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The Economics of Recycling and Recycled Materials

RECYCLING TECHNOLOGY ASSISTANCE PARTNERSHIP
ReTAP

NIST MEP
Environmental Program

Clean Washington Center

e Departm f Community, Tr de nd Economic Development

The Economics of Recycling and Recycled Materials

FINAL REPORT

Prepared for

Recycling Technology Assistance Partnership (ReTAP)
A program of the **Clean Washington Center,**
a division of the Department of Community, Trade & Economic Development
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Report No. PP-93-1

ADDENDUM OF DECEMBER 1993
REPORT REVISIONS

The Economics of Recycling and Recycled Materials was published in June 1993. In September the City of Spokane informed the Clean Washington Center that costs in the report for Spokane's residential curbside recycling and disposal systems needed to be revised. This addendum updates the original report to reflect those changes.

This addendum provides a revised Executive Summary (Chapter 1); new Tables B-2 and B-5 for Chapter 2 listing revised cost components for recycling and disposal systems; and new Figures A-1, A-4 and A-5 for Chapter 3 showing revised bar graphs for recycling vs. disposal net costs per ton, recycling costs per ton, and disposal costs per ton. In addition, a brief explanation is provided in the following paragraphs of significant changes in the analysis or conclusions of Chapters 2, 3 and 6. There are no changes in other chapters of the original report.

Overview of Revisions

In Spokane, recyclables and waste are collected by the City. Waste is delivered for disposal to the waste-to-energy facility which is operated by Wheelabrator Spokane, Inc. under contract to the Spokane Regional Solid Waste Disposal Project (Project), a city-county interlocal agency.

In providing figures for this report the City erroneously included in its collection costs the tipping fees it paid to the Project for disposal. When combined with the actual incineration costs reported by the Project, this resulted in a double counting of approximately $7.0 million in disposal costs for Spokane in the original version of this report. While reviewing records to prepare this correction, the City also refined some other cost and tonnage figures.

The revised net costs for recycling and disposal for Spokane are $168 and $158 per ton, respectively. These revised costs are lower than the $175 and $188 respective per ton costs for recycling and disposal that were reported in the study published in June. Collection costs were reduced for both recycling and disposal, while costs for waste-to-energy were increased.

Unfortunately, the City is still unable to separate collection costs for residential from commercial garbage collection. Single-family residential curbside garbage pick-up generally involves many more stops per ton collected than does commercial collection. The latter accounts often use a dumpster or other high capacity collection container rather than a household garbage can. This tends to make residential collection less efficient and leads to significantly higher per ton collection costs for residential accounts. As a result, by combining commercial and residential, the disposal collection cost per ton for Spokane probably understates the actual cost for residential collection and overstates cost per ton for commercial.

The actual effect of combining residential and commercial collection costs cannot be determined for Spokane because data to segregate costs are not available from the City. However, based on comparing residential and commercial collection costs in other cities, residential collection costs can exceed commercial costs by a margin that would make disposal cost the same or more than recycling in Spokane, if disposal cost figures reflected only the expense of residential garbage collection. Because disposal cost significantly exceeded recycling cost for Spokane in the previous edition of this study, the fact that the City's cost figures were as combination of residential and commercial collection costs did not affect the conclusions of the original report.

Spokane also revised tonnages reported for both recycling and disposal. The revision increased tons recycled by less than 1%. However, disposal tonnage decreased substantially, from 174,720 to 111,387 tons. Originally self-haul tons were reported as collection tons for disposal. The City has subsequently been able to separate self-haul tons from residential and commercial collection tons. However, the tables allocating tons, cubic yards and costs to specific materials were not revised for these reasons: residential and commercial disposal quantities are still inseparable, the changes in recycling tons are not substantial, and revised recycling tonnage figures are not available by material.

Chapter 2: Major Revisions to Analysis and Conclusions

1. Spokane recycled 6,769 tons in its curbside program in 1992 (p.41 and Table B-1).
2. Spokane's recycling system net cost in 1992 was $168 per ton (p.43 and Table B-2).
3. Recycling costs per material changed as a result of new recycling total cost (p.45 and Table B-3).
4. Spokane collected 111,387 tons for disposal from residences and business in 1992 (p.45 and Table B-4); revised tons by material can be derived by multiplying previously reported percentage distribution by revised total tons.
5. Spokane's disposal system net cost in 1992 was $158 per ton (p.46 and Table B-5).
6. Disposal costs per material changed as a result of new disposal total cost (p.49 and Table B-6).
7. Recycling vs. disposal system costs per material for Spokane changed as a result of the new recycling and disposal system costs (p.51 and Table B-7).

Chapter 3: Major Revisions to Analysis and Conclusions

1. Spokane's recycling costs were higher than disposal system costs (p.79 and Figure A-1). However, collection costs per ton for waste in Spokane were reported with residential and commercial costs combined. Collection costs for residential waste alone could have been higher than the combined costs per ton, resulting in disposal system costs that would be similar to or even exceed recycling system costs.
2. Recycling net cost per ton was revised to $168 for Spokane (Figure A-4).
3. Spokane realized $23 per ton from selling recycled materials in 1992 (p.84 and Figure A-4).
4. Disposal system net cost per ton was revised to $158 for Spokane (Figure A-5).
5. Spokane's revised disposal system cost was less after revisions than Bellingham's, and only slightly more expensive than Vancouver's. Spokane's disposal system cost for collection was less than in the other three cities. Perhaps this was because Spokane reports residential and commercial collection costs combined, while residential collection costs are reported separately in the other three cities. However,

Spokane's transfer/disposal cost was higher than in the other three cities (p.85 and Figure A-5).

6. The cost of waste-to-energy incineration in Spokane in 1992 was $112 per ton before deducting energy revenues. Net cost was $102 per ton (pp. 96 and 99). These costs included transfer system costs and amortization of $60 million in state grants that helped fund disposal system construction.

Chapter 6: Major Revisions to Analysis and Conclusions

1. Recycling cost more per ton than disposal in Spokane in 1992. However, it is possible that recycling costs might have been less than disposal for residential service if residential disposal system collection costs could be segregated from commercial collection costs (p.151).
2. When costs are allocated by material according to weight collected for Spokane, curbside recycling of each material except aluminum cans, PET bottles and auto batteries was more expensive than disposal. When costs are allocated by material according to volume in the collection truck, all materials (including aluminum cans) cost more to recycle than to dispose in Spokane (p.151).
3. Revised costs show that in comparison with the other cities studied Spokane's disposal system is only less expensive than Bellingham's. With respect to recycling, Spokane's system is the most expensive of the four cities studied (p.152).

D. Revised Tables and Figures

Table B-2. RECYCLING SYSTEM: SPOKANE - Residential Curbside (1992)

	Recycling System Component Costs		
Cost Components	Total Costs (000)	Costs Per Ton	Distribution of Costs
Collection	$1,059	$156.35	82.1%
Overhead	$230	$34.03	17.9%
Total Cost	$1,289	$190.38	100.0%
Less: Revenues	($152)	($22.57)	
Net Cost	$1,137	$167.81	

Note: Recycled materials are sorted curbside by the driver and "marketed" off-the-truck at the end of each route to one of two local processing and marketing contractors who prepare the materials for resale to end-use markets.

Table B-5. DISPOSAL SYSTEM: SPOKANE - Residential and Commercial Collection (1992)

Cost Components	Disposal System Component Costs		
	Total Costs (000)	Cost Per Ton	Distribution of Costs
Collection	$5,004	$44.92	26.8%
Transfer	$726	$6.52	3.9%
Incineration	$10,289	$92.38	55.2%
Bypass Landfill	$154	$1.38	0.8%
Ash Landfill	$1,256	$11.28	6.7%
Overhead	$1,227	$11.01	6.6%
Total Cost	$18,656	$167.49	100.0%
Less: Revenues	($1,060)	($9.52)	
Net Cost	$17,596	$157.97	

Note: Transfer and incineration costs include amortization of capital (including $60 million state grant) over 30 years at 8.15%.

Figure A-1
Recycling vs. Disposal Net Costs Per Ton (1992)

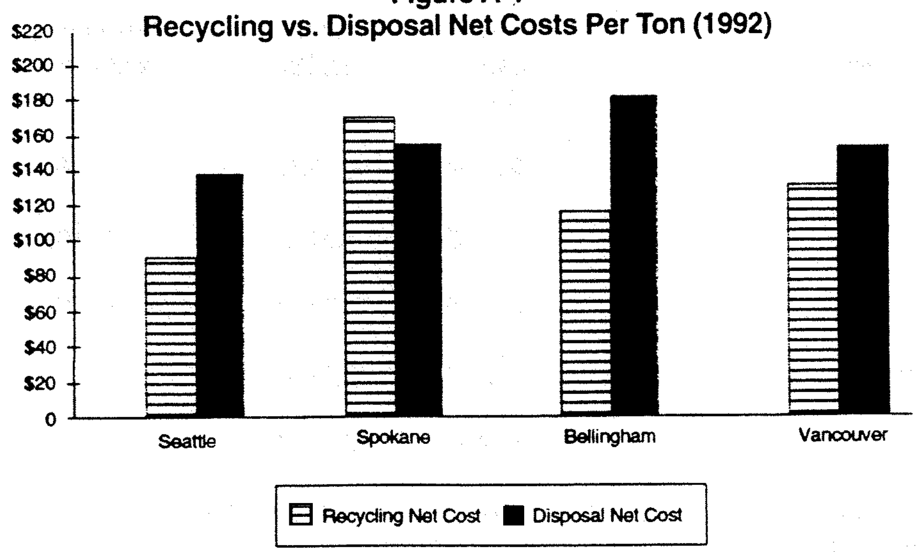


Figure A-4
Recycling Costs Per Ton (1992)

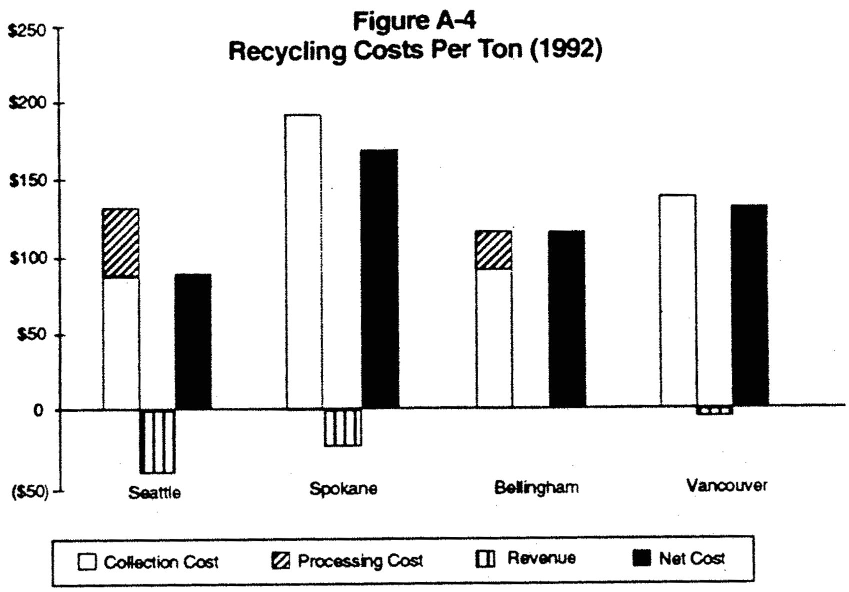
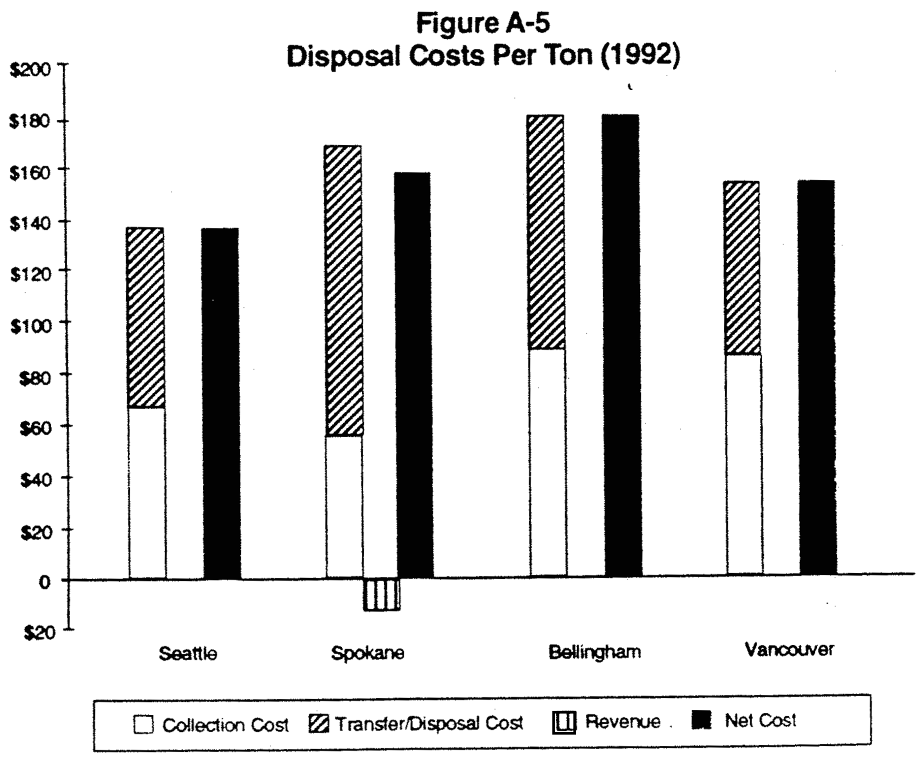
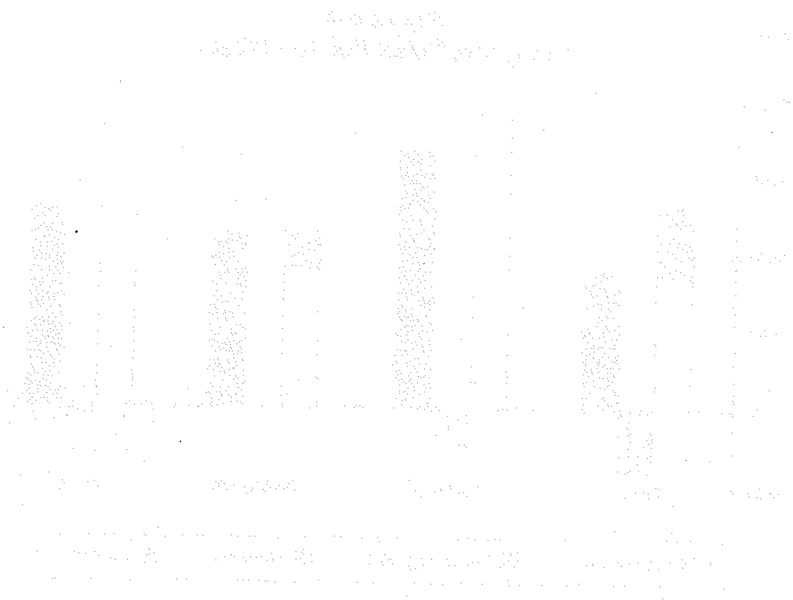
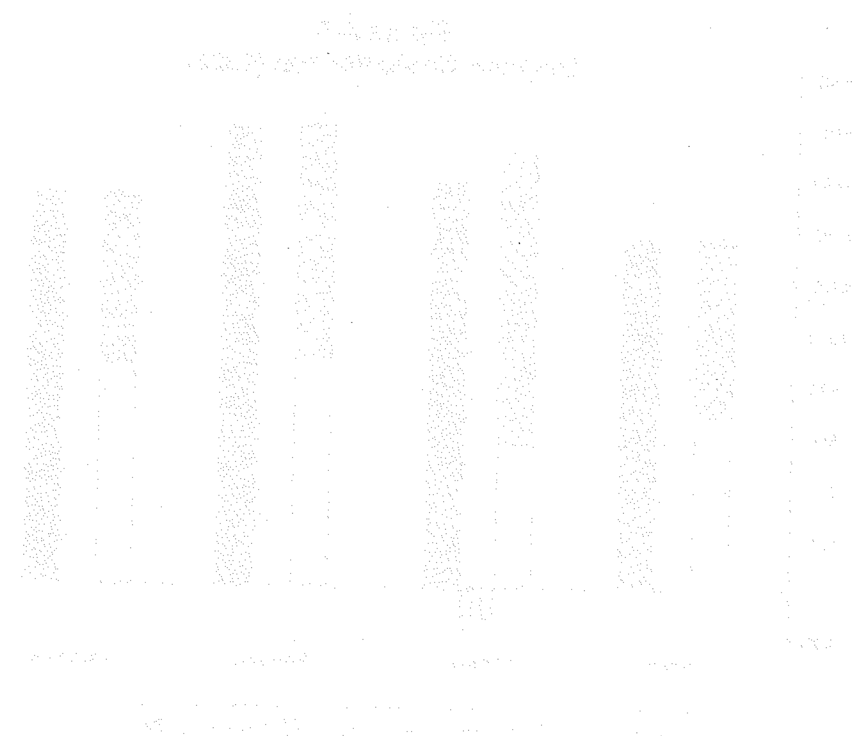


Figure A-5
Disposal Costs Per Ton (1992)







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1. EXECUTIVE SUMMARY

The State of Washington and the Clean Washington Center (Center) are committed to developing markets to consume recycled materials. The Center has chosen an approach that fosters development and growth of private businesses and market demand. In such a market approach, recycled materials must become competitive with the materials for which they substitute. Cost is the significant long term barrier to recycled materials competing successfully.

One of the Center's primary goals is to help make recycled materials cost competitive with virgin materials and disposal options. This report looks at where selected communities and commodities in Washington state are today.

The Center funded this study to provide reliable data on the current cost of recycling. This report examines and compares the costs of recycling and disposal, and the costs of using recycled materials as substitutes for virgin materials in manufacturing and other end uses. Policy debate on recycling has tended to take place in an information void. Data in this report will help to fill that void.

A. Goal and Purpose

The goal of this report is to examine and document the current (1992) costs of recycling versus disposal systems in several Washington state cities, and recent costs and prices of using recycled materials versus substitute materials in manufacturing high value products.

By documenting costs, the Center intends to provide an information foundation from which policy makers can discuss and develop initiatives that will make recycled materials cost competitive in the future. In addition, this work will serve as a model to encourage others in documenting and understanding their own recycling costs.

B. Scope

This study examines 1992 Washington state costs and prices for two phases of recycling – recovery of materials from waste and their use in making valuable products. As closely as possible, actual public data are reported with minimal adjustment.

Recycling and Disposal System Costs

Costs are reported and compared for residential curbside recycling and disposal systems, from collection through resale or disposal. Systems were studied in four Washington cities – Seattle (northend), Spokane, Bellingham and Vancouver.

Costs and market prices are presented from each city's perspective. No attempt was made to estimate the profitability and internal cost structure of a city's contractors or the purchasers of recyclables. System characteristics are fully described for each city.

Recycled and Virgin Materials Use Costs

Purchase prices and costs for using recycled and virgin raw materials are reported and compared, from materials purchase through sale of manufactured or composted product. Five curbside collected materials were studied – old newspapers (ONP), glass containers (cullet), plastic milk jugs (HDPE), plastic pop bottles (PET) and yard waste.

Production is discussed for six markets – newsprint, glass containers, plastic (HDPE) bags, polyester (PET) carpet fiber, plastic (PET) pop bottles and soil conditioners. In several of these markets cost structure information on advanced processing and product manufacturing is proprietary and unavailable. Some attempt has been made to estimate internal costs based on industry or other reliable, but unofficial and not necessarily representative, sources.

In measuring costs it is important to identify who pays and over what time period costs are incurred.

For system costs, this report takes the point of view of the city operating curbside recycling and disposal systems. For recycling versus disposal system costs, this study examines actual costs incurred during 1992 for residential curbside recycling and disposal systems in Seattle, Spokane, Bellingham and Vancouver, WA. System costs in the four communities are reported in total, averaged per ton, and allocated by specific material.

For materials costs, the report takes the point of view of the manufacturer or other end user buying recycled or virgin materials in 1992. Costs are considered for raw materials purchase, processing in preparation for manufacturing, production and sale.

Costs for current recycling and disposal systems indicate what is now being spent on recycling versus disposal. This report does not attempt to estimate what portion of disposal system costs are avoided by recycling. To do so would involve substantial cost accounting and modeling effort beyond the scope and budget for this study. While many disposal system costs do vary directly with tonnage disposed, it is important to remember that data reported here are not sufficient to determine whether total system costs would go up or down, or by how much, if recycling levels changed.[1]

The data reported are not intended to represent the state as a whole or on average. The report shows actual costs for specific localities and for specific materials markets. Some of the information can be generalized with validity; other information cannot. Many localities in Washington, especially rural communities, have limited or no recycling programs; others have recycling and disposal systems that differ significantly from those examined in this report.

In addition the information reported generally is specifically for 1992. To provide actual data, the study had to select a particular time period. The report explores influencing factors and trends, but does not project future costs or market values of

[1]It is also important to note that if competition exists in the provision of waste management services, or if other forces push the waste management system toward minimizing average costs, then avoided disposal cost (in economic terms, the marginal cost of disposal) will tend to be approximately equal to average disposal cost per ton.

materials, nor does it project effects, and potential savings, from technological changes or economies of scale.

Finally, this report presents data, and attempts to examine causal factors, relationships and significant trends. It does not prescribe solutions or make recommendations. Nor does it define the problems or benefits of recycling. The policy makers who use the information in this report will determine recycling's future.

C. Communities and Materials Examined

The four Washington cities for which recycling and disposal system costs were examined are Seattle, Spokane, Bellingham and Vancouver. These cities are geographically diverse, use different collection and marketing approaches, and range in population from Seattle (530,000) to Vancouver (47,000).

Recycling and disposal system costs in each community are reported in total, and as an average for the tonnage handled by each system. For each material recycled through curbside collection, material specific recycling and disposal system costs are also reported.

The five recycled materials for which market price and productive use cost data were compared with virgin materials are ONP, glass container cullet, HDPE bottles, PET beverage containers and yard waste. These commodities are diverse in market maturity, market value, and geographic market breadth.

One high value use was examined for each recycled material, except that two markets were chosen for recycled PET. The specific waste materials and associated end products examined were ONP remanufactured into newsprint, used glass food and beverage containers remanufactured into glass containers, used PET beverage containers manufactured into polyester carpet fiber or remanufactured into two liter beverage containers, used HDPE milk jugs manufactured into plastic grocery and merchandise bags, and yard waste processed into compost.

D. Background: The Economics of Recycling and Recycled Materials

Recycling refers to a series of activities that diverts used materials from waste disposal and returns them to productive use. Diversion involves collecting materials, cleaning and preparing them to a marketable condition, and shipping them for further processing and end use. Recycling is completed when materials are returned to productive use, for example when a manufacturer substitutes recycled materials for more conventional, often virgin, manufacturing feedstocks.

Closed-loop recycling uses a waste material to manufacture the same product that generated the waste material. Making newsprint out of recycled old newspapers (ONP), glass containers from recycled glass food and beverage containers, and soda bottles from recycled polyethylene terephthalate (PET) beverage bottles are three examples of closed-loop recycling.

In addition, recycling includes use of diverted materials in manufacturing products different from those which generated them as wastes. High density polyethylene (HDPE) milk jugs are recycled into plastic merchandise bags. PET beverage bottles are recycled into polyester carpet fiber.

Finally, non-manufacturing uses for waste materials may also be recycling. For example, yard and other organic wastes can be shredded for mulch or composted to generate valuable soil amendments.

Recycling begins by diverting materials from waste disposal, separating them from refuse and collecting adequate quantities. After collection, diverted materials are often delivered to a material recovery facility (MRF) to be sorted by material type, cleaned and processed into marketable raw materials for shipment to end users, manufacturers or advanced processors.

A recycled commodity's market price as an industrial feedstock will generally be set by prices for competing materials that sell in larger quantities and are more established in the marketplace. As a result, market price for a recycled commodity cannot much exceed prices for substitute materials. These prices for substitute materials represent what the feedstock user is accustomed to paying, though users will usually seek to pay the lowest price possible.

The higher the price at which a recycled material can be sold, the greater the revenue available to pay for collection and processing. Until recently most materials were recycled by the private sector, and then only if their market price covered collection and processing costs. Materials with low market prices, thus, could not be diverted from disposal until other sources of revenue were found to cover their recycling costs.

Disposal costs (collection plus landfill or incineration) represent a large expense which households, at least to date, are willing to pay, typically through public sector agencies, for removal of used materials. When materials are recycled rather than thrown away certain costs of disposal are not spent; these are often called the "avoided costs" of waste disposal. Since this amount would otherwise be spent to get rid of waste, communities can afford to contribute it toward the cost of recycling materials.

Thus, avoided disposal costs provide the other revenue source to cover costs of recycling materials with low market value. Avoided disposal costs plus market prices for recycled materials show what may be available to spend to recycle materials.

E. Methodology

Where possible, reported costs are based on publicly available documents such as municipal contracts, market quotes or industry reports. Recycling and manufacturing industry personnel also provided information and data used throughout. To assure accuracy, drafts of the report have been reviewed extensively by many of the information sources themselves, as well as by a wide range of professionals involved in recycling, solid waste, materials markets, and product manufacturing. However, any inaccuracies that may still exist in the report remain the responsibility of the Center's contractor for this project Sound Resource Management Group, Inc., Seattle, WA.

1. Recycling and Disposal Systems Costs

In researching the costs of recycling versus disposal, the existence of multiple recycling and disposal methods for each material was of concern. For example, a waste material can be recycled through single-family residential curbside collection, multifamily residential on-site or curbside collection, commercial business on-site collection, or residential and commercial self-haul to buy-back or drop-off recycling centers. For refuse collection and disposal, there are usually collection and self-haul options for each generator, not to mention illegal dumping.

In principle, it would have been possible to ascertain costs for each method in a city. However, accurate data are not generally available on every recycling and disposal method in use in a community. For example, drop-off/buy-back centers often are privately owned; their capital and operating costs are confidential; and they often serve both residential and business customers.

This study concentrated on costs for curbside collection from single-family residences – the predominant publicly-sponsored recycling method for each material in the cities studied. This allowed consistent comparisons of recycling costs across localities. Also, public recycling programs are more likely to be able to use avoided disposal costs than private recyclers. Curbside recycling costs typically exceed costs of operating a drop-off/buy-back recycling center. Thus, it is no accident that most curbside recycling programs are sponsored by public agencies. System costs for curbside recycling provide an estimate of what can be spent on recycling, taking into account both revenues from selling recycled materials and avoided disposal costs.

This study reports costs for the disposal system that parallels curbside recycling. That is, curbside waste collection from single-family households. The exception is Spokane where collection costs are an average for residential and commercial waste collection. As an additional complication, there are communities in Washington in which multiple disposal methods are used, e.g., Whatcom County uses two incinerators and long-haul to Roosevelt Regional Landfill in Klickitat County. However, the typical locality uses only a single disposal method for which costs must be determined. Fortunately for this study, waste from Bellingham in Whatcom County is all received by Recomp at a single tipping fee of $90.94 per ton, regardless of disposal method.

2. Materials Costs

This project examined high value markets for, and use of, five materials currently recycled in Washington. In each of these markets the recycled waste competes with conventional (usually virgin) materials purchased by a product manufacturer or, in the case of yard waste compost, a direct consumer. For recycled materials other than yard waste, a product that could be, and in fact is, manufactured with either recycled or virgin material was selected.

If both recycled material and its virgin substitute are freely traded in existing commodity markets, then their relative prices provide some indication of how well the recycled material can compete. Of course, any differences in material quality or process modifications associated with using recycled materials in place of other feedstocks must also be addressed. Where such differences are important, a combination of price, quality or performance, and supply availability, rather than price alone, will determine how well recycled materials compete with virgin feedstocks.

However, a recycled or virgin material typically is only one among several inputs in manufacturing a product. Thus, a bundle of inputs including the recycled waste material substitutes for a bundle of virgin material inputs. For example, to manufacture glass containers, recycled glass cullet substitutes for a bundle of virgin inputs that includes silica sand, soda ash, limestone and small amounts of other materials such as feldspar. In addition, melting the virgin input bundle typically requires additional energy compared with melting recycled glass.

Recipes for both the recycled-content bundle and the virgin-content bundle vary from manufacturer to manufacturer, depending on such factors as geographical location, age of plant and equipment, energy costs, and labor force skills. Because a manufacturer cannot simply substitute a single waste material for a single virgin material, and quantities and mixes of inputs vary from manufacturer to manufacturer, comparisons of cost increases or decreases from using recycled versus virgin materials are complex.

In some cases substitution can occur over an industry but not within a given facility. Some operations are equipped to be 100% recycled or 100% virgin, but substitution of recycled materials for virgin, or vice versa, would require major equipment additions and/or modifications. For example, many paper or paperboard manufacturers in the past produced either 100% virgin-content products or 100% recycled-content products. These manufacturers typically are equipped to make pulp from wood or pulp from recycled paper, but not to do both.[2]

Because comparative prices for recycled and virgin materials do not tell the whole story, additional costs of manufacturing are presented as well, where possible, including: estimates of any difference in costs for other materials, energy or labor expended or saved by the use of recycled materials; equipment cost additions or savings; and product price differentials.

F. Findings and Conclusions

The four cities studied are diverse in geographic location, size and experience with curbside recycling. Seattle is the largest with a population of about 530,000 located on Puget Sound. Its curbside program began five years ago.

Spokane is Washington's second largest city with a population over 180,000 located on the eastern border of the state. Its curbside recycling program started in the fall of 1990.

Bellingham is located in northwestern Washington on Bellingham Bay and has a population of about 55,000. Its city-contracted curbside recycling program started in 1989, replacing a local nonprofit organization's curbside operation that had been collecting recyclables in various neighborhoods since the early 1980s.

Vancouver is located in the southwestern part of the state and has a population of about 47,000. Its curbside program was initiated during the first two months of 1992.

[2] An empirical econometric study of the substitutability between recycled paper and virgin wood in papermaking would tend to find that the two materials are quite poor substitutes, because of there being very few producers who can use both recycled paper and virgin wood to make paper. For example, Edgren, John A., and Kemper W. Moreland, "An Econometric Analysis of Paper and Wastepaper Markets," *Resources and Energy*, v11, n3 (Mar 90): p.229(21).

The five materials and their six specific markets also are diverse in terms of maturity of processing infrastructure, market breadth and maturity, market value, and size of the typical manufacturing operation in which the recycled material is used. For example, ONP has been recycled for years, is used in a broad range of products, and requires large scale investment in deinking equipment when used in producing newsprint. By contrast, plastic jugs and bottles have just recently begun to be recycled, and processors and product manufacturers using recycled plastics tend to be smaller scale operations.

1. Recycling and Disposal Systems

Average net cost per ton for recycling in 1992 was lower than for disposal in three of the cities, as shown by comparing Figures in Table F-1 with those in Table F-2, or by comparing costs bars in figure F-1. Disposal costs exceeded recycling costs by a range from $25 per ton in Vancouver to $65 per ton in Bellingham, with Seattle (northend) in between at $47 per ton. Recycling costs shown for Spokane exceeded disposal costs by $10 per ton. However, actual residential disposal system costs in Spokane may be higher and could exceed recycling system costs, for two reasons. Residential waste collection costs in Spokane were averaged with commercial waste collection costs. Also, collection of waste from commercial dumpsters is often cheaper per ton than collection of waste from residential garbage cans due to the smaller amount collected at each residential collection stop. Of the cities studied only Seattle offered curbside collection of yard waste. **Yard waste composting was cheaper than disposal by $21 per ton in 1992.**

Figure F-1
Recycling vs. Disposal Net Costs Per Ton (1992)

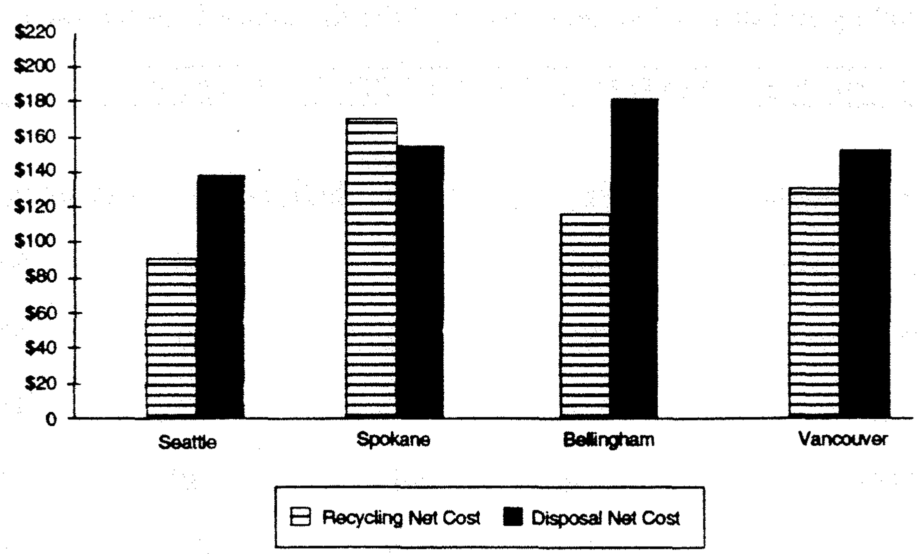

Table F-1. RECYCLING SYSTEM NET COSTS PER TON (1992)

Cost Components	Seattle Recyclables	(Northend) Yard Waste	Spokane	Bellingham	Vancouver
Collection/Overhead	$89	$103	$191	$91	$137
Processing	$42	$13	0[2]	$25	0[4]
Total Costs	$131	$116	$191	$116	$137
Less: Revenue	$41	0[1]	$23	0[3]	$6
Net Cost	$90	$116	$168	$116	$131

Notes: (1) Yard waste delivered to private composter who keeps compost sales revenues.
(2) Materials sorted on route and "sold" off the truck to private processors.
(3) Materials delivered to private processor for net processing fee of $25.06 in 1992.
(4) Materials delivered to processor for net of cost and revenue averaging positive $6.00 in 1992.

Despite the favorable cost comparison for recycling versus disposal, it cannot be assumed that any city's 1992 recycling versus disposal cost difference per ton would be realized as the actual amount of new savings or cost if additional tons were shifted from disposal to recycling or composting, or vice versa. Costs per ton are determined by the system as it was at the time costs were measured (i.e., by the specific tonnage, operating methods, materials collected, market conditions, fixed costs and other factors). Thus, a substantial shift in tonnage would be expected to change both recycling and disposal system costs and the difference between them.

Table F-2. DISPOSAL SYSTEM NET COSTS PER TON (1992)

Cost Components	Seattle	Spokane	Bellingham	Vancouver
Collection/Overhead	$67	$56	$90	$85
Transfer/Disposal	$70	$112	$91	$71
Total Costs	$137	$168	$181	$156
Less: Revenue	0[1]	$10	0[1]	0[1]
Net Cost	$137	$158	$181	$156

Notes: (1) Any revenue obtained from processing mixed waste is reflected in the disposal facility's tipping fee.

Density of materials collected has significant impacts on collection system costs. In all cities studied except Bellingham, there are materials whose recycling costs exceed their disposal system costs when costs are allocated to materials on the basis of their volume in the collection truck. In some cases even aluminum cans were more expensive for a city to recycle because of the processing charges incurred for separating commingled food and beverage containers.

These results indicate the potential costs of inefficiencies in collecting low density materials. However, much more work needs to be done to determine how a material's weight, volume and handling time on the collection route interact to determine the specific cost of collecting that material for either recycling or disposal. Thus, extreme caution should be used when making calculations regarding which specific materials are, and which are not, profitable to recycle in an existing curbside recycling program. The real costs of handling specific materials probably depend on a weighted average of weight, volume and other factors such as time required to collect and load each material into the recycling truck. These weights are likely to be different for different curbside programs due to variations in containers, truck types, number and type of materials collected, and degree of commingling versus source or on-route separation.

Seattle was the only city studied for which information was available on processing costs at the materials recovery facility (MRF) and on market revenues for materials cleaned and prepared for sale. The other three cities deliver their materials, unprocessed, from the curbside collection truck to a private recycling company which either buys the materials or is paid to take them, depending on quality of materials and their eventual market value. The private recycler(s) operates a MRF that cleans, prepares and markets the materials independently of the city. Net charges or revenues from delivery of materials to a private recycler in these three cities are shown as processing costs or revenues, respectively, in Table F-1.

In Seattle average processing costs to clean and prepare recycled materials for market were almost covered by average revenues from their sale as manufacturing feedstocks. By contrast, current costs of cleaning and composting yard waste are two to four times the price at which compost is sold in the metropolitan Seattle area. Seattle currently has a favorable $12.50 per ton processing cost for cleaning and composting its yard waste, as shown in Table F-1. However, even this low processing cost substantially exceeds revenue generated from selling finished compost.

Seattle has the lowest per ton cost among the four cities for both recycling and disposal. Several factors contribute to this:

- Seattle attempts to maintain competition among providers of recycling and refuse collection services by dividing the city into sectors and contracting with multiple providers.
- Seattle is the only city of the four in which the curbside recycling contractor has responsibility for the complete recycling system. The contractor determines its own choice of collection bin and distribution, degree of household sorting of recyclables, type of collection vehicle and route size, type of materials processing facility, effectiveness of material preparation for market, and the market in which each material is sold. In the other cities, one organization collects recyclables, while another cleans, processes and markets materials.
- Seattle has written its contracts for recycling and disposal so that as much as possible of its payments are variable, i.e., paid on a per actual ton basis. This enables

Seattle to decrease disposal costs when materials are diverted to recycling. This is the opposite of a put-or-pay type of contract in which a city pays a fixed cost to its contractor, regardless of the actual tonnage handled.

Spokane has substantially higher curbside recycling collection costs than the other cities, in part because sorting of recyclables is done by the truck driver collecting the materials. Also, collection costs per ton are significantly influenced by the amount collected at each stop. Within limits, extra weight can be collected without significantly increasing the time to stop the truck and pick up a household's recyclables. As a result Spokane's higher cost per ton collected may be because Spokane does not include mixed waste paper in its curbside recycling program.

Residential mixed wastepaper plus corrugated cardboard accounts for 31% to 37% of curbside recycling tonnage in the other three cities, while corrugated cardboard accounts for only 2% of recycling tonnage in Spokane. Furthermore, Spokane collected about 225 pounds per household during 1992. This is only one third of Seattle's curbside recycling collection rate of 650 pounds, slightly over 50% of Vancouver's 435, and less than 50% of Bellingham's 1992 rate of 485 pounds of recyclables per household.

2 Recycled and Virgin Materials Use

Prices for virgin materials appear to set a loose upper limit in feedstock markets for recycled materials prices. This is due in part to greater risks from contamination and variability in performance characteristics of recycled materials, as well as to increased transactions costs from dealing with a number of smaller scale recycled materials suppliers rather than one or a few virgin materials suppliers.

ONP and recycled glass prices have trended downward in the past few years, while prices for virgin substitutes in the Northwest, Douglas fir woodchips and glassmaking silica sand, respectively, have tended to rise. This has been a favorable trend for those manufacturers of newsprint and glass containers using recycled content.

By contrast, virgin HDPE prices have trended downward, pushing prices for both flaked and pelletized recycled HDPE down as well. This price trend has not been favorable for manufacturers of recycled-content HDPE products. In addition, prices for virgin HDPE pellets are not substantially higher than recycled HDPE pellets.

Virgin and recycled PET pellet prices have remained fairly constant for the past few years, with virgin pellet prices more than $0.15 per pound above recycled. This margin has allowed producers of recycled-content products such as carpet fiber to compete successfully with virgin producers.

On the product output side, prices for recycled-content products vary little, if at all, from prices for virgin content products. This fact combined with the fact that virgin feedstocks have only recently begun to be more expensive than recycled feedstocks for some of the products studied has meant that manufacturers have been reluctant to switch to using recycled feedstocks. Even when manufacturing with recycled materials is cheaper, producers may not find it profitable to switch to recycled content if they must make substantial investments in recycled materials processing equipment and, at the same time, abandon virgin manufacturing capacity. This is especially true during times of slow growth in product demand.

G. Issues the Report Does Not Address

This study was focused tightly for two reasons – to assure reliability of data and to accomplish the tasks within budget. Data reported have not been derived from modeling, simulation or compositing. As closely as possible, information is from actual cases; where data were not accessible, none were reported. 1992 was the only year studied, except where historical prices are included for perspective on manufacturing with recycled versus virgin raw materials.

As a result this report can only address some of the recycling issues that are of interest to policy makers today. This report's data does not directly support conclusions regarding the following:

- Cost of a disposal only system ("before") versus a disposal plus recycling system ("after").
- Savings or "avoided costs" from diverting materials from disposal to recycling or vice versa.
- Cost or savings from adding or dropping a material from curbside recycling.
- Cost comparison of recycling versus disposal in other cities or rural locations.
- Future market value of recycled versus virgin materials.
- Economy of scale potential for recycled materials users.

This study also does not explore potential effects of various equalization schemes currently being suggested to "level the playing field" for recycled materials, e.g., advanced disposal fees, virgin materials taxes, subsidies or content/utilization requirements.

H Report Organization

Data are presented as charts or graphs wherever possible. Narrative describes the context and assumptions which the data represent. Appendices contain additional documentation and more detail which may be useful but not critical to understanding the data. That is, Appendix 1 includes an annotated bibliography of reports and reference materials evaluated in the early stages of this study. Appendix 2 contains estimates from a variety of sources on densities for materials loaded on recycling or refuse collection trucks.

Chapter 2 examines, documents and compares the costs of the recycling and disposal systems in the four Washington cities. For this report, recycling system costs are for municipal curbside programs. In some cities, this includes the cost of a materials recovery facility (MRF) and shipment to processors. In other cities, which sell what they collect to private recyclers, costs do not include processing cost at the private recycler's MRF or shipping costs.

Disposal system costs in most cities include costs for at home collection and disposal of residential waste. Spokane does not track their commercial and residential collection costs separately, so Spokane disposal system costs are the average for residential and commercial waste. Inasmuch as collection of commercial waste, especially from generators of larger quantities of waste, is typically cheaper then collection of residential waste, residential-only disposal system costs in Spokane are likely to be higher than the combined figures reported here.

Chapter 3 compares and contrasts system cost data developed in Chapter 2, analyzing the impact of management and system configuration on costs. In particular the impacts of collection strategies, materials targeted for recycling, and disposal methods on system costs and recycling diversion levels are examined. Significant new trends or anticipated changes from past trends in recycling and disposal system costs are discussed.

Chapter 4 examines production practices and prices in high value markets for five recycled materials – ONP, glass food and beverage containers, HDPE milk jugs, PET beverage bottles, and yard waste. Costs are documented and compared for recycled materials versus the virgin or other materials for which they substitute. Other cost differences associated with using recycled versus virgin materials, such as labor, energy, or equipment needed to manufacture with recycled materials are analyzed qualitatively.

Materials price comparisons for 1992 and historical movements in recycled and virgin materials prices in earlier years are discussed. In some markets, such as pelletized HDPE for use in manufacturing grocery bags, feedstocks are sold ready for product manufacturing. Market prices used in this report in this case are for fully processed materials. By contrast, in markets such as newsprint where manufacturers are vertically integrated, materials are processed at the manufacturing site. In such cases market prices for processed materials, e.g., deinked ONP versus mechanically pulped wood chips, are not available, and prices for unprocessed or less fully processed materials are reported.

Chapter 5 draws conclusions from prices and costs of recycled materials use reported in Chapter 4. Generalizations are presented from the commodity markets and materials uses examined. Significant new trends or anticipated deviations from past trends that are likely to occur in materials use costs are discussed.

Chapter 6, the final chapter, provides a brief summary and conclusions based on data and information gathered in this study. Manufacturing price and cost data are combined with Seattle's recycling and disposal system costs. The intent is to examine the combined cost of recycling and manufacturing with recycled materials versus the combined cost of manufacturing with virgin materials and disposing of used products. Thus, materials use costs are tabulated and compared from product manufacture through recycling or disposal of the used product.

I. Sources and Acknowledgments

Much of the data on system costs and materials prices used in this report came from publicly available sources such as existing contracts or market price quotes. However, an equally important amount of information was gathered from city as well as recycling and manufacturing industry personnel.

For Seattle, Jenny Bagby, Ray Hoffman and others at the Solid Waste Utility provided data and information on recycling and disposal systems, and reviewed report drafts. For Spokane, Damon Taam and Jessie Lang provided information and reviewed drafts; Dennis Hein, Eric Larson and Phil Williams provided revised recycling and

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At Sound Resource Management Group, Jeffrey Morris was principal investigator, Jeff Brown researched system costs, Tim Morrissey did research on the glass industry, Paul Hood researched newsprint manufacturing costs, Jim Jensen researched yard waste composting costs, Diana Canzoneri examined market trends, Phil Zach researched system cost trends, and Susan Scott researched historical prices and produced the camera ready report.

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2. RECYCLING AND DISPOSAL SYSTEM COSTS FOR RESIDENTIAL CURBSIDE PROGRAMS [BY LOCALITY]

Throughout North America, the debate rages. Does recycling, especially curbside recycling, cost too much? Which specific materials are most profitable to recycle? Which materials can be added cost effectively to an existing curbside program? Which materials, if any, should be dropped from a recycling program when markets decline?

Some economic events can simultaneously encourage and discourage recycling. For example, the drastic drop in recycled materials market prices since mid-1988 has made recycled materials cheaper for use in manufacturing, but more expensive for communities to divert from the waste stream. This dual effect naturally leads to the question: Will private market economic forces provide a net stimulus or be a barrier to further diversion of materials from landfills and further development of a recycled-materials-based manufacturing sector?

To inform the debate on these issues, this chapter reports baseline data on the costs of recycling versus disposal in a variety of Washington state communities. Recycling and disposal costs were gathered under a common set of assumptions from four communities in Washington state – Seattle, Spokane, Bellingham and Vancouver.

Material Specific Cost Methodology

This chapter reports system costs not only on average, but also for a variety of specific waste stream materials. A central methodological issue in the cost of recycling versus disposal for specific materials involves allocating curbside collection, processing and marketing costs, as well as garbage collection, transfer and disposal costs to each material. Costs allocated simply according to tonnage collected may not adequately reflect the amount of cost incurred to handle relatively lightweight, but bulky materials, e.g., extra trips to unload collected materials. Costs allocated simply according to relative volumes (cubic yards) collected might not adequately reflect the costs incurred to handle heavier, dense materials, e.g., heavier duty equipment to handle greater total weight.

The "true" recycling or disposal system cost for each type material might be based on a weighted average of each material's tonnage and volume. However, no detailed study has as yet been conducted to determine what this weighted average cost might be for each component of recycling and disposal systems.

To add further complexity, collection weight and volume are not the only characteristics of each material that affect its specific recycling or disposal system costs. For example, for the processing component of recycling, labor time to hand sort recycled materials at the MRF will depend more on how materials are sorted by the household before they are placed at the curb for collection, as well as how they are separated when loaded into the collection truck, and less on either weight or volume.

The National Solid Wastes Management Association (NSWMA) in its recent study on the costs of MRF's attempted to take a variety of such factors into account.[3]

For disposal components, relatively greater compaction is achieved in long-haul containers and in landfills than in refuse collection compactor trucks. However, no convincing data were found to suggest greater average compaction changed relative densities among the various materials. Thus, when allocating costs on the basis of material volume, all collection, transfer and landfill costs were allocated according to refuse truck collection volumes.[4]

As a final example, in theory incinerator capacity and energy revenues are dependent on Btu value, as well as tonnage, of each material burned.[5] Incineration costs and revenues, thus, might be allocated according to relative material heating values.

Both Spokane and Bellingham incinerate some or all of their disposed waste. However, Bellingham pays Recomp a flat $90.94 per ton for each ton delivered for incineration. Spokane pays a fixed annual fee for what in 1992 amounted to 85% of waste it delivered for incineration, and is guaranteed a minimum net electricity production of 505 kilowatt hours for each ton burned at their incineration with energy recovery facility operated by Wheelabrator Spokane, Inc. (WSI),, a Waste Management , Inc. (WMI) subsidiary. Thus, there is little direct connection between Btu content of the disposed waste and the net cost to Spokane or Bellingham for waste disposal via incineration. For this reason, incineration costs and revenues were not allocated proportionally to Btu values.

This project had neither time nor budget to conduct detailed cost allocation studies to determine material specific costs for each component of the four cities' recycling and disposal systems. However, to estimate the range within which more accurately calculated material specific system costs might fall, two sets of costs were calculated. One calculation used material weight and the other material volume in the collection vehicle as the basis for allocating total system costs to specific materials.[6]

In the case of the volume-based allocation, the assumption is made that recycling collection truck compartment sizes are adjusted so that all compartments fill up at about the same time. In this situation it is the in-truck density of each material that determines the amount of truck capacity any given material uses. That is, there is no dead space associated with a particular material due to its collection compartment filling up more slowly than other compartments in the collection vehicle.

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[3]National Solid Wastes Management Association, *The Cost to Recycle at a Materials Recovery Facility*, 1992. See the annotated bibliography in Appendix 1 for a short summary of this report. The accounting technique used in the NSWMA MRF study is called activity based costing. That is, costs for specific equipment operations or particular labor tasks are allocated to the material being handled by each particular activity.

[4]See Tellus Institute, *Disposal Cost Fee Study Final Report*, Tables 6.3 and 6.9 for a comparison of in-truck and in-landfill garbage material densities.

[5]Heat content for a material is typically measured in terms of British Thermal Units (Btu) per pound.

[6]Appendix 2 contains a table that summarizes a number of different estimates of densities for the recycled materials examined in this report. The density figures actually used to allocate costs are reported in the tables included for each community's recycling and disposal system costs. Density figures used in cost allocations are believed to accurately reflect in-truck material densities for the recycling and disposal systems used in each particular community.

In the case of Seattle's recycling system, this chapter also reports a third set of cost figures. That is, collection costs are allocated according to collected material volumes, but processing costs are allocated in proportion to relative processing costs for each material as reported in NSWMA's MRF study.

This third set of cost figures is reported only for Seattle where market price data were available by material for recyclables sold after processing at the local MRF. The other three curbside recycling systems deliver materials off the collection truck to private recyclers who are independent of the curbside collection system operator. These private recyclers do not reveal the revenues obtained when they re-sell materials they have cleaned and packaged for market. Processing costs for these three cities are implicitly allocated to specific materials through the net price paid (or cost charged) to the city for each type of material delivered by the collection truck.

System Types Examined

Curbside recycling and household garbage collection were selected as the specific forms of recycling and disposal systems on which to gather cost information. These two systems handle a majority of the recyclables and garbage generated by residences. Unlike drop-off/buy-back recycling and self-haul disposal, the cost of transporting material from the household to a management facility can be readily included in system cost estimates. Because recycling adds collection costs to a waste management system, it seems important to capture these added collection costs.

Also, drop-off/buy-back recycling facilities are for the most part smaller, private operations. Collecting cost and diversion information from numerous small operations, especially when each private operator regards most of the data as proprietary, was not believed to be a productive use for project time and money.

A. Seattle

1. Overview

Seattle is a medium-sized city of 530,000 located on Puget Sound in western Washington state. The city of Seattle manages residential solid waste through the Solid Waste Utility located in the City's Engineering (public works) Department. The Utility contracts with the private sector for most residential solid waste management functions -- e.g., collection of residential garbage, collection of residential recyclables and yard waste, and rail long-haul and disposal of residential garbage. The Utility provides transfer and hauling to the railhead for residential, some commercial and most self-hauled waste through two City-owned transfer stations, one in the southend and one in the northend.

The Solid Waste Utility controls all residential waste generated in the city, except for any materials that are recycled through the extensive network of drop-off/buy-back operations located in and near Seattle. At present the commercial waste stream is not regulated by the City, except for the flow control requirement that all non-recycled commercial waste generated in Seattle must be delivered to one of the City's transfer stations or the long-haul railhead for disposal.

Businesses and institutions can self-haul their waste to a transfer station, or obtain collection through one of the five commercial garbage haulers certified by the

Washington Utilities and Transportation Commission (WUTC) to collect commercial waste. Two of these commercial certificates are limited to collection of construction and demolition waste. Two of the remaining three certificates are for Seattle Disposal and Emerald City Disposal, which are owned by a common holding company, Northwest Waste Industries. The fifth WUTC certificate is held by Waste Management of Seattle, a subsidiary of WMI, which purchased Bayside Disposal, the previous holder of that WUTC certificate.

Seattle Disposal and Emerald City Disposal deliver most of their collected commercial waste to Rabanco's private transfer station at Third Avenue South and Lander. Rabanco and Northwest Waste Industries are the two firms that resulted when the former Rabanco partnership split in 1991. Waste Management delivers most of the commercial waste it collects to its own Eastmont transfer station. Both private transfer stations then compact the commercial waste, and deliver it to the Union Pacific railhead.

The Utility funds its operations and pays private sector contractors mainly through money raised from residential garbage collection/disposal fees, transfer station tipping fees, and tipping fees for commercial waste at the railhead for long-haul disposal. These fees and rates cover 85 to 90% of the Utility's annual budget. The Utility also receives income from interest earnings, operating grants, reimbursements from the Regional Household Hazardous Waste Assessment Fund, and sale of materials recycled through the transfer station drop-off sites. Revenue from residential garbage collection rates more than covers costs for collection and disposal of residential waste, as well as the Utility's waste reduction and recycling programs targeted for residential waste generators.

Description of Solid Waste Disposal System

Weekly garbage collection is mandatory for Seattle residents, i.e., each household is charged a monthly fee which is included on their combined water, sewer and garbage bill. The monthly rate is a function of the size container used by the household for weekly collection, and whether the container is set at the curb or alley by the resident or collected from the backyard by the collection truck crew.

Seattle's current fees per month for weekly garbage collection are:

Service Location	19 Gallon	32 Gallon	60 Gallon	90 Gallon
Curb or Alley	$11.50	$14.98	$29.96	$44.94
Backyard		$20.96	$41.94	$62.92

The minimum monthly rate is $11.50 per household for mini can (19 gallon) curb or alley collection. Mini can collection from a household's backyard is not available. Approximately 28% of residential customers are signed up for mini can service, 62% for single can (32 gallon) service, and 10% for 60- or 90-gallon cart service.

Higher rates for disposing greater volumes of waste, the "variable can" rate structure, is an important part of the Solid Waste Utility's plan to achieve a 60% waste reduction/recycling level by 1998. For the 32-gallon can, 60-gallon cart, and 90-gallon cart service levels, the monthly rate is proportional to container volume. For example, the charge for 60-gallon cart service is double the charge for the 32-gallon can service level. By contrast, the mini can service level has a rate that is higher than other service levels in comparison to collection container volume.

Household waste is collected weekly by two contractors serving different sections of the City, U.S. Disposal, a Rabanco subsidiary, and General Disposal. These two firms also provide curbside yard waste collection under contract with the Utility. Collected household garbage is taken to either the northend or southend city-owned transfer stations. There the waste is compacted, 25 to 28 tons at a time, into sealed, 40-foot shipping containers for delivery to a Union Pacific railhead located in Seattle.

At the rail yard the shipping containers are lifted onto rail cars for delivery to the Columbia Ridge Landfill in Gilliam County, OR. The long-haul disposal contractor Washington Waste Systems (WWS), a subsidiary of WMI, provides rail cars, shipping containers, intermodal lift equipment, and landfill equipment, as well as the landfill site itself. The City provides transfer station compactors, as well as the tractors and chassis to haul waste from its two transfer stations to the railhead.

Description of Recycling System

Before any of the City's recycling programs were started, existing private recycling efforts had already attained a recycling rate of 24%. The City's last landfill was closed in 1986, leaving Seattle dependent on King County's landfill and development/siting of relatively expensive new incineration or landfill disposal capacity. As a result of subsequent garbage collection rate increases and citizen desire to give recycling a chance before siting new disposal capacity in or near the city, Seattle established a new direction for waste management based on ambitious waste reduction and recycling goals and ambitious public sector strategies to implement them.

One strategy toward achieving these ambitious goals had already been implemented in 1981– volume-based residential garbage collection rates. More recently collection rates have been set to escalate even more steeply as a household increases its service level (i.e., garbage container size) to dispose of more waste.

To further encourage reduction/recycling, curbside collection of recyclables is provided free to single-family through fourplex households. Curbside collection of yard waste is available on a fee-for-service basis, and yard waste has been banned from disposal in Seattle. The yard waste collection fee is intended to cover most costs of the yard waste recycling program. In addition, the fee is intended to give an incentive for yard waste reduction choices such as backyard composting or grasscycling.

Other waste reduction and recycling programs offered to city residents include backyard composting bins distributed free, citywide apartment building recycling to be fully implemented in 1993, drop boxes for all types of PET and HDPE plastic containers, and transfer station drop sites for all recyclable materials and lawn and garden wastes. As is the case with curbside recycling, all these programs are provided free to participants and paid for through garbage collection rates and tipping fees.

Contract Payment

As with residential garbage collection, the Utility chooses to have at least two contractors provide its curbside recycling service. Under the present contracts the City is divided into north and south ends with a different contractor and a different curbside recycling system used in each half. The southend contractor is Recycle Seattle, a Rabanco subsidiary. The northend contractor is Recycle America, a subsidiary of WMI.

Participation in curbside recycling in Seattle is voluntary, although each household gets charged for the service in the garbage collection rate on its monthly bill. The city has about 148,500 single-family through fourplex households eligible for curbside recycling. Each household must sign up for curbside by contacting the Solid Waste Utility, which in turns notifies the appropriate contractor to deliver recycling container(s) to the residence. Of the 78,500 eligible southend households, almost 66,000 were signed up as of the end of 1992. Of the 70,000 northend households, almost 67,000 were signed up by the end of 1992. Overall the city has a sign up rate above 89%.

Over 48,000 tons of recyclables were collected, processed and marketed through the City's curbside recycling program in 1992. This represents about 18% of residential waste. Overall, the City's residential waste reduction and recycling programs for single family and multifamily households, in combination with private sector drop-off/buy-back recycling, diverted an estimated 46% of residential waste generated in Seattle in 1992.

Northend: Recycle America

Waste Management's subsidiary Recycle America offers weekly curbside collection in the north half of Seattle using three stackable 14-gallon bins– one for old newspapers (ONP); one for residential mixed waste paper (MWP); and one for commingled glass food and beverage containers, aluminum cans, tin food and beverage cans, plastic polyethylene terephthalate (PET) pop and liquor bottles, and light colored plastic high density polyethylene (HDPE) bottles. In April 1993 ferrous metals were added to curbside recycling collections.

During the early years of the City's curbside program which started in 1988, Recycle America collected materials in 20-cubic-yard capacity three-compartment manual loading trucks. These small capacity trucks had to unload collected materials twice each day. In addition, due to the volume of mixed paper recycled and the relatively low density of residential MWP, the manual trucks also had to unload the mixed paper compartment mid-route into a waiting rear packer truck twice each day. Now, Recycle America has switched to much larger capacity automated top loading trucks that recently began to be manufactured for curbside recycling. Satellite packer trucks are no longer used for mid-route unloading of residential MWP. However, these larger recycling trucks still need to unload recyclables twice each day.

Curbside materials are delivered to Recycle America's MRF, located in south Seattle, for unloading and processing into marketable commodities. Recovered materials that were actually marketed in 1992 averaged over 2,100 tons per month, a total of 25,475 tons. In addition, almost 500 tons of material were collected that could not be marketed. These tons represented non-recyclable materials incorrectly placed in household recycling bins, or processing residues from the MRF such as bottle caps and neck rings. According to Recycle America, about 90% of the non-recyclables are associated with the commingled glass, metal and plastic containers, and 10% are associated with residential MWP. The newspapers come in relatively clean. The process of preparing ONP for marketing as a deinking grade consists mainly of removing recyclable paper such as kraft grocery bags. These paper contaminants in ONP are recycled with residential MWP.[7]

Southend: Recycle Seattle

Rabanco's subsidiary Recycle Seattle offers monthly curbside recycling in the south half of Seattle using a 90-gallon wheeled cart in which, until recently, all

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[7]Phone conversation with Nick Harbert, General Manager, Waste Management of Seattle, 3/9/93.

recyclable materials were commingled by the household. The southend program has recently added an insert to the wheeled cart that hangs outside the cart on the top rim and holds glass containers separately from the remaining commingled recyclables. This addition increases cart capacity for non-glass materials by about 17%.

Before the insert for glass was added, Recycle Seattle collected commingled recyclables in standard 20-cubic-yard rear-load garbage trucks equipped with semi-automatic cart dumpers. As the cart inserts for glass were distributed to recycling participants in the last half of 1992, Recycle Seattle began to switch to packer trucks modified to include recycling compartments behind the cab where household separated glass can be further sorted on route into flint, amber and green colors. Collected materials are taken to the contractor's MRF, which was constructed to separate commingled recyclables and, in addition, to recover recyclable materials from mixed commercial waste. The facility contains extensive processing equipment, including disc screen, trommel, magnetic separator, and air classification equipment.

Curbside materials collected and marketed in the southend program in 1992 averaged about 1,900 tons per month. An additional 761 tons of material were collected that could not be marketed, a contamination/residue rate of about 3%. The greater amount of non-recyclable material resulting from collection and processing of materials in the southend program is due both to collection crews not being able to readily observe contaminant materials as the 90-gallon carts are loaded into the truck, and to the more complex, mechanically automated separation system used at Rabanco's MRF to process the commingled paper, metal and plastic materials into marketable commodities.

2 Recycling System

The curbside recycling contractors are paid a fee for each ton collected and actually sold to market. Under the recent contract extension agreements with each contractor, the City's per ton payment is tied to an agreed upon index for each recycled commodity's market price. All market risk is borne by the City, so that when prices fall, the City's payment per ton rises. When prices rise, the City's cost drops. Meanwhile, each contractor sells their collected recyclables for the best price they can obtain. These revenues are kept by the contractors to be used in conjunction with the City's contract payment to cover costs of collecting, processing and marketing the recycled waste materials.

Previous to the contract extension, Recycle America's contract called for a flat per ton payment plus a guaranteed minimum annual total payment (which was met midway through the first year of curbside recycling). Recycle America initially was more concerned that Seattle households would not participate and recycle enough to cover its basic costs of providing curbside recycling. They were less concerned about market prices. When the initial curbside contract was being negotiated, recycled materials were at historical price peaks.

On the other hand, Recycle Seattle's original contract called for a sharing of market risk with the City, which through 1992 has resulted in additional payments by the City to Recycle Seattle. Thus, in 1992, out of an average per ton payment to Recycle Seattle of $65.93, $9.85 was for market risk sharing and $56.08 was the basic contract obligation for each ton collected and processed for market.

Scope: Northend

The remainder of this section details costs for Recycle America's three bin curbside recycling system. This report focuses on this program and not the southend program for several reasons:

- The Recycle America curbside recycling system is like curbside systems elsewhere in Washington state that are examined in this report.
- Detailed information was made available by Recycle America on market revenues by material type and the split between collection and processing costs.

Furthermore, this report in general focuses on residential curbside recycling rather than drop-off/buy-back recycling, apartment building recycling, or industrial/commercial/institutional recycling because:

- Residential curbside programs are highly visible generators of substantial quantities of recycled materials for resale on recycled commodity markets.
- Involvement of the public sector with residential curbside recycling allows greater access to cost data for use in comparison with disposal system costs.
- The methods used to collect, process and market materials in many curbside programs are similar enough to allow for valid comparisons among programs in different locales in Washington state.
- A broad enough range of materials is typically collected to allow for comparisons for specific materials in different locales.

Weight and Volume

Table A-1 gives tonnage and cubic yards, in total and by material type, for Recycle America's curbside recycling in 1992. In total 25,475 tons, or about 232,600 cubic yards, of material were collected, processed and marketed. An additional 498 tons of collected material was not marketable.

Table A-1. RECYCLING SYSTEM: SEATTLE - Northend Residential Curbside (1992)

	Volumes				
Materials	Tons (Actual)	Distribution of Tons	Cubic Yds (Calculated)	Distribution of Cu.Yds	Conversion Lbs/Cu.Yds
Newspaper	7,915	31.1%	42,784	18.4%	370
Mixed Paper	9,289	36.5%	123,855	53.2%	150
Glass Containers	6,596	25.9%	21,625	9.3%	610
Aluminum Cans	575	2.3%	23,008	9.9%	50
Tin Cans	917	3.6%	12,229	5.3%	150
PET Bottles	80	0.3%	4,018	1.7%	40
HDPE Bottles	102	0.4%	5,114	2.2%	40
TOTAL	25,475	100.0%	232,632	100.0%	219

Notes: (1) Cubic yards were calculated using in truck densities for "lbs/cu.yds" conversion (See Appendix 2).
(2) Tons and cubic yards are ready to market, i.e., net of 498 tons of contaminants.

Mixed paper made up 36.5% by weight and 53.2% by volume of the recycled materials. Newspaper was second with 31.1% of the weight but only 18.4% of the volume. ONP tends to be compactly stacked in its household storage bin, reducing truck space per ton of collected material. By comparison, the multi-paper-type residential MWP is typically rather irregularly and loosely stacked in its household storage bin.

Glass represented 25.9% of the recycled tonnage. Despite the air space inside each whole glass container, the density of glass and the fact that some containers are broken when loaded into the truck leave glass needing only 9.3% of the total in-truck volume occupied by recycled materials.

Aluminum, PET and HDPE containers are like glass in filling up truck space with air. But plastic and aluminum containers also are quite different in that they don't break and are lighter than glass in comparison to the air space each container occupies. Thus, aluminum, PET and HDPE accounted for 2.3%, 0.3% and 0.4%, respectively, of recycled tonnage; but 9.9%, 1.7%, and 2.2%, respectively, of recycled materials volume.

Finally, tin-plated steel cans are heavier than aluminum or plastic for a given container capacity, and they don't break. Tin cans accounted for 3.6% of the weight and 5.3% of the volume of material successfully recycled in the northend curbside program.

<u>Cost of Recycling System</u>

In 1992 the Solid Waste Utility paid Recycle America about $1.5 million for the 25,475 tons of recycled materials collected in the northend program, a per ton payment of $57.08. In addition, Recycle America sold the materials for an average amount of $40.63 per ton, or $1.0 million. Thus, Recycle America had about $98 per ton ($57.08 plus $40.63), or $2.5 million dollars, to cover its costs of collecting, processing and marketing materials from the northend curbside program.

During 1992 the City and Recycle America renegotiated their collection contract, with amendments effective March 1993. The renegotiated contract entails a substantial increase in the base amount the Solid Waste Utility will pay for each ton recycled. Also, the contract places all market price risk on the Utility, so that total payments in any year will depend on average recycled commodity market prices in that year as compared with baseline prices listed in the contract. The market prices used to calculate additions to or subtractions from the base payment are reported in objective, third party publications that routinely gather information on prices for the various recycled materials.

The Utility currently projects a payment to Recycle America of $87 per ton recycled for 1993. Based on low recycling market prices in January and February of 1993, this anticipated $87 per ton payment includes a supplement to the base contract amount to compensate Recycle America for continued weakness in recycling market prices during 1993.

In addition to this $87 payment from the City, Recycle America keeps whatever revenue they obtain by selling the recyclables they collect from northend residences. This encourages Recycle America to find high value markets for recycled materials.

The renegotiated contract involves a payment amount that, when combined with current market revenues, more closely reflects the actual costs of collecting, processing and marketing recyclables. This more accurate reflection of costs that are embodied in the renegotiated curbside recycling contract is used in Table A-2, which shows costs for the northend curbside recycling program in total and on a per average ton recycled basis. Thus, the table uses $87.00, rather than $57.08, as the City's portion of total costs for northend curbside recycling. At this higher per ton payment, the Utility would have paid over $2.2 million, rather than $1.5, to Recycle America in 1992. Combined with marketed materials revenue, Recycle America then would have had more than $3.2 million, or nearly $128 per ton actually recycled, to cover its costs. These figures are given in the "Total Cost" line of Table A-2.

Based on an estimate obtained from Recycle America that 67% of its curbside program costs are incurred in collection and 33% in marketing, Table A-2 reports a per ton curbside collection cost of $86. Processing costs are estimated at $42 per ton, out of Recycle America's total costs of $128 per ton. In addition, the Solid Waste Utility estimates that administrative, promotional and educational costs associated with residential curbside recycling amount to almost $3 per ton. Table A-2 shows the total cost for northend curbside at $131 per ton, or $3.3 million dollars.

However, $41 per ton of these costs are paid by users of the recycled secondary materials and, ultimately, by purchasers of recycled-content products. Deducting these market revenues, then, gives a net cost of $90 per ton, or $2.3 million, as shown in the bottom line "Net Cost" in table A-2. Had the City's renegotiated contract been in force, residential garbage collection customers would have had to cover the $2.3 million through garbage collection rate payments in 1992. Under the old contract, northend ratepayers actually spent $60 per ton recycled, or about $1.5 million for their curbside program in 1992.

Table A-2. RECYCLING SYSTEM: SEATTLE - Northend Residential Curbside (1992)

	Recycling System Component Costs		
Cost Components	Total Costs (000)	Costs Per Ton	Distribution of Costs
Collection (1)	$2,178	$85.51	65.5%
Processing (1)	$1,073	$42.12	32.3%
Overhead	$74	$2.90	2.2%
Total Cost	**$3,325**	**$130.53**	100.0%
Less: Revenues (2)	($1,035)	($40.63)	
Net Cost	$2,290	$89.90	

Notes: (1) Estimate of costs if 1993 contract terms had been in effect in 1992.
(2) Recycled materials revenue is FOB contractor's dock.

Recycle America's revenue from selling recycled materials is net of transportation costs to the many geographically scattered purchasers of secondary commodities with whom Recycle America dealt during 1992. The actual price paid by any one of these purchasers would thus be higher by the average per ton transportation cost between the dock at Recycle America's MRF in south Seattle and the purchaser's dock.

Average revenue for each of the recycled materials in 1992 is given in the following list. It should be noted that Johnson Controls provided price support for recycled PET bottles at the $320 per ton level throughout 1992. That price support is being phased out in 1993.

Newspaper (ONP)	$ 42.30
Mixed Paper	5.24
Glass Containers	23.84
Tin Cans	22.47
Aluminum Cans	750.31
PET Bottles	320.00
HDPE Bottles	160.04

Recycling Cost By Material

Table A-3 provides material specific recycling cost data when total curbside program costs are allocated according to either weight or volume for the materials recycled by Seattle's northend curbside program. As expected, the amount of cost allocated to the light, but voluminous materials such as plastic containers goes up rather dramatically when in-truck density is the cost allocation criteria.

Thus, per ton costs for handling plastic containers rise from $135 when total costs are allocated according to weight, to $715 when volume is used as the allocation criteria. Newspapers, on the other hand, fall from $128 to just $77. In fact, ONP and glass containers are the less voluminous materials, so their cost allocations fall when volume is used as the allocation basis. Residential MWP and the metal and plastic containers all have increased costs when volume is the cost allocation basis.

The reason all materials don't have the same per ton cost when weight is used as the allocation basis is due to some materials being associated with more contamination and processing residues than other materials. In 1992 the northend curbside recycling program collected 498 tons of materials which could not be marketed, and for which Recycle America therefore received no payment from the city of Seattle.

Recycle America estimates that about 90% by weight of the contaminants and processing residues in their curbside recycling program is associated with collecting commingled bottles and cans, 10% with collecting mixed paper and none with collecting ONP. To reflect the costs of collecting and processing materials that could not be sold to market, the $3.3 million total cost for recycling is allocated to each material based on tons collected, including contaminants and residues. Glass accounts for 80% of the weight of commingled containers, so on this basis glass containers absorb over 70% of the costs of collecting unmarketable material.

Table A-3. RECYCLING SYSTEM: SEATTLE - Northend Residential Curbside (1992)

Materials	Total Costs (000)	Costs Per Material – Allocated By Tons			
		Costs Per Ton	Revenue Per Ton	Net Cost Per Ton	Distribution of Tons
Newspaper	$1,013	$128.02	$42.30	$85.72	31.1%
Mixed Paper	$1,196	$128.71	$5.24	$123.47	36.5%
Glass Containers	$890	$134.96	$23.84	$111.13	25.9%
Aluminum Cans	$78	$134.96	$750.31	($615.35)	2.3%
Tin Cans	$124	$134.96	$22.47	$112.49	3.6%
PET Bottles	$11	$134.96	$320.00	($185.04)	0.3%
HDPE Bottles	$14	$134.96	$160.04	($25.07)	0.4%
Total/Average	$3,325	$130.53	$40.63	$89.90	100.0%

Note: Tons are "ready to market" rather than collected. Costs per ton for materials differ from average due to adjustment for contaminants eliminated before marketing. Total costs are allocated among materials using distribution of tons.

Materials	Total Costs (000)	Costs Per Material – Allocated By Cubic Yards			
		Costs Per Ton	Revenue Per Ton	Net Cost Per Ton	Distribution of Cu.Yds
Newspaper	$612	$77.26	$42.30	$34.96	18.4%
Mixed Paper	$1,770	$190.58	$5.24	$185.34	53.2%
Glass Containers	$309	$46.86	$23.84	$23.03	9.3%
Aluminum Cans	$329	$571.73	$750.31	($178.58)	9.9%
Tin Cans	$175	$190.58	$22.47	$168.11	5.3%
PET Bottles	$57	$714.67	$320.00	$394.67	1.7%
HDPE Bottles	$73	$714.67	$160.04	$554.63	2.2%
Total/Average	$3,325	$130.53	$40.63	$89.90	100.0%

Note: Cubic yards are "ready to market" rather than collected. Costs per cubic yard for materials differ from average due to adjustment for contaminants eliminated before marketing. Total costs are allocated among materials using distribution of cubic yards.

Table A-4 provides material specific recycling cost estimates when collection and overhead costs are allocated according to recycling truck volumes, but processing costs are allocated according to the NSWMA MRF cost study. Material density was only one of several criteria used in the NSWMA study to allocate processing costs. Other criteria included material weight for such costs as conveyor equipment amortization, and labor and equipment time for operations used exclusively for some period of time to process a single type material, such as paper baling time to allocate baler labor and amortization costs.

As shown by comparing material net costs per ton in Table A-4 with the weight and volume allocated material costs given in Table A-3, using a more complicated cost allocation methodology for MRF costs gives net cost estimates that fall in between weight and volume allocation costs. This result lends some support to the notion that weight and volume allocations of recycling or disposal system costs may provide lower and upper bounds for material specific cost estimates developed using more complex cost allocation methods.

Table A-4. RECYCLING SYSTEM: SEATTLE - Northend Residential Curbside (1992)

Costs Per Material – Collection/Overhead Allocated By Cubic Yards And Processing Allocated According to NSWMA MRF Study

Materials	Collection & Overhead Costs Per Ton	Processing Costs Per Ton	Revenue Per Ton	**Net Cost Per Ton**	Distribution of Costs
Newspaper	$52.33	$29.10	$42.30	**$39.13**	19.4%
Mixed Paper	$129.08	$31.84	$5.24	**$155.69**	45.0%
Glass Containers	$31.74	$59.48	$23.84	**$67.38**	18.1%
Aluminum Cans	$387.25	$124.22	$750.31	**($238.84)**	8.8%
Tin Cans	$129.08	$58.49	$22.47	**$165.11**	5.2%
PET Bottles	$484.07	$159.24	$320.00	**$323.31**	1.6%
HDPE Bottles	$484.07	$162.80	$160.04	**$486.83**	2.0%
Total/Average	$88.41	$42.12	$40.63	**$89.90**	100.0%

Note: National Solid Wastes Management Association (NSWMA) MRF study allocated costs by tons, cubic yards, labor time or equipment time depending on the particular operation in the sequence of MRF processing steps.

3. Solid Waste Disposal System

Scope: Citywide

The City's two contractors for residential garbage collection each serve sections of Seattle that are not coincident with the north-south division at the ship canal for curbside recycling contracts. Citywide costs for residential waste collection are, thus, reported in this section. When reduced to a per ton collected for disposal basis, the citywide residential disposal system costs are comparable to per ton northend curbside recycling costs.

Weight and Volume

Table A-5 shows 1992 residential disposed waste in total and by material type for 22 categories of waste materials. Included in the categories are all the materials collected for curbside recycling, so that material specific costs of curbside collection for recycling can be compared to costs of collection for disposal of these same materials. The distribution of total waste among the various materials as reported in Table A-5 is based on the City's 1990 waste stream composition study. This composition study involved sampling disposed residential waste at various times throughout the year. It was conducted after the City's curbside recycling and yard waste programs were fully implemented, and so provides a reasonably accurate estimate of the composition of garbage that is not currently being recycled or composted.

About 142,000 tons of residential sector generated waste were collected for disposal in 1992.[8] The "Other Paper" category, typically non-recyclable types of paper such as wax coated corrugated containers or soiled tissues and paper towels, and food waste are the only two material categories accounting for more than 10% of disposed residential waste, each accounting for about 18% of total residential waste disposed in 1992. On the basis of density in the garbage truck's compactor, plastic packaging and corrugated containers are also prominent in the residential disposed waste stream.

Cost of Disposal System

Table A-6 shows total system and system component costs for collection and disposal of residential waste. In total, including Utility overhead costs for such functions as contracts administration, billing and customer service, residential waste cost $19.4 million, or $137 per ton, in 1992.

Payments to the two collection contractors to cover garbage containers and collection routes amounted to 45.5% of total costs, or about $62 per ton disposed. Costs for the City's two transfer stations amounted to almost $18 per ton, while the City spent $9 per ton to haul waste compacted into shipping containers at the transfer stations to the Union Pacific railhead. Payments to the Waste Management subsidiary WWS to rail haul and dispose waste at WWS's Oregon landfill amounted to $43 per ton.

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[8]Seattle collects waste from single family through fourplex households and from five unit or above apartment buildings on combined routes. Thus, disposal tonnage includes all multi-family residential waste. Single family through fourplex waste disposed is estimated at between 95,000 and 100,000 tons in 1992.

Table A-5. DISPOSAL SYSTEM: SEATTLE - Citywide Residential Curbside

Materials	Tons (Actual)	Distribution of Tons	Volumes: Cubic Yards (Calculated)	Distribution of Cu.Yds	Conversion Lbs/Cu.Yds
Newspaper	8,444	5.9%	18,764	3.7%	900
Kraft/Corrugated	9,041	6.4%	60,273	12.0%	300
Office Paper	426	0.3%	1,066	0.2%	800
Mixed Paper	10,491	7.4%	34,970	6.9%	600
Other Paper	25,417	17.9%	84,724	16.8%	600
Glass Containers	7,890	5.6%	15,779	3.1%	1,000
Other Glass	412	0.3%	824	0.2%	1,000
Aluminum Cans	768	0.5%	7,676	1.5%	200
Tin Cans	2,104	1.5%	14,026	2.8%	300
Other Ferrous Metals	697	0.5%	2,143	0.4%	650
Other Non-Ferrous Metal	526	0.4%	2,104	0.4%	500
PET Bottles	398	0.3%	3,980	0.8%	200
HDPE Bottles	469	0.3%	4,691	0.9%	200
Other Bottles	1,350	1.0%	13,505	2.7%	200
Plastic Packaging	13,348	9.4%	88,988	17.7%	300
Other Plastics	2,388	1.7%	15,921	3.2%	300
Food	25,972	18.3%	51,943	10.3%	1,000
Yard Waste	3,938	2.8%	15,751	3.1%	500
Other Organics	11,955	8.4%	26,567	5.3%	900
Wood	1,848	1.3%	8,213	1.6%	450
Construction Debris	1,095	0.8%	2,189	0.4%	1,000
Miscellaneous	13,178	9.3%	29,284	5.8%	900
Total	142,154	100.0%	503,383	100.0%	565

Memo: Disposal Data (from above) for Materials Also Recycled Curbside

Newspaper	8,444	5.9%	18,764	3.7%	900
Mixed Paper	10,491	7.4%	34,970	6.9%	600
Glass Containers	7,890	5.6%	15,779	3.1%	1,000
Aluminum Cans	768	0.5%	7,676	1.5%	200
Tin Cans	2,104	1.5%	14,026	2.8%	300
PET Bottles	398	0.3%	3,980	0.8%	200
HDPE Bottles	469	0.3%	4,691	0.9%	200

Notes: (1) Cubic yards were calculated using in truck densities for "lbs/cu.yds" conversion (See Appendix 2).

(2) Distribution of tons is for 1992 residential disposed waste (excluding self-haul) based on 1990 Seattle Waste Stream Composition Study.

Table A-6. DISPOSAL SYSTEM: SEATTLE - Citywide Residential Curbside (1992)

Cost Components	Total Costs (000)	Costs Per Ton	Distribution of Costs
	Disposal System Component Costs		
Collection	$8,842	$62.20	45.5%
Transfer	$2,505	$17.62	12.9%
Shipping	$1,295	$9.11	6.7%
Disposal	$6,162	$43.35	31.7%
Overhead	$625	$4.40	3.2%
Total Cost	**$19,430**	**$136.68**	100.0%
Less: Revenues			
Net Cost	**$19,430**	**$136.68**	

Disposal Cost By Material

Table A-7 shows disposal system costs allocated to each waste material on both a weight basis and an in-compactor-truck cubic yard basis. As with curbside recycling costs, the light weight containers absorb relatively more disposal system cost on a volume basis than they do on a weight basis. For volume-based costs, plastic bottles and aluminum cans are the most expensive materials at $386 per ton. This compares with a per ton cost of $137 when weight is used as the basis for allocating cost. Unlike curbside recycling, there are no collection contaminants or processing residues on the disposal side, so that every material has this identical $137 per ton cost when total costs are allocated according to weight of the materials collected.

The relatively dense materials – ONP, glass, food, other organics (e.g., dirt and small rocks), and construction debris have per ton costs that are substantially lower on a volume basis than on a weight basis. Besides plastic and aluminum containers, corrugated cardboard boxes, tin cans, plastic packaging and miscellaneous plastics, also have much higher per ton costs under a volume-based allocation of total costs.

4. Comparison of Recycling and Disposal Costs

Table A-8 shows recycling and disposal system costs per ton for the seven materials currently recycled through the City's northend curbside recycling system. Recycling system costs in total are reported in the "Recycling Total Cost Per Ton" column of Table A-8. Recycling costs net of revenue received from selling each material are reported as "Recycling Cost Net of Revenue,", in Table A-8. Per ton disposal system costs are reported in the "Disposal Total Cost Per Ton" column of Table A-8.

As shown in Table A-8, other than for a small variation in recycling costs due to contamination associated more with commingled containers than with recycled paper materials, recycling costs per ton, allocated on the basis of tons collected, are nearly constant - varying from a low of $128 per ton for ONP up to $135 for glass, metal and plastic containers. Disposal system costs are constant across materials at $137 per ton, which is higher than the cost of recycling any material. Even without taking into account revenue from marketing recycled materials, recycling is cheaper than disposal for all materials collected through the curbside program.

Taking into account recycled materials revenues, curbside recycling costs between $123 per ton for residential MWP and $86 for ONP, with glass and tin falling in between, to a net profit of $25 per ton for HDPE containers up to $615 per ton for aluminum cans, with PET bottles yielding a profit of $185 per ton. Of course, it is problematic whether PET plastics will maintain its market price as the Johnson Controls subsidy to that market is gradually withdrawn during 1993. In any event, on a weight-based allocation of system costs, curbside recycling in Seattle currently costs less than disposal for all materials - ranging between a favorable cost difference that is highest at $752 per ton for aluminum cans and lowest at $13 per ton for mixed paper.

However, volume-based system cost allocation does change some of the relationships between recycling and disposal system costs for specific materials rather dramatically, compared with weight-based cost allocations. As shown in the bottom half of Table A-8, ignoring market revenues, aluminum and plastic containers are more costly to recycle than dispose when total costs are allocated according to collection truck volume. Yet, aluminum's market price in 1992 was high enough to make it cheaper to recycle than dispose. Market prices for PET and HDPE plastic containers were not high enough during 1992 to offset their cost disadvantage when recycled versus disposed, based on volume allocated costs.

Except for residential MWP, the other materials remain cheaper to recycle than dispose when system costs are allocated on the basis of in-truck material densities, even excluding the credit for market revenues. Residential MWP is less dense than the average recycled material, and has the lowest market price per ton. On a volume-based allocation of costs, residential MWP cost $57 more per ton to recycle than dispose in Seattle in 1992.

Finally, Table A-9 shows comparative recycling and disposal system costs when all costs are allocated according to collection vehicle materials volumes, except for recycled materials processing costs, which are allocated in proportion to overall average costs per ton in the same way that the NSWMA MRF study allocated costs to specific materials. In general, the cost differences for recycling versus disposal of specific materials shown in Table A-9 are either close to or fall in between the cost difference figures shown in the two parts of Table A-8.

Table A-7. DISPOSAL SYSTEM: SEATTLE - Citywide Residential Curbside (1992)

Recyclable Materials	Total Costs (000)	Costs Per Material – Allocated By Tons Costs Per Ton	Revenue Per Ton	Net Cost Per Ton	Distribution of Tons
Newspaper	$1,154	$136.68		$136.68	27.6%
Mixed Paper	$1,434	$136.68		$136.68	34.3%
Glass Containers	$1,078	$136.68		$136.68	25.8%
Aluminum Cans	$105	$136.68		$136.68	2.5%
Tin Cans	$288	$136.68		$136.68	6.9%
PET Bottles	$54	$136.68		$136.68	1.3%
HDPE Bottles	$64	$136.68		$136.68	1.5%
Total/Average	$4,177	$136.68		$136.68	100.0%

Notes: (1) Only materials in recycling program are shown. Tons are "collected."
(2) Total costs are allocated among materials using distribution of tons.

Recyclable Materials	Total Costs (000)	Costs Per Material – Allocated By Cubic Yards Costs Per Ton	Revenue Per Ton	Net Cost Per Ton	Distribution of Cu.Yds
Newspaper	$724	$85.77		$85.77	18.8%
Mixed Paper	$1,350	$128.66		$128.66	35.0%
Glass Containers	$609	$77.20		$77.20	15.8%
Aluminum Cans	$296	$385.98		$385.98	7.7%
Tin Cans	$541	$257.32		$257.32	14.0%
PET Bottles	$154	$385.98		$385.98	4.0%
HDPE Bottles	$181	$385.98		$385.98	4.7%
Total/Average	$3,855	$126.15		$126.15	100.0%

Notes: (1) Only materials in recycling program are shown. Cubic yards are "collected."
(2) Total costs are allocated among materials using distribution of cubic yards.

Table A-8. RECYCLING vs. DISPOSAL SYSTEM COSTS: SEATTLE - Residential Curbside (1992)

	Costs Per Material - Allocated By Tons			
Recyclable Materials	Recycling Total Cost Per Ton	Recycling Cost Net of Revenue	Disposal Total Cost Per Ton	Recycling Cost Difference
Newspaper	$128.02	$85.72	$136.68	$50.96
Mixed Paper	$128.71	$123.47	$136.68	$13.21
Glass Containers	$134.96	$111.13	$136.68	$25.55
Aluminum Cans	$134.96	($615.35)	$136.68	$752.03
Tin Cans	$134.96	$112.49	$136.68	$24.19
PET Bottles	$134.96	($185.04)	$136.68	$321.72
HDPE Bottles	$134.96	($25.07)	$136.68	$161.75
Total/Average	$130.53	$89.90	$136.68	$46.78

	Costs Per Material – Allocated By Cubic Yards			
Recyclable Materials	Recycling Total Cost Per Ton	Recycling Cost Net of Revenue	Disposal Total Cost Per Ton	Recycling Cost Difference
Newspaper	$77.26	$34.96	$85.77	$50.81
Mixed Paper	$190.58	$185.34	$128.66	($56.68)
Glass Containers	$46.86	$23.03	$77.20	$54.17
Aluminum Cans	$571.73	($178.58)	$385.98	$564.56
Tin Cans	$190.58	$168.11	$257.32	$89.21
PET Bottles	$714.67	$394.67	$385.98	($8.69)
HDPE Bottles	$714.67	$554.63	$385.98	($168.65)
Total/Average	$130.53	$89.90	$126.15	$36.25

Note: The difference between recycling and disposal costs per ton may not be indicative of the actual cost decrease or increase when tonnage recycled increases or decreases.

Table A-9. RECYCLING vs. DISPOSAL SYSTEM COSTS: SEATTLE - Residential Curbside (1992)

Costs Per Material – All Allocated By Cubic Yards
Except MRF Processing Allocated According to NSWMA MRF Study

Recyclable Materials	Recycling Total Cost Per Ton	Recycling Cost Net of Revenue	Disposal Total Cost Per Ton	Recycling Cost Difference
Newspaper	$81.43	$39.13	$85.77	$46.65
Mixed Paper	$160.93	$155.69	$128.66	($27.03)
Glass Containers	$91.22	$67.38	$77.20	$9.81
Aluminum Cans	$511.47	($238.84)	$385.98	$624.82
Tin Cans	$187.58	$165.11	$257.32	$92.21
PET Bottles	$643.31	$323.31	$385.98	$62.67
HDPE Bottles	$646.87	$486.83	$385.98	($100.85)
Total/Average	$130.53	$89.90	$126.15	$36.25

Note: The difference between recycling and disposal costs per ton may not be indicative of the actual cost decrease or increase when tonnage recycled increases or decreases.

5. Yard Waste Composting and Disposal Systems

In late 1988, Seattle adopted an ordinance requiring separation of yard waste from garbage. Households were directed to use one or more of three alternatives for yard waste management - curbside collection, transfer station drop sites, or backyard composting.

Scope: Citywide

General Disposal collects yard waste on a weekly basis from the approximately two-thirds of Seattle's households located north of Yesler Avenue, except for the winter months November through February when General Disposal collects monthly. General Disposal delivers collected yard waste to a City-owned transfer station. Until the recent shift to the north transfer station, this meant General Disposal drove fully-loaded trucks from the northend to the south transfer station.

U.S. Disposal collects yard waste in the southern third of Seattle on a biweekly basis for eight months of the year and on a monthly basis during the four winter months.

All yard waste collected in Seattle is delivered to Cedar Grove compost facility for processing, composting and marketing. Cedar Grove is located approximately 20 miles southeast of Seattle in King County. The Solid Waste Utility transports all yard waste delivered to its transfer station by General Disposal to Cedar Grove in 40 foot trailers. U.S. Disposal delivers all its yard waste to a Rabanco transfer station, from where it is long-hauled to Cedar Grove.

Weight and Volume

As shown in Table A-10, in 1992 Seattle residents set out 34,790 tons, or about 139,000 cubic yards of yard and garden debris for collection by the Utility's two contractors - General Disposal and U.S. Disposal (a Rabanco subsidiary). By contrast, only about 3,900 tons, or about 16,000 cubic yards of yard waste, were collected in the garbage for disposal from Seattle residences in 1992.

Table A-10. YARD WASTE COMPOSTING AND DISPOSAL SYSTEM: SEATTLE - Residential Curbside (1992)

			Volume		
Systems	Tons (Actual)	Distribution of Tons	Cubic Yards (Calculated)	Distribution of Cu.Yds	Conversion Lbs/Cu.Yds
Composting					
North (of Yesler)	24,547	70.6%	98,188	70.6%	500
South (of Yesler)	10,243	29.4%	40,972	29.4%	500
Total	34,790	100.0%	139,160	100.0%	
Disposal					
Citywide	3,938		15,751		500

Cost of Composting System

Table A-11 shows yard waste collection and composting system costs for Seattle in 1992. Because Cedar Grove was a Rabanco subsidiary when U.S. Disposal bid to collect yard waste from residences south of Yesler Avenue, the Utility pays a single per ton fee to U.S. Disposal that covers collection, transfer, long haul and compost processing. In 1992 that fee was an average $93 per ton. The amount of that fee collected by Cedar Grove is agreed upon privately between Northwest Waste Industries, the current owner of Cedar Grove, and Rabanco.

In 1992 the Utility paid General Disposal $62 per ton to collect yard waste and deliver to the City's transfer station. The Utility, then, incurred $34 per ton in costs to transfer and long haul the yard debris to Cedar Grove, where an additional $12.50 per ton was paid for processing and composting.[9] Cedar Grove is responsible for marketing the composted yard debris and collects whatever revenue is generated from compost sales.

[9]Composting cost drops from $12.50 to $11.00 per ton in January 1994 when a Health Department ban on use of plastic bags to set yard waste out for collection takes effect.

Including overhead costs, the City paid $116 per ton for the 71% of curbside yard waste collected by General Disposal and $100 per ton for the 29% collected by U.S. Disposal. In total, costs for collecting, transferring, processing and composting yard debris were almost $3.9 million in 1992, or an average cost of $111 for each ton diverted from disposal.

Table A-11. YARD WASTE COMPOSTING SYSTEM: SEATTLE - Residential Curbside (1992)

	Yard Waste Composting System Component Costs						
	North (of Yesler)			South (of Yesler)		Citywide	
Cost Components	Total Costs (000)	Costs Per Ton	Distribution of Costs	Total Costs (000)	Costs Per Ton	Total Costs (000)	Costs Per Ton
Collection	$1,531	$62.39	53.9%				
Transfer	$433	$17.62	15.2%	$956	$93.31	N/A	N/A
Shipping	$400	$16.29	14.1%				
Composting	$307	$12.50	10.8%				
Overhead	$172	$7.00	6.0%	$72	$7.00		
Total Cost	$2,843	$115.80	100.0%	$1,027	$100.31	$3,870	$111.24

Cost of Disposal System

Table A-12 shows the cost of disposing of the small amount of residential yard and garden debris that was thrown out in refuse by Seattle households in 1992. About 46% of costs were expended on collecting yard waste in refuse, while 54% of costs were for transfer, shipping and rail long-haul disposal in Oregon. The average cost per ton for yard waste disposal was $137, for costs allocated on the basis of weight. On the other hand, when costs are allocated according to relative density in mixed refuse, the per ton costs for yard debris goes up slightly to $154 per ton. This is because compacted yard debris is slightly less dense than the average density of compacted refuse.

Table A-12. YARD WASTE DISPOSAL SYSTEM: SEATTLE - Residential Curbside (1992)

	Disposal System Component Costs	
Cost Components	Cost Per Ton	Distribution of Costs
Collection	$62.20	45.5%
Transfer	$17.62	12.9%
Shipping	$9.11	6.7%
Landfill	$43.35	31.7%
Overhead	$4.40	3.2%
Total	$136.68	100.0%

Comparison of Yard Waste Composting and Disposal Costs

Table A-13 summarizes yard waste composting and disposal system costs reported in Tables A-11 and A-12. When system costs are allocated according to weight collected, curbside yard waste collection and composting was cheaper in Seattle in 1992 than yard waste disposal by $25 per ton. When disposal costs are allocated according to relative collection volumes, yard waste disposal absorbs more system cost because it is somewhat less dense than compacted refuse. On this basis, yard waste composting saves almost $43 per ton.

It is probably important to note that because yard waste is collected on separate routes for composting, it doesn't matter how costs are allocated. In this situation there is only one material, yard waste, which must absorb all the costs of curbside collection, processing and marketing. Chapter 3 details the comparative market prices for yard waste compost and some of its competitors, such as compost made from sludge biosolids and sawdust.

Table A-13. YARD WASTE COMPOSTING vs. DISPOSAL SYSTEM COSTS: SEATTLE - Residential Curbside (1992)

Costs - Disposal Allocated By Tons

Systems	Total Cost (000)	Costs Per Ton	Revenue Per Ton	Net Cost Per Ton
Composting	$3,870	$111.24	$0.00	**$111.24**
Disposal	$538	$136.68	$0.00	**$136.68**
Composting Cost Difference		$25.44		**$25.44**

Costs - Disposal Allocated By Cubic Yards

Systems	Total Cost (000)	Costs Per Ton	Revenue Per Ton	Net Cost Per Ton
Composting	$3,870	$111.24	$0.00	**$111.24**
Disposal	$608	$154.39	$0.00	**$154.39**
Composting Cost Difference		$43.15		**$43.15**

Note: The difference between composting and disposal costs per ton may not be indicative of the actual cost decrease or increase when tonnage composted increases or decreases.

6. Additional Comments

Seattle has been quite aggressive in its contractual arrangements to assure that as much money is saved as possible when waste is diverted from disposal through any of its waste reduction or recycling programs. Thus, the rail haul and landfill disposal contract with WWS is strictly on a per ton shipped for disposal basis. That is, the City is charged an agreed amount per ton for each ton sent for disposal, regardless of the actual number of tons disposed over the course of a year. A ton diverted from disposal through a residential recycling program saves city ratepayers that per ton disposal charge of $44.

Similarly, when the City rebid its residential garbage collection contracts, one of the bid specifications was that 50% of collection costs be on a per ton basis. Tonnage diverted to recycling saves city ratepayers 50% of the $62 collection costs, or $31.

The fact that the City has constructed its contractual arrangements around per ton charges that are constant across materials tends to argue for the choice of weight as the basis for allocating costs to specific materials when one wishes to compare the costs of recycling against disposal.

B. Spokane

1. Overview

Spokane is Washington's second largest city, with an estimated 1992 population of over 180,000. The city is located in Spokane County, on the eastern border of the state, and is the largest city in eastern Washington. The city comprises approximately 50% of the county population and is a regional center of government and commerce.

The City and County formed an interlocal agency, the Spokane Regional Solid Waste Disposal Project ("Project"), to operate the solid waste processing and disposal system. The Project is charged with solid waste planning, contract management for the Project's new waste-to-energy (WTE) facility, ash disposal, landfill operation, and closure activities. The City serves as the lead agency and managing partner of the Project. The City also manages solid waste and recycling collection operations within the city through their public works department. The Project and the City's collection operations are administratively distinct, with collection operations managed by the City's public works department. Yard waste collection is not offered at this time.

Residences and businesses within the city are served by the City's municipally-operated collection system. City trucks and crews are used for garbage and residential recycling collection. Two WUTC certified collection companies also operate in the city of Spokane: Waste Management of Spokane and Valley Garbage Service. Both companies operate in small areas of the City that have been recently annexed. The companies will continue to operate during the five year period between annexation and the point at which the City can extend collection services to these areas previously served by the two WUTC certified companies. The combined volume of the two private collection companies represents a relatively minor portion of the total volume collected throughout the city.

Collected waste is disposed directly at the Project's WTE facility, or occasionally, through one of the Project's two transfer facilities. Residentially collected recyclables are delivered to one of two contracted private recyclers: Spokane Recycling Products and Pacific Hide & Fur. The City splits collected volumes evenly between the two recycling processing contractors. The contractors pay the City a percentage of a market index price for delivered, source-separated materials. The current contract does not allow processors to charge the City for materials, so that zero is the lowest any material's price can go.

<u>Description of Solid Waste Disposal System</u>

Garbage collection is mandatory for Spokane residents and businesses. Collection charges are billed on combined water, sewer, and garbage collection invoices to residents. Residential collection charges are variable, depending on the size of container used. 1992 monthly collection charges for weekly service were $7.72 for a 15- to 20-gallon minican, $9.98 for a single can, and $15.40 for two cans. These fees cover the costs of garbage and recycling collection, tipping fees at the Project's disposal facilities, and costs related to administering the City collection system. At the end of 1992, 1% of residential customers were on minican service, 30% were on one can service, 64% were on two can service, and 5% were on other service levels.

Once waste is collected, route trucks are directed either to the Project's WTE facility, or to one of the Project's two transfer stations. The WTE facility is located near the Spokane International Airport, on the southwestern border of the city. All waste is ultimately directed to the WTE facility, as required by the County's flow control ordinance

The solid waste disposal system in Spokane has undergone substantial change from 1990 to 1993. The former landfill-based disposal system has been changed to a new system featuring WTE with a waste export component for WTE facility ash. The base year for this study, 1992, was a point of significant change in Spokane's system.

The Project's WTE facility started operation in fall 1991. It has a design capacity of 800 tons per day (TPD) as constructed, with an intermediate storage capacity of 4,800 or 6,000 tons including the tipping floor. Waste received in excess of the WTE facility's 800 TPD capacity and non-incinerable waste is bypassed to landfill. The facility was designed to allow construction of an additional 400 ton per day furnace and boiler.

Facility operation is contracted to Wheelabrator Spokane, Inc. (WSI), a Waste Management, Inc. (WMI) subsidiary. The service contract requires that WSI make available 248,200 tons per year of disposal capacity, or 680 TPD on average during 365 days of operation. A fixed fee is paid to WSI for processing up to 248,200 tons per year, regardless of whether the Project actually delivers that much waste. If more than 248,200 tons per year of waste are delivered to the facility, an additional per-ton service fee is charged. In 1992 the Project delivered 291,241 tons. The WTE facility incinerated about 293,000 tons, operating at 100% of design capacity for the full 365-day year.[10] The fee paid to Wheelabrator in 1992 was $7.5 million.

Once waste is burned, ferrous materials are recovered from the ash (8,598 tons of ferrous were recovered in 1992), and the remaining ash is hauled via rail to an ash monofill in Klickitat County operated by Rabanco Regional Landfill Company. Bypass waste (waste unacceptable for incineration and waste generated during periods of WTE facility downtime) is currently landfilled at the County's Northside landfill, although bypass waste may also be shipped to Rabanco's Regional Landfill in the future.

The disposal facility is designed for energy recovery, and generated an average 609 kWh of electricity per ton of solid waste burned in 1992, of which a portion was used for plant operations and the remainder sold to Puget Power & Light. In 1992 net energy generation for sale to Puget Power averaged 506 kWh per ton incinerated. The Project received $0.019 out of $0.024 paid by Puget Power per kWh transmitted (or $9.52 per ton incinerated out of $12.15 paid); the difference went to WSI as an energy credit. The contract with Puget Power specifies a significant increase in nominal purchase price for electricity after ten years of WTE facility operation.

Description of Recycling System

Prior to implementation of curbside recycling, Spokane had an extensive drop-off based recycling system. This system included both private recyclers and City-sponsored drop-off bins located at elementary schools and other sites.

Spokane's single-family residential curbside recycling collection started in the fall of 1990. Materials collected curbside include newspaper, glass containers,

[10] The difference between delivered and incinerated waste quantities is due to waste inventory in the storage pit at the beginning and end of 1992.

aluminum and tin cans, PET plastic bottles, and household and vehicle batteries. In June 1992 the program was expanded to include natural (uncolored) HDPE bottles. All 60,000 single through fourplex households within the city were provided with one blue recycling bin. The 14-gallon bin is used to contain loose recyclables, while household batteries are placed in plastic bags on top of the bins. Newspaper and overflow materials may be bagged and set next to the resident's bin.

Weekly collection is provided by a fleet of 14 trucks. Each truck is operated by one driver/collector, and features seven compartments, one each for newspaper, corrugated cardboard, three colors of glass, commingled aluminum and tin cans, and commingled PET and HDPE plastic bottles. Route drivers sort bin contents into the appropriate truck compartments at each stop.

The collection vehicles used in Spokane are front wheel drive, low entry, 30 cubic yard capacity trucks manufactured by Crane Carrier Company to include customized side-dumping compartments. The front wheel drive trucks are particularly useful in Spokane, where snow might otherwise hamper regular rear wheel drive vehicles.

Since blue bins were distributed to all households, no sign-up was required for participants. Thus, participation is measured in terms of actual set-outs rather than calculating the percentage of eligible households signed up for recycling. In 1992, approximately 56% of all single-family through fourplex households set out their container at least once each month, resulting in a total of 6,717 tons of materials collected during the year. The collected materials are delivered to either of two private contractors for processing and marketing.

Prior to implementation of the City's recycling collection program, a three year recycling processing contract with Spokane Recycling Products, Inc. and Pacific Hide & Fur and was awarded through a request-for-proposals process. Under this contract, the City agreed to deliver all collected materials to these two existing processors, and the processors agreed to pay the City a floating market rate for clean acceptable commodities.

Although the contract shares the benefit of market price increases through the monthly commodity prices paid to the City, no provisions were made for net material values (value after processing and transportation) dropping below zero. Thus, under the current contract, the City has not been required to pay for the processing of commodities with negative values. This has been an issue of concern for the processors, since net market values on some commodities (e.g. glass, tin cans) have declined substantially since the contract was signed.

The current contract expires at the end of 1993. At this juncture contract provisions will likely be renegotiated. The market risk provisions may be reexamined, which could affect the future net revenues or costs received by the City.

The City is currently phasing in multifamily collection and will be servicing multifamily units on single-family collection routes.

2 Recycling System

Since household recycling collection in Spokane is municipally operated, program costs are subject to the annual municipal budgeting process, unlike contracted programs (such as Seattle's) that often rely on consumer price index inflation mechanisms. Spokane receives funding for its curbside collection program from several sources, including garbage collection charges, grants, and the sale of materials.

Spokane's recycling system varies from the three other recycling programs examined (Seattle, Bellingham, and Vancouver) in that it does not accept mixed waste paper. This difference significantly changes the composition of collected materials and decreases per-household collection weight and volume over which relatively fixed collection costs may be spread. This may account in part for the comparatively high per ton cost of Spokane's curbside program.

Weight and Volume

Table B-1 provides tonnage and cubic yards, in total and by material type, for Spokane's curbside recycling program in 1992. In total, 6,717 tons, or about 46,000 cubic yards, of material were collected, processed, and marketed. Since materials are separated on-route by drivers, material contamination in the recycling truck is minimal.

Old newspapers (ONP) accounted for 64% of the weight and 50% of the volume of materials collected in 1992 by Spokane's curbside recycling program. Glass containers represented the second largest quantity and volume of material recycled, accounting for 26% of weight and 13% of volume. Both ONP and glass containers account for less volume than weight because their densities in the recycling truck exceed the average density for all materials collected. Aluminum and tin cans account for 2% and 5%, respectively, of weight, but about 10% of volume each. Plastic bottles account for less than 2% of weight but almost 12% of volume, because they have the lowest density of all recycled materials.

Table B-1. RECYCLING SYSTEM: SPOKANE - Residential Curbside (1992)

			Volumes		
Materials	Tons (Actual)	Distribution of Tons	Cubic Yds (Calculated)	Distribution of Cu.Yds	Conversion Lbs/Cu.Yds
Newspaper	4,264	63.5%	23,049	50.1%	370
Corrugated Cardboard	114	1.7%	2,533	5.5%	90
Glass Containers	1,751	26.1%	5,741	12.5%	610
Aