg (seven tons) each per day. Of the 180 Mg (200 tons) of total waste produced in Baselyn each day, 25.3 Mg (27.7 tons) are collected in this manner. Private firms collect 5.0 Mg (5.5 tons) of corrugated materials and 1.6 Mg (1.8 tons) of office paper from commercial business and office buildings.

The remaining waste is collected by three person crews with regular packer trucks. They collect an average of approximately 18 Mg (20 tons) each per day.

Without the source separation program, 10 crews and trucks would be needed to collect all of Baselyn's waste. With the source separation program, only eight crews and trucks are needed for the 149.6 Mg (164.9 tons) of waste remaining each day.

The source separation program recovers more newsprint and other household paper than any other separated material--12.2 Mg (13.4 tons), or 38 percent of the separated materials. Including office and corrugated paper, 59 percent of the separated materials are paper products (Table 2). The rates of recovery for each separated material are derived from the experience of Marblehead, Massachusetts and applied to national figures for the generation of waste.

Program Economics--The source separation program costs Baselyn $982 per day, or about $39 per Mg ($35 per ton) of separated materials. Revenue from sale of the recovered materials is $546 per day. The elimination of 31.8 Mg (35.1 tons) from the waste stream reduces disposal costs from $8,890 to $7,330 per day if the waste is used as landfill, or from $7,770 to $6,406 per day if the waste is delivered to a mixed-waste processing facility. Hence, the net daily disposal cost for Baselyn is $7,766 with landfill or $6,842 with mixed-waste processing. Source separation, then, saves Baselyn $1,124 per day if remaining wastes are used for landfill and $928 per day if they are delivered to a mixed-waste processing plant (Appendix A).

Energy Expenditures--High multimaterial source separation provides an energy return of 27 x 10^{10} Joules (2.57 x 10^{8} Btu) per day (Appendix A).

Contract Structure--At the outset of the source separation program, Baselyn offered separate one year contracts under competitive bidding for each of the separated materials: mixed paper (such as newsprint, books, and magazines), clear glass and cans mixed, and colored glass and cans mixed.

Bidders were asked to specify the net price per kg (ton) for each material, to guarantee a minimum price per Mg (ton), and to agree to purchase all collected materials. In return, the city agreed to collect each material separately and to store it in bins provided by the processor for periodic collection. Although Marblehead, Massachusetts, agreed to deliver its separated materials directly to the intermediate processor, this is an unusual practice. The processor usually picks up the collected materials, and this arrangement is most likely for new programs. The contracts granted the processor sole rights to all the separated material collected by Baselyn.

TABLE 2. RECOVERY EFFICIENCIES AND WASTE DISTRIBUTION FOR HIGH MULTIMATERIAL RECOVERY

Waste Components	Recovery Efficiency %*	Solid Waste Distribution Mg/d (t/d) Recovered Waste		Mg/d (t/d) Remaining Waste	
Newsprint	60	8.2	(9.0)	5.4	(6.0)
Other household paper	13	4.0	(4.4)	26.7	(29.4)
Subtotal		12.2	(13.4)	32.1	(35.4)
Corrugated	25	5.0	(5.5)	15.0	(16.5)
Office paper	25	1.6	(1.8)	4.7	(5.2)
Glass beverage	55	5.0	(5.5)	4.1	(4.5)
Other glass	54	4.6	(5.2)	4.0	(4.4)
Ferrous beverage	43	0.7	(0.9)	1.0	(1.1)
Other ferrous	36	2.2	(2.2)	3.6	(4.0)
Nonferrous beverage	50	0.5	(0.5)	0.5	(0.5)
Other nonferrous	0	0.0	(0.0)	0.5	(0.6)
Subtotal		19.6	(21.7)	33.3	(36.7)
Remaining waste	0	0.0	(0.0)	84.2	(92.8)
Total	0	31.8	(35.1)	149.6	(164.9)

* Recovery efficiencies are based on data available for the program in Marblehead, Mass., applied to national figures for the generation of waste(3,10).

Baselyn does not guarantee a minimum quantity or quality of wastes in its contract with the intermediate materials processor. However, municipal ordinances require residents to separate their waste and prohibit scavenging of separated materials. The contract requires the city to enforce these ordinances and take "reasonable steps" to avoid contamination of separated materials.

The city received bids from several intermediate processors. The highest bidder for all materials agreed to a price set at a fixed dollar amount per Mg (ton) under the wholesale market price published monthly in a trade journal. Monthly adjustments will be based on this published price, but the city is guaranteed a fixed floor price.

Baselyn has also entered into a contract with the operator of the mixed-waste processing facility. This contract requires the city to deliver all its remaining (i.e., unseparated) wastes to the facility for 20 years. It provides for renegotiation of prices and required delivery quantities at five year intervals, subject to binding arbitration if agreement is not reached. This contract is modeled after the one between the City of Milwaukee and Americology, Inc. The city pays a tipping fee for all mixed wastes delivered to the plant and, in turn, receives a share of the profits from ferrous materials recycled at the plant. The city is guaranteed a fixed revenue credit per ton for each recovered material up to a set market price; above this level, the city receives 50 percent of the market price.

The contract with the mixed-waste facility requires that Baselyn guarantee minimum deliveries of mixed solid wastes during the first five years of the agreement. The city is required to pay a minimum tipping fee regardless of actual deliveries. The required minimum tonnage and tipping fee are based on the past experience of the source separation program.

Social and Political Implications--The source separation program has been supported by a continuing program of public education stressing its financial and environmental benefits. Leaflets, doorknob hangers, and newspaper articles have been used. City officials, citizens groups, and the intermediate processor have all cooperated in the education program.

The issue of political support for the program arose during the campaign for the ordinance requiring curbside separation. This ordinance would not have been passed if a voluntary separation program had not been in existence for several years before the letting of contracts with the intermediate processor, as was the case in Marblehead, Massachusetts. The antiscavenger ordinance was less politically controversial. While both ordinances have proved somewhat difficult to enforce, the quantities of material collected increased substantially after their passage. This assumption is based on the experience of West Orange, New Jersey, where collection increased from an average of 83 Mg (92 tons) per month in 1976 to 180 Mg (200 tons) per month in 1977 after passage of an ordinance requiring source separation.(4)

Program Flexibility--Basclyn began its source separation program on approximately half its collection routes, which allowed testing of the procedures, as was the case in Madison, Wisconsin. After a one year trial period, the program was expanded to the remainder of the city with little difficulty. However, city officials reported they had an arduous and lengthy job (up to one year) persuading adjacent communities to enter the program.

The source separation program has not been interrupted since it began. City officials considered stopping the program when prices for recycled materials were low, however, they decided that the high recovery rate would probably decrease sharply as a result, with a proportional decrease in revenues when market prices recovered. Hempstead, New York, has abandoned its program, which formerly recycled large quantities of waste paper, despite current high prices for waste paper. This decision was based partially on the decrease in participation after the city suspended the program when paper prices were low. Recovery rates also fell in Somerville, Massachusetts, when the source separation program was resumed after an interruption. Local political commitment to the program and the floor price written into the contract with the intermediate processor give the program reasonable stability. However, the short term of the contract gives the city an escape if conditions change drastically.

Environmental Impacts--The source separation program has extended the 20-year life of the county's landfill by 3.6 years by recovering nearly 18 percent of total household wastes. However, there has been little change in the major environmental landfill problem: pollution of groundwater, rivers, and streams in the area due to leaching of groundwater. High levels of heavy metals, bacteria, and plant nutrients in leachate from the landfill are generated by the remaining material (other than that recovered), and would not be substantially altered by reducing the fill rate.

The most significant environmental benefits resulting from source separation stem from reuse of the separated materials. Manufacture of paper, metal, and glass products from recycled rather than raw materials has two effects on the environment: lower pollution emissions during the total production process and slower resource depletion. Table 3 compares the raw material use and environmental impacts of using recovered materials to produce four industrial products (aluminum, carbon steel, box board, and glass containers) with the impacts of producing the same products from virgin materials. The calculations assume manufacture of aluminum from all recycled cans; production of carbon steel from a mix of 70 percent source separated cans and 30 percent "in-house" steel mill scrap; box board, from 100 percent waste paper; and glass containers, from a mixture of raw materials and 50 percent "outside cullet" from recycled glass. The data indicate substantial reductions in the use of raw materials and, in most cases, reductions in industrial solid waste and water- and air-polluting emissions.

However, in some cases, processing recovered materials requires more energy, which may outweigh the benefits of reduced emissions during mining and transportation for raw materials. For example, more energy is needed to manufacture carbon steel when a large amount of scrap is used, because it requires using an electric furnace and a detinning operation rather than a basic oxygen furnace. Consequently, emissions of sulfur oxides, carbon monoxide, hydrocarbons, and nitrogen oxides are higher when scrap is used However, this result is based on the assumption that furnaces would meet all environmental standards, and many old furnaces currently in use do not meet these standards.

TABLE 3 HIGH MULTIMATERIAL SEPARATION COMPARISON OF ENVIRONMENTAL IMPACTS AND RESOURCE USE FOR INDUSTRIAL MATERIAL PRODUCTION USING SEPARATED WASTES AND RAW MATERIALS (in Kg/d (lb/d) unless otherwise specified)

Resource Use	Aluminum			Carbon Steel			Boxboard*			Glass Containers		
	Raw Materials		Recovered Materials	Raw Materials		Recovered Materials	Raw Materials		Recovered Materials	Raw Materials		Recovered Materials
Separated Materials			450 (1,000)			2,900 (6,400)			18,700 (41,200)			9,800 (21,600)
Industrial Material Production			392 (865)			3,3/5 (7,433)			15,677 (34,531)			19,600 (43,200)
Equivalent Raw Material Use	Bauxite	2,018 (4,444)	0 (0)	Iron Ore	4,215 (9,284)	0 (0)	Roundwood	48,927 (107,768)	0 (0)	Sand	13,141 (28,944)	
	Limestone	45 (100)	0 (0)	Limestone	1,179 (2,596)	225 (496)	Wood Chips	15,900 (35,060)	0 (0)	Limestone	7,453 (16,416)	
	Sodium Chloride	55 (121)	47 (104)	Sodium Chloride	0 (0)	267 (587)				Feldspar	1,569 (3,456)	
	Aluminum Fluoride	16 (35)	0 (0)	Sodium Nitrate	0 (0)	19 (45)						
	Cryolite	4 (9)	0 (0)	Other Fluxes	26 (53)	6 4 (14)						
	Fluorspar	20 (43)	0 (0)	Fluorspar	22 (43)	9 3 (20)						
				Scrap	1,123 (2,674)	1,174 (2,586)						
Pollution Residuals												
Solid Wastes	Overburden	11,318 (24,929)	107 (235)	Overburden	22,492 (49,542)	5,376 (11,841)				Overburden	0 (0)	0 (0)
	Process	6,082 (13,398)	119 (261)	Process	16,337 (35,984)	648 (1,427)	Process	2,973 (6,548)		Process	8,991 (19,805)	4,519 (9,954)
Water Pollutants												
Waste Water Discharge M^3/D (10^3 Gal/D)		-	-		-	-		(758)	(297)		(17)	(8 9)
BOD		0 05 (0 1)	0 (0)		0 01 (0 03)	0 (0)		78 (171)	24 (52)		1 3 (2.8)	0 7 (1.5)

(Continued)

TABLE 3 (Continued)

Resource Use	Aluminum Raw Materials	Aluminum Recovered Materials	Carbon Steel Raw Materials	Carbon Steel Recovered Materials	Boxboard Raw Materials	Boxboard Recovered Materials	Glass Containers Raw Materials	Glass Containers Recovered Materials
Suspended Solids	0 6 (1 4)	0 07 (0 15)	0 1 (0 20)	0 (0)	71 (156)	24 (52)	3 0 (6 7)	1 5 (3 3)
Dissolved Solids	7.3 (16 0)	0 2 (0 5)	3 8 (8 3)	1.3 (2 8)				
Air Pollutants								
Particulates	14 4 (31 7)	0 45 (1.0)	32.7 (72.1)	4 1 (9 0)	51 (112)	7 (16)	16 (36)	12 (26)
Sulfur Oxides	34 8 (76 7)	0 3 (0 6)	10 2 (22 5)	13.2 (29.0)	203 (447)	247 (544)	48 (105)	39 (85)
Carbon Monoxide	14 (30)	1 0 (2 1)	3 3 (7 2)	8 (18)	20 (44)	12 (26)	3.4 (7 4)	5 (12)
Hydrocarbons	34 (75)	2 0 (4 3)	6 0 (13 3)	7 (15)	7 (15)	3 1 (6 9)	6 (13)	5 (12)
Nitrogen Oxides	54 (120)	2.6 (5 7)	6 3 (13 8)	15 (34)	94 (208)	88 (194)	44 (98)	45 (100)

* Comparison based on combination paperboard from recycled paper, solid bleached paperboard from recycled paper, and solid bleached paperboard from raw materials.

Source Midwest Research Institute, Combination Paperboard and Solid Bleached Kraft Paperboard. Comparison of Costs and Environmental Impacts, 1972, U.S Environmental Protection Agency, Impacts of Virgin and Recycled Steel and Aluminum, 1974

Multimaterial Recovery, Low - Case No. 2--

This case is similar to Case No. 1, but differs in two major respects:

- The residential source separation program is voluntary rather than mandatory and participation rates are low, resulting in a lower recovery rate for paper, glass, and metals

- There is no program for recovery of office or corrugated paper wastes.

These differences result in lower program revenues and in lower energy, economic, and environmental benefits. However, the program demands less of homeowners and requires less effort on the part of the municipality.

The case is largely based on the program in Somerville, Massachusetts. Other communities operating similar voluntary multimaterial programs are Summit, Bound Brook, and Cranford, New Jersey.

Program Description--The program operates much the same as the program described in Case No. 1. However, residents are asked to separate wastes into only three components: (1) mixed papers, (2) mixed bottles and cans, and (3) all remaining wastes. Only two special trucks and crews are used and only 12.4 Mg (13.7 tons) of separated materials (6.9 percent of total waste) are collected each day (see Table 4). Recovery efficiencies for source separated materials are based on data from Somerville

Program Economics--The cost of the source separation program is $513 per day, or $41.20 per Mg ($37.45 per ton). Revenues are $303 per day. The source separation program reduces the community's total disposal costs by $399 per day with landfill, and $322 per day with delivery to a mixed-waste processing facility (see Appendix A).

Energy Expenditures--The energy return from source separation is 13 x 10^{10} Joules (121 x 10^6 Btu) per day. A net return of 2 x 10^{10} Joules per day is provided if the remaining waste is disposed of at the landfill.

TABLE 4. RECOVERY EFFICIENCIES AND WASTE DISTRIBUTION FOR LOW MULTIMATERIAL RECOVERY

Waste Components	Recovery Efficiency %	Solid Waste Distribution* Mg/d (t/d) Recovered Waste		Mg/d (t/d) Remaining Waste	
Newsprint	42	5.7	(6.3)	4.0	(8.8)
Other household paper	6	1.8	(2.0)	28.9	(31.8)
Subtotal		7.5	(8.3)	36.8	(40.6)
Glass beverage	26	2.4	(2.6)	6.7	(7.4)
Other glass	16	1.5	(1.6)	7.1	(7.8)
Ferrous beverage	12	0.2	(0.2)	1.6	(1.8)
Other ferrous	14	0.7	(0.8)	5.1	(5.6)
Nonferrous beverage	14	0.2	(0.2)	0.7	(0.8)
Other nonferrous	0	0.0	(0.0)	0.5	(0.6)
Subtotal		4.9	(5.4)	21.8	(24.0)
Remaining waste	0	0.0	(0.0)	110.4	(121.7)
Total		12.4	(13.7)	169.0	(186.3)

* Assuming 181.4 Mg/d (200 t/d) waste collected.

Contract Structure--Baselyn collects separated household wastes and sells them to one or more intermediate materials processors in essentially the same fashion as described in Case No. 1. It employs the same basic contract price structure: a guaranteed floor price with actual prices tied to market conditions by a published price.

In Case No. 2, however, waste separation by residents is voluntary, rather than mandatory. As in Case No. 1, there is an ordinance against scavenging.

Because waste separation is voluntary, Baselyn has no contractual commitment to enforce source separation by residents. As a result, both the city and the intermediate materials processor were somewhat more reluctant to enter into a long term contract. The period during which Baselyn agrees to sell its wastes to no other purchaser is still one year, but the contract specifies a severance period of only 30 days, during which either the city or the processor can discontinue the arrangement if waste volumes are less than expected. This provision is based on the procedure followed by Young-Guenther Company with communities in northern New Jersey that have voluntary separation programs.

Because the program does not include recovery of office paper, commercial establishments did not alter existing private disposal contracts.

Contract arrangements with the operator of the mixed-waste processing facility are essentially the same as those described in Case No. 1. However, the contract provides for renegotiation if Baselyn makes source separation mandatory or significantly alters the content of the waste stream. This provision is modeled after that contained in the contract between the City of Milwaukee and Americology, Inc.

Social and Political Implications--City officials and appropriate municipal departments publicized the source separation program in the beginning but did not continue to do so on a long term basis. Hence, volunteer citizens groups have borne the brunt of the public relations effort.

Because the program is voluntary, it has not been politically controversial or substantially changed the lifestyle of Baselyn residents.

Program Flexibility--The source separation program was implemented in two stages, as in Case No. 1. Municipal sanitation workers and residents take the program less seriously because it is voluntary, and contamination problems have been more severe.

The program was also discontinued temporarily on several occasions because of winter storms and strikes by sanitation workers. As a result, the program has not had the favorable publicity that might induce nearby communities to join, and expansion of the program has been more difficult than in Case No. 1.

Environmental Impacts--The source separation program has extended the life of the county's landfill by recovering nearly seven percent of Baselyn's household wastes. As in Case No. 1, the program has had little effect on groundwater pollution from the landfill.

Table 5 indicates the environmental benefits (that is, reduced use of raw materials and generally lower air and water pollution emissions) from one day's operation of the source separation program. Less separated materials are collected in Case No. 2 than in Case No. 1. therefore, less finished materials can be produced from them, and reductions in pollution emissions are proportionately lower.

Newsprint Recovery, High and Low - Case No. 3--

In this case, residents separate only one material; newsprint. Two subcases have been established for different rates of recovery: Case No. 3a, a mandatory program achieving 60 percent, and Case No. 3b, a voluntary program achieving only 20 percent, recovery. The high recovery efficiency corresponds to that achieved at Marblehead, but other features of the program's operation are more similar to those in communities where newsprint is collected in separate trucks (such as West Orange, New Jersey). The low recovery efficiency is typical of cities with voluntary newsprint only programs. There is no program of paper separation by commercial establishments.

Program Description--In Case No. 3a, the source separation program employs two special crews and trucks to collect newsprint. Each collects 4.1 Mg (4.5 tons) of newsprint per day.

TABLE 5 COMPARISON OF ENVIRONMENTAL IMPACTS
AND RESOURCE USE FOR LOW MULTIMATERIAL RECOVERY
(in kg/d (lb/d) unless otherwise specified)

Resource Use	Aluminum Raw Materials	Aluminum Recovered Materials	Carbon Steel	Carbon Steel Raw Materials	Carbon Steel Recovered Materials	Boxboard	Boxboard Raw Materials	Boxboard Recovered Materials	Glass Containers	Glass Containers Raw Materials	Glass Containers Recovered Materials
Separated Materials	-	180 (400)		-	900 (2,000)		-	7,500 (16,600)		-	3,800 (8,400)
Industrial Material Production	-	157 (345)		-	1,055 (2,323)		-	(6,319) (13,913)		-	7,600 (16,800)
Equivalent Raw Material Use											
Bauxite	807 (1,778)	0 (0)	Iron Ore	1,317 (2,901)	0 (0)	Roundwood	23,519 (51,806)	0 (0)	Sand	5,110 (11,256)	2,555 (5,628)
Limestone	18 (40)	0 (0)	Limestone	369 (812)	69 (153)	Wood Chips	7,652 (16,854)	0 (0)	Limestone	2,898 (6,354)	1,449 (3,192)
Sodium Chloride	22 (48)	19 (42)	Sodium Chloride	0 (0)	84 (184)			0 (0)	Feldspar	610 (1,344)	305 (672)
Aluminum Fluoride	6 (14)	0 (0)	Sodium Nitrate	0 (0)	6 (14)			0 (0)	Rock Salt	1,525 (3,360)	763 (1,680)
Cryolite	1.6 (3.5)	0 (0)	Other Fluxes	8 (18)	2.0 (4.4)						
Fluorspar	8 (17)	0 (0)	Fluorspar	7 (15)	2.9 (6.3)						
			In-House Scrap	351 (773)	367 (808)						
Pollution Residuals											
Solid Wastes											
Overburden	4,529 (9,975)	43 (94)		7,029 (15,482)	1,680 (3,700)		-	-		0 (0)	0 (0)

(Continued)

TABLE 5 (Continued)

Resource Use	Aluminum Raw Materials	Aluminum Recovered Materials	Carbon Steel Raw Materials	Carbon Steel Recovered Materials	Boxboard Raw Materials	Boxboard Recovered Materials	Glass Containers Raw Materials	Glass Containers Recovered Materials
Process	2,888 (5,361)	47 (104)	5,105 (11,235)	200 (446)	1,429 (3,148)	1,953 (4,301)	3,498 (7,702)	1,757 (3,871)
Water Pollutants Wastewater M^3/D (10^3 Gal/D)								
Suspended Solids	0 4 (0 6)	0 04 (0 06)	0.03 (0 06)		284 (75)	95 (25)	9 8 (2 6)	4 9 (1 3)
Dissolved Solids	2 9 (6 4)	0.09 (0 13)	1 2 (2 6)	0 4 (0.9)	-	-	-	-
BOD	0 04 (05)	0 (0)	Trace	0 (0)	37 (82)	11 (25)	0 5 (1 1)	0 3 (0.6)
Oil and Grease	0 2 (0 4)	0 (0)	Trace	Trace	-	-	-	-
Air Pollutants								
Particulates	5 76 (12 69)	0.19 (0 41)	10 22 (22.50)	1 28 (2 82)	25 (54)	3.5 (7 6)	6 (14)	5 (10)
Sulfur Dioxide	13 93 (30 69)	0 11 (0 25)	3 20 (7 04)	4 13 (9.10)	98 (215)	118 (261)	19 (41)	.5 (33)
Carbon Monoxide	5 45 (12.00)	0 38 (0 83)	1 01 (2.23)	2 60 (5.73)	10 (21)	5 (12)	1 3 (2 9)	2 0 (4 5)
Hydrocarbons	13 65 (30 06)	0 79 (1.74)	1 84 (4 14)	2 2 (4 73)	3 2 (7 0)	1 5 (3 3)	2 3 (5 0)	2.0 (4 5)
Land Acres Disturbed		-	-	-				

Source Midwest Research Institute, Combination Paperboard and Solid Bleached Kraft Paperboard. Comparison of Costs and Environmental Impacts 1972

U S Environmental Protection Agency, Impacts of Virgin and Recycled Steel and Aluminum, 1974

In Case No. 3b, racks with the capacity to carry 90-135 kilograms (200-300 pounds) of newsprint are installed underneath the regular refuse trucks. A total of 2.7 Mg (three tons) of newsprint are collected each day (see Table 6).

Program Economics--Both programs reduce disposal costs (see Appendix A). In Case No. 3a, the program costs $503 per day and has total revenues of $270 per day. It reduces net disposal costs by $167 per day if the newspapers would otherwise have been used for landfill and by $117 per day if the newspapers would have been delivered to a mixed-waste processing plant. In Case No. 3b, the program incurs no costs but has revenues of $90 per day. It reduces net disposal costs by $223 per day with landfill and by $207 per day with mixed-waste processing.

Energy Expenditures--High newsprint recovery provides an energy return of 71×10^9 Joules (67×10^6 Btu) per day. The program in Case No. 3b provides a return of 25×10^9 Joules (24×10^6 Btu) per day (see Appendix A).

Contract Structure--The contract arrangements in these two cases are similar to those in Case No. 1. However, since only newsprint, rather than mixed wastepaper, is separated by homeowners, the material requires less handling by the intermediate processor. Consequently, the processor pays higher floor and market prices.

Neither Case No. 3a or 3b includes a program for separation of office waste paper. Therefore, commercial establishments are not required to alter any existing private disposal contracts.

Contract arrangements with the operator or the mixed-waste processing plant are essentially the same as those in Case No. 1. However, for Case No. 3b, an additional clause specifies that the contract may be renegotiated if Baselyn makes source separation mandatory or significantly alters the content of the waste stream.

TABLE 6. RECOVERY EFFICIENCIES AND WASTE DISTRIBUTION FOR NEWSPRINT RECOVERY (HIGH AND LOW)

Waste Components	Recovery Efficiency %	Solid Waste Distribution* Mg/d (t/d) Recovered Waste	Solid Waste Distribution* Mg/d (t/d) Remaining Waste
Newsprint recovery, high	60	8.2 (9.0)	173.3 (191.0)
Newsprint recovery, low	20	2.7 (3.0)	178.7 (197.0)

* Assuming 181.4 Mg/d (200 t/d) collected waste.

Source: Recovery efficiencies were taken from actual efficiencies found in Marblehead, Massachusetts, and West Orange, New Jersey.

Social and Political Implications--The programs differ in their social and political implications; Case No. 3a is similar to Case No. 1, and Case No. 3b is similar to Case No. 2. The voluntary program would probably be less controversial, but also less effective than a mandatory program. In addition, long-term public support would probably be harder to establish for a voluntary program.

Each case includes an ordinance against scavenging. Both Cases No. 3a and 3b are less burdensome for Baselyn residents than multimaterial separation (Cases No. 1 and 2).

Program Flexibility--These programs for separating only newsprint have the advantage of initial simplicity, because many (perhaps most) residents bundle newspapers separately even when they are collected with other waste. The programs are easily explained to residents and easily extended within the city or to other communities. These programs also educate residents to the benefits of source separation and make future expansion of the program to other materials much easier.

The voluntary program can be cancelled on short notice if market conditions are unfavorable. While this flexibility is an advantage for the city, it is a liability for the intermediate materials processors, as it makes long-term planning difficult.

Environmental Impacts--Both Cases No. 3a and 3b extend the life of the county's landfill somewhat. There is little or no change in the effects of the landfill on groundwater quality in the area.

Collection of only newsprint increases the likelihood that the collected material will be recycled to produce new newsprint rather than combination paperboard, although both products could be produced.

Table 7 compares the raw material use and environmental impacts of producing new newsprint (from a one-day accumulation of waste newsprint) with the impacts of producing newsprint from raw materials. The figures show that Case No. 3b provides the smallest environmental benefits of all the cases. Production of newsprint from wastepaper results in lower emissions of most air pollutants, although emissions of sulful dioxide are significantly higher. However, water pollutants are higher for use of recycled paper (primarily due to de-inking).

Beverage Container Recovery - Case No. 4--

This case differs appreciably from the others in that it results from state legislation rather than local initiative. The program is similar to those legislated in Oregon, Vermont, and Maine. While several county and municipal governments (including Montgomery and Howard Counties, Maryland, and Berkeley, California) have passed ordinances requiring deposits, these ordinances have generally been challenged on legal grounds. Baselyn's waste disposal operation is not altered in this case, since consumers return beverage containers directly to retail stores or refund facilities. There is increased inconvenience and expense for certain private businesses, but no new local contract arrangements are required. The recovery rate is 90 percent.

TABLE 7 COMPARISON OF ENVIRONMENTAL IMPACTS AND RESOURCE USE FOR NEWSPRINT PRODUCTION USING RECOVERED PAPER AND RAW MATERIALS

Resource Use kg/d (lb/d)	Newsprint Recovery, High: Raw Materials	Newsprint Recovery, High: Recovered Materials	Newsprint Recovery, Low: Raw Materials	Newsprint Recovery, Low: Recovered Materials
Recovered materials		8,200 (18,000)		2,700 (6,000)
Finished newsprint production				
Equivalent raw material use				
Roundwood	14,720 (32,430)	-	491 (1,081)	
Wood chips	4,850 (10,680)	-	1,620 (3,560)	
Pollution residuals[a]				
Solid waste process	1,038 (2,287)		346 (762)	510 (1,123)
Water pollutants				
Waste water volume m^3 (10^3 gallons)	587 (155.1)	589 (155.7)	196 (51 7)	196 (51 9)
Total suspended solids	20 (45)	41 (90)	7 (15)	14 (30)
BOD_5	17 (37 5)	34 (75)	5.7 (12 5)	11 (25)
Air pollutants				
Particulates	10 4 (22 8)	3 6 (7 95)	3 5 (7 6)	1 20 (2 65)
Sulfur dioxide	69 3 (152 7)	108 (237)	23 1 (50 9)	35 9 (79 0)
Hydrogen sulfide	3 0 (6 6)	0 0 (0)	1 0 (2.2)	0 0 (0)
Other sulfur compounds		0 0 (0)	0 89 (1 95)	0 0 (0)
Carbon monoxide	7.1 (15 7)	4 5 (10 0)	2 38 (5 25)	1 52 (3 35)
Nitrogen oxides	41 0 (90 3)	39 0 (85 8)	13 7 (30 1)	13 0 (18 6)
Land				
Hectares (Acres) disturbed	5 9 (14 5)	0 0 (0 0)	2.0 (4 84)	0.0 (0 0)

[a] kg/d (lb/d) unless otherwise specified

Source Midwest Research Institute, Combination Paperboard and Solid Bleached Paperboard. Comparison of Costs and Environmental Impacts. 1972

Program Economics--The program is entirely within the private sector and does not require direct expenditures of municipal funds. However, removing beverage containers from the waste stream reduces the total volume of remaining waste and the associated handling costs. Approximately 10.7 Mg (11.8 tons) of beverage containers are recovered each day (see Table 8). However, the operator of a mixed-waste processing facility might raise the tipping fee if beverage containers are removed from the waste stream. To simplify the analysis, however, no raise has been included.

TABLE 8. WASTE DISTRIBUTION FOR BEVERAGE CONTAINER RECOVERY (90 Percent Recovery)*

Container Type	Solid Waste Distributions** Mg/d (t/d) Recovered Waste	Solid Waste Distributions** Mg/d (t/d) Remaining Waste
Glass beverage	8.2 (9.0)	0.9 (1.0)
Ferrous beverage	1.5 (1.7)	0.2 (0.3)
Nonferrous beverage	1.0 (1.0)	0.1 (0.1)
Remaining waste		169.7 (186.9)
Total	10.7 (11.8)	170.9 (188.2)

* Assumed to be typical based on experiences in Oregon, Vermont, and Maine.

** Assuming 181.4 Mg (200 tons) per day of collected waste.

Energy Expenditures--Beverage container recovery provides a net energy return of 102 x 10^9 Joules (969.3 x 10^5 Btu) per day. Appreciable energy is conserved through use of recycled rather than raw materials to manufacture beverage containers (see Appendix A).

Contract Structure--Because this case does not include a program for collection of office waste paper, existing contract arrangements for waste disposal need not be altered. Contract arrangements between Baselyn and the operator of the mixed-waste facility are similar to those discussed in Case No. 1.

Social and Political Implications--Although mandatory beverage deposit legislation is usually very controversial, the political conflict is generally expressed at the state rather than local level. Therefore, no local public education program or new ordinances are required.

Program Flexibility--This program is legislated by the state and, therefore, is inherently inflexible. It is implemented uniformly across the entire service area. Recovery efficiency should be relatively constant, provided deposits keep up with inflation. This stability allows intermediate materials processors and operators of mixed-waste facilities a high degree of certainty for capital investment planning.

Environmental Impacts--The mandatory deposit program would extend the life of the county landfill slightly. There would be little effect on groundwater pollution problems caused by landfill. However, roadside litter in the community would be reduced -- an aesthetic benefit unlikely to accrue in other cases. Vermont experienced a two-thirds reduction in the beverage container portion of roadside litter.(5)

Environmental benefits from manufacturing industrial products (aluminum, steel, and glass beverage containers) from recovered materials rather than raw materials are displayed in Table 9. For glass containers, data for resource use are from a 1974 EPA study(6) and are based on a comparison of one-way and refillable glass bottles made from all raw materials and a hypothetical case assuming 100 percent recycled cullet. Data for environmental impacts are not shown, as this study assumed operation of a mixed-waste processing plant to separate cullet. No reduction in resource use or pollution emissions due to a likely change in the mix of refillable and one-way containers has been included.

TABLE 9 COMPARISON OF ENVIRONMENTAL IMPACTS AND RESOURCE USE FOR BEVERAGE CONTAINER PRODUCTION USING RAW AND RECOVERED MATERIALS (in Kg/d (lb/d) unless otherwise specified)

Resource Use	Aluminum			Carbon Steel			Glass Beverage Containers[a]		
		Raw Materials	Recovered Materials		Raw Materials	Recovered Materials		Raw Materials	Recovered Materials
Recovered Materials			817 (1,800)			1,634 (3,600)			8,165 (18,000)
Industrial Material Production			707 (1,557)			1,898 (4,181)			43,902 one-way bottles or 29,508 refillable bottles
Equivalent Raw Material Use									
							Wood Fibers	1,717 (3,777)	818 (1,804)
	Limestone	82 (180)	0 (0)	Limestone	663 (1,460)	127 (279)	Limestone	3,538 (7,784)	558 (1,231)
	Cryolite	7 (16)	0 (0)	Iron Ore	2,371 (5,222)	0 (0)	Iron Ore	116 (255)	116 (255)
	Sodium Chloride	99 (218)	85 (188)	Sodium Chloride	0 (0)	150 (330)	Sodium Chloride	1,858 (4,087)	342 (755)
	Fluorspar	35 (77)	0 (0)	Sodium Nitrate	0 (0)	11 8 (26 1)	Glass Sand	5,346 (11,761)	802 (1,767)
	Bauxite	3,632 (7,999)	0 (0)	Fluorspar	12 (27)	5 (11)	Natural Soda Ash	628 (1,381)	94 (207)
	Aluminum Fluoride	29 (63)	0 (0)	Other Fluxes	15 (32)	3 6 (7.9)	Water M^3 (10^3 Gal/D)	575 (152)	238 (63)
				In-House Scrap	632 (1,392)	661 (1,455)	Feldspar	611 (1,345)	92 (202)
Pollution Residuals									
Solid Wastes - Mining		20,372 (44,872)	192 (423)		12,652 (27,867)	3,024 (6,661)			

(Continued)

TABLE 9 (Continued)

Resource Use	Aluminum Raw Materials	Aluminum Recovered Materials	Carbon Steel Raw Materials	Carbon Steel Recovered Materials	Glass Beverage Containers* Raw Materials	Glass Beverage Containers* Recovered Materials
- Process	10,949 (24,116)	213 (470)	8,189 (20,241)	365 (470)		
Water Pollutants						
Suspended Solids	1.1 (2 5)	0 14 (0 3)	0 05 (0 1)	0 (0)		
Dissolved Solids	13 (29)	0 4 (0 9)	2 1 (4 7)	0 7 (1 6)		
BOD	0 09	-	0.01	-		
Air Pollutants						
Particulates	26 (57)	0 8 (1 8)	18 (41)	2 (5)		
Sulfur Oxides	63 (138)	0.5 (1.1)	6 (13)	7 (16)		
Carbon Monoxide	26 (54)	1 7 (3 7)	2 (4)	5 (10)		
Hydrocarbons	61 (135)	3 5 (7 8)	3 4 (7 5)	3 9 (8.5)		
Nitrogen Oxides	98 (216)	4 7 (10 3)	3 5 (7 7)	8 6 (19)		

* For glass containers, data are from the 19[illegible] EPA study, "Resource and Environmental Profile Analysis of Nine Beverage Container Alternatives", and are based on a comparison of one-way and 10-trip refillable glass bottles.

MIXED-WASTE PROCESSING OPTIONS

Resource recovery from mixed municipal solid wastes requires centralized processing to separate recyclable materials and to convert the remaining mixed fractions into useful materials or forms of energy. Because of the heterogeneous nature of mixed wastes and the economics of recovery, virtually all such processing systems are designed as multiple product operations. At a minimum, ferrous metal is magnetically extracted for recycling, and at least one major commodity is derived from the organic fraction--usually, but not necessarily, a fuel or steam.

Energy can be recovered as electricity, hot water or steam for domestic or industrial use or for district heating, steam for drying sewage sludge, or as fuel for later use.

The magnetic equipment required to separate ferrous metals from municipal solid waste is relatively inexpensive, simple to operate, and recovers a ferrous product. However, demand and prices paid for this product are relatively low.

Historically, heat recovery from incineration has been very limited in the United States. The heating value of U.S. refuse averages about 10.7×10^6 Joules per kg (4,600 Btu per lb). Nearly half this heat is usually dissipated to the atmosphere through the stack. Only a few U.S. incinerators are designed for heat recovery. Most European incinerators, in contrast, are large, modern installations built since World War Two which recover heat via boilers.

Depending on technologies and markets, inorganic materials selected for recycling besides ferrous metal can include glass cullet (either mixed-color or color-sorted), aluminum, and nonferrous metals. Alternatively, slag or frit can be thermally converted into various mixed inorganic fractions for use as a construction aggregate or in other building products, although these technologies have not been proven. Also, markets for these products have not yet been established.

The organic components of solid waste may also be converted into compost, animal feed, or chemical industry feedstocks. Mechanical processes for separating paper and plastics (the light fraction) from metals and glass (the heavy fraction) are under development by Triple S/Dynamics, Inc. of Dallas, Texas; Rader Company, Inc., Portland, Oregan; and Allis-Chalmers, Appleton, Wisconsin; among others. Paper fibers can be separated by the Black-Clawson Hydrapulper process, exemplified at Franklin, Ohio.

Modern mixed-waste processing plants are complex and capital intensive. A long-term commitment as well as sophisticated planning, management, and marketing are required to reduce amortization costs per unit of municipal solid waste. Most such facilities recover ferrous metal and energy in the form of refuse derived fuel (RDF) or steam.

In this study, the following mixed-waste processes have been selected as typical commercial alternatives:

- o Unprocessed combined waterwall combustion and ferrous (UWCF) recovery
- o Processed combined waterwall combustion and ferrous (PWCF) recovery
- o Refuse-derived fuel production and ferrous (RDFF) recovery
- o Modular incineration (MI).

MIXED-WASTE PROCESSING ALTERNATIVES(8,9)

Unprocessed Waterwall Combustion and Ferrous Recovery

This method of mixed-waste processing consists of mass burning of collected mixed-waste in a thick bed on a moving grate in a waterwall furnace. The waste is received in collection trucks which are weighed for billing and control purposes. The waste is dumped into a pit from which it is moved into the furnace by a grappel, screw, vibrating feeder, or a ram mechanism. The waste is burned on a moving grate in a thick mat provided with underfire and overfire air.

The hot combustion gases raise steam to as much as 4.8 MPa/468 C (690 psig/875°F) in the waterwall tubes and in downstream convection passes before passing through an electrostatic precipitator for particle emission control.

The bottom ash is quenched before passing over a magnetic separator to recover ferrous material. The residue is combined with the fly ash from the precipitator and sent to landfill.

Furnace capacities range from 50 to 1200 tons per day.

Examples: Chicago, Illinois; Harrisburg, Pennsylvania; Nashville, Tennessee; Saugus, Massachusetts.

See Figure 3 for a typical schematic.

Processed Waterwall Combustion and Ferrous Recovery

The waste is mechanically processed to concentrate the combustible fraction and to reduce particle size. The waste is received in collection trucks which are weighed for billing and control purposes. The waste is dumped onto conveyors for transport to a shredder. An air density separator divides the shredded waste into two fractions. The heavy underflow fraction is conveyed to a magnetic separator to recover ferrous material.

The alternative of air classifying prior to shredding has been suggested(7) to reduce wear on the shredder by removing metals, and particularly glass, before shredding. Shredding first tends to imbed finely divided glass into the combustible fraction which then tends to increase erosion in the furnace and may cause slagging problems as well.

The light overflow fraction is conveyed by the air to the waterwall furnace, where its combustion in suspension and in a thin bed on a traveling grate raises steam in the waterwall tubes and in convection passes. Due to the increased heating value and decreased ash content, higher quality steam

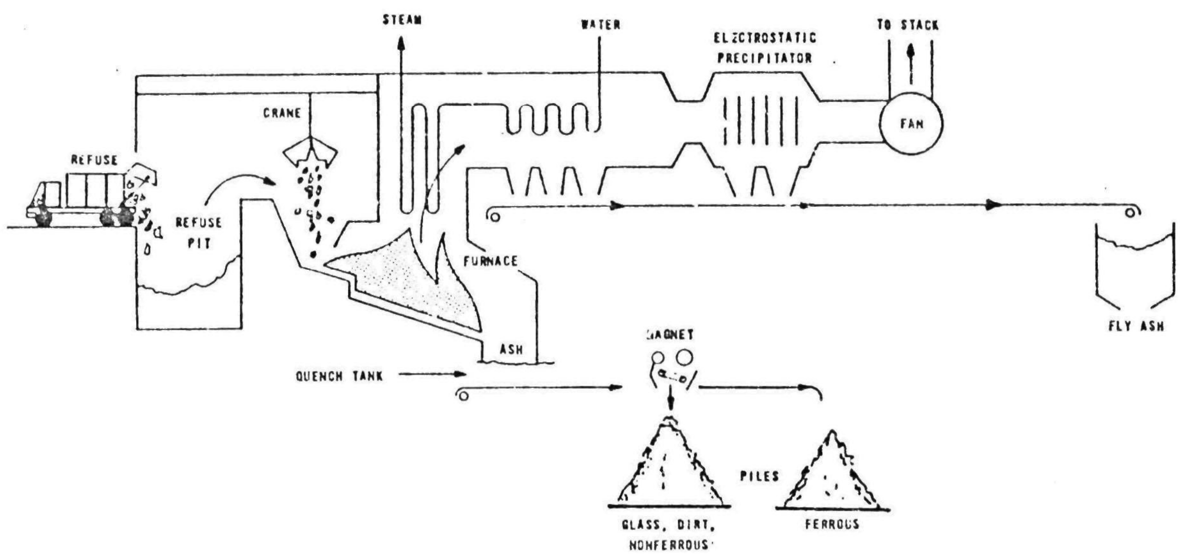

Figure 3. Unprocessed waterwall combustion and ferrous recovery.

up to 6.9 MPa/495 C (1000 psig/925°F) can be raised than that in an unprocessed waterwall facility. An electrostatic precipitator is used to control particle emission.

The glass, dirt, and non-ferrous material from the magnetic separator is combined with the bottom ash and the fly ash and sent to landfill.

Furnace capacities range from 50 to 1200 tons per day. Since not all the waste received passes through the furnace, more raw waste can be handled than in an unprocessed waterwall facility.

Examples: Detroit, Michigan; New Orleans, Louisiana; Niagara Falls, New York.

See Figure 4 for a typical flow sheet.

Refuse Derived Fuel Production and Ferrous Recovery

This alternative is somewhat similar to the previous one, but it allows combustion to take place away from the MWPF, if so desired or required.

Waste receiving, shredding, and classifying are done as previously, but the shredding is usually done to finer particle size. Shredding may take place in two stages, before and after air classifying. Magnetic separation is used to recover ferrous material. Tromelling may be used also as a separation means.

The combustible fraction may be pelletized, briquetted, or extruded for ease of handling during transport to a remote site, where it can be burned in a spreader-stoker or suspension-fired or semisuspension-fired furnace. Alternatively, it may be used directly, on site in a dedicated boiler or remotely. In any form, it may be burned either alone or mixed with coal, to raise high quality steam.

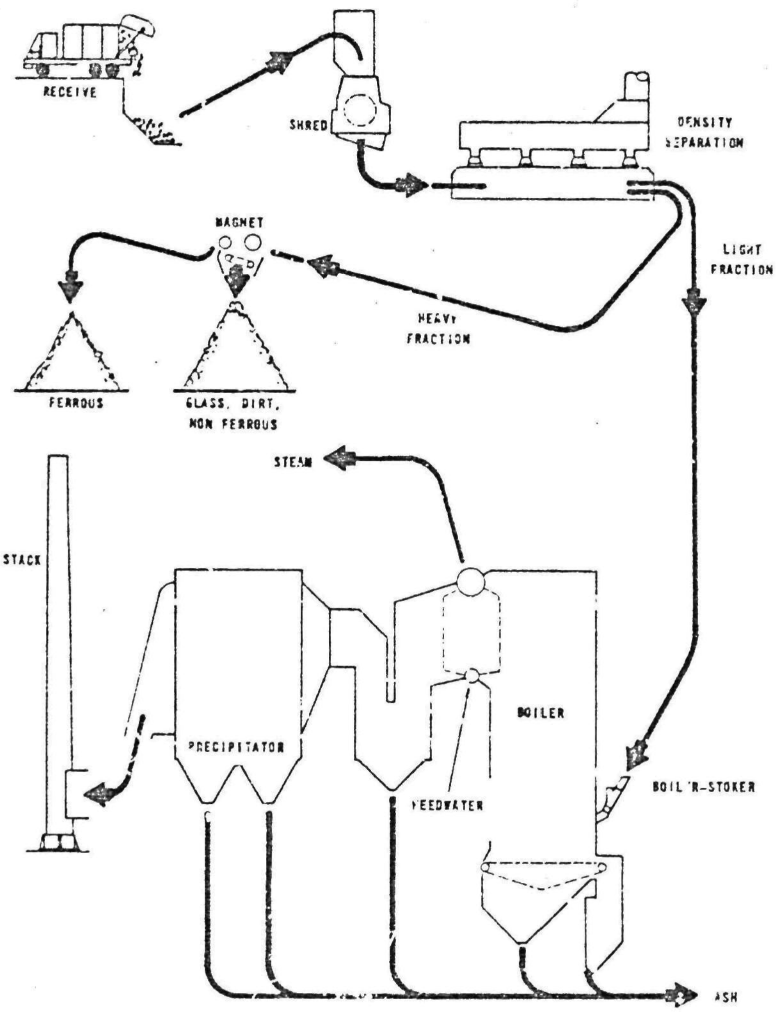

Figure 4. Processed waterwall combustion and ferrous recovery.

The residue from the magnetic separator is sent to landfill, along with bottom ash and fly ash if the RDF is consumed on site. Otherwise, the bottom and fly ash must be disposed of by the furnace operator.

Unfortunately, some of the combustible fraction is lost in the formation of RDF, so that the residue to landfill is increased over previous alternatives while Btu recovery is decreased.

Furnace capacities range from 100 to 2000 tons per day with correspondingly larger raw waste capacities.

Examples: RDF dedicated: Akron, Ohio; Ames, Iowa
RDF auxiliary: Bridgeport, Connecticut; St. Louis, Missouri.

Figure 5 shows the process of RDF production only, firing can be done as in the previous two figures.

Modular Incineration

Modular incinerators may be of the batch type or of the continuous feed type. A batch type is shown in Figure 6. Batch types are installed in municipal incinerator plants in identical modules to achieve the desired plant capacity.

Since a typical size is less than 50 tons per day, over 20 units would be required to handle 1000 tons per day of MSW. The probable arrangement would be to have several small plants located throughout the service area to reduce haulage costs rather than a single large plant.

The incinerator is loaded by a ram feeder which is remotely controlled by the operator of the loading vehicles that move the waste from the plant floor to the loader. The incoming waste is spot checked to remove items that are too large or otherwise incompatible with the feeder equipment. The removed items may be salvaged, separately shredded, or landfilled.

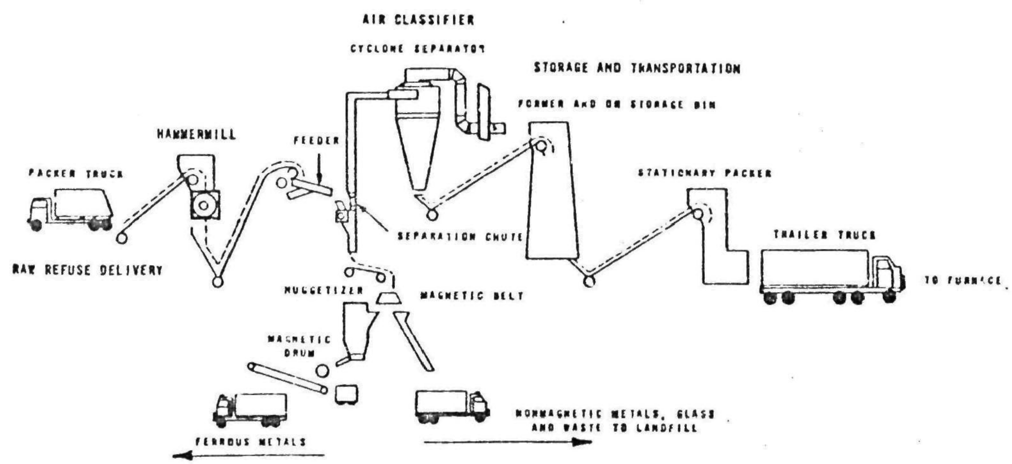

Figure 5. Refuse-derived fuel production and ferrous recovery.

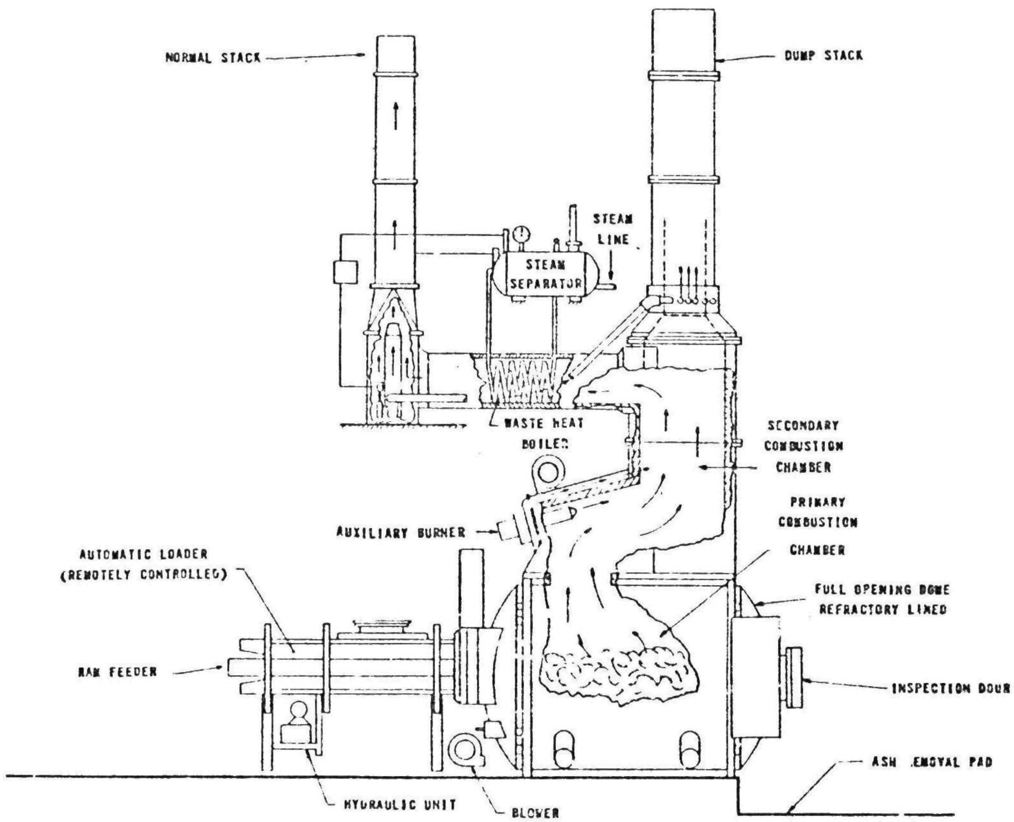

FIGURE 6. Modular incinerator.

There are five basic modes of operation: warm-up using the auxiliary burner, charging, burn-out, cooling, and cleaning. The waste in the unit at the end of the charging day is consumed during the burn-out period. The ash is relatively cool upon removal and quenching water is required only sparingly. No materials are recovered, all residue goes to landfill.

The modular incinerator has a primary combustion chamber operating on reduced ("starved") air and a secondary chamber operating on controlled excess air to assure complete combustion. The hot gases from the secondary combustion chamber can be exhausted directly out the dump stack or can be diverted through the tubes of a waste heat recovery boiler to generate saturated steam at 1.0 MPa/164 C (150 psig/328°F).

The air and fuel controls assure a more complete combustion and lower stack emissions. Pollution control equipment is not usually installed.

Examples: Blytheville, Arkansas; Groveton, New Hampshire; Salem, Virginia; Siloam Springs, Arkansas.

SECTION 4

THE OPERATOR'S VIEWPOINT

The operator of the mixed-waste processing facility has a major role in selecting the optimum resource recovery system for a community, which may include source separation. The operator has several objectives: To receive enough processible waste, to recover the full cost of operations and marketing, and to realize a reasonable profit. To achieve these objectives and avoid risks, the operator usually requires several guarantees from the community.

Source separation may or may not be explicitly covered in such contract provisions; moreover, detailed evaluations of its impacts have seldom been made. To assess its impacts, the effects of various source separation options on energy conservation, environmental quality, institutional considerations, and economics as they concern the operator of the mixed-waste facility are analyzed in this section.

ENERGY AND MATERIALS CONSERVATION

Issue

The primary energy and materials conservation issue for the operator is the effect of source separation on the production of usable plant energy (steam or electricity). The operator's main concern is the effect of the various source separation options on the quantity (tons per day) and quality (Btu per lb) of the municipal solid waste sent to the mixed-waste processing plant.

Objective

The objective of this section is to determine how source separation affects the production of usable plant steam energy.

Approach

Assumptions and Analysis--

The quantity and composition of the source-separated and mixed-waste processing streams developed for Baselyn, along with an assumed Btu content of each component in the streams, were used to calculate the Btu content of these streams. The following scenarios were used: 1) a fixed service area of 907 Mg (1000 tons) per day with either a fixed or variable plant size (as far as energy or material conservation are concerned, these two cases are the same), and 2) an expanded service area from which 907 Mg (1000 tons) per day is delivered to a 907 Mg (1000 tons) per day mixed waste processing facility.

Table 10 shows the Btu and ash or non-combustible content assumed for the components in the waste flow stream. The values used are typical of reported numbers for municipal solid waste although large variations, especially in the moisture content, are common.(11,12) Using the quantity and composition data for Baselyn and the assumed Btu and ash content of the individual components, the weight, non-combustible, and Btu content of the mixed-waste processing stream for each of the five source separation options were calculated.

Table 11 shows the results of these calculations expressed as a percent of either the total Btu content or the total weight of the mixed-waste generated. Since the composition of source separated and mixed-waste streams is the same for all scenarios, the percentages are the same for all scenarios (although the total quantity and energy content of the waste is different in each case).

TABLE 10. WASTE FLOW STREAM COMPOSITION AND HIGH HEATING VALUE (HHV)

Component	Composition (Wt %)	HHV (Btu/lb)	Ash (%)
Paper			
Newspaper	7.5	7,979	1.52
Office	3.5	6,088	13.72
Corrugated	11.0	7,043	5.34
Other	16.9	6,800	6.00
Glass			
Beer and soft drink	5.0	0	100.0
Other	4.8	0	100.0
Metals			
Ferrous	4.1	182	100.0
Nonferrous	0.8	182	100.0
Remaining waste	46.4	4,000	15.0
Total	100.0	4,600	23.9

The Btu recovery (as steam) for each option is the product of the Btu content of the mixed-waste processing stream and net energy efficiency for each mixed-waste process. The net energy efficiency is the energy recovered as steam minus the energy used in waste processing. The following net conversion efficiencies of mixed-waste processes were assumed: unprocessed waterwall combustion, 65%; processed waterwall combustion, 59%; refuse derived fuel, 58%; and modular incinerator, 60%. The net efficiencies are based on an energy analysis by Hecklinger(13) using, wherever possible, operating data, pilot plant data and conceptual designs. For the refuse-derived fuel alternative, it was assumed that the RDF was burned in a dedicated boiler.

TABLE 11. PERCENT WEIGHT AND PERCENT BTU CONTENT OF MIXED-WASTE PROCESS (MWP) STREAM FOR EACH SOURCE SEPARATION OPTION

Source Separation Option	Mixed Waste (Wt %)	Ferrous Material (Wt %)	Other Non-Combustible (Wt %)	Btu to MWP (Btu %)	Heating Value (Btu/lb)
Multimaterial, high	82.4	2.6	13.7	83.8	4660
Multimaterial, low	93.1	3.6	17.5	93.0	4590
Newsprint, high	95.5	4.1	19.6	92.2	4440
Newsprint, low	98.5	4.1	19.6	97.4	4550
Beverage containers	94.1	3.3	14.7	99.9	4890
No source separation	100.0	4.1	19.8	100.0	4600

Note: Expressed as percent of either the total weight or total Btu content of the mixed-waste generated.

Table 12 shows the calculated Btu recovery (as steam) expressed as a percent of the Btu content of the mixed-waste generated in the service area. Table 13 presents the amount of energy recovered for each alternative for the fixed and expanded areas scenarios. The Btu recovery calculations are a measure of both the efficiency of the process and the effect of source separation in reducing the amount of energy available for recovery. For the fixed service area scenario, the same Btu recovery will occur for both the fixed and variable plant size.

TABLE 12. BTUS RECOVERED AS STEAM IN BOTH FIXED AND EXPANDED SERVICE AREAS (%)

Source Separation Option	Unprocessed Waterwall Combustion	Processed Waterwall Combustion	Refuse-Derived Fuel	Modular Incinerator
Multimaterial, high	54	49	48	50
Multimaterial, low	60	54	54	56
Newsprint, high	60	54	53	55
Newsprint, low	63	58	56	58
Beverage containers	65	59	58	60
No source separation	65	59	58	60

Results--

As shown in Table 11, the type of source separation affects the Btu content of the mixed-waste processing stream. The separation of newsprint at high and low efficiency reduces the Btu content per pound of waste slightly (3.5 and 1.1 percent, respectively), whereas the separation of glass and metal enhances its content (6.2 percent). However, the variations of the Btu content resulting from source separation are small and well within the range of variation expected in raw municipal solid waste.

For a fixed service area, source separation reduces the total amount of Btu's going to mixed-waste processing and thus reduces both the percent and total amount of Btu recovery. The source separation option which removes the most Btus, multimaterial high, reduces energy recovery the most (around 16 percent).

TABLE 13. BTUS RECOVERED AS STEAM IN FIXED (EXPANDED) SERVICE AREA (10^9 Btu/Day)

Source Separation Option	Unprocessed Waterwall Combustion	Processed Waterwall Combustion	Refuse-Derived Fuel	Modular Incinerator
Multimaterial, high	5.01 (6.06)	4.55 (5.50)	4.47 (5.41)	4.63 (5.59)
Multimaterial, low	5.56 (5.97)	5.05 (5.42)	4.96 (5.32)	5.13 (5.51)
Newsprint, high	5.51 (5.77)	5.00 (5.24)	4.92 (5.15)	5.09 (5.33)
Newsprint, low	5.82 (5.92)	5.29 (5.37)	5.20 (5.28)	5.38 (5.46)
Beverage containers	5.97 (6.36)	5.42 (5.77)	5.33 (5.67)	5.51 (5.87)
No source separation	5.98 (-)*	5.43 (-)*	5.34 (-)*	5.52 (-)*

* Service area would not be expanded since fixed area alone supplies MWPF capacity of 1000 tons per day.

For an expanded service area, since a thousand tons per day are processed for each source separation option, the total Btu recovery for each waste processing option is proportional to the Btu content per pound of the mixed-waste processing stream. Therefore, the highest total Btu recovery (about 6 percent higher than for no source separation) is obtained with the source separation option that enhances the Btu content per pound the most (beverage containers). However, the percentage Btu recovery is, of course, the same for the fixed and expanded scenario.

It was assumed that Btu recovery w in the form of steam, the most common option. If some other form of Btu recovery is assumed, then the efficiency rating of the high technology options could change (for example, RDF can produce a higher quality steam and, thus, could rate better for producing electricity).

ENVIRONMENTAL IMPACT

Issues

Although energy and materials can be recovered from municipal solid waste, processing can be done in an environmentally acceptable manner. The recovery operation should not result in more air, land, and water pollution than from common landfill disposal techniques. If the recovery does result in more pollution, then a more-than-offsetting benefit should be achieved.

The operator is faced with two environmental issues: What are the emissions? How can they be controlled?

Objective

The objective of this section is to delineate, insofar as possible from available data, the amounts of pollutants emitted to the land, air, and water from each MSW source separation option, each resource recovery alternative, and their combinations, and how the emissions may be controlled.

Approach

Emission Standards--

Regulations established under the Federal Clean Air Act Amendments have set primary and secondary National Ambient Air Quality Standards (NAAQS). The NAAQS affect individual MWP plant emissions indirectly, in that operation of a new facility will not be permitted if it would cause the Air Quality Control Region (AQCR) in which it is located to violate NAAQS. In this case, or if the AQCR already violates NAAQS, emission controls and offsetting reduction in emissions elsewhere must be established to demonstrate that the net impact on air quality is maintained. This determination must be made on a site specific basis, typically using air quality modeling of ambient concentrations before and after operation of the new facility. Hence, NAAQS do not provide a direct guide to probable levels of emissions from a typical proposed MWP facility.

Under the same amendments, specific regulations have also been established to limit emissions to air of certain criteria pollutants from specific sources in order to prevent violations of the NAAQS. For instance, the New Source Performance Standards (NSPS) for coal-burning boilers used to generate electricity have established emission limits for particles, SO_2 and NO_x. NSPS has been established for incinerators, but it applies only to particles. No regulations have been specifically established for mixed-waste processing facilities as yet. The U.S. Environmental Protection Agency has ruled that a utility boiler that has been modified for MSW supplementary firing is not classed as a new stationary source of emissions, therefore, those standards applicable to coal-fired boilers will continue to apply. This means, in general, that refuse-derived fuel combustion would be covered by the existing standards.

While the NSPS for utility boilers are legally applicable to waste combustion only for co-firing of RDF, they regulate a source that is somewhat similar, and may provide a rough guide to possible future emission limitations for MWP facilities. Hence, these standards will be used as a point of comparison to evaluate whether emission control technology for SO_2 and NO_x might be required at typical MWP plants. The incinerator particulate standard, which is legally applicable, will be used for this pollutant. The relevant NSPS emission limits for incinerators and coal-burning utility boilers are given in Table 14.

Analysis--

Determining the amount of pollutants emitted required making several assumptions. It was assumed that the source separations were clean, with no waste carried over into the source separated material and with none of the source separated material left behind in the waste. Ferrous recovery was also assumed to be clean.

Assuming complete combustion, 1,000 tons per day of municipal solid waste was taken for the basis for calculations. The higher heating value of the waste was taken as 4,600 Btu per pound from the analysis previously given in this report (Table 10).

TABLE 14. NEW SOURCE PERFORMANCE STANDARDS

Pollutant	Utility Boilers [1]		Incinerators [2]
	ng/J	$lb/10^6$ Btu	gr/dscf
Particle	13	0.03	-
SO_2 [3]	<260	<0.60	-
NO_x	260	0.60	0.08 at 12% CO_2

1 Federal Register, 11 June 79, p. 33615

2 40 CFR Part 60.50.

3 Assuming less than 0.5% sulfur in MSW and 70% removal of SO_2 from stack gas.

The estimates of residuals to landfill in Table 15 were derived by doing a material balance on the ash content of the mixed-waste stream (see Table 10), assuming complete combustion for all MWP options. This assumption is reasonable because in actual operation combustion levels of at least 98 percent are typically achieved. Ferrous material recovery occurs for all processes except modular incineration; thus this option sends somewhat larger amounts to landfill. In preparing RDF, a portion of the MSW will not be burned (up to 25 percent), which increases landfill requirements for this option.

Particulate matter produced in pre- or postprocessing of the waste or residual was not included because it is insignificant compared to that produced in processing. Such particles will be captured in a baghouse or routed into the process in the input air stream.

The excess air assumed in burning and the standard cubic feet (scf) of flue gas produced per pound of processed waste are shown in Table 16.

TABLE 15. ENVIRONMENTAL EFFECTS: RESIDUALS TO LANDFILL TONS/DAY FOR 1,000 TONS OF MIXED-WASTE GENERATED

Source Separation Option	Mixed-Waste Processing Alternative			
	UWCF	PWCF	RDFF	MI
Multimaterial, high	137	137	337	163
Multimaterial, low	175	175	375	211
Newsprint, high	196	196	396	238
Newsprint, low	196	196	396	238
Beverage containers	147	147	347	180

TABLE 16. EXCESS AIR ASSUMED IN BURNING AND FLUE GAS AMOUNTS RESULTING

Technology Option	Excess Air (%)	Flue Gas scf/lb
Unprocessed waterwall combustion with ferrous recovery	75	75
Processed waterwall combustion with ferrous recovery	50	65
Refuse-derived fuel with ferrous recovery	50	65
Modular incinerator	50	65

The emission concentrations (Table 17) for air pollutants were taken from the literature on the various recovery techniques and from personal communications with vendors and operators (References 14 to 28), using considerable engineering judgment in view of the wide diversity in reported results.

TABLE 17. EMISSION CONCENTRATIONS FOR AIR POLLUTANTS

Technology Option	Emission Concentrations Particulate (g/scf)	SO_2 (ppm)	NO_x (ppm)
Unprocessed waterwall combustion with ferrous recovery	0.17	38	145
Processed waterwall combustion with ferrous recovery	0.07	241	168
Refuse-derived fuel with ferrous recovery	0.06	241	144
Modular incinerator	0.16	168	156

These concentrations were converted to tons per day of emissions from a 1,000 ton per day municipal solid waste processing plant by using appropriate equations to determine particulate and gas emissions (Appendix B).

Several assumptions were made in using published data to obtain the total air pollution emissions for each combined alternative. In all cases, we assumed that 900 Mg (1,000 tons) MSW per day were available from the collection area. This amount and the amounts remaining after applying the various source separation options were assumed to be processed through the various mixed-waste processing systems to produce steam, so the figures would be comparable. Three air pollutants were calculated: particulates, SO_2, and NO_x.

The pollutants emitted after source separation were ratioed on the basis of the heat content of the waste remaining to be processed, (Table 18).

TABLE 18. HEAT CONTENT OF WASTE REMAINING TO BE PROCESSED

Source Separation Option	Btu/day	MJ/day
Multimaterial, high	7.71×10^9	8.13×10^6
Multimaterial, low	8.55×10^9	9.02×10^6
Newsprint, high	8.48×10^9	8.94×10^6
Newsprint, low	8.96×10^9	9.45×10^6
Beverage containers	9.19×10^9	9.69×10^6

The air emissions calculated according to the methods given in Appendix B for the various recovery options are listed in Table 19.

Data on the composition of waste water pollutants resulting from mixed-waste processing facilities are limited. The total amount of discharged water serves as an indication of the magnitude of water pollution. One can also consider waste water quality and reductions in leachability of the residual solid waste from the processing plant as compared to the leachability of the raw waste.

Again, some assumptions were made. Only water actually used in processing the wastes is considered. The much larger boiler and cooling tower blowdowns required in steam production are not included.

The residuals to water were determined by mass inputs of the waste remaining after source separation, as follows:

TABLE 19. ENVIRONMENTAL EFFECTS: EMISSIONS TO AIR, TONS/DAY FOR 1,000 TONS OF MIXED-WASTE GENERATED

Source Separation Option		Mixed-Waste Processing Alternative			
		UWCF	PWCF	RDFF	MI
Multimaterial, high	(a)*	1.53	0.50	0.47	1.26
	(b)	0.43	2.35	2.35	1.63
	(c)	1.17	1.17	1.17	1.09
Multimaterial, low	(a)	1.69	0.56	0.52	1.40
	(b)	0.47	2.61	2.61	1.81
	(c)	1.30	1.30	1.12	1.21
Newsprint, high	(a)	1.68	0.55	0.52	1.38
	(b)	0.47	2.69	2.69	1.80
	(c)	1.29	1.29	1.11	1.20
Newsprint, low	(a)	1.77	0.58	0.55	1.46
	(b)	0.50	2.76	2.76	1.90
	(c)	1.36	1.36	1.17	1.27
Beverage containers	(a)	1.82	0.60	0.56	1.50
	(b)	0.51	2.80	2.80	1.95
	(c)	1.40	1.40	1.20	1.30
No source separation	(a)	1.82	0.60	0.56	1.50
	(b)	0.51	2.80	2.80	1.95
	(c)	1.40	1.40	1.20	1.30

* (a) Particles, (b) SO_2, (c) NO_x

Source Separation Option	Tons Per Day
Multimaterial, high	824
Multimaterial, low	931
Newsprint, high	955
Newsprint, low	985
Beverage containers	941.

After source separation, the quantity of material sent an MWP facility is the same; hence the ash content, as well as the water used for asn quenching and sluicing, is the same, except for modular incinerators.

The latter will require several units, perhaps as many as 20, to handle the postulated waste load. As a result their water discharge was set slightly greater than for the other processes. The waste water discharges are listed in Table 20.

TABLE 20. ENVIRONMENTAL EFFECTS: WASTEWATER DISCHARGED TONS/DAY FOR 1,000 TONS OF MIXED-WASTE GENERATED

Source Separation Option	Mixed-Waste Processing Alternative			
	UWCF	PWCF	RDFF	MI
Multimaterial, high	1,154	1,154	1,154	1,195
Multimaterial, low	1,303	1,303	1,303	1,350
Newsprint, high	1,337	1,337	1,337	1,385
Newsprint, low	1,379	1,379	1,379	1,428
Beverage containers	1,317	1,317	1,317	1,364

Few data are available on the composition of water pollution emissions resulting from mixed-waste processing facilities. The concentrations of pollutants in the wastewater from the various mixed-waste processing alternatives and from landfills are estimated in Table 21, which has been derived from data compiled in Reference 26.

TABLE 21. WASTEWATER POLLUTANT CONCENTRATIONS (ppm)

	Mixed-Waste Processing Alternative				Landfill Leachate	
	UWCF	PWCF	RDFF	MI	Residue	Direct
Aluminum	20	20	~0	20	NA	NA
Barium	5	5	5	5	NA	NA
Calcium	42	42	42	42	27	~3000
Chloride	~1000	~1000	~100	~1000	NA	~1000
Chromium	0.13	0.13	0.13	0.13	NA	NA
Copper	0.02	0.02	~0	0.02	1	~5
Cyanide	5	5	5	5	NA	NA
Iron	~0	~0	~0	1	~0.01	~1500
Lead	1	1	~0	1	0	~1
Manganese	0.3	0.3	~0	0.3	2	~75
Phenols	2	2	2	2	NA	NA
Phosphorus	~50	~50	~5	~50	NA	NA
Sulfate	~1000	~1000	~25	~1000	12	~2000
Zinc	2	2	~0	2	0.1	~200

Results--

Any of the source separation options will extend the life of a landfill. Low newsprint separation will extend it by only 1.5 percent, but high multimaterial separation will extend it by 17.6 percent. However, much greater extensions can be attained by coupling source separation with the mixed-waste processing alternatives, which yield landfill lifetime extensions of 76.2 to 86.3 percent. Obviously, the processing, not the separating, yields these larger extensions, because of the great reduction in mass and volume that results from combustion of the waste.

Source separation alone will cause little change in the major environmental problem of landfills namely, pollution of surface and groundwater resulting from leaching. Mixed-waste processing residuals are much less leachable, so that the problem is greatly reduced. These residuals typically contain less than 0.1 percent putrescibles. One caveat is necessary. In the preparation of RDF, a portion of the MSW (which may be as large as 25 percent) will not be burned, and, therefore, the total residual going to landfill will not be clean. In this case, the leachate problem is still troublesome. Encapsulating this unburned portion with the residual from burning in a correctly managed landfill will materially reduce leaching.

The flue gases from mixed-waste processing contain solid as well as gaseous pollutants. The concentrations vary considerably among processing alternatives. Emissions of SO_2 will be lower than from coal- and/or oil-fired plants with equivalent heat capacity, because refuse has a lower sulfur level. Chloride emissions can be as much as 2-1/4 to 7 times the 0.10 lbs of chloride ion per million Btu typical from coal(16,29), because refuse contains considerable quantities of chlorinated plastics. The chloride emission can create significant corrosion problems. Although it can be removed from the gas stream by scrubbing, its subsequent removal from the scrubbing water can result in water pollution. Chloride emissions to air are not presently believed to be an environmental hazard even in the absence of controls.(30) Trace elements such as beryllium, cadmium, copper, lead, and mercury have been reported to be present in the flyash from MSW combustion, at concentrations higher than in emissions from coal-only combustion. It is not known if these emissions are environmental hazards.(30)

In general, particulate emissions are high enough to present potentially significant problems for all combined alternatives involving mixed-waste processing facilities. High newsprint source separation significantly reduces particulate emissions for all alternatives.

For large facilities, an applicable EPA standard for particulates may be 13 ng/J (0.03 lb per 10^6 Btu), which is equivalent to 0.13 Mg (0.14 tons) per day in the Baselyn case. All mixed-waste processing alternatives will require particulate emission controls to meet existing and proposed standards. Electrostatic precipitators or baghouses are suitable control methods. Cyclones alone will probably not be suitable.

Emissions of SO_2 will be low enough because of the low sulfur content of the MSW (approximately 0.2% sulfur) that only 70 percent removal will be required if the utility NSPS is assumed to apply. The optimistic assumption is that desulfurization will not be required. However, the current approach in EPA seems to be to require scrubbing in all cases, so that some minimal SO_2 removal may probably be needed.

The EPA limit of NO_x under the utility NSPS, which is 0.27 gram per MJ (0.6 lb per 10^5 Btu) but which may not apply to these processes, equals 2.50 Mg per day (2.76 tons per day). It appears that NO_x controls would probably not be necessary if such a regulation were to be applied.

Few data are available on the composition of water pollution emissions resulting from mixed-waste procssing facilities. Water quenching of the ash is usually necessary to break up the clinkers and extinguish burning materials. Thus, water pollution problems can occur, but they should be successfully handled by straightforward industrial water treatment processes such as those currently applied at electric utility plants to very similar waste streams. Most operating mixed-waste processing facilities discharge their liquid wastes into municipal sewer systems. Usually, mixing the ash, processing, and any scrubbing wastewaters suffices for neutralization purposes. Total suspended solids are reduced by settling the mixed wastewater before discharge. The settled solids are periodically added to the residue going to landfills.(31)

Solid waste emissions consist of bottom and fly ash. Both can be disposed of in ordinary landfills such as those used by electric generating plants. The great reduction in residue volume and mass resulting from all the mixed-waste processing alternatives makes them far more attractive than direct landfilling of unprocessed waste. The probable reduction in residue leaching is also attractive. The reductions resulting from the various source separation options are much smaller than from mixed-waste processing and do not reduce leaching.

The air quality standards that the mixed-waste processing alternatives must meet are still unknown. Hence, actual emissions from an MWPF are difficult to predict. However, considering the standards applying to utility boilers of over 2,636 MJ per hr heat input (2.5×10^6 Btu/hr), 907 Mg/d (1000 tpd) yields about 0.13 Mg (0.14 tons) per day of particulate, 5.01 Mg (5.52 tons) per day of SO_2 and 2.92 Mg (3.22 tons) per day of NO_x.(29) Alternatively, the large incinerator standard yields 0.73 Mg (0.8 tons) per day of particulates.(32) For comparison, 9.7×10^6 MJ (9.2×10^9 Btu) per day from a three percent sulfur coal of 2.56×10^7 J per Kg (11,000 Btu per lb) would emit 22.7 Mg (25 tons) per day of SO_2 if uncontrolled. Allowable emissions from such a coal are 2.50 Mg (2.76 tons) of SO_2 per day. A percentage reduction with a floor, such as 0.27 gram SO_2 per MJ (0.6 lb SO_2 per 10^6 Btu), which is equivalent to 2.49 Mg (2.76 tons) per day of SO_2, will require desulfurization.

With or without source separation options, the mixed-waste processing alternatives of UWCF and MI will require particulate emission control. In view of the fact that the waste contains far less sulfur than coal or oil, possibly no SO_2 emission controls will be needed; however, if the applicable standard requires a 70 percent reduction, then desulfurization will be necessary. The source separation options change the SO_2 emissions by less than 20 percent, which is not significant. Emissions of NO_x do not appear to be a problem for any mixed-waste processing alternative regardless of the source separation option.

Inspection of Table 21 discloses that RDFF results in the least surface water pollution of the MWPF alternatives while other alternatives cannot be distinguished from the standpoint of concentration. Since MI discharges the most wastewater (see Table 20), it is probably the least desirable alternative, with RDFF being the most desirable.

The table indicates that the leachate from the residue of an MWPF has a much smaller impact on groundwater than does the leachate from the raw MSW when it is directly landfilled. Coupled with its smaller volume and higher density, the residue thus will contribute much less pollution to groundwater than will the raw waste.

Waste water discharges may be the most difficult to control, but relevant data are so sparse that it is premature to make any quantitative predictions at this time. Disposal to municipal sewer is the current practice.

Conclusions

The amount of residuals to be landfilled are greatly reduced by any of the mixed-waste processes. On the other hand, the reduction in landfill requirements due to the various source separation options are quite small. In summary, the reductions due to processing will significantly extend landfill life.

The foregoing environmental impact analysis shows that uncontrolled particulate emissions to the atmosphere will present a problem. Baghouses and electrostatic precipitators will reduce the emissions to suitable levels. Wet particulate control (scrubber) should be considered in view of the probable need for SO_2 control.

Emissions of SO_2 to the atmosphere may be excessive, depending on site- and process-specific control regulations. Since the probable required emission reductions are small, standard scrubbing techniques will be suitable means of control.

All mixed-waste processing facilities produce minimal NO_x emissions. Source separation effects are negligible.

Considering residuals to air and water, no mixed-waste processing alternative is clearly superior Multimaterial separation (either high or low) at the source is the desirable source separation alternative from the viewpoint of environmental impact.

Additional data on water pollutants are needed, both in water discharged directly and in leachate, before an assessment can be made of the most compatible resource recovery system. However, it appears that RDFF will be the most desirable option and MI the least desirable.

The great reduction in volume, mass, and leachability of the residuals to landfill from all the mixed-waste processing alternatives as compared to direct landfilling of wastes makes any processing alternative attractive, coupled with any form of source separation.

From environmental considerations alone, no mixed-waste processing alternative is uniquely selected, although MI and especially UWCF are favored. The various forms of paper separation, except the newsprint, low-recovery option, are favored. Any combinations of the favored options would also be suitable.

INSTITUTIONAL AND TECHNOLOGICAL IMPACT

Issues

Because it changes the quantity and quality of the waste stream, source separation can raise significant issues for several different types of private firms involved in solid waste disposal. For an operator of a mixed-waste processing plant, source separation offers both potential risks and benefits. The most important risks include:

- Reductions (or greater variability and uncertainity) in the supply of waste delivered to the plant, thus affecting its ability to operate efficiently

- Lower profits for plant operators hat result either from reduced tipping fees, reductions in wastes delivered to the plant, lower revenues from the sale of recovered materials, or increased operating costs

- Difficulties or increased costs in financing the plant, either through private capital or the sale of bonds.

Balanced against these risks are several potential benefits:

- Removal of unwanted materials from the waste stream (for example, removal of glass by source separation can lower facility maintenance costs by reducing erosion)

- The possibility of persuading additional communities to deliver their wastes to the facility if they can be assured that ongoing source separation programs can continue; thus, increased quantities of waste can be delivered to the plant.

Increasingly, local source separation programs have developed relationships with private companies or individual entrepreneurs. These companies act as brokers for the sale of separated materials to industrial purchasers and often partially process the material prior to resale. For these brokers who frequently act as catalysts for setting up local separate collection systems, mixed-waste processing plants pose a similar range of potential risks and benefits.

In some cases, when a major mixed-waste processing (MWP) plant is proposed, such small, local companies and their much larger customers (e.g., recycled newsprint and paperboard manufacturers) are frequently concerned that the municipality will redirect all wastes to the new MWP facility. As a result, local entrepreneurs would lose their source of supply and be forced to cease operations. For example, private entrepreneurs conducting source separation are currently opposing construction of a major MWP facility in Seattle, Washington.

On the other hand, the customers for the energy (steam, RDF, or electricity) or materials produced by the mixed-waste facility may feel that source separation could prevent the facility from producing required contract quantities. Such firms and MWP plant operators may desire legislative assurances from the municipality that all wastes from the area will be directed to the facility. When projects are financed by revenue bonds, underwriters may also favor such assurances, on the grounds that they make bond sales easier.

In this context, source separation is part of the larger issue of "flow control," that is, the ownership of wastes and the legal rights of political jurisdictions to specify where and how their wastes are to be disposed. This issue is of great concern to private refuse haulers, who may face increased tipping fees at an MWP plant, or private landfill operators, who fear that they will be forced out of business. These groups may find themselves allied with advocates of source separation against flow control legislation.

A recent bill in Akron, Ohio, requiring all wastes to be delivered to a planned MWP facility, is now being challenged in court. In several other cases, the political controversy resulting from similar legislation must be overcome before a successful solution to a regional solid waste problem can be implemented.

Objectives

It is important to determine whether most perceived conflicts between source separation and mixed-waste processing systems result from poor coordination or from inherent contradictions between the two resource recovery approaches under particular circumstances. Poor coordination can be avoided by well-written contracts that adequately share risks and revenues and by designing MWP facilities that are compatible with source separation programs. If, however, some or all approaches to source separation and mixed-waste processing are inherently conflicting, public officials will be required to make difficult political decision on the relative merits of each.

Five institutional and technological issues must be addressed by MWP plant operators and other interested private firms:

- o Can a reliable supply of municipal solid waste be assured for an MWP facility operator if source separation is also carried out in the service area?

- o Can an MWP facility operator maintain adequate profitability with source separation?

- o How does source separation influence the cost of private financing of an MWP facility?

- o Will source separation inhibit recycled materials purchasers and energy product consumers from committing themselves to product purchases?

- o Can mechanisms be identified that allow continuation and reasonable expansion of existing source separation programs in connection with implementation of an MWP facility?

To address these questions, implemented or proposed contractual arrangements of waste flow and profitability in several case studies will be analyzed. Those contract provisions and approaches that might serve as models for specific combinations of mixed-waste processing and source separation facilities in a community will be identified, using the hypothetical Baselyn community as an example.

Approach: Assumptions, Analysis, and Results

Typical provisions of a contract between operators of MWP facilities and municipalities are:

- o Long-term contracts for the delivery of waste to be accepted at a set charge ("tipping fee")

- o Guaranteed annual, weekly, or monthly tonnages to be delivered

- o Guaranteed payment of tipping fees whether or not delivery is made

- o Established (tipping) fees that cover all operating and maintenance costs, local property taxes on all facilities and equipment, and a reasonable profit

- o Automatic annual adjustment in dump fees that cover inflation

- o Adjustments in dump fees or participation in revenues from recovered products to account for significant changes in the composition of delivered wastes that affect either the cost of operations or the terms of the marketing agreements

- o Adjustments in dump fees to account for any uncontrollable increases in operating and maintenance costs beyond the annual rate of inflation

- o Deduction of the cost of marketing (e.g., transportation costs) from revenues from the sale of recovered products before such revenues are shared with other participants.

It is difficult to determine which factors are most important in specific contract agreements because of frequent trade-offs and compromises. Each case is unique, and the institutional area is particularly affected by psychological and political factors that cannot be anticipated. The best contract agreement for a given situation is probably not that which is most technically equitable to all sides, but rather one that is acceptable to all parties and provides a mechanism for resolving future contingencies. Moreover, all contract provisions are interrelated, even though they are discussed separately here.

Assurance of a Reliable Waste Stream

Most, if not all, municipal contracts with private operators of MWP facilities specify minimum daily or weekly quantities that must be delivered. These contracts require payment for this minimum amount even if it is not delivered (Appendix C). The specific wording of such "put or pay" provisions in the New Orleans and Milwaukee contracts are also included in Appendix C.

The quantities specified in such provisions are determined by each community's minimum expected waste generation for a given time period. The contract is generally fairly long; five years is the minimum time reported. From the operator's viewpoint, the length of the contract should correspond to the lifetime of the plant, generally between 20 and 25 years, and operators usually attempt to gain as long a contract as possible during negotiations.

Minimum quantity provisions are generally acceptable to communities with source separation programs, as long as the quantity specified corresponds to its estimates of the minimum quantity generated. In most communities (particularly in large metropolitan areas), source separation currently accounts for only a very small percentage of total waste generated. For example, in Massachusetts, source separation is particularly well established; 183 of the 351 cities and towns in the State have some form of recycling program. However, the average community with a separation program recovered only three percent of its total waste volume in this manner, and this sample excluded the largest cities (Boston, Worcester, and Springfield). Although a few small communities managed to recover as much as 24-25 percent of their total wastes via source separation, the total material recovered statewide in 1978 was less than one percent of all waste generated in the state.(33)

From practical experience, plant operators have noted that variations during the year in the quantity of waste generated are larger than the amount removed by source separation, and, as a result, have generally not seen source separation as an important factor in negotiating waste quantity provisions. Some operators have found communities reluctant to agree to long term contracts specifying set minimum quantities when the possibility arose that source separation could become more profitable in the future. This issue arose during negotiations for deliveries to the RESCO waterwall incineration plant in Saugus, Massachusetts, and was resolved by a contract provision that sets a 'base tonnage" for each community during the first year of deliveries to the plant. In subsequent years, each community may reduce its base tonnage by up to five percent per year and may deliver up to 10 percent less than the base tonnage:(34)

"For example, if a community delivered 100,000 tons to RESCO during year one of the contract, its base tonnage for year two would be 100,000 tons. If during the second year, the community started a source separation program it could deliver as little as 90,000 tons without penalty and could establish 95,000 as the base tonnage for year three. Then, in year three, it could deliver as little as 85,500 tons without penalty. This downward ratcheting of the base tonnage coupled with the 90 percent minimum delivery provision should accommodate a reasonably successful source separation program."

The operators of the RESCO facility see source separation as beneficial because of the removal of glass. Because substantial waste quantities are available in this area, they were willing to agree to liberal provisions on waste quantities in exchange for long term commitments. The same general mechanism could also be used in other situations with a smaller rate of annual decrease permitted. The phasing of reductions in waste quantities over a period of several years should allow operators sufficient time to obtain additional waste sources, as they would have to do if the population of the area declined.

Problems with assuring adequate waste supplies to an MWP facility are probably more likely to result from plant overdesign than from source separation. In planning for a number of proposed facilities (e.g., in Newark, New Jersey and Memphis, Tennessee), it has been determined that initial estimates of waste generation were too high. In other cases (as in Akron, Ohio), facilities have been designed to serve a region to achieve economies of scale, but contractual commitments to deliver wastes were obtained from only part of the service area.(35) This issue may lead to flow control legislation and political conflict with private haulers and supporters of source separation if the service area cannot be expanded. To prevent such situations from occurring, plant operators can size facilities according to the most accurate and conservative estimates of available wastes and provide capacity for subsequent facility expansion.

Assurance of Adequate Profitability--

The potential impact of source separation on profitability is usually the issue of greatest concern to the operator of an MWP facility.

Plant revenues are a combination of tipping fees charged for delivery of waste to the facility and revenues from the sale of recovered materials and energy. Because tipping fees should be as low as possible to compete with private or public landfills, the MWP plant profit structure may be set so that most of the profit is derived from selling recovered materials or energy. However, the components in the waste stream that are of the greatest value (such as aluminum) make up only a small percentage of the total, and their variable quantity is less well known than the total.

The possibility of source separation of such materials introduces an additional element of uncertainity and, hence, risk for the operator. As a result, the contract for the operation of the facility must adequately allow for this increased risk to provide sufficient profitability for the operator.

Several contractual approaches have been used for dealing with this issue. One method is to simply provide for renegotiated compensation (probably through increased tipping fees) if source separation programs are subsequently implemented. This approach is taken in New Orleans and Milwaukee. The Connecticut Resource Recovery Agency has a similar provision in the contract for its Bridgeport facility, but the operator must also demonstrate an operating loss of a set size before it becomes effective (see Appendix C). The New Orleans contract states that "if the quantity of recoverable resources in the solid waste delivered by the City or its delivering agent is significantly reduced as a result of laws or ordinances passed by the City ... the City shall provide offsetting adjustments to the corporation to compensate for the Corporation's loss of revenues."(35) This provision allows the operator to keep tipping fees as low as possible until source separation significantly affects his revenues. Without such provisions, the risk would probably be offset by a higher requested tipping fee at the onset of the project. Such provisions offer a reasonable means for risk sharing between public and private parties, while avoiding two extreme options: legislation forbidding source separation and allocation of all risks to the private sector (which would result in high bidding prices).

Another type of contract provision intended to resolve this issue defines a permissible maximum for materials removed from the waste stream by source separation. When this maximum is reached, the contract must be renegotiated. This type of provision is more likely to be used where source separation programs exist prior to an MWP facility, and greater experience with their impact is available. Such provisions, based on economic calculations by the prospective plant operator, are being included in service agreements for the proposed Northeast Project of the Massachusetts Bureau of Solid Waste Disposal in North Andover, Massachusetts. The proposed source separation agreement is included in Appendix C. In this facility, which would employ unprocessed waterwall combustion and ferrous recovery, removal of metals alone adversely affects the operator's revenues.(36) Glass removal has a beneficial effect that is explicitly provided for by including incentives for communities to remove it.

These provisions were set after substantial negotiation between communities engaged in source separation and the plant operators. The permissible maximum quantities allow for substantial expansion of existing source separation programs.

The specific provisions of this contract are unlikely to be applicable elsewhere. However, several features, including a maximum permissible quantity of source separation of particular materials according to expected revenue impacts, and an incentive for a compatible program, could be useful as a model for other communities.

Ultimately, the profitability of an MWP operator would be best protected by allowing the operator to act as a broker for the sale of source separated materials. In this manner, off-setting revenues would be available to cover any losses from the sale of either recovered materials or energy from the MWP plant. Several of the larger firms marketing MWP systems are moving in this direction. However, this approach could become politically controversial unless it can be used in conjunction with a means of paying communities differently according to the quantity and quality of the wastes they deliver to the plant.

Assurance of Sufficient Financing--

It is conceivable that source separation could create an additional uncertainty that would increase the risk of default on municipal bonds or private loans by MWP facility operators, and, hence, increase the cost of financing such a facility. This possibility was discussed during a series of interviews with private operators of MWP facilities and public agencies involved in such projects. These interviewees agreed that, rather than being reflected in higher interest rates, this uncertainty was usually accounted for by a higher degree of reliance on tipping fees by the plant operator for revenue, as opposed to revenues from selling energy and materials. When combined with contractual "put or pay" provisions specifying minimum quantities of waste that will be paid for regardless of deliveries, this profit structuring provides adequate assurance for bondholders or private investors that debt service charges will be covered. If contracts cannot be obtained, however, there may be pressure for flow control ordinances that would foreclose either source separation or disposal at private landfills.

Though data are limited on this issue, it appears unlikely that source separation would have an important effect on interest rates for public or private financing of MWP facilities. Rather, the uncertainty it creates will result in a higher tipping fee for each ton of waste delivered to the plant, and, hence, higher total disposal costs, unless municipalities are willing to share in some of the risks resulting from possible changes in the waste stream.

Assurance of Markets for Energy and Recovered Materials--

Review of current on-going projects for mixed-waste processing did not reveal any situations in which source separation programs have inhibited sales of recovered materials from mixed-waste plants. Such conflicts are probably unlikely. because recovered materials purchasers would also be able to purchase the source separated materials in this approach, and, hence, should be indifferent to their source of supply.

Energy product customers could conceivably be concerned about the possibility of source separation reducing the energy output of the facility.

As with the sale of materials from MWP plants, no clear-cut cases could be identified in which energy customer concern about source separation has become important.

Existing contracts for energy product sales indicate that customers of plants producing steam for district heating and industrial use are likely to be more sensitive to reductions in the Btu content of the waste stream than RDF purchasers. Steam customers require a minimum quantity on a continuing basis; lower-than-normal steam generation could be a major problem. There are some indications that concern about the reliability of steam deliveries played a role in development of Akron's flow control ordinance. On the other hand, RDF customers are purchasing a supplemental fuel that can be used as needed. Because alternative fuels must be available in any case, little penalty is attached to lower than expected RDF deliveries. Existing contracts for RDF deliveries have not generally attached penalties to lower than expected RDF deliveries. This fact is significant because utilities generally do not accept the risks associated with RDF use and transfer these risks to the mixed-waste processor.(37)

Despite the potential for conflict between steam customers and source separation, such problems are unlikely to interfere with project implementation as long as projects are sized in proper proportion to the amount of waste that is reliably available. If, however, this problem is not taken into account in the planning process, some potential purchasers could prove reluctant to commit themselves to buy such energy on a long term basis.

Assurance of Continuation of Source Separation Program--

Several means have been used to protect communities and entrepreneurs engaged in source separation programs. The state enabling legislation for the Connecticut Resources Recovery Authority includes a statement that local source separation cannot be discouraged or prohibited by the agency unless it can determine that source separation increases the total cost for solid waste management (Appendix C). The provisions in the proposed Northeast project contract stating maximum permissible amounts of source separation also protect such programs, at least until the upper limit is reached.

Technological Issue: Effect on Waste Stream Quality

Source separation not only changes the Btu content of the waste stream, it also changes its physical characteristics. When glass is removed, in particular, this change can be beneficial for the operator of a mixed-waste processing facility. Glass contained in municipal solid waste is the major cause of wear to shredders, waste conveyors, and other waste handling equipment in the MWP plant. In addition, glass not removed during air classification in making refuse-derived fuel results in lower heating value and greater ash content, which has caused problems in boiler operation due to slagging of the tube banks. Reducing glass inputs can thus substantially reduce facility maintenance.

In several instances (most notably the proposed Northeast facility in North Andover, Massachusetts) prospective operators of mixed-waste processing facilities have encouraged communities to conduct active glass removal programs. The beverage container recovery option and high-efficiency multi-material recovery both remove significant quantities of glass from the waste stream, and hence are highly compatible with mixed-waste processing options from an engineering standpoint.

Conclusions

One of the sample contract provisions discussed in this section coupled with proper facility design should help to resolve all the major issues outlined in this section: assurance of adequate waste deliveries to MWP facilities, assurance of adequate profitability for MWP plant operators, assurance of sufficient financing, prevention of inhibiting customers for energy and materials from committing themselves to the facility, continuation of pre-existing source separation programs, and impacts on waste stream quality. Restrictive flow control legislation should not be necessary. However, prospective plant operators may have to devote considerable time and effort to developing satisfactory contract agreements. Furthermore, the interests of MWP facility operators and other private entrepreneurs may sometimes conflict if operators propose acting as brokers for source separated materials.

Cooperative arrangements can be achieved in many cases. However, it may be necessary to choose between arrangements where (1) the MWP facility is a centralized storage facility and broker for the disposal of source separated materials, or (2) where the MWP facility processes waste, and another private firm acts as a broker for the source separated materials. In the latter case, problems could occur if source separation affected the operator's revenues; usually, however, only some municipalities in the area have separation programs. To prevent inequities under these circumstances, some means would have to be developed to ascertain the quality of the waste delivered by each community, or, more feasibly, good records would have to be kept on the materials separated to allow for compensation to the MWP facility operator.

Because no communities have yet to our knowledge had to renegotiate contracts with MWP operators because of changes in the waste stream caused by source separation, little or no data are available on the most equitable way this should be accomplished.

From the operator's viewpoint, the compatibility of the specific source separation and mixed-waste processing options outlined for Baselyn will depend largely on whether operators store and sell the separated materials. If they do not, as has generally been the case to date, the low newsprint and low multi-material recovery options should be the most compatible, as they will have the smallest effect on revenues and would cause the least contracting problems. Beverage container recovery, high-efficiency multi-material recovery, and high newsprint recovery would be less compatible, in direct proportion to their effect on the operator's revenues, provided they all resulted from the actions of contracting municipalities. However, if beverage container recovery resulted from state or national action rather than that of the municipality, the operator might or might not be protected against the loss of tipping revenue equivalent to the reduced tonnage of beverage containers and ferrous material revenues, depending upon the contract provisions. These results occur where contracts are poorly written and financial compensation for changes in the waste stream due to source separation may not be as equitable as required by the operator

However, such changes might be offset by increased revenue from energy sales if the Btu content of the waste stream is increased by removal of beverage containers. Furthermore, when well written contracts provide adequate relief in the event of such changes, the four low and high recovery scenarios are equally compatible.

If the MWP facility operator does serve as a broker for separated materials, high newsprint and multi-material recovery (in particular, an effective glass removal program in combination with waterwall combustion options) should be the most compatible, because they will generate higher revenues with little increase in administrative costs over the less efficient programs. For beverage container recovery, the contract considerations discussed above would remain unchanged, as 90% of these containers would not reach the MWP facility. It is interesting to note, however, that under these circumstances any beverage containers recovered undamaged would be worth their full deposit price to the operator - which could more than offset any reduction in weight. MWP facilities employing pre-processing of the wastes would have an advantage here. It is possible that this would be a significant enough revenue source to justify hand picking of wastes or other changes in recovery methods.

From a purely engineering standpoint, beverage container recovery is most desirable for the plant operator because the high efficiency of glass removal would reduce erosion of machinery and reduce the amount of facility maintenance that is necessary. High-efficiency multi-material recovery would have a similar but smaller beneficial effect.

ECONOMIC IMPACT

Issue

A major concern of an operator of an MWP facility is the effect of source separation on the economics of the facility. Source separation will affect the economics in two major ways: quality of MSW processed and quantity of steam produced.

Objective

The objective of this section is to determine whether source separation adversely affects the economics of the waste-processing facility.

Approach

Net processing costs (total costs minus revenues) were calculated for each combination of source separation options and MWP facilities. The net processing cost is, in effect, the tipping fee an operator must charge in order to break even. The tipping fee must be higher in order to make a profit.

The objective of this study is to determine the interaction between source separation and mixed-waste processing technologies, not to compare or evaluate the different mixed-waste processing technologies. Therefore, the net processing costs were assumed to be the same for each technology. Typical cost and revenue breakdowns were then made for each technology (Table 22) by using cost figures provided by EPA from available data.(38)

The costs are based on a 1,000 ton per day plant; they include capital and operating and maintenance costs as well as costs and revenues from RDF or steam and ferrous material. Three scenarios were considered. For the fixed service area it was assumed either that a 1,000 tons per day plant already existed or that a "correctly" sized plant would process the amount of waste produced by each source separation option. For the expanded service area, all plants were assumed to have 1,000 tons per day capacity.

Results

The net processing costs for the various combinations of source separation and MWP processing technologies are listed in Tables 23 through 26. In all cases, the fixed service area 1,000 tons per day scenario is considerably more costly than the expanded service area. The fixed service area 1,000 tons per day plant has the same capital charge spread over fewer tons

TABLE 22. EPA ESTIMATES OF NET PROCESSING COST FOR MWP ($/TON)*

Item	Unprocessed Combined Waste Combustion	Processed Combined Waste Combustion	RDF	Modular Incinerator
Costs[+]				
Capital cost	19.00	18.90	8.45	14.40
O&M cost	11.00	10.85	11.00	14.35
Total	30.00	29.75	19.45	28.75
Revenues				
RDF	-	-	5.25	-
Steam	17.00	15.55	-	15.75
Ferrous	-	1.20	1.20	-
Total	17.00	16.75	6.45	15.75
Net processing cost	13.00	13.00	13.00	13.00

* 1,000 ton per day capacity; public ownership and funding via general obligation bonds; 20-year life and 7% interest rate; $3.00 revenue per 1,000 pounds of steam; and net ferrous revenue of $20 per ton.

\+ The cost figures were estimated by EPA from available data. Average or typical cost figures available in the published literature for the various MWP categories are relatively limited.

processed, resulting in the higher cost per ton processed. The "correctly sized" plant in a fixed service area causes much less adverse changes in processing costs, ranging from a $0.99 a ton increase in costs for the high newprint option to a $1.41 reduction for beverage container recovery when combined with processed waterwall combustion.

Differences in costs for different source separation options in the expanded service area result primarily from the effect of source separation on the Btu content of the waste processing stream. The beverage container scheme, which yields the greatest Btu enrichment in the waste processing stream, also results in the lowest processing costs. The beverage container

TABLE 23. NET PROCESSING COST FOR UNPROCESSED WATERWALL COMBUSTION ($/TON)

Source Separation Option	Fixed Service Area: Existing Plant (1000 t/d)	Fixed Service Area: New Plant (Correctly Sized)	Expanded Service Area: New or Existing Plant (1000 t/d)
Multimaterial, high	$18^{\underline{57}}$	$13^{\underline{40}}$	12 [illegible]
Multimaterial, low	$15^{\underline{76}}$	$13^{\underline{95}}$	$13^{\underline{54}}$
Newsprint, high	$15^{\underline{14}}$	$13^{\underline{99}}$	$13^{\underline{73}}$
Newsprint, low	$13^{\underline{67}}$	$13^{\underline{30}}$	$13^{\underline{21}}$
Beverage containers	$13^{\underline{12}}$	$11^{\underline{59}}$	$11^{\underline{24}}$
No source separation	$13^{\underline{00}}$	$13^{\underline{00}}$	$13^{\underline{00}}$

TABLE 24. NET PROCESSING COST FOR PROCESSED WATERWALL COMBUSTION ($/TON)

Source Separation Option	Fixed Service Area: Existing Plant (1000 t/d)	Fixed Service Area: New Plant (Correctly Sized)	Expanded Service Area: New or Existing Plant (1000 t/d)
Multimaterial, high	$18^{\underline{92}}$	$13^{\underline{65}}$	$12^{\underline{51}}$
Multimaterial, low	$15^{\underline{76}}$	$13^{\underline{97}}$	$13^{\underline{56}}$
Newsprint, high	$15^{\underline{03}}$	$13^{\underline{89}}$	$13^{\underline{63}}$
Newsprint, low	$13^{\underline{90}}$	$13^{\underline{54}}$	$13^{\underline{45}}$
Beverage containers	$13^{\underline{40}}$	11- [illegible]	$11^{\underline{53}}$
No source separation	$13^{\underline{00}}$	$13^{\underline{00}}$	$13^{\underline{00}}$

TABLE 25. NET PROCESSING COST FOR REFUSE-DERIVED FUEL ($/TON)

Source Separation Option	Fixed Service Area: Existing Plant (1000 t/d)	Fixed Service Area: New Plant (Correctly Sized)	Expanded Service Area: New or Existing Plant (1000 t/d)
Multimaterial, high	18.36	14.43	13.29
Multimaterial, low	14.84	13.50	13.09
Newsprint, high	14.33	13.44	13.18
Newsprint, low	13.74	13.45	13.36
Beverage containers	14.52	13.27	12.92
No source separation	13.00	13.00	13.00

TABLE 26. NET PROCESSING COST FOR MODULAR INCINERATOR ($/TON)

Source Separation Option	Fixed Service Area: Existing Plant (1000 t/d)	Fixed Service Area: New Plant (Correctly Sized)	Expanded Service Area: New or Existing Plant (1000 t/d)
Multimaterial, high	18.31	13.41	12.27
Multimaterial, low	15.94	14.22	13.81
Newsprint, high	15.04	13.95	13.69
Newsprint, low	13.64	13.29	13.20
Beverage containers	13.12	11.67	11.32
No source separation	13.00	13.00	13.00

and high-efficiency multi-material options, both of which enrich the mixed-waste processing stream, were the only options which showed a lower net processing cost than the no source separation option.

Conclusions

Compared to the expanded service area scenario, the fixed service area scenario with a 1,000 tons per day plant is relatively unattractive because of considerably higher costs per ton processed resulting from plant underutilization. However, if the facility is correctly sized for the quantity of waste available, the impacts of source separation are much less negative and would be positive for beverage container recovery.

In the expanded service area, the only source separation scheme that has more than a minor effect on processing costs is the removal of beverage containers. In this case, source separation affects processing costs primarily by enriching the feed stream's Btu content. The removal of beverage containers enriches the Btu content significantly (5.? percent) and, thus, lowers costs. The other options have only a small effect on Btu content and, thus, have only minor effects on processing economics. In fact, in these cases, the normal variation in Btu content that naturally occurs in refuse will probably outweigh any effect of source separation.

SUMMARY

Effective waste management is a complementary combination of four main elements - solid waste reduction, materials recovery, energy conservation, and pollution control. Source separation is a viable resource recovery method encompassing the elements of solid waste reduction, materials recovery, and pollution control. Another viable method of resource recovery is mixed-waste processing in which the elements of materials recovery, energy conservation, and pollution control are directly involved. Since these two methods of resource recovery cover the four main elements of effective waste management, a compatible combination of the two methods is a means for optimizing waste management.

The main objective of the compatibility analysis has been to determine whether or not the impacts of jointly operating particular source separation options and mixed-waste processing options are adverse enough to seriously affect the viability of either.

The preceding analysis covered each of the issues likely to be of concern to operators of mixed-waste processing facilities. For most issues and assumed scenarios, the impact of all source separation options is either positive or too small to be important by comparison to other factors such as the normal range of variation of solid waste.

For the issue of the amount of Btu's recovered as steam, high-efficiency multi-material source separation causes a moderate level of adverse impacts (16-17 percent reduction) if a fixed service area and plant size are assumed. If the steam purchaser or purchasers have critical requirements, this level of reduction could cause problems, possibly making the high-efficiency multi-material option incompatible. However, this problem would be eliminated if the service area could be expanded. Furthermore, the projected level of impact can be regarded as a theoretical maximum upper limit, as it is very unlikely that in actual practice a large region would have uniform high-efficiency multi-material source separation.

For the issue of net processing cost, relatively large cost increases are expected with the high-efficiency multi-material option, assuming a fixed service area and plant size, making this combination possibly incompatible. However, either by reducing the size of the MWP plant or be expanding the service area, this theoretical cost increase can be eliminated. Furthermore, tipping fees could be increased. Given these factors, we feel that with proper planning, all source separation options and mixed-waste processing alternatives are economically compatible. The fixed service area and plant size scenario essentially represents a situation in which the MWP facility has been designed too large for the amount of waste securely available, without considering the possibility of source separation. The analysis also indicates that beverage container recovery could also be a significant economic benefit to a mixed-waste processing facility by increasing the Btu content of the waste stream.

SECTION 5

THE MUNICIPAL VIEWPOINT

Municipal officials seek to dispose of the community's solid waste in the most economical and environmentally acceptable manner possible. They also seek to stimulate local employment. As a result, they consider landfill requirements, property tax revenues, and overall costs when choosing among various resource recovery options.

This chapter analyzes the effects of various combinations of source separation and mixed-waste processing options on energy conservation, environmental quality, institutions, and economics.

ENERGY AND MATERIALS CONSERVATION

Issue

A major issue for municipalities is the effect of source separation on the energy used in collection and transportation of solid waste and recovered material to an MWPF or to a landfill.

Objective

The objective of this section is to document this effect.

Approach

An energy analysis was performed for the different source separation options which considered the energy expended in collection of the source separated material for recycle and transportation (Appendix A, pages 159 to 166). The total energy content of the raw mixed-waste is 9200 x 10^6 Btu/day. The energy in 10^6 Btu/day required for collection, preparation, and transportation of source separated and other waste is as follows (expressed as 10^6 Btu/day):

Source Separation Option	Service Area Fixed	Service Area Expanded
Multimaterial, high	386	469
Multimaterial, low	322	346
Newsprint, high	313	328
Newsprint, low	285	290
Beverage containers	276	293
No source separation	220	-

Results and Conclusions--

The amount of energy used for collection and transportation of source separated materials and remaining mixed-waste is a relatively small fraction of the energy available in the mixed-waste. Source separation options range in energy use from 4.2% of the energy content of the raw MSW for multimaterial, high recovery, to 3.0% for beverage containers. Differences in energy usage for collection and transportation would have an insignificant impact on the selection of a source separation option.

ENVIRONMENTAL IMPACT

Issues

A municipality may consider source separation or mixed waste processing, as a means to reduce environmental problems such as overburdened landfills, air pollution due to waste handling, and truck traffic. Source separation can also cut down on solid waste emissions and refuse disposal costs.

Objectives

This section has a two-fold objective: to determine the variations in landfill requirements and pollutant emissions for the various scenarios.

Approach

Assumptions--

There is only one U.S. EPA emission standard which may apply to mixed-waste processing facilities (MWPFs): that which limits particulate emissions from incinerators. In the absence of other standards, the New Source Performance Standards for Electric Utility Steam Generating Units were taken as guides to permitted emissions, as discussed in Section 4.

The source-separated materials from the five Baselyn communities are assumed to be hauled 10 miles to a market; mixed-waste is hauled 25 miles to a landfill (Section 3).

Analysis--

The reduction in landfill use due to source separation alone ranges from 0.7 percent for low newsprint recovery to 17.6 percent for high multimedia recovery.

Modular incinerators can achieve a 76.1 percent reduction in landfill use; the other three mixed-waste processing options an 80.3 percent reduction, (Table 15).

A reduction of 76.2 percent in landfill use can be obtained by combining low newsprint recovery with modular incineration; a reduction as great as 86.3 percent can be achieved by combining high multimaterial separation with any of the other three alternatives.

Mixed-waste processing yields larger reductions in landfill use than does source separation. In fact, combination of the two yields only slightly larger reductions than processing alone.

An MWPF will probably be located close to its steam market so that haulage of the MSW through Baselyn will not change. However, the residuals to be landfilled from the MWPF are considerably less than the original MSW so that total haulage will be reduced. Since air pollution emissions from trucks are generally taken as being directly proportional to miles driven, a reduction in tonage hauled will result in a reduction in mileage driven and a reduction in emissions. These reductions are the same as the landfill requirement reductions. Separating beverage containers can reduce haulage emissions by 3.6%, high multimaterial source separation can reduce haulage emissions by 17.6%. The largest emissions reductions arise as a result of mixed-waste processing, ranging up to 80.3%. Combinations of source separation and mixed-waste processing can result in reductions as great as 86.3%. These haulage emissions reductions may not be too important from the municipal viewpoint, however, since haulage within Baselyn changes very little whereas the main reduction of haulage emissions occurs outside Baselyn, enroute to the landfill.

Emissions from processing will be as given previously in Section 4. Particulate and SO_2 emissions may require control, but not NO_x emissions. Unprocessed waterwall and modular incineration have low emissions, with the former lower. However, all alternatives are expected to satisfy the regulatory emission limits when air pollution control equipment is installed.

Ground water impacts are somewhat decreased by source separation, in proportion to the reduced amounts of waste going to landfill. Mixed waste processing will drastically reduce ground water impacts for two reasons. It will reduce the amount of waste to landfill, and produce less leachable residue. On the other hand, sluicing, quenching, and any scrubbing waters required by an MWPF will negatively affect surface water, even after treatment.

Conclusions--

Source separation will slightly lengthen landfill life while a mixed-waste processing facility alone or in combination with source separation will greatly extend landfill life.

Air pollution may be increased by the operation of an MWPF, even if pollution controls are installed, unless the combustion of the MSW replaces a dirtier combustion of fossil fuels. If it is assumed that Baselyn meets NAAQS, no offset in pollutant releases will be required and increments in NAAQS concentrations are available. Thus, some net increase in air pollution will result from the operation of an MWPF.

Ground water pollution will be slightly decreased by source separation and greatly decreased by an MWPF. Surface water pollution will be increased by an MWPF.

In general, municipalities will prefer to combine source separation with mixed waste processing. If landfill availability is the overriding consideration, however, mixed waste processing will be preferred. Any source separation option except low newsprint recovery could be chosen. Either UWCF or MI mixed waste processing alternative could be chosen, with UWCF preferred.

INSTITUTIONAL/POLITICAL IMPACT

Issues

Both the officials and citizens of a municipality are likely to be particularly sensitive to the effect of changes in solid waste collection and disposal practices on local government. Either source separation or mixed-waste processing (MWP) may require municipal actions with significant financial, legal, employment, tax, and political implications. Particularly in the current climate of heightened public concern over the size and role of government, any proposal requiring additional government spending, new enforcement actions, or long-term legal commitments will be very closely scrutinized.

Since municipalities frequently become involved in financing MWP facilities even if they do not intend to own or operate them, they need to consider the effect of on-going public or private source separation programs on MWP facilities. The municipality should be able to demonstrate to investors that source separation will not jeopardize the MWP facility's waste stream.

Closely related to this issue is the question of whether municipal legislation should be used to implement particular resource recovery options. The decision rests, in part, on overall administrative requirements. While public attention has focused on "bottle bills" (beverage containers deposit legislation), it is less well known that flow control laws have been passed to support mixed waste processing and that anti-scavenger and mandatory separation ordinances have been passed to support separate collection programs. The equity and administrative workability of flow control legislation have been disputed.

Government and private employment are major municipal concerns. Although separate collection and operation of MWP facilities may cause significant shifts in sanitation employee responsibilities and necessitate new hiring, they will not have a major indirect effect on employment in the private sector. By contrast, beverage container deposit legislation, which induces shifts in manufacturing procedures, has a debatable but definite indirect effect on private sector employment.

If a major private facility, such as a MWP plant, is proposed for a municipality, the prospect of large property tax payments may be attractive to officials and citizens. The desire for increased tax revenues may influence municipal attitudes toward resource recovery options.

A final common concern is whether municipal decision-making powers would be compromised by entering into long-term commitments with private companies or other governments, such as regional authorities or neighboring towns. Communities may be strongly attracted to options that allow the greatest amount of local autonomy.

Objectives

This section will address the following questions:

- o Will a different financing method or higher interest rates for a municipal MWP facility be necessary if the municipality also conducts a source separation program?.
- o What (if any) legislation is generally necessary to implement mixed-waste processing and source separation options? What are the administrative obstacles?
- o What are the probable effects of each source separation and MWP option on municipal employment levels for solid waste collection and disposal?
- o Would resource recovery options have a beneficial effect on community property taxes? How large would this effect be?
- o Which resource recovery options are likely to require greater intergovernmental coordination and thus affect local political autonomy?

These questions cover the major issues of concern to municipalities with one very important exception - the indirect effects of beverage container deposit legislation on local employment. This issue requires special attention, since impacts on employment both within and outside municipalities, regions, and states must be considered. Hence, while such legislation is an important municipal concern, it will be discussed in Section 6 in the context of the nation as a whole.

Approach, Assumptions, Analysis, and Results

The analyses of financing, legislative requirements, property taxes, and local autonomy will be essentially qualitative; they will be based on typical case histories of communities that have combined mixed-waste processing and source separation. They will employ "Baselyn" as an example to calculate employment levels for each possible combination of the five source separation options with the four MWP options and landfill. These calculations will be made for 1,000-tpd plants operating in both "fixed" and "expanded" service areas.

Financing of Resource Recovery Options--

Municipal capital expenditures for source separation programs are small compared to those for mixed-waste processing. A study of 22 separate collection programs by SCS Engineers for EPA indicated that most programs began using equipment that they already owned, such as standard rear-loading compactor trucks.(39) However, if new specialized trucks are purchased (as assumed in our source separation options to fully allocate cost to the options) new equipment for Baselyn would cost $125,000 and $50,000 for high and low multi-material recovery, respectively and $40,000 for high newsprint recovery. There might be an opportunity to achieve savings by reducing the number of standard packer trucks required to pick up mixed-waste. Capital costs for mixed-waste processing facilities vary with the process involved, but generally range between $10,000 and $50,000 per ton of plant capacity (see Table 27) or $10 to $50 million for a 1,000 tpd plant. Hence, even with very conservative assumptions about the cost of source separation, source separation options will require only a low percentage of the capital costs of mixed-waste processing alternatives.

The most common means available to municipalities to finance resource recovery options include: 1) use of current revenues or taxation, 2) short-term bank borrowing, 3) general obligation bonds, 4) municipal revenue bonds, and 5) public-private bonding arrangements. The first two options commonly are used by municipalities to finance small capital investments, such as the purchase of collection vehicles. The maximum a community can muster from current revenues or taxation is currently estimated at $100,000 and from short-term bank borrowing (usually periods up to 5 years), $500,000. Most municipalities will not need to use more complex financing arrangements to pay for source separation options. Long-term borrowing, however, using general obligation or revenue bonds, will be necessary to municipalities that wish to own or operate a mixed-waste processing facility.

TABLE 27 PUBLIC FINANCING ARRANGEMENTS AT LARGE MIXED-WASTE PROCESSING FACILITIES

Public Institution/Project	Total Amount Financed (million $)	Facility Ownership	Financing Method	Net Interest Cost*
City of Madison Wisconsin 200-[illegible] tpd	2 45	City	$2 million - General Obligation (G O) bonds, $450,000-current revenues	5.1+
Town of Saugus, Massachusetts (RESCO project) - 1,500 tpd	30	Private-(RESCO) after bond repayment	Industrial revenue bonds	7.8838
Connecticut Resources Recovery Agency (Bridgeport project) - 1,300-1,600 tpd	53	CRRA	Industrial revenue bonds	
New Orleans Industrial Development Authority-700 tpd	7	Private - Waste Management, Inc.	Industrial revenue bonds	7 [illegible]2
Monroe County, New York (Rochester) - 2,000 tpd	50 4	County	$31.9 million - Monroe County G O bonds 18 5 million - New York State omnibus bond	5 2494**
Ohio Water Development Authority (OWDA) - City of Akron, Ohio	56	City of Akron	$46 million - municipal revenue bonds, $5 million - city G O. bonds; $5 million Summit County, G O. bonds	8 034
Nashville Tennessee Metropolitan Government (Metro) - 720 tpd	16 5***	Public non-profit Corporation (Nashville Thermal Transfer Corp)	Municipal revenue bonds	5 7

* Average cost to municipalities (average interest rate paid to investors is different due to underwriting fees)
** For initial issue of $14 4 million
*** Subsequently increased to $24 million
\+ Actual bond interest rate

Sources. References 40 to 42

Because interest paid to investors by both types of municipal bonds is generally tax-exempt, municipalities can offer them at a low interest rate. The types differ in the degree of risk assumed by the municipality. General obligation ("G.O.") bonds commit the "full faith and credit" of the municipality to repaying the principal and interest of the loan, requiring it to use its powers of taxation if necessary. These bonds require voter approval, and are often limited in amount by state statutes. Revenue bonds, however, commit only the stream of revenues from the particular project being financed. Since they involve greater risk for the investor, revenue bonds usually pay higher interest rates (up to 0.5 percent more than general obligation bonds), and thus incur greater financing costs to the municipality

The ability of municipalities to offer tax-free bonds has led to creation of a variety of hybrid public-private financing arrangements, including "industrial revenue bonds," "pollution control bonds," and "leveraged leasing". A municipality or other public institution issues revenue bonds on behalf of a private firm, which backs the payment of principal and interest with its assets and project revenues, and eventually obtains title to the facility. Industrial revenue bonds have interest rates up to two percent below those of comparable private bonds but higher than general obligation and municipal revenue bonds. An August 1978 comparison of financing costs for a hypothetical $84 million bond issue resulted in estimates that interest rates could be 7.0 percent for general obligation bonds, 7.5 percent for municipal revenue bonds, and 7.75 percent for industrial revenue bonds. When the initial costs of setting up each of these methods was taken into account, the effective debt service rates were 9.7 percent for general obligation bonds, 11.2 percent for municipl revenue bonds, and 11.4 percent for industrial revenue bonds.(40) In choosing a financing method, then, municipalities must balance costs with degree of risk and decide whether they wish to own the facility. Despite their low financing cost, general obligation bonds will only be chosen by communities that are relatively certain of project costs and revenues. Most municipalities have used municipal revenue bonds or mixed public-private bonding mechanisms to finance MWP plants.

Because the capital costs of source separation programs are low compared to MWP options, they require a change in financing method or higher interest rates only if project revenues are uncertain. We evaluated 7 recent cases of municipal financing of MWP plants (see Table 27) and found that projects in three areas (Madison, Wisconsin; Saugus, Massachusetts; and Greater Bridgeport, Connecticut) did not experience changes in financing methods or higher interest rates due to source separation. In fact, the long-time operation of a newsprint source separation program in Madison probably substantially improved this community's knowledge of its quantity of waste enabling it to use the less expensive general obligation bonds. Previous experience in Saugus suggested little likelihood that source separation would have a significant adverse impact on MWP facility revenues. Saugus officials discussed the possibility of state beverage container deposit legislation. They concluded that although it would cause at most a 10 percent reduction in waste tonnages, it would enhance the energy content of the waste and thus would have little effect on revenues. Hence, source separation options had no effect on interest rates or financing methods (see Table 27). In the Greater Bridgeport projects, contract agreements between the regional authority financing the project and municipalities delivering waste to the facility defined an orderly procedure for determining possible economic impacts due to source separation. Similar contract agreements between the city and the private facility operator were used in New Orleans (see Section 4).

In Nashville, municipal financing of source separation apparently did not become an issue. In Rochester and Akron, the major financing problem was that private haulers did not make contract committments to deliver mixed waste to the proposed MWP facility instead of to private landfills.

The experiences of these seven representative cases suggest that source separation had no identifiable impact on financing costs. Source separation is unlikely to adversely affect MWP facility financing when general obligation bonds are used, because investors are concerned with the fiscal health of the municipality rather than that of the project. If municipal revenue bonds or mixed public-private bonding mechanisms are used, any municipal revenues from sale of energy or recovered material - regardless of whether derived from source separation or mixed-waste processing - would in all likelihood be applied to the project debt. It is unlikely that a municipality would initiate source separation unless resulting revenues would more than offset reductions in revenues from the MWP plant. If any doubt exists as to its use, a bond's prospectus could be worded to explicitly commit revenue from source separation to debt service. Bondholders should be indifferent to the source of the revenues as long as they accrue to their benefit.

Among the source-separation options considered, only beverage container deposit legislation would reduce inputs of waste to an MWP facility without delivering offsetting municipal revenues. However, beverage container deposit legislation affects metals and glass, which generally make up a fairly small percentage of the weight of the waste stream and contribute less to plant revenues than do energy sales (which would be increased due to the increased Btu content of the waste). Hence, we consider the prospect of such legislation unlikely to have a significant impact on the cost of municipal financing of proposed facilities. It may, however, contribute to an overall climate of uncertainty that makes municipalities hesitant to commit themselves to a major change from current disposal practices.

Legislative and Administrative Requirements--

Municipal ordinances requiring home owners to separate waste before setting them at the curb and prohibiting scavenging of separated materials have frequently been passed in conjunction with separate collection programs. In addition, public relations campaigns to explain the program to residents are commonly employed. The previously cited study of separate collection programs by SCS Engineers concluded that well-enforced anti-scavenger ordinances and active public relations programs are necessary in order to achieve a high recovery rate. Municipalities which began source separation programs without anti-scavenger ordinances, such as Cincinnati and Chicago, suffered substantial losses of newsprint, the largest revenue source. Hempstead, New York, reported losses of 40 percent of its newsprint when paper prices were high; enforcement of an existing anti-scavenger ordinance by sanitation inspectors substantially reduced this rate of loss. Enforcement of anti-scavenger ordinances also proved necessary in the EPA demostration programs in Marblehead and Somerville, Massachusetts.

The SCS study also concluded that municipalities not conducting active publicity programs before and during implementation of separate collection have substantially lower participation rates. Experience indicates that initially successful programs suffer a gradual drop-off in participation unless publicity is continued but with continued publicity they can experience increases in participation. Publicity programs are an administrative burden to the municipality, but need not be a substantial one if volunteer groups take an active role.

A recent survey of separate collection programs by EPA found that 59 percent of the mandatory programs had participation rates of 50 percent or more while only 19 percent of the voluntary programs had such high rates.(43) It is reasonable to conclude that passing legislation that requires source separation serves as an indication of municipal commitment and, other things being equal, should tend to increase the participation rate.

This conclusion is supported by evidence from West Orange, New Jersey, whose collection increased from an average of 83 Mg (92 tons) per month in 1976 to 180 Mg (200 tons) per month in 1977 after passage of a mandatory participation ordinance.(44)

Experience indicates that multi-material separation programs are substantially more complex to administer than newsprint-only programs, whether voluntary or mandatory. If enacted by municipal governments, beverage container deposit legislation could involve substantial legal and enforcement efforts, due to possible legal challenges and resistance by manufacturers and retailers. However, if enacted by state governments (as assumed in this study), such legislation would place no additional administrative burden on the municipality, and would reduce its waste collection costs.

Mixed-waste processing does not require administrative and public relations efforts to deal with homeowners. The legislative issues of mixed-waste processing are questions of where wastes will be disposed. In a number of cases (metropolitan areas such as Akron, Ohio, and Rochester, New York), municipal collection serves only part of the geographic service area of a proposed MWP facility, the remainder is served by private haulers. Private landfills compete with the municipal landfill for waste collected by private haulers, who are generally reluctant to enter into long-term delivery contracts. To gain access to privately-collected waste, the city and county governments in these two areas have adopted a carrot-and-stick approach. They are charging low dumping fees ($3.50 - $4.00 per ton) at the MWP plant to attract private haulers and have passed restrictive "flow control" legislation requiring all trash haulers licensed to do business in the area to deliver solid waste to the facility. Those ordinances are being legally contested.(45) Even if upheld, further administrative and legal efforts to enforce them may reduce or eliminate the administrative advantages of mixed-waste processing. The Akron ordinance has been upheld in Federal District Court but is currently being appealed.

Mayor John Ballard of Akron has stated that the city's ordinance is not intended to apply to source separated materials such as commercially collected waste paper.(46)

> "Our interpretation of our ordinance is that it is directed at rubbish and garbage that is mixed and co-mingled. Once the trash and garbage is co-mingled it becomes part of the trash stream and may not be separated thereafter but must be dumped at the project plant. It was never our purpose to interfere with pre-sorting: that is, separating papers or magazines or paper board products so that they do not become part of the waste stream."

Despite this interpretation, supporters of source separation often fear that loosely worded legislation of this type could be used to prohibit municipal or private source separation programs. This might well occur if an MWP plant is proposed that is larger than the municipally controlled waste supply will support. The need for flow control legislation can be avoided by designing smaller plants that correspond to the waste supply and allow for current or potential source separation. Plants can be built in a modular fashion so that they can be expanded later if necessary (as is commonly done in Europe). However, several underlying legal issues of waste ownership and disposal remain unresolved.

Another legal problem that municipalities may find is statutory restrictions on the length of time over which contract agreements can be made. A number of large cities have time restrictions as short as one year, and in other areas legal precedents are unclear. New state enabling legislation to permit municipalities to enter into long-term agreements (as recently passed in New York and Connecticut) may be necessary. In the absence of such legislation or local legal expertise, some municipalities may see source separation as a more attractive approach than mixed-waste processing.

Employment--

We estimated the net impact of each combination of source separation and mixed waste processing (MWP) options on the number of people directly employed in solid waste collection and disposal. We also estimated the impact of additional combinations that assumed: 1) no source separation and 2) landfill rather than processing of mixed-wastes. To account for off-setting changes in employment levels throughout the entire system of solid waste collection and disposal we took into account six distinct activities:

- collection of source separated materials
- collection of remaining mixed-wastes
- operation of transfer stations
- administration
- operation of landfill
- operation of mixed-waste processing facilities.

For the first four activities (generally conducted by municipal employees) we used the efficiency levels and assumptions described in Section 3 and Appendix A. For high-efficiency multi-material separation, employment requirements for collection of source separated materials are based on an average crew productivity of 5-7 Mg (6-8 tons) per day, crew sizes of 2 or 3 persons, and separated material quantities of 25.3 Mg (27.7 tons) collected each day by four municipal crews (excluding privately collected office and corrugated paper) in each of five Baselyn communities. For low-efficiency multi-material collection, similar productivity rates require only two crews of 2-3 persons each in each community. For high-efficiency newsprint recovery, two crews of 2-3 persons each are also assumed (see Table 2''). All options assume collection of mixed-waste by 3-person crews coll[illegible]ing an average of 20 tons per day.

Employment levels for operation of public or private landfills were estimated using data from a standard engineering reference, <u>Municipal Refuse Disposal</u>, which estimates seven personnel required for a 1,000 tpd landfill and two for a 200 tpd landfill,(47) along with the calculated residual to landfill for each combination of options.(47) Employment levels for each of the five MWP alternatives (which may be either privately or publicly operated) were estimated on the basis of data acquired during our review of actual employment at similar existing facilities and data contained in a recent study conducted by Franklin Associates for the American Paper Institute.(48) The estimates assume operation at full capacity (1,000 tpd) and no reductions in facility employment due to operating such facilities at less than full capacity in the fixed service area scenario. However, a wide range in the number of employees for modular incinerators is given for both service area scenarios (48-80 employees for 1,000 tpd capacity). Fewer employees would be needed to operate a large number of modules (up to 20) at a single location than to operate modules at five or six locations. The latter arrangement is much more probable.

The results of the analysis are shown in Table 28 for the fixed service area and Table 29 for the expanded service area. The lowest employment levels occur when no source separation is combined with landfill (167 and 204

TABLE 28 DIRECT EMPLOYMENT REQUIREMENTS IN FIXED SERVICE AREA (NO OF EMPLOYEES)

Combinations of Source Separation (SS) Mixed-Waste Processing (MWP) Options									
	SS Option	MWP Option	Collection of Separated* Wastes	Collection of Mixed Wastes	Operation of Transfer Stations	Administration of Source Separation	Operation of Landfill	Operation of MWP Facility	Total Employees Required
1	No source separation	Landfill	0	150	10	0	7	0	167
2	No source separation	Unprocessed waterwall	0	150	10	0	2	55	217
3	No source separation	Processed waterwall	0	150	10	0	2	59	221
4	No source separation	Refuse-derived fuel	0	150	10	0	2	59	221
5	No source separation	Modular incineration	0	150	10	0	2	59-80	221-242
6	High multimaterial	Landfill	40-60	120	10	2 5	6	0	176.5-198 5
7	High multimaterial	Unprocessed waterwall	40-60	120	0	2 5	2	55	219 5-239 5
8	High multimaterial	Processed waterwall	40-60	120	0	2 5	2	59	223 5-243 5
9	High multimaterial	Refuse-derived fuel	40-60	120	0	2 5	2	59	223 5-243 5
10	High multimaterial	Modular incinerator	40-60	120	0	2.5	2	59-80	223 5-264 5
11	Low multimaterial	Landfill	20-30	135	10	2 5	7	0	174 5-184 5
12	Low multimaterial	Unprocessed waterwall	20-30	135	0	2 5	2	55	214 5-224 5
13	Low multimaterial	Processed waterwall	20-30	135	0	2 5	2	59	218 5-228 5
14	Low multimaterial	Refuse-derived fuel	20-30	135	0	2.5	2	59	218 5-228 5
15.	Low multimaterial	Modular incinerator	20-30	135	0	2.5	2	59-80	218 5-249 5
16	High newsprint	Landfill	20-30	150	10	2.5	7	0	189.5-199 5
17	High newsprint	Unprocessed waterwall	20-30	150	0	2 5	2	55	229 5-239 5
18	High newsprint	Processed waterwall	20-30	150	0	2 5	2	59	233 5-243 5
19	High newsprint	Refuse-derived fuel	20-30	150	0	2.5	2	59	233 5-243 5
20	High newsprint	Modular incinerator	20-30	150	0	2.5	2	59-80	233 5-264 5
21	Low newsprint	Landfill	0	150	10	0	7	0	167
22	Low newsprint	Unprocessed waterwall	0	150	0	0	2	55	207
23	Low newsprint	Processed waterwall	0	150	0	0	2	59	211
24	Low newsprint	Refuse-derived fuel	0	150	0	0	2	59	211
25	Low newsprint	Modular incinerator	0	150	0	0	2	59-80	211-232
26	Beverage container	Landfill	0	150	10	0	7	0	167
27	Beverage container	Unprocessed waterwall	0	150	0	0	2	55	207
28	Beverage container	Processed waterwall	0	150	0	0	2	59	211
29	Beverage container	Refuse-derived fuel	0	150	0	0	2	59	211
30	Beverage container	Modular incinerator	0	150	0	0	2	59-80	211-232

* Calculation based on number of crews required per day for each of 5 Baselyn communities, crew productivity from Section 3, and crew sizes of 2-3 persons

TABLE 29 DIRECT EMPLOYMENT REQUIREMENTS IN EXPANDED SERVICE AREA

Combinations of Source Separation (SS) Mixed-Waste Processing (MWP) Options: SS Option	MWP Option	Collection of Separated* Wastes	Collection of Mixed Wastes	Operation of Transfer Stations	Administration of Source Separation	Operation of Landfill	Operation of MWP Facility	Total Employees Required
1 No source separation	Landfill	0	183	12	0	9	0	204
2 No source separation	Unprocessed waterwall	0	183	12	0	2	55	252
3 No source separation	Processed waterwall	0	183	12	0	2	59	256
4 No source separation	Refuse-derived fuel	0	183	12	0	2	59	256
5 No source separation	Modular incineration	0	183	12	0	2	59-80	256-277
6 High multimaterial	Landfill	48-72	147	12	3	7	0	217-241
7 High multimaterial	Unprocessed waterwall	48-72	147	0	3	2	55	255-279
8 High multimaterial	Processed waterwall	48-72	147	0	3	2	59	259-283
9 High multimaterial	Refuse-derived fuel	48-72	147	0	3	2	59	259-283
10 High multimaterial	Modular incinerator	48-72	147	0	3	2	59-80	259-364
11 Low multimaterial	Landfill	24-36	165	12	3	7	0	211-223
12 Low multimaterial	Unprocessed waterwall	24-36	165	0	3	2	55	249-261
13 Low multimaterial	Processed waterwall	24-36	165	0	3	2	59	253-265
14 Low multimaterial	Refuse-derived fuel	24-36	165	0	3	2	59	253-265
15 Low multimaterial	Modular incinerator	24-36	165	0	3	2	59-80	253-286
16 High newsprint	Landfill	24-36	160	12	3	8	0	227-239
17 High newsprint	Unprocessed waterwall	[illegible]4-36	180	0	3	2	55	264-276
18 High newsprint	Processed waterwall	24-36	180	0	3	2	59	268-260
19 High newsprint	Refuse-derived fuel	24-36	180	0	3	2	59	[illegible]-280
20 High newsprint	Modular incinerator	24-36	180	0	3	2	59-80	268-301
21 Low newsprint	Landfill	0	183	12	0	9	0	264
22 Low newsprint	Unprocessed waterwall	0	183	0	0	2	55	240
23. Low newsprint	Processed waterwall	0	183	0	0	2	59	244
24 Low newsprint	Refuse-derived fuel	0	183	0	0	2	59	244
25 Low newsprint	Modular incinerator	0	183	0	0	2	59-80	244-265
26 Beverage container	Landfill	0	183	12	0	7	0	202
27 Beverage container	Unprocessed waterwall	0	183	0	0	2	55	240
28 Beverage container	Processed waterwall	0	183	0	0	2	59	244
29 Beverage container	Refuse-derived fuel	0	183	0	0	2	59	244
30 Beverage container	Modular incinerator	0	183	0	0	2	59-80	244-265

* Calculation based on number of crews required per day in each of 5 Baselyn communities, (see Section 3), crew sizes of 2-3 persons, and comparable number and productivity of crew required in expanded service area

for the fixed and expanded service areas, respectively). When modular incineration occurs at a single location and two-person collection crews are used, high newsprint separation coupled with either refuse-derived fuel, processed waterwall or modular incineration demands the most employees (233.5 in the fixed and 310 in the expanded service area). However, if modular incineration is dispersed by community and three-person crews are used, the highest employment (264.5 to 364) would occur when incineration is coupled with high multi-material or high newsprint separation.

These differences are large enough to be economically significant. Taking into account all six activities considered in the overall system of waste disposal and resource recovery, the choice of waste disposal options can cause increases of as much as 50 to 75 percent in the total number of people employed. For a metropolitan region of 500,000 - 650,000 population, the difference in jobs would be comparable to gain or loss of a medium sized manufacturing plant. If these people were directly employed by municipalities, the differences in annual sanitation budgets could be in the area of $1 - 1.5 million.

However, the majority of the increased employment will be at the mixed-waste processing facility, which would in most cases be privately operated. Differences in waste collection employment resulting from source separation are at most 20 percent (assuming 3-man crews). This estimate probably represents an upper limit as it does not include possible improvements in waste collection efficiency due to rerouting and reassignment in manpower in conjunction with implementation of a source separation program. Furthermore, most municipal collection programs have a certain number of reserve forces which could be used, thus, new hiring would not necessarily be required. A particularly important variable is the size of the collection crew. The survey of separate collection programs by SCS Engineers concluded that while most such programs employed three-man crews, this crew size was excessive. Important efficiencies could have been achieved by switching to two-men crews (loader plus driver), or one-man crews with side-loading collection vehicles. Reassigning crews could reduce or eliminate the need for a municipality to hire additional employees to begin a source separation program. When two-man crews are assumed, high-efficiency multi-material source separation causes an increase of only 6.7 percent in personnel engaged in solid waste collection.

A smaller work force than assumed in our analysis is also possible at the MWP facility, particularly if it is privately operated. For example, the 600-1500 tpd RDF facility in Baltimore County, Maryland, operated by Teledyne National, employs only 26 people. However, some facilities in areas where reducing unemployment is a key municipal objective will operate with larger work forces than we assumed. The 700 tpd RDF facility in Newark, for example, is projected to have 100 full-time employees.

To be consistent with assumptions made in defining source separation options, our analysis does not include one possible additional source of employment: intermediate processing of source-separated materials. Contamination of separated materials or incomplete separation of materials (i.e., mixing of bottles and cans) may necessitate processing prior to re-sale. Private recycling companies in a number of areas, including the north shore of Massachusetts, northern New Jersey and Seattle have used intermediate processing, but sufficient data are not available to estimate employment levels per ton processed.

Property Tax Effects--

In considering approval of large new industrial facilities, municipalities are always interested in possible tax revenues. Source separation options do not involve land improvements or new construction and hence do not generate such revenues. While privately-operated MWP facilities do often pay taxes, the municipalities pay them tipping fees and frequently finance them. Hence, property taxes are open for negotiation as part of the financial arrangements made between the plant and the town. Tipping fees may be reduced in lieu of payment of property taxes or tipping fees may be increased if property taxes are increased (as in the proposed 140 tpd waterwall facility at Pittsfield, Massachusetts). Property taxes are usually not a major issue in a municipal decision as to which resource recovery option to pursue; tax rates are not changed by construction of MWP facilities except as a reflection of reduced disposal costs.

Political Autonomy--

One of the major attractions to municipalities of source separation options is that they do not require long-term legal agreements. Municipalities and private haulers of mixed-waste are both reluctant to make long-term committments for waste deliveries. The short-term contract committments required by recovered materials purchasers seem less risky than the 15 to 20 year contracts common for MWP facilities. Moreover, neither source separation options nor beverage container deposit legislation requires joint action with neighboring municipalities or regional authorities. Furthermore, no mixed waste from other communities need be transported through the municipality on its way to a regional facility with accompanying noise, air pollution, and traffic congestion - often opposed by local residents.

Regional MWP facilities serving more than one municipality at a single site are assessed in this study (i.e., 1000-tpd plants with differing technologies, serving fixed and expanded service areas that include the five "Baselyn" communities). These facilities are managed by a single municipality or regional authority, which shares costs and profits with participating municipalities. This structure usually raises difficult questions of political autonomy, which may require considerable negotiation for resolution. Controversies have arisen at virtually every MWP facility serving more than one municipality and increase in proportion to the number of municipalities involved. Each municipality questions whether the economic advantages of sharing labor and materials out-weigh the political and administrative benefits of operating an independent facility. This question is outside the scope of the present study, but deserves further analysis due to its frequent importance in local decision-making.

Conclusions

Implementing either source separation or mixed-waste processing options may cause institutional problems for a municipality, but these problems can be solved with sufficient foresight and planning. Source separation programs may be difficult to administer, but they rarely impede the financing or implementation of mixed-waste processing plants. Many of the institutional problems of proposed mixed-waste processing plants are due to capacities that are larger than the available waste supply. More study is needed to determine the relative merits of centralized and decentralized MWP facilities, and their interaction with source separation programs.

ECONOMIC IMPACT

Issues

The primary issue, from the municipal viewpoint, is the effect of source separation on the economics of collection, transportation, and disposal of mixed solid waste.

Objective

The objective is to determine if various source separation scenarios reduce or increase solid waste disposal costs for municipalities.

Approach

An analysis of the source separation program costs and revenues is presented in Appendix A. In this analysis, two alternatives were considered for disposal of the remaining mixed-waste: landfilling and delivery to a mixed-waste processing facility. In both cases, a constant disposal or tipping fee of $\$13^{\underline{00}}$ per ton was assumed for all source separation options. However, as discussed in Section 4, the tipping fee or net processing cost to the mixed-waste processing facility is not constant but varies for each combination of source separation option and mixed-waste processing alternatives.

The net total costs for material recovery and waste disposal were calculated by summing the net processing cost for each combination and the net collection costs (source separation program costs minus the $\$13^{\underline{00}}$ per ton tipping fee) for the mixed-waste processing alternatives. The net total cost for the different combinations were compared to net total landfill costs. The landfill costs are based on those given in Appendix A.

Results

The net costs, including collection, transportation and revenues, for the various combinations of source separation and mixed-waste processing technologies are listed in Tables 30 through 33. Three scenarios were considered: a 1,000 ton per day plant already existing, a "correctly" sized plant, both serving a fixed service area, and an expanded service area feeding a 1,000 ton per day plant.

Differences in net costs for different source separation options are small and result primarily from the effect of source separation on the energy content of the remaining waste stream. The source separation option which most enriches the Btu content of the waste stream, beverage container recovery, results in the lowest net cost.

In all cases, the scenario which assumes service within a fixed area for an already existing plant is costlier than the other two scenarios. The capital cost is spread over fewer tons processed, resulting in a higher cost per ton processed. Also in all cases, the "correctly" sized and expanded service area scenarios are less costly than landfills alone, with the expanded area scenario having the slightly lower cost.

Conclusions

Compared to the other two scenarios, the fixed service area, existing plant scenario is relatively unattractive. Its plant is under-utilized; hence it processes materials at a higher cost per ton.

The effect of source separation options on costs is moderate or relatively small, at the most 9 percent for multi-material and processed waterwall. The least costly source separation options are the ones that enrich the Btu content of the waste processing stream, i.e., high-efficiency multi-material (assuming correct plant sizing) and beverage container recovery.

TABLE 30. NET COST FOR UNPROCESSED WATERWALL COMBUSTION ($/TON)

Source Separation Option	Fixed Service Area: Existing Plant (1000 t/d)	Fixed Service Area: New Plant (Correctly Sized)	Expanded Service Area: New or Existing Plant (1000 t/d)	Landfill
Multimaterial, high	$42^{\underline{17}}$	$36^{\underline{90}}$	$35^{\underline{76}}$	$38^{\underline{83}}$
Multimaterial, low	$40^{\underline{89}}$	$39^{\underline{08}}$	$38^{\underline{67}}$	$42^{\underline{46}}$
Newsprint, high	$40^{\underline{99}}$	$39^{\underline{84}}$	$39^{\underline{58}}$	$43^{\underline{62}}$
Newsprint, low	$38^{\underline{58}}$	$38^{\underline{31}}$	$38^{\underline{22}}$	$43^{\underline{34}}$
Beverage containers	$37^{\underline{46}}$	$35^{\underline{93}}$	$35^{\underline{58}}$	$41^{\underline{85}}$
No source separation	$38^{\underline{85}}$	$38^{\underline{85}}$	$38^{\underline{85}}$	$44^{\underline{45}}$

TABLE 31. NET COST FOR PROCESSED WATERWALL COMBUSTION ($/TON)

Source Separation Option	Fixed Service Area: Existing Plant (1000 t/d)	Fixed Service Area: New Plant (Correctly Sized)	Expanded Service Area: New or Existing Plant (1000 t/d)	Landfill
Multimaterial, high	$42^{\underline{42}}$	$37^{\underline{12}}$	$36^{\underline{01}}$	$38^{\underline{83}}$
Multimaterial, low	$40^{\underline{89}}$	$39^{\underline{10}}$	$38^{\underline{69}}$	$42^{\underline{46}}$
Newsprint, high	$40^{\underline{88}}$	$39^{\underline{74}}$	$39^{\underline{48}}$	$43^{\underline{62}}$
Newsprint, low	$38^{\underline{91}}$	$38^{\underline{55}}$	$38^{\underline{46}}$	$43^{\underline{34}}$
Beverage containers	$37^{\underline{74}}$	$36^{\underline{22}}$	$35^{\underline{87}}$	$41^{\underline{85}}$
No source separation	$38^{\underline{85}}$	$38^{\underline{85}}$	$38^{\underline{85}}$	$44^{\underline{45}}$

TABLE 32. NET COST FOR REFUSE-DERIVED FUEL ($/TON)

Source Separation Option	Fixed Service Area: Existing Plant (1000 t/d)	Fixed Service Area: New Plant (Correctly Sized)	Expanded Service Area: New or Existing Plant (1000 t/d)	Landfill
Multimaterial, high	41.86	37.93	36.79	38.83
Multimaterial, low	39.97	38.63	38.22	42.46
Newsprint, high	40.18	39.29	39.03	43.62
Newsprint, low	38.75	38.46	38.37	43.34
Beverage containers	38.86	37.61	37.26	41.85
No source separation	38.85	38.85	38.85	44.45

TABLE 33. NET COST FOR MODULAR INCINERATOR ($/TON)

Source Separation Option	Fixed Service Area: Existing Plant (1000 t/d)	Fixed Service Area: New Plant (Correctly Sized)	Expanded Service Area: New or Existing Plant (1000 t/d)	Landfill
Multimaterial, high	41.31	36.91	35.[illegible]	38.83
Multimaterial, low	41.07	39.35	38.94	42.46
Newsprint, high	40.89	39.80	39.54	43.62
Newsprint, low	38.[illegible]5	38.30	38.[illegible]1	[illegible]
Beverage containers	37.46	36.01	35.66	41.85
No source separation	3[illegible].85	38.85	38.85	44.4[illegible]

SUMMARY

The major question to be answered in evaluating issues important to the overall municipal prospective on the compatibility of source separation options and mixed-waste processing alternatives is whether any situations exist where implementing one type would clearly interfere with the viability of the other. The analyses indicate that this would only be the case with the issue of net solid waste collection and disposal costs under a fixed service area and fixed plant size scenario. In this scenario, high-efficiency multi-material separation moderately increases net cost for all mixed-waste processing alternatives (by 7-9 percent). As previously mentioned, this scenario may be taken to represent a situation whereby the MWP facility has been designed with too large a capacity for the amount of waste securely available.

For all other issues considered in this section, none of the source separation options would cause any significant problem with the viability of any mixed-waste processing alternative (or vice versa), and hence they all may be considered basically compatible.

SECTION 6

THE NATIONAL VIEWPOINT

The primary national interests relating to resource recovery include:

- Reduction of the total energy required to produce commercial products by replacing part of the original raw materials with recycled materials
- Reduction of fuel imports by extensive energy recovery from waste
- Conservation of valuable material resources by recycling recovered materials
- Improvement of national environmental quality by a reduction in landfill requirements, air pollution, and water pollution.

In this chapter, various combinations of source separation options and mixed-waste processing alternatives are analyzed in terms of their effects on environmental quality, net energy conservation, institutional considerations affecting national interests, and economics.

ENERGY AND MATERIALS CONSERVATION

Issue

From a national viewpoint, source separation combined with mixed-waste processing provides an opportunity to:

1) Increase overall net energy efficiency
2) Increase national energy supplies
3) Reduce depletion of scarce resources.

Objective

The objective of this section is two fold: to determine recyclable material and energy conservation potential for each source separation and mixed-waste processing option, and to project these savings on a national scale.

Approach

The net energy efficiency includes not only the Btu recovery of the mixed-waste processing facility but also the energy credit for recycling the source separated material less the energy requirements for collection and transportation of the waste. The net energy efficiency was calculated for each source separation option and mixed-waste processing option. In order to project these results to a national basis, the following technique was used to estimate the potential market penetration for mixed-waste processing facilities.

A 1,000 t/d facility would require the support of a population of 540,000 (5 times Baselyn) in a fairly small area. Of the 243 standard metropolitan statistical areas (SMSA) in the nation, 66 have a population of 540,000 or greater.(1) The 66 SMSAs contain 46.5 percent of the population and should generate close to the same percentage of solid waste produced in the United States (~150 x 10^6 t/y). This amount of solid waste would support 191 1,000 tpd MWPF's which was used as the potential national market.

Results

Table 34, compiled from the source separation profiles developed in Section 3, shows the quantity of material available for recycling in the various source separation scenarios, for both fixed and expanded service

TABLE 3-. RECYCLED MATERIAL FOR A 1,000 T/D SERVICE AREA

Source Separation Option	Component	Fixed Service Area (t/d)	Expanded Service Area (t/d)
Multimaterial, high	Paper	104	126
	Glass	53	64
	Ferrous	16	19
	Aluminum	3	4
Multimaterial, low	Paper	42	45
	Glass	21	23
	Ferrous	12	13
	Aluminum	1	1
Newsprint, high	Paper	45	47
Newsprint, low	Paper	15	15
Beverage containers	Glass	45	48
	Ferrous	9	10
	Aluminum	6	6

areas. The net energy credit (i.e. the net energy saved by recycling glass, metals, and papers) as a percentage of the mixed waste energy content is as follows:

Source Separation Option	% Energy Content of Mixed Waste
Multimaterial, high	15.7
Multimaterial, low	6.2
Newsprint, high	4.2
Newsprint, low	1.4
Beverage containers	5.4.

Table 35 shows the projected national reduction in material use and the amount of energy saved using source separation.

TABLE 35. NATIONAL RESOURCE AND ENERGY CONSERVATION DUE TO SOURCE SEPARATION, FIXED SERVICE AREA (EXPANDED SERVICE AREA)

Source Separation Option	Resource 10^3 t/d		Energy Saved (10^{10} Btu/d)		Energy Saved (10^3 BBl oil/d)	
Multimaterial, high	34	(41)	28	(33)	47	(57)
Multimaterial, low	15	(16)	11	(12)	19	(20)
Newsprint, high	9	(9)	7	(8)	12	(13)
Newsprint, low	3	(3)	2	(2)	4	(4)
Beverage containers	11	(12)	10	(10)	16	(17)

Of more importance is the net energy efficiency, which is determined by adding together the energy recovered in mixed-waste processing and the energy credit for recycled material, and then subtracting the energy used for collection and transportation. Table 36 shows the net energy efficiency matrix as a percentage of the energy content of the mixed-waste stream. Because the composition of the waste stream is the same for both fixed and expanded service areas, the percentage of net energy efficiency is the same for both cases (although the total amount of source separated material and energy recovery is different in each case). Table 37 shows the net energy recovery, expressed as equivalent barrels of oil per day, projected on a national basis for both fixed and expanded service areas.

TABLE 36. NET ENERGY EFFICIENCY (% of total available in mixed-waste)

Source Separation Option	Unprocessed Waterwall Combustion	Processed Waterwall Combustion	Refuse-Derived Fuel	Modular Incinerator
Multimaterial, high	66	61	60	62
Multimaterial, low	60	55	54	56
Newsprint, high	61	55	54	56
Newsprint, low	61	56	54	56
Beverage containers	67	61	60	62

TABLE 37. NATIONAL NET ENERGY RECOVERY WITH SS AND MWP (10^3 BOE*/d) FIXED SERVICE AREA (EXPANDED SERVICE AREA)

Source Separation Option	Unprocessed Waterwall Combustion	Processed Waterwall Combustion	Refuse-Derived Fuel	Modular Incinerator
Multimaterial, high	195 (237)	180 (218)	177 (215)	183 (222)
Multimaterial, low	183 (136)	168 (180)	165 (177)	171 (184)
Newsprint, high	183 (192)	165 (173)	162 (170)	168 (176)
Newsprint, low	183 (186)	168 (171)	162 (164)	166 (169)
Beverage containers	201 (213)	183 (194)	180 (191)	186 (198)

* BOE = barrels of oil equivalent

Conclusions

Source separation can make a significant contribution to reducing resource use and conserving energy. On a national basis, energy demand can be reduced by up to approximately 50,000 bbl of oil per day. The combining of source separation and mixed-waste processing has an even greater potential for energy reduction. In terms of energy conservation, the source separation options that separate and recycle metals is more important than those separating paper and newsprint only. The energy recovery for paper is roughly the same whether the paper is recycled or processed, while the energy credit for metals can only be obtained by source separation and recycling. Therefore, source separation scenarios that maximize metal recycling are the most net energy efficient. Nationally, combined source separation and mixed-waste processing has the potential to reduce energy demand by the equivalent of over 200,000 BOE per day.

ENVIRONMENTAL IMPACT

Issues

The paramount national issues are the reduction of the amount of waste and provisions for proper solid waste disposal.

Objectives

The objectives of this section are to determine whether the various scenarios will reduce the amount of solid waste and will lead to its proper disposal. Additionally, the environmental effects of the various scenarios will be determined.

Approach

Assumptions--

Since Baselyn meets the National Ambient Air Quality Standards (Section 3), if overall emissions from processing of solid waste do not exceed those from landfilling, processing is to be preferred.

Because landfill sites are becoming more difficult to obtain and the regulations governing them are becoming more stringent, any action leading to a reduction in landfill requirements should be considered. On the other hand, a landfill site may be currently available, whereas a new MWPF must be built; thus, considerable landfill area would be required for the immediate future even if an MWPF is chosen.

Those materials obtained by source separation and resource recovery, and recycled rather than disposed of, represent a threefold gain: (1) an immediate reduction in landfill requirements, (2) a reduction in the need for raw materials in primary production, and (3) a reduction in energy required both for primary production and production of finished products.

Analysis--

As stated in Sections 4 and 5, source separation will extend landfill life from 1.5 to 17.6 percent, depending on the source separation option adopted. Mixed-waste processing will further extend landfill life, by 76.1 to 80.3 percent. Scenarios combining both source separation and mixed-waste processing will extend landfill life somewhat more, by 76.2 to 86.3 percent. Clearly, processing extends landfill life more than source separation does.

Source separation will decrease atmospheric emissions from waste haulage by 3.6 to 17.6%. Mixed-waste processing will reduce these emissions by as much as 80.3%. Combinations of source separation and mixed-waste processing can reduce emissions as much as 86.3%. Consequently, from the national viewpoint, the combinations are to be preferred.

The emission of pollutants into the air by mixed-waste processing, even though controlled to meet regulations, will still occur. If an equivalent amount of coal is burned to yield the energy recovered in mixed waste processing, particulate emissions will be unchanged (both will be controlled to the same standards), but SO_2 and NO_x emissions will be reduced in mixed waste processing. Additionally, emissions occasioned by coal mining, processing, and transportation will be eliminated by mixed waste processing energy recovery. Thus, emissions will be reduced nationwide, both at coal producing localities and at localities where mixed-waste processing occurs.

Existing municipal waste landfills will have less effect on ground water, to the extent that landfill residuals are reduced by source separation and mixed-waste processing. The leachability of the residuals from mixed-waste processing is also reduced.

Mixed-waste processing will have a greater effect on surface water then the equivalent combustion of coal. This will only be partially offset by a reduction in coal combustion.

Conclusions--

On balance, it would appear desirable from the national viewpoint to accept the surface water impacts from mixed waste processing. The gains are a reduction in air pollution and haulage emissions due to mixed waste processing and a reduction in ground water pollution obtained by using source separation, or mixed waste processing, or a combination of the two. Multimaterial separation and UCWCF or MI again appear to be the best choices.

INSTITUTIONAL/TECHNOLOGICAL IMPACTS

Issues

Some institutional and legislative actions taken by local or state governments to promote resource recovery will have impacts well beyond the boundaries of the implementing institutions. Among the options considered in this study, beverage container recovery through mandatory deposit legislation is likely to have the most wide-ranging impacts. Although an exhaustive analysis is outside the scope of this study, the issue has attracted considerable public attention and will thus be concisely evaluated for the benefit of the reader.

Other institutional issues of national significance concern whether the regulatory actions of the Federal government (i.e., freight rate ceilings for commodities shipped interstate, and tax laws and regulations) tend to favor either the source separation or the mixed-waste processing approach.

Finally, the question of overcoming institutional barriers to the further use of mixed-waste processing for energy recovery has recently been analyzed in some depth, and has received significant attention from policy makers. Recently, progress has been made in overcoming economic barriers because of the large price increases, and the scarcity, of fossil fuels. There is now some concern that valuable source separable materials (notably high-grade papers) will increasingly be used for their energy content in waste processing systems, and thus not achieve their highest potential economic value. Hence the question arises as to whether analogous institutional barriers to increased source separation exist that merit further federal analysis and possible action.

Objectives

This section will address the following questions:

- Does overall employment, considered on a regional and national basis, increase or decrease as a result of beverage container deposit legislation, and do market distortions and inequities result from enactment of different legislation in different states and communities?

- Is there a difference in the effects of mixed-waste processing and source separation options on railroad freight rates regulated by the Interstate Commerce Commission (ICC) for virgin and recycled materials?

- How do federal tax laws and regulations influence local decisions on resource recovery options?

- Are there institutional barriers beyond the ability of local or state government to resolve, but potentially soluble by federal action, that tend to make source separable material the captive product of mixed-waste facilities?

Approach

The results of previous studies are summarized and from this summary, conclusions are developed about the institutional compatibility of specific source separation and mixed-waste processing combinations.

Employment and Equity Effects of Beverage Container Recovery Legislation--

This issue can be considered on the state, regional, or federal level. First, we will discuss the documented employment impacts in Oregon and Vermont, the first states to enact such legislation. Then we will comment on the conclusions of a study by a task force of the New York State Senate on the probable impacts of proposed mandatory deposit legislation for New York State. Finally, we will present estimates of the potential impact of national mandatory deposit legislation.

The Oregon bill, which took effect in 1972, required a minimum five-cent deposit on all beverage containers sold in the state. As a result, nonreturnable bottles were largely replaced by returnable bottles, which now account for 90% of beverage sales. The return rate for returnable bottles ranges from 80 to 95 percent and for cans the return rate is about 70 percent. Employment impacts showed a pattern in which a net loss of primarily skilled jobs in the beer and soft drink container manufacturing industries was offset by a larger net gain of less skilled jobs in the retail and distribution sectors of the economy. One contract canning plant in the state closed down, with a net loss of 75 to 252 jobs, excluding the retail sector. Increases in the number of retail jobs were less well documented, but were estimated at 400, resulting in a net job gain of 148 - 325.(49)

In Vermont, which enacted a five-cent minimum deposit law in 1973, initial shifts in container types were much less marked; many brewers simply labelled non-returnable bottles for deposit and disposed of them upon return. There has been a gradual shift toward the use of returnable bottles. Return rates were reported in 1977 to have increased to 80 - 95 percent.(50) By 1979, state officials were estimating rates as high as 97 percent statewide.(51) Data on employment are somewhat incomplete. Some soft drink distributors and beer wholesalers reported increases in employment to handle returnable bottles, while no significant declines in sales or employment were experienced by container manufacturers. This is probably due to the small population of the state and the previously mentioned slowness of the shift to returnables. Retail stores in towns near the state border experienced declines in beer and soft drink sales because Vermonters made fewer purchases in adjoining states.

The New York State study concluded that net employment impacts would be as follows.(52)

> A shift to a beverage market made up of 80 to 90 percent refillable bottles would result in an increase in employment of about 5,200 jobs due to the labor intensive nature of the refillable bottle filling and handling operations. The decrease in the total number of containers consumed each year would result in employment dislocation affecting approximately 1,200 workers. How quickly such dislocations would be assimilated would be dependent upon industry and union strategies, employment turnover rates, and whether or not the shift toward refillable bottles was gradual. The net increase in employment, then, would be over 4,000 jobs. The net increase in payrolls in the state as a result of this net increase in employment would be approximately $35 million annually.

Impacts in each municipality would vary, but the most widespread would be increases in unskilled bottle- and can-handling jobs at supermarkets and convenience stores.

For national beverage container deposit legislation, a similar pattern was predicted for the United States as a whole. A comprehensive EPA analysis resulted in the conclusion that a nationwide deposit system would cause a decrease of 82,000 in employment levels in the container manufacturing and supply industries by 1980; however, these losses would be offset by increases of 164,000 in the beverage, beverage distribution, and retailing industries.(53) Table 38 summarizes the national employment impacts.

TABLE 38. NATIONAL EMPLOYMENT LEVELS IN CONTAINER PRODUCTION AND USE*: IMPACT OF DEPOSIT LEGISLATION
(In thousands of jobs)

Year	Soft Drink Inds.†	Malt Liquor Inds.†	Wholesale Beer Distr.	Retail	Glass Container Mfg.	Metal Can Inds.	Metal Supp.	Total
1975 baseline	102	19.8	56.2	13.4	36.5	42.0	22.8	293
1980 baseline	119	23.6	67.1	13.1	40.7	55.5	30.2	349
1980 deposit legislation	154	31.9	90.2	111.0	11.0	21.5	11.7	431
Net change (1980 deposit legislation minus 1980 baseline)	+35	+8.3	+23.1	+97.9	-29.7	-34.0	-18.5	+82

* EPA analysis of data from Bingham, T.H, and P.F. Mulligan (Research Triangle Institute), "The Beverage Container Problem: Analysis and Recommendations," U.S. Environmental Protection Agency, Sept. 1972 190 p. (Distributed by National Technical Information Service Springfield, Va., as PB-213 341); "Bottle Survey '71; A California Supermarket Report on the Cost of Handling Returnable Soft Drink Bottles." Le Habra, Calif., Alpha Beta Acme Markets, 1971, 16 p.; "Employment Dislocations Data," Research Triangle Institute, Research Triangle Institute Park, N.C., 31 p., April 10, 1974.

† Container distribution employment only.

At present, seven states - Oregon, Maine, Vermont, Connecticut, Iowa, Michigan, and Delaware - have adopted container deposit laws. This patchwork of differing legislation may in the long run produce additional local distortions of the type described in Vermont if federal mandatory deposit legislation is not passed.

Freight Rate Differentials--

For a number of years, it has been debated whether railroad freight rates, regulated by the ICC for commodities moved in interstate commerce, tended to promote the use of virgin as opposed to recycled materials. EPA analysis in 1972 indicated that no consistent trend existed, and that rates for each set of primary virgin products and equivalent secondary products had to be examined individually.(50) It concluded that existing rates at that time were likely to discriminate against ferrous scrap and glass cullet, but could favor use of scrap aluminum and wastepaper.

In February 1977, the ICC, after conducting its own investigations, ordered rollbacks in freight rates for several recycled commmodities, including glass cullet, in several geographic regions. At that time, the ICC ruled against lowering the rates for ferrous scrap and wastepaper, but ordered further reduction of rates for other secondary materials.

On April 16 1979, the ICC, in a more far-reaching judgment, stated that existing rates often favored raw materials; the Commission announced an overall guideline, according to which recyclable commodities should not be priced at more than 180 percent of actual handling costs. Specific reductions in freight rates were ordered primarily for scrap metals, with significant reductions for recycled aluminum and copper in all areas and for ferrous scrap in the South. In issuing its judgment, the ICC stated that it considered the rate levels necessary to encourage recycling. This action and the 1977 decision on glass cullet should substantially reduce freight rate inequities.(54)

In general, the overall ICC freight rate structure and its recent changes will affect the choice between source separation and mixed-waste processing options as follows: they will probably have some influence on which materials are most economical to recover, but little effect on the choice of the best way to recover them. When the same material (e g.. ferrous and nonferrous cans) can be recovered by either source separation or MWP, both options will have the same freight costs and thus neither will have an advantage. Hence, although the recovery of recycled material would be encouraged over that of raw material, this would not affect the economics of the choice between source separation and MWP.

The current ICC freight rate structure is probably more balanced now between virgin and recycled materials than it has been in the past. The recent changes should tend somewhat to encourage multimaterial source separation options compared to the newsprint recovery programs that have been most common to date. Since all mixed-waste processing alternatives considered (except MI) include ferrous recovery, none of them should receive a distinct advantage over the other mixed-waste processing and multi-material source separation options.

Federal Tax Laws and Regulations--

Taxes and tax shelters that apply to production of virgin materials but not their secondary equivalents could use varying freight rates, alter relative production costs and thus encourage or discourage resource recovery. Examples of such "discriminatory" (i.e., differential, rather than undesirable or unfair) tax treatment include 1) tax credits granted for payment of taxes to foreign governments; 2) percentage depletion allowances for mineral production; 3) "expensing" (i.e., deferment of tax payments) of expenditures for mining exploration and development; 4) treating earnings from timber sales as capital gains rather than income; and 5) state and local taxes on the value of resources produced. All but the last provide tax benefits for virgin materials compared with their recovered equivalents.

A 1974 study for EPA concluded that discriminatory federal tax treatment reduced the cost of production of virgin materials compared with recovered equivalents for each of several commodities examined: aluminum, pulp and paper, glass, steel, and five plastic and rubber products. Hence, discriminatory tax treatment consistently tended to benefit virgin material production,(55) compared with the impact of freight rates. The largest percentage steel and paperboard manufacturers experienced the biggest impacts; tax benefits of 2.8 to 4.3 percent before taxes and 1.4 to 2.2 percent after taxes.

Although these benefits are significant, the authors of the study did not predict whether or not elimination of discriminatory tax treatment would increase use of secondary material. The authors concluded that, in the short term, demand for steel would probably increase if such tax treatment were eliminated, but demand for other products would not. Long-term impacts of changes in federal tax policy were considered impossible to predict; however, glass is less likely to be affected than other products, as most industrial source glass cullet is already recycled and the economies of glass recovery are considered unfavorable. According to the study, price instability of markets for other recovered materials has a much greater effect on demand than federal tax policy. Specifically, if tax policies were the critical determinant of demand for ferrous scrap, current policies would tend to slightly discourage multimaterial source separation options. However, since the price changes resulting from discriminatory taxation are much smaller than fluctuations in recovered material prices (newsprint prices, for example, increase or decrease by as much as 50-75 percent within a single year), they apparently do not have a major impact on the local choice of options.

Possible Institutional Barriers to Source Separation--

As discussed in Section 5, compared with mixed-waste processing, source separation may involve more effort in communicating with homeowners and altering collection practices, but fewer difficulties with capital financing, length of contract restrictions, and political autonomy. Overall, then, administrative capability should not impede source separation programs. However, this reasoning does not explain why many programs that were initially quite successful (for example, Hempstead, New York) were dropped several years after their initiation, or why these such programs have generally failed to significantly reduce the quantity of material disposed.

One factor that plays a role in inhibiting municipalities from beginning such projects is the short-term instability of prices for paper, the mainstay of such programs. Between 1974 and 1979, prices for used newspapers varied from $5 per ton to $50 per ton. Below roughly $15 per ton, newsprint recovery is no longer economically profitable. While over the course of a longer term (such as one year), average paper prices are much more constant, many municipalities face very tight budgets and are reluctant to risk even short-term operating losses from separation programs.

Long-term waste paper contracts with fixed floor prices are usually cited as a solution to this problem. However, many waste paper purchasers are reluctant to guarantee prices without assurance of long-term deliveries and municipalities may be reluctant to commit themselves for long periods, particularly if they are also considering mixed-waste processing. Dealers may not wish to guarantee accepting waste paper at low market prices if their own storage capacity is limited and they anticipate problems in reselling the material. They are also limited by their own contracts (usually one year) with used newsprint mills. As energy prices are far more likely to remain above a fixed floor price and in fact increase, many municipalities seem to favor mixed-waste processing. Once they have taken such a major resource recovery project, local source separation may seem less urgent. Hence, there are market and institutional forces that discourage negotiation of long-term waste paper contracts with fixed floor prices by municipalities. It does appear quite reasonable to conclude that if the market for waste paper and other materials continues to be so volatile, these materials will sometimes become captured products of MWP facilities. Since most MWP systems have not yet demonstrated an ability to recover waste paper as a material, the highest economic value of waste paper would not be recovered.

In essence, municipal source separation programs face a situation not unlike that of family farmers, or other small producers of commodities subject to extreme market price fluctuations, who cannot long sustain operating losses. It appears unlikely that local action can remedy this situation, as waste paper markets respond to fluctuations in national and international demand.

Federal price supports for source separation programs have been discussed. A study prepared for the National Commission on Supplies and Shortages, a Congressionally mandated body, concluded that municipal and private paper recycling programs could eliminate sudden spot shortages in the pulp and paper industry. As one of six long-term recommendations, the study recommended a policy of active stimulation of and, if need be, subsidization of paper recycling programs. (56)

A recent study conducted for the Garden State Paper Company analyzed the economics of paper recycling.(57) This study examined these economic relationships as they are affected by the average relative prices of energy and waste newspaper. The study concluded that source separation of newsprint is profitable at or above $15 per ton (in 1977 dollars). This study also addressed the effect of local variables such as costs of newspaper recovery, landfilling, energy recovery and other factors in determining the level of price support that might be needed. Additional analysis of these economic relationships and the marginal increase in demand resulting from waste paper price support programs, other mechanisms for subsidizing source separation programs and policy alternatives should be considered before recommending a particular federal program.

Mixed-waste processing options may soon benefit from federal efforts to support the development of synthetic fuels and other alternative energy sources. Consequently, an evaluation of parallel federal support for waste paper recovery may be timely.

ECONOMIC IMPACT

Issue

From a national perspective, the major economic issue is the potential of source separation and mixed-waste processing to reduce solid waste disposal costs while reducing fuel import needs.

Objective

The objective is to determine the potential material economic impact of source separation and mixed-waste processing.

Approach

National cost savings from source separation and mixed-waste processing over landfilling from the expanded service area were projected from the difference between the costs of the two scenarios. Table 39 shows the projected national savings matrix. Of greater economic impact is the reduction in fuel import costs due to energy conservation. Table 40 shows the projected yearly cost savings due to the reduction in energy required. It was assumed that the energy conserved was originally imported oil at $30 per barrel.

TABLE 39. PROJECTED NATIONAL SAVINGS FOR SOURCE SEPARATION AND MIXED-WASTE PROCESSING ($ million/yr)

Source Separation Option	Unprocessed Waterwall Combustion	Processed Waterwall Combustion	Refuse-Derived Fuel	Modular Incinerator
Multimaterial, high	214	197	142	215
Multimaterial, low	264	263	296	245
Newsprint, high	282	289	320	284
Newsprint, low	357	340	346	358
Beverage containers	437	417	320	432

Conclusions

Source separation and mixed waste processing can reduce net solid waste disposal costs and even more important, reduce oil import costs by up to $2.6 billion per year.

SUMMARY

For the issues examined in this section from a national perspective, all source separation options result in positive or neutral impacts (a beneficial effect or no change) when combined with mixed-waste processing alternatives, and hence can be considered compatible with them.

TABLE 40. PROJECTED NATIONAL FUEL IMPORT COST SAVINGS ($billion/yr)

Source Separation Option	Unprocessed Waterwall Combustion	Processed Waterwall Combustion	Refuse-Derived Fuel	Modular Incinerator
Multimaterial, high	2.6	2.4	2.4	2.4
Multimaterial, low	2.2	2.0	1.9	2.0
Newsprint, high	2.1	1.9	1.9	1.9
Newsprint, low	2.0	1.9	1.8	1.9
Beverage containers	2.3	2.1	2.1	2.2

More materials are recovered with source separation than with mixed-waste processing alone. Net energy efficiencies (taking into account energy recovery in mixed-waste processing, energy credits for recycled material, and energy used in collection and transportation) is also higher, as are overall energy savings measured in equivalent barrels of oil per day on a national basis. Pollution emissions and waste delivered to landfill are also lower than with no source separation.

One major institutional issue examined is the employment impact of beverage container deposit legislation. Studies of states having adopted such legislation suggest higher net employment, as did an EPA analysis of potential impacts of a nation wide deposit system. Hence, this option would be beneficial from a national perspective. For two other institutional issues - freight rate differentials for recovered materials and Federal tax laws and regulations - source separation options and mixed-waste processing alternatives would be equally affected by current Federal policies. Hence, no compatibility issues would arise. Federal policies to encourage development of mixed-waste processing - loan guarantees and price supports for recovered materials - would not apply to source separated materials.

There may be justification for evaluating the possible benefits of similar price supports for source separated materials. However, when local markets exist for source separated materials, it is unlikely that any Federal policies favoring mixed-waste processing would adversely affect operation of source separation programs.

The national economic impact of combining source separation and mixed-waste processing consists of reductions in total national solid waste disposal costs and fuel import savings, as compared with no source separation and landfill.

The analysis for these issues suggest two general conclusions. First, source separation and mixed waste processing are compatible, as neither interferes with the viability of the other. Second, combining the two approaches results in a greater net benefit than implementing either separately. The greatest benefits occur with the most efficient source separation programs, beverage container recovery and high-efficiency multi-material recovery.

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APPENDIX A

SOURCE SEPARATION

PROGRAM ECONOMICS

In calculating the costs and effects of the five source separation options, the city is assumed to operate all programs except beverage container recovery. For each source separation option, two options are considered for the remaining waste: disposal to the county landfill and disposal to a privately operated mixed-waste processing facility.

Other assumptions based on the experience of the Somerville and Marblehead programs include:

- Source separated waste is collected in four ton, compartmentalized trucks
- Each truck is operated by three persons
- Each truck and crew collect five to seven Mg (six to eight tons) per day.

The daily quantities of materials recovered in Baselyn are shown in Table 41.

Source Separation Program Revenues

The revenue per ton of recycled material has been determined from current national averages:(58)

TABLE 41. SOURCE SEPARATION MATERIALS RECOVERY

Case	Source Separation Option	Source-Separated Material* in Mg(tons)/day and Percent of Total Waste Generated: Newsprint and Other Paper Mg(tons)	%	Corrugated Mg(tons)	%	Office Mg(tons)	%	Glass and Metals Mg(tons)	%	TOTAL RECOVERED WASTE Mg(tons)	%	Remaining Waste Waste Mg(tons)	%
1	High multimaterial recovery	12 2(13.4)	6 7	5 0(5 5)	2.8	1.6(1 8)	0 9	13 1(14 4)	7.2	31 8(35.1)	17 6	149.6(164.9)	82.4
2	Low multimaterial recovery	7.5(8 3)	4.2					4.9(5 4)	2.7	12.4(13.7)	6.9	169.0(186.3)	93 1
3a	High newsprint recovery	8 2(9 0)	4 5							8.2(9 0)	4 5	173 2(191 0)	95 5
3b	Low newsprint recovery	2.7(3 0)	1.5							2 7(3 0)	1.5	178.7(197.0)	98 5
4	Beverage container recovery							10.6(11.7,	9 0	10 6(11.7)	9 0	170 8(188.3)	91

* Total waste generation is 131.4 Mg (200 tons) per day.

- Newsprint and other household paper $33/Mg ($30/ton)
- Corrugated paper $33/Mg ($30/ton)
- Office paper $66/Mg ($60/ton)
- Mixed glass and cans $11/Mg ($10/ton).

Baselyn's daily revenues from source separation are shown in Table 42.

TABLE 42. SOURCE SEPARATION PROGRAM QUANTITY AND REVENUES (Per Day)

Source Separation Option	Newsprint		Glass and Metals		Totals*	
	Mg(tons)	Revenue	Mg(tons)	Revenue	Mg(tons)	Revenue
1. High multimaterial recovery**	12.2(13.4)	$402	13.1(14.4)	$144	25.3(27.7)	$546
2. Low multimaterial recovery	7.5 (8.3)	249	4.9 (5.4)	54	12.4(13.7)	303
3a. High newsprint recovery	8.2 (9.0)	270			8.2 (9.0)	270
3b. Low newsprint recovery	2.7 (3.0)	90			2.7 (9.0)	90
4. Beverage container recovery***			10.6(11.7)		10.6(11.7)	

* Assuming 181.4 Mg (200 tons) per day collected waste.

** Office paper and corrugated recovery are privately operated and therefore no municipal revenues are generated.

*** The municipality receives no direct revenue in this program.

Source Separation Program Costs

Labor and equipment requirements are summarized in Table 43. Baselyn's cost per Mg (ton) and per day for the source separation program are given for each option (see Table 44).

TABLE 43. EQUIPMENT AND LABOR REQUIREMENTS FOR SOURCE SEPARATION*

Source Separation Option	Mg(tons) or Waste Recovered per day	Collection Vehicles Required** per day	Crews Required per day	Crew Productivity Mg(tons) day/crew
1. High multimaterial recovery	25.3(27.7)	4	4	6.3(6.9)
2. Low multimaterial recovery	12.4(13.7)	2	2	6.4(7.0)
3a. High newsprint recovery	8.2(9.0)	2	2	4.1(4.5)
3b. Low newsprint recovery***	2.7(3.0)	0	0	2.7(3.0)
4. Beverage container recovery	8.2(9.0)	0	0	0

* Municipal program only

** Each collection vehicle has a capacity of 3.6 Mg (4 tons) and can make two trips day. Therefore, the daily productivity of a vehicle and crew is estimated to be five to seven Mg (six to eight tons). Each vehicle is operated by a three-man crew.

*** No additional equipment or labor required for source separation.

1. Vehicle Costs(59)

a. Capital costs: For Cases No. 1 and 2, the cost of each compartmentalized collection vehicle was $25,000. The cost is amortized over five years at nine percent per year, yielding an annual cost of $6,430 or a daily cost of $24.70.

In Case No. 3a, flat-bed collection vehicles costing $20,000 each are used. This implies a daily amortized cost of $19.75. For Case No. 3b, modified refuse trucks are used to collect newsprint. The additional costs ($500 per truck) are assigned in remaining mixed-waste costs.

TABLE 44. SOURCE SEPARATION PROGRAM COSTS

Source Separation Option	Mg(tons) Recovered per day	Collection Vehicles per day	Labor per day	Admin Cost per day	Total Cost per day	Total Cost per Mg(tons)
1. High multimaterial recovery	25.3(27.7)	$239	$700	$43	$982	$39($35)
2. Low multimaterial recovery	12.4(13.7)	120	350	43	513	41(37)
3a. High newsprint recovery	8.2(9.0)	110	350	43	503	62(56)
3b. Low newsprint recovery*	2.7(3.0)					
4. Beverage container recovery*	10.6(11.7)					

*The municipality incurs no direct costs in this program.

b. Maintenance, operation and depreciation is $35 per day per truck.

2. Labor Costs

The average cost of wages and 25 percent fringe benefits is $175 per day per crew.

3. Administrative Costs

The cost for half the time of an administrator who earns $18,000 per year plus 25 percent fringe benefits is $43.25 per day. Cases No. 3b and 4 were not assigned administrative costs because these costs were insignificant.

Disposal for Mixed-Waste

Two options are considered for disposal of Baselyn's mixed-waste: landfilling and delivery to a mixed-waste processing facility. In the case of landfilling, Baselyn pays for collection of the remaining mixed-waste, operation of the transfer station, transportation to the county-owned landfill and a tipping fee. The cost breakdown is:

Type	Cost $/Mg (per ton)	% Total
Collection Labor(60),*	$19.70 ($17.85)	41
Collection Equipment(60),**	8.80 (8.00)	18
Transfer Station***	0.65 (0.60)	1
Tipping Fee at Landfill	14.35 (13.00)	29
Transportation to Landfill	5.50 (5.00)	11
Totals	49.00 (44.45)	100

* Including fringe benefits.

** Including operating costs, overhead and depreciation.

*** Assuming $15,000 per year labor including fringe benefits and $50/day equipment costs.

For disposal to the mixed-waste processing facility, the labor and equipment costs for collection are the same. The mixed-waste plant, located in Baselyn, is owned and operated by a private enterprise.

Type	Cost $/Mg (per ton)	% Total
Collection Labor	$19.70 ($17.85)	46
Collection Equipment	8.80 (8.00)	21
Tipping Fee at MWPF	14.35 (13.00)	33
Totals	42.85 (38.85)	100

Total Solid Waste Program Costs

The total solid waste program costs for each source separation option are shown in Table 45. The net program costs (gross costs less revenues) are given for two disposal options. The lowest net program costs are for multimaterial recovery and beverage container recovery. The case with no source separation has the highest overall net costs.

TABLE 45 MATERIAL-RECOVERY AND WASTE-DISPOSAL COST SUMMARY

Daily Collection and Disposal Costs

		Source Separation		Remaining Mixed-Waste			Source Sep.	Net Total Costs for All Solid Waste			
Case	Source Separation Option	Mg(tons)	$	Mg(tons)	Landfill $	MWPF $	Daily Rev $	$**	Landfill $/Mg(ton)	$**	MWPF $/Mg(ton)
0	No source separation	0	0	181 4(200)	8,890	7,770	0	8,890	49(44)	7,770	43(39)
1	High multimaterial recovery	31.8(35.1)	982	149 6(164 9)	7,330	6,406	546	7,766	43(39)	6,842	37(34)
2	Low multimaterial recovery	12.4(13 7)	513	169.0(186.3)	8,281	7,238	303	8,491	47(42)	7,448	41(37)
3a	High newsprint recovery	8 2(9 0)	503	173.3(191 0)	8,490	7,420	270	8,723	48(44)	7,653	42(38)
3b	Low newsprint recovery	2 7(3.0)	0	178.7(197.0)	8,757	7,653	90	8,667	48(43)	7,563	42(38)
4.	Beverage container recovery	10 6(11.7)	0	170.8(188.3)	8,370	7,315	0	8,370	46(42)	7,315	40(37)

* Landfill and mixed-waste processing facility (MWPF) disposal costs assume a constant $13.00 tipping fee as presented on page 170

** Waste disposal costs plus source separation costs less source separation revenues.

ENERGY ANALYSIS

This analysis considers the energy expended in collection, preparation, transportation, and treatment of source separated and remaining mixed waste. Energy uses and savings were computed on the basis of joules per Mg (Btu per ton) of recovered waste or remaining waste, depending upon the system covered.

Collection

In Cases No. 1, 2, and 3a, Baselyn's vehicles use 512 x 10^6 joules of fuel per Mg (440 x 10^3 Btu per ton) of separated waste collected and 201 x 10^6 joules per Mg (173 x 10^3 Btu per ton) of remaining mixed-waste collected.(61) The difference is mainly due to the fact that separated waste is delivered to a materials processor 16 kilometers (10 miles) from Baselyn and the remaining mixed-waste is delivered to the transfer station in Baselyn. The mixed-waste collection vehicles are also somewhat more efficient since they can carry larger loads than any source separation vehicles.

In Case No. 3b, mixed-waste vehicles are used for both newsprint recovery and mixed-waste collection. However, the newsprint is then taken from the transfer station to the materials processor 16 kilometers (10 miles) away in a 4.5 Mg (5 ton) flat-bed truck. The truck consumes about 1.69 x 10^6 joules per Mg-km (3.5 x 10^3 Btu per ton-mile) when empty and 2.53 x 10^6 joules per Mg-km (5.25 x 10^3 Btu per ton-mile) when full.(62) Therefore, about 101.7 x 10^6 joules per Mg (87.5 x 10^3 Btu per ton) are used for the 32 km (20 mile) round trip.

Preparation

Preparation of remaining mixed-waste that is destined for the county landfill consists essentially of compacting the wastes into a 16 Mg (18 ton) tractor-trailer for transport to the landfill. About 120 x 10^6 joules per Mg (103 x 10^3 Btu per ton) are used in this process.(63) For wastes going directly to the mixed-waste processing facility, no other processing is used.

Separated cans and glass are mechanically sorted at the materials processor and loaded onto rail cars for shipment to a manufacturer. About 134×10^6 joules per Mg (115×10^3 Btu per ton) are used in this process.(63) Energy used for shredding, baling, and loading separated paper products is about 593×10^6 joules per Mg (510×10^3 Btu per ton).(63)

Transportation

Transportation for remaining mixed-waste consists of hauling by 16 Mg (18 ton) tractor-trailer to the county landfill 40 km (25 miles) away. About 256×10^6 joules of fuel are used per Mg of waste (220×10^3 Btu per ton). If a mixed-waste processing facility is used, no additional transportation is needed.

Separated paper, glass cullet, and metal are hauled by rail to manufacturers 320 km (200 miles) away. Rail transport consumes 24×10^6 joules per Mg-km (33×10^3 Btu per ton-mile).(64) A one-way haul is assumed, so that 767×10^7 joules per Mg ($6,600 \times 10^3$ Btu per ton) are used.

Treatment

The energy expenditures for treatment of remaining mixed-waste are calculated for sanitary landfilling. In the landfill system, treatment consists of spreading and covering the waste by a bulldozer that consumes fuel at the rate of about 70×10^6 joules per Mg (60×10^3 Btu per ton) of waste.(62)

Less energy is used in recycling than in manufacturing from virgin materials. The energy savings due to recycled glass, metals, and paper are as follows:

o Glass cullet to new glass saves 9.2×10^9 joules per Mg ($7,940 \times 10^3$ Btu per ton) of cullet.(65)

- Mixed paper to new corrugated paper saves 9.9×10^9 joules per Mg ($8,490 \times 10^3$ Btu per ton) of recovered paper.(65)

- Substituting scrap metal for pig iron saves 19×10^9 joules per Mg ($16,340 \times 10^3$ Btu per ton) of scrap.(66)

- Recycling aluminum saves about 47×10^9 joules per Mg ($40,450 \times 10^3$ Btu per ton) of recovered aluminum.(67)

<u>Energy Analysis Summary</u>

The net energy used per Mg (ton) of waste handled was then multiplied by the quantities of waste for each case to yield total energy used per day for each system (see Tables 46 through 50).

The total energy used by each source separation system (including energy used for remaining waste) is shown in Table 51. Total energy used for handling waste with no source separation is over 117 billion joules (111 million Btu) per day for land disposal. This is equivalent to the energy in 3.0 m^3 (19 barrels) of crude oil or about 3,000 liters (800 gallons) of gasoline per day.

The energy balance for each source separation case shows some energy savings. In fact, multimaterial recovery shows a net energy savings, because of the energy credit. High multimaterial recovery has the highest savings - over 174 billion joules (165 million Btu) per day or 965 million joules per day are saved if the remaining waste is landfilled. This savings is equivalent to over 4.5 m^3 (28 barrels) of crude oil per day.

TABLE 46 ENERGY EXPENDITURES FOR SOURCE SEPARATION CASE NUMBER 1 HIGH MULTIMATERIAL RECOVERY

Waste Type	Waste Quantity mg (ton)/d	Collection: Unit Joules/mg (10^3 Btu/ton)	Collection: Total Joules/d (10^3 Btu/d)	Preparation: Unit Joules/mg (10^3 Btu/ton)	Preparation: Total Joules/d (10^3 Btu/d)	Transportation: Unit Joules/mg (10^3 Btu/ton)	Transportation: Total Joules/d (10^3 Btu/d)	Treatment: Unit Joules/mg (10^3 Btu/ton)	Treatment: Total Joules/d (10^3 Btu/d)	Total Joules/d (10^5 Btu/d)
Recovered Waste Paper	18 8 (20 7)			593×10^{6} (510)	12×10^{9} (11,385)			*99×10^{8} *(8,490)	*19×10^{10} *(175,740)	
Ferrous Metal	2 5 (2 7)			134×10^{6} (115)	33×10^{7} (310)			*$.9 \times 10^{9}$ *(16,340)	*47×10^{9} *(44,120)	
Glass	10 1 (11 1)			134×10^{6} (115)	13×10^{8} (1,275)			*46×10^{8} *(3,970)	*46×10^{9} *(44,070)	
Nonferrous Metal	0 5 (0 6)			134×10^{6} (115)	73×10^{6} (69)			*47×10^{9} *(40,450)	*26×10^{9} *(24,270)	
Total	31 8 (35 1)	512×10^{6} (440)	16×10^{9} (15,445)		14×10^{9} (13,040)	77×10^{6} (66)	24×10^{8} (2,315)		*30×10^{10} *(288,200)	*27×10^{10} *(2,570 0)
Remaining Waste to Landfill *	149 6 (164 9)	203×10^{6} (175)	20×10^{9} (28,860)	120×10^{6} (103)	18×10^{9} (16,995)	256×10^{6} (220)	38×10^{9} (36,280)	70×10^{6} (60)	10×10^{9} (9,895)	97×10^{9} (920 2)
Remaining Waste to Processing	149 6 (164 9)	203×10^{6} (175)	30×10^{9} (28,860)	120×10^{6} (103)	16×10^{9} (16,985)					48×10^{9} (458.5)

* Denotes an energy return

TABLE 47 ENERGY EXPENDITURES FOR SOURCE SEPARATION CASE NUMBER 2 LOW MULTIMATERIAL RECOVERY

Waste Type	Waste Quantity mg (ton)/d	Collection Unit Joules/mg (10^3 Btu/ton)	Collection Total Joules/d (10^3 Btu/d)	Preparation Unit Joules/mg (10^3 Btu/ton)	Preparation Total Joules/d (10^3 Btu/d)	Transportation Unit Joules/mg (10^3 Btu/ton)	Transportation Total Joules/d (10^3 Btu/d)	Treatment Unit Joules/mg (10^3 Btu/ton)	Treatment Total Joules/d (10^3 Btu/d)	Total Joules/d (10^3 Btu/d)
Recovered Waste Paper	7 4 (8 1)			593×10^{6} (510)	435×10^{7} (4,130)			*99×10^{8} *(490)	*73×10^{9} *(68,770)	
Ferrous Metal	0 9 (1 0)			134×10^{6} (115)	121×10^{6} (115)			*19×10^{9} *(16,340)	*17×10^{9} *(16,340)	
Glass	3 9 (4 3)			134×10^{6} (115)	522×10^{6} (115)			*46×10^{8} *(3,970)	*18×10^{9} *(17,070)	
Nonferrous Metal	0 27 (0 3)			134×10^{6} (115)	37×10^{6} (35)			*47×10^{9} *(40,450)	*13×10^{9} *(12,135)	
Total	12 4 (13 7)	512×10^{6} (440)	636×10^{7} (6,030)		504×10^{7} (4,775)	77×10^{6} (66)	95×10^{7} (904)		*12×10^{10} *(114,315)	*13×10^{10} *(1,206 1)
Remaining Waste to Landfill	169 (186 3)	203×10^{6} (175)	34×10^{9} (32,600)	120×10^{6} (103)	20×10^{9} (19,190)	256×10^{6} (220)	43×10^{9} (40,985)	70×10^{6} (60)	12×10^{6} (11,180)	11×10^{10} (1,039 6)
Remaining Waste to Processing	169 0 (186 3)	203×10^{6} (175)	34×10^{9} (32,600)	120×10^{6} (103)	20×10^{9} (19,190)					55×10^{9} (571 9)

* Denotes an energy return

TABLE 48 ENERGY EXPENDITURES FOR SOURCE SEPARATION CASE NUMBER 3a HIGH NEWSPRINT RECOVERY

Waste Type	Waste Quantity mg (ton)/d	Collection: Unit Joules/mg (10^3 Btu/ton)	Collection: Total Joules/d (10^3 Btu/d)	Preparation: Unit Joules/mg (10^3 Btu/ton)	Preparation: Total Joules/d (10^3 Btu/d)	Transportation: Unit Joules/mg (10^3 Btu/ton)	Transportation: Total Joules/d (10^3 Btu/d)	Treatment: Unit Joules/mg (10^3 Btu/ton)	Treatment: Total Joules/d (10^3 Btu/d)	Total Joules/d (10^5 Btu/d)
Recovered Newsprint	8.2 (9.0)	512×10^6 (440)	418×10^7 (3,960)	593×10^6 (510)	484×10^7 (4,590)	77×10^6 (66)	627×10^6 (594)	*99×10^8 *(8,490)	*81×10^9 *(76,410)	*71×10^9 *(672.7)
Remaining Waste to	173.3 (191.0)	203×10^6 (175)	35×10^9 (33,425)	120×10^6 (103)	21×10^9 (19,670)	256×10^6 (220)	44×10^9 (42,020)	70×10^6 (60)	*12×10^9 *(11,460)	11×10^{10} (1,065.7)
Remaining Waste to Processing Facility	173.3 (191.0)	203×10^6 (175)	35×10^9 (33,425)	120×10^6 (103)	21×10^9 (19,670)					56×10^9 (530.9)

* Denotes an energy return

TABLE 49 ENERGY EXPENDITURES FOR SOURCE SEPARATION CASE NUMBER 3b LOW NEWSPRINT RECOVERY

Waste Type	Waste Quantity mg (ton)/d	Collection: Unit Joules/mg (10^3 Btu/ton)	Collection: Total Joules/d (10^3 Btu/d)	Preparation: Unit Joules/mg (10^3 Btu/ton)	Preparation: Total Joules/d (10^3 Btu/d)	Transportation: Unit Joules/mg (10^3 Btu/ton)	Transportation: Total Joules/d (10^3 Btu/d)	Treatment: Unit Joules/mg (10^3 Btu/ton)	Treatment: Total Joules/d (10^3 Btu/d)	Total Joules/d (10^5 Btu/d)
Recovered Newsprint	2.7 (3.0)	102×10^6 (87.5)	274×10^7 (260)	$5?3 \times 10^6$ (510)	161×10^7 (1,530)	77×10^6 (66)	209×10^6 (198)	*987×10^8 *(8,490)	*27×10^9 *(25,470)	*25×10^9 *(234.8)
Remaining Waste to	178.7 (197.0)	203×10^6 (175)	36×10^9 (34,475)	120×10^6 (103)	21×10^9 (20,290)	256×10^6 (220)	46×10^9 (43,340)	70×10^6 (60)	*12×10^9 (11,820)	12×10^{10} (1,099.3)
Remaining Waste to Processing Facility	178.7 (197.0)	203×10^6 (175)	36×10^9 (34,475)	120×10^6 (103)	21×10^9 (20,290)					58×10^9 (547.6)

* Denotes an energy return.

TABLE 50 ENERGY EXPENDITURES FOR SOURCE SEPARATION CASE NUMBER 4 BEVERAGE CONTAINER RECOVERY

		Collection		Preparation		Transportation		Treatment		
Waste Type	Waste Quantity mg (ton)/d	Unit Joules/mg (10^3 Btu/ton)	Total Joules/d (10^3 Btu/d)	Unit Joules/mg (10^3 Btu/ton)	Total Joules/d (10^3 Btu/d)	Unit Joules/mg (10^3 Btu/ton)	Total Joules/d (10^3 Btu/d)	Unit Joules/mg (10^3 Btu/ton)	Total Joules/d (10^3 Btu/d)	Total Joules/d ([illegible] Btu/d)
Recovered Beverage Containers										
Ferrous Metal	2.0 (2.2)							*19 x 10^9 *(16,340)	*465 x 10^8 *(44,120)	
Glass	8.2 (9.0)							*462 x 10^7 *(3,970)	*377 x 10^8 *(35,730)	
Nonferrous Metal	0.45 (0.5)							*47 x 10^9 *(40,450)	*213 x 10^8 *(20,225)	
Total	10.6 (11.7)	102 x 10^6 (87.5)	108 x 10^7 (1,025)	134 x 10^6 (1,115)	142 x 10^7 (1,345)	77 x 10^6 (56)	812 x 10^5 (770)		*106 x 10^9 *(100,075)	*102 x 10^9 *(969.3)
Remaining Waste to Landfill	171.7 *(189.3)	203 x 10^6 (175)	349 x 10^8 (33,130)	120 x 10^6 (103)	206 x 10^8 (19,500)	256 x 10^6 ([illegible])	439 x 10^8 (41,650)	70 x 10^6 (60)	120 x 10^8 (11,350)	112 x 10^9 (1,056.0)
Remaining Waste to Processing	171.7 (189.3)	203 x 10^6 (175)	349 x 10^8 (33,130)	1.20 x 10^6 (103)	206 x 10^8 (19,500)					555 x 10^8 (526.3)

* Denotes an energy return

TABLE 51 TOTAL ENERGY EXPENDITURES FOR SOURCE SEPARATION AND REMAINING WASTE

	Waste Quantities				Energy Expended Joules/d (10^6 Btu/d)			Total Energy Expended Joules/d (10^6 Btu/d) Including Source Separation	
	Recovered		Remaining						
	mg (ton)	%	mg (ton)	%	Source Separation	Disposal to Landfill	Disposal to Processor	Disposal to Landfill	Disposal to Processor
High multimaterial recovery	31 8 (35 1)	17 6	149 6 (164 9)	82 4	*2 71 x 10^{11} *(2,570 0)	9 71 x 10^{10} (920 2)	4 83 x 10^{10} (458.5)	*1 74 x 10^{11} *(1,649 8)	*2 23 x 10^{11} *(2,111 5)
Low multimaterial recovery	12 4 (13 7)	6 9	169 0 (186 3)	93 1	*1 27 x 10^{11} *(1,206 1)	1 10 x 10^{11} (1,039 6)	5 46 x 10^{10} (517 9)	*1 76 x 10^{10} *(156 5)	*7.26 x 10^{10} *(688 2)
High newsprint	8 2 (9 0)	4 5	173 3 (191 0)	95 5	*7 09 x 10^{10} *(672 7)	1 12 x 10^{11} (1,065.7)	5.60 x 10^{10} (530 9)	4 15 x 10^{10} (393 0)	*1 50 x 10^{10} *(141 8)
Low newsprint	2 7 (3 0)	1 5	178 7 (197.0)	98.5	*2 48 x 10^{10} *(234 8)	1 16 x 10^{11} (1,099 3)	5.78 x 10^{10} (547 6)	9.12 x 10^{10} (864 5)	3.30 x 10^{10} (312 8)
Beverage container recovery	10 6 (11 7)	5 9	170 8 (188 3)	94 1	*1 02 x 10^{11} *(969 3)	1.11 x 10^{11} (1,056 0)	5.55 x 10^{10} (526 3)	9 15 x 10^{9} (86.7)	*4 67 x 10^{10} *(443 0)

* Denotes an energy return

APPENDIX B

SAMPLE CALCULATIONS

1. tons per day of particulate $= \frac{gr}{scf} \times \frac{scf}{lb} \times \frac{2{,}000\ lb}{t} \times \frac{1{,}000\ tons}{d}$

$$\times \frac{lb}{7{,}000\ gr} \times \frac{tons}{2{,}000\ lb} \qquad \text{Equation (1)}$$

2. tons per day of gases $= \frac{ppm}{10^6} \times \frac{scf}{lb} \times \frac{2{,}000\ lb}{t} \times \frac{1{,}000\ tons}{d}$

$$\times \frac{mole}{359\ scf} \times \frac{M}{mole} \times \frac{tons}{2{,}000\ lb} \qquad \text{Equation (2)}$$

Where M is the molecular weight of the pollutant gas.

PARTICULATES

Consider particulate emissions from unprocessed waterwall combustion, for which the emission concentration is 0.17 gr/scf, and 75 scf/lb of flue gas is released:

$$0.17\ \frac{gr}{scf} \times \frac{75\ scf}{lb} \times \frac{2{,}000\ lb}{t} \times \frac{1{,}000\ tons}{d} \times \frac{lb}{7{,}000\ gr} \times \frac{tons}{2{,}000\ lb}$$

= 1.82 tpd.

Also, the heat content for high multi-material source separation is 7.71×10^6 Btu/d vs. 9.20×10^9 Btu/d for no source separation; therefore,

$$1.82\ tpd \times \frac{7.71 \times 10^6}{9.20 \times 10^6} = 1.53\ tpd$$

SO_2

Consider SO_2 emissions from modular incinerators, for which the emission concentration is 168 ppm, and 65 scf/lb of flue gas released. After beverage container source separation (9.19×10^6 Btu/d), the tons per day calculate to:

$$\frac{168}{10^6} \times \frac{65\ \text{scf}}{\text{lb}} \times \frac{2{,}000\ \text{lb}}{\text{t}} \times \frac{1{,}000\ \text{t}}{\text{d}} \times \frac{64}{359\ \text{scf}} \times \frac{\text{t}}{2{,}000\ \text{lb}} \times \frac{9.19 \times 10^6\ \text{Btu/d}}{9.20 \times 10^6\ \text{Btu/d}}$$

= 1.95 tpd.

APPENDIX C

CONTRACT EXCERPTS

PROVISIONS RELATED TO SOURCE SEPARATION IN CONTRACTS BETWEEN MUNICIPALITIES AND MWP FACILITY OPERATORS AND ENABLING LEGISLATION

1. City of New Orleans - Waste Management, Inc.

Section 5.01 Delivery of Solid Waste

a. The City shall deliver or have delivered to the Corporation each Operating Day commencing the day following the Completion Date, in accordance with a schedule mutually established by the City and the Corporation, a minimum of five hundred and fifty (550) tons, but no more than seven hundred and fifty (750) tons of Solid Waste, with an average of no less than six hundred and fifty (650) tons per day six days per week for any consecutive four (4) month period, the first of which shall commence on the day after the Completion Date. Such delivery shall be made by the City at its own expense to the Facility.

The weight of each delivery the City shall be determined by the Corporation at the Facility Site. Detailed records of such weight shall be maintained by the Corporation and may be reviewed by the City. The City may verify the accuracy of scales and monitor the way in which the tonnage delivered is weighed.

b. The City or its delivering agent shall deliver the Solid Waste in such form and under such terms and conditions with respect to time and manner of delivery as are agreeable to both the City and the Corporation.

c. The City or its delivering agent shall deliver the Solid Waste to the Corporation in a sanitary manner such that none is blown, leaked, or spilled before acceptance by the Corporation, and shall correct any deficiencies in the manner of delivery which are caused by the City or its delivering agent.

d. The Corporation may refuse to accept the delivery of (i) any waste which is not Solid Waste as defined in Section 1.23, (ii) any Solid Waste not delivered in the form or under the terms and conditions as defined herein, or (iii) any Solid Waste delivered in excess of seven hundred and fifty (750) tons per Operating Day.

e. The foregoing notwithstanding, by mutual agreement between the City and the Corporation, the maximum daily tonnage and the average daily tonnage of Solid Waste may be increased.

f. Title to the Solid Waste shall vest in the Corporation upon its acceptance at the Facility Site by the Corporation. However, title to the Unrecoverable Waste vests in the owner of the Landfill Site in accordance with the provisions of Section 6.02.

g. If the quantity of Recoverable Resources in the Solid Waste delivered by the City or its delivering agent is significantly reduced as a result of laws or ordinances passed by the City or acts of persons subject to City control or acts of law violators, the City shall provide offsetting adjustments to the Corporation to compensate for the Corporation's loss of recovery revenues. Baseline data from which deviation shall be measured shall be that developed by Dr. Stephen E. Steimle, P.E., under contract to the City, as shown in Exhibit 3 attached hereto and made a part hereof. To a reasonable extent, the City shall provide the Facility with Solid Waste with as high a recovery potential as practicable.

2. Connecticut Resource Recovery Authority - State of Connecticut Enabling Legislation, Title 19, 19-524r, Provision 10

(10) That it being to the best interest of the state, municipalities, individual citizens and the environment to minimize the quantity of materials entering the waste stream that would require collection, transportation, processing, or disposal by any level of government, it is the intent of this legislation to promote the presegregation of recoverable or recyclable materials before they become mixed and included in the waste stream; and that this intent shall be reflected in the policy of the resources recovery authority and that no provision of this chapter or action of this authority shall either discourage or prohibit either voluntary or locally ordained solid waste segregation programs or the sale of such segregated materials to private persons, unless the authority has determined based upon a feasibility report filed with the applicable municipal authority that the reduced user fees charged to it should result in its total cost of solid waste management including user fees paid to the authority to be less without presegregation than with it.

3. Connecticut Resources Recovery Authority - Occidental (OXY) Contract for Bridgeport, Conn. MWP Facility

Section 401. Intent

In entering into this long-term Agreement, the parties hereto recognize that is is impracticable to make provision for every contingency which may arise during the term hereof and the parties hereby declare it to be their intention that this Agreement shall operate between them with fairness and without detriment to the interests of either and that if in the course of performance of this Agreement unfairness to either party is expected or disclosed, then the parties shall use their best efforts to agree upon such action as may be necessary to remove all or a portion of the cause or causes thereof in accordance with this Article. The parties further recognize that the continued operation of the System is the primary objective and is of substantial and material public importance.

In particular, the parties recognize that a long-term Agreement at fixed payments which includes escalation factors tied to specific indices and/or which does not protect against material changes in the composition of Solid Waste may result at some point in time in an inequity to the Company. Therefore, it is the purpose of this Section to provide for continued operation of the System without termination while providing a mechanism for protecting the Company against significant economic frustrations that might result over the long-term period involved from events which are beyond the control of the parties and could not reasonably have been anticipated at the date of execution of these contracts.

It is not the intent of this provision that there shall be any adjustment at a result of mis-estimates, errors in calculation, changes in the price levels of Recovered Products or the development of alternative systems for processing Solid Waste and producing Recovered Products that might be materially more or less favorable.

Section 402. First Condition of Economic Frustration.

The Company shall furnish to the Authority prior to the Commercial Operation Date an initial operating budget showing in reasonable detail the quantities and costs of the labor, materials and services constituting the Base Operating Fee and Base Labor Fee.

Section 403. Second Condition of Economic Frustration.

Within 120 days following the end of the fifth, tenth, fifteenth and twentieth Contract Years, the independent auditors then servicing the Company shall issue an "Economic Frustration Certification" if an economic frustration exists. A copy of such Economic Frustration Certificate shall be delivered to the Authority and to the Company. An Economic Frustration Certificate shall be issued if the Company shall have incurred a cumulative Net Loss Before Taxes of not less than Three Million Dollars during the period of three (3) Contract Years immediately prior to the end of the five-year period involved and shall project a Net Loss Before Taxes of not less than One Million Dollars for each of the next two (2) succeeding Contract Years. If the provisions of Section 406 become operative but no adjustment has been made pursuant to this Article IV either by negotiation or arbitration, then at the end of any Contract Year after the end of the fifth Contract Year an Economic Frustration Certificate shall be issued if the Company shall have incurred a Net Loss Before Taxes of not less than Three Million Dollars in the preceding Contract Year or not less than Five Million Dollars in the two (2) preceding Contract Years.

Section 404. Further Conditions of Economic Frustration.

If the Authority has received an Economic Frustration Certificate pursuant to Section 403 above, the Company may undertake to claim economic frustration if it first demonstrates to the Authority that the conditions which occurred which caused the economic frustration occured as a result of one of the following:

a. The actual increases in the Cost of Operation resulting from inflation not having been properly reflected by the adjustment provided by the indices applied in the Plan of Operation, or

b. Either the Cost of Operation or Net Revenues have been materially affected as the result of the composition of Class I Solid Waste delivered to the System by or on behalf of the Municipalities significantly changing from the following composition:

Constituent		Weight (%)
Paper, plastics and organics		54.4
Glass		9.0
Ferrous Metal		7.6
Non-Ferrous Metals		0.8
Moisture		25.0
Miscellaneous		3.2
	Total	100.0

Section 405. Exercise by the Company of the Provisions of this Article

If the conditions contained in this Article IV have been met, the Company shall given written notice to the Authority setting forth the manner in which the Company has been economically frustrated. The Company and Authority thereupon agree to negotiate in good faith over the changes required in this Agreement in order to reduce or eliminate the causes giving rise to the economic frustration and to adjust the amounts payable by or to the Company, provided that no such change shall cause the Authority to be in violation of any of the provisions of the Municipal Contract or result in the Authority being unable to pay Debt Service from the aggregate Service Payments collected under such Municipal Contract. During such period of negotiations both the Company and the Authority shall continue to perform all of their obligations under this Agreement. Any such agreement by the parties shall become effective immediately.

Section 406. Arbitration.

In the event that the Company and the Authority are unable to agree on the changes to this Agreement in accordance with Section 405 within 180 days after the Company has notified the Authority that it has met the conditions specified in this Article, then the Company or the Authority may demand arbitration pursuant to the conditions of this Section. The demand for arbitration shall be issued under and pursuant to Section 506 hereof. The costs of the arbitration proceedings shall be borne equally by the Authority and by the Company and any decision by the arbitrators shall be retroactive to the date of the demand for arbitration. The arbitration decision may provide that the parties execute an appropriate amendment to this Agreement in order to effect the provisions of this Article IV provided that no such amendment shall cause the Authority to be in violation of any of the provisions of the Municipal Contract or result in the Authority being unable to pay Debt Service from the aggregate Service Payments collected under such Municipal Contract.

4. <u>Universal Oil Products (UOP) - Contracting Communities for Northeast Project, North Andover, Massachusetts,</u>

Section IV, Part 11: Delivery of Acceptable Waste

To the extent that capacity is available, except as provided in Exhibit 3 which is attached hereto and made a part hereof, and except as otherwise herein provided, the Customer shall, beginning on the Commencement Date of Operations and for the term of this Agreement, deliver all Acceptable Waste that the Customer is either legally obligated to accept or has the right to dispose of to the Facility or to any Transfer Station which is identified on Exhibit 4, which is attached hereto and made a part hereof, for subsequent delivery to the Facility, all without cost to the Company, and shall pay to the Company on the terms provided in Section VI hereof the Service Fee then in effect for such deliveries.

Section VI, Part 5: Change in Composition or Laws or Unforeseen Circumstances

(i) The Customer recognizes that the profit incentive of the Company is predicated upon recovery of certain marketable or usable fractions of the Acceptable Waste and that changes in the composition of the Acceptable Waste, especially in the components of recognized value, could disrupt the income from the sale of energy and reclaimed material and thereby reduce the revenues to the Customer and profits for the Company. The Customer agrees therefore that in the event the composition of the Acceptable Waste changes from that described in Exhibit 2, which is attached hereto and made a part hereof, as a result of any change in any applicable law, ordinance, regulation or for any other reason, the Company shall have the right, at its option, to request by notice to the Customer that the Service Fee be adjusted as provided in (iv) below.

(ii) The Customer also recognizes that the Company has entered into this Agreement based upon the law and governmental regulations in effect as of the date of this Agreement. If such laws are changed so as to increase materially the cost of operating the Facility or performing the services contemplated hereunder, or to reduce resource recovery revenues, the Company would suffer adverse financial consequences. Accordingly, the Customer agrees that in the event there is any change in any federal, state, or local law, rules or regulations, or there occur any other acts of any such governmental authority which cause or result in a material increase in the cost of operating the Facility performing the services contemplated hereunder or a material reduction in resource recovery revenues, including but not limited to, any laws or regulations relating to the protection of the environment, the Company shall have the right at its option, to request by notice to the Customer that the Service Fee be adjusted as provided in (iv) below so as to recognize such increases in costs and/or reductions in revenues.

(iii) The Customer and the Company further recognize that, over the course of a twenty-year period, the possibility exists for the occurrence of an unforeseen change in circumstances of a continuing nature which could alter the financial conditions upon which this Agreement has been based and entered into by the Company, but which would not alter the need and desirability of continuance in the performance of the obligations of the parties.

It is explicitly understood that such Unforeseen Circumstance does not include the consequences of errors of design, construction, or operation on the part of the Contractor, the Company, the Operator or any of their wholly-owned subsidiary corporations.

Accordingly, the Customer and the Company agree that in the event there should occur any such Unforeseen Circumstance having a major effect in altering the financial conditions upon which this Agreement was based and entered into by the Company, the Company shall have the right, at its option, to request by notice to the Customer that the Service Fee be adjusted as provided in (iv) below so as to restore equivalent financial conditions for the performance of the Company's obligations under this Agreement.

(iv) In the event of a request by the Company for an adjustment pursuant to any of the first three paragraphs of this section, it shall provide data and anaysis supporting the requested adjustment. Providing the Contract Community Representative and the Company cannot agree on the amount of adjustment, either party may call for the formation of an arbitration panel, consisting of three arbitrators (one of such arbitrators shall be selected by the Company, while the second arbitrator shall be selected by the Contract Community Representative, and the two so selected arbitrators shall mutually select a third abritrator), which shall be requested to prepare for the Company and the Contract Communities a report of findings determining whether or not the Company has suffered adverse financial consequences. If it is determined that there has been an adverse change in financial circumstances of the Company and that such change was due to circumstances contemplated under this Section, then such report shall also determine the amount of such change so as to place the Company in a position with respect to financial consequences which shall be substantially equivalent to that in which the Company would have been in the event such change had not occurred. Company shall cooperate with such arbitration panel by providing the necessary cost data to enable the arbitration panel to determine the appropriate adjustment to be made. The finding of such arbitration panel, as to the amount of adjustment, shall be binding upon the Company, the Customer and Contract Communities. Notwithstanding any provision of this Section, no finding of such arbitration panel shall in any way have the effect of reducing the amount of A or B as set forth in Section VI (2) above

5. <u>City of Milwaukee - Americology, Inc. Contract - Clause for Re-negotiation</u>

"In the event any federal or state legislation or County or City ordinance is enacted which substantially affects or alters any component contained in the composition of solid wastes or which requires the separation of solid waste by CITY households, CONTRACTOR or CITY shall have the right to request prompt contract negotiations. Notwithstanding the enactment of such legislation or ordinance, and subject to the outcome of renegotiations, the enactment of such legislation or ordinance shall not be cause for CONTRACTOR to abandon or fail to fulfill the Agreement in any manner whatsoever."

6. <u>Contract #1 with City of New Orleans: Section 5.01,g - Recoverable Resource Quantity Baseline Data</u>

The recoverable resource quantity baseline data was developed by Dr. Stephen E. Steimle, P.E., and presented in his report <u>Solid Waste Composition Study</u> dated September 1, 1972.

Dr. Steimle estimates the citywide composition of solid waste, for those materials sampled, in Exhibit XI on page 18 of his report. This data has been extracted to show the expected average quantities of the recoverable resources. These are presented in the following table.

Quantities of Recoverable Resources

Material	Percent Composition of Solid Waste
Ferrous Metals	7.50
Glass	10.87
Aluminum	0.92

The study found nonferrous metal (excluding aluminum) to exist only in a trace amount. In addition the report quotes a previous study which found paper to comprise 39.4 percent of solid waste on an as-delivered basis. The Battelle Memorial Institute (BMI) study <u>Recovery and Utilization of Municipal Solid Waste</u> shows a range for paper of 37 to 60 percent based upon a large number of local studies. The New Orleans paper figure falls at the lower end of this range. Based upon the EMI finding of 7 to 15 percent newsprint, the baseline newsprint figure for New Orleans is estimated at 8 percent. Because the percentage of nonferrous metals (excluding aluminum) is low, these materials are excluded from the baseline data for quantity of recoverable resources.

The method of computation of the data for quantity of recoverable resources shall be an average over any consecutive four (4) month period, the first of which shall commence on the day after the Completion Date. These averages shall then be compared to the baseline data.

For the purposes of Section VI (5) (i), the reference composition of Acceptable Waste delivered by Contract Communities is:

Refuse Category	% of Total (By Wet Weight)	% Moisture Content of Each Refuse Category as Disposed
Paper	35.8	23.1
Glass	8.4	3.0
Ferrous metals	7.6	5.5
Nonferrous metals	6.0	5.5
Plastics	1.3	13.0
Leather, rubber	1.4	13.0
Textiles	1.9	20.0
Wood	2.3	15.0
Nonfood product total	59.3	
Food wastes	18.7	63.0
Yard wastes	20.4	34.0
Miscellaneous	1.6	4.0
Total	100.0	28.3**

Minimum Btu content 4,200 (HHV)* per pound

*Weighted Average
**Contract #4 with UOP: Section VI, Part 5,(i).

7. Source Separation Agreement*

Nothing in this Agreement shall be deemed to restrict the rights of any participating Contract Community to practice source separation for the recovery and recycling of waste materials for the benefit of the Contract Community or any charitable purpose.

Recognizing that the Service Fee each Contract Community pays under the terms of this Agreement is strongly affected by the value of materials and energy recovered and marketed by the Solid Waste Recovery Facility and that in turn the materials and energy available for recovery by the Facility are reduced by source segregation programs, it is agreed as follows:

1. The Customer pledges to agressively support enlargement of the collection area by inclusion of additional Contract Communities as participants under the same terms and conditions as this Agreement, if required to attain near full capacity quantities (17,000 or more tons per week) of Acceptable Waste. with the tonnage of such additional waste at least equal to the aggregate tonnage of all source segregated materials.

2. UOP shall not be responsible for marketing or handling of source segregated materials.

3. No adjustment in Service Fee, except as provided in Section VI (5)(i), shall be made as a consequence of source segregation programs removing:

   a. paper only or glass only, or

   b. both paper and glass, or

* Agreement between Universal Oil Products (UOP) and Contracting Communities in Northeast Project of Massachusetts Bureau of Solid Waste (Ref. IV-4).

c. metals in conjunction with effective programs for removal of both paper and glass, or

d. metal removal up to an aggregate tonnage removed by all Contract Communities of 175 tons per month, excluding tonnage of metal removed in conjunction with effective programs for removal of both paper and glass.

4. Any glass removed from the Acceptable Waste stream by a source segregation program shall not at any time be returned to the Acceptable Waste stream.

5. Removal of aggregate tonnages of metals under 3(d) above, in excess of 175 tons per month average for a period of six months or more, shall constitute a change of composition under Section VI (5)(i), irrespective of any other aspect of Acceptable Waste composition.

6. UOP will cooperate with Customer and Customer approved citizen organizations' source segregating interests by providing advice and counseling from time to time with respect to establishing source segregation programs and marketing of segregated materials at no charge to the Customer or Customer sponsored citizen groups.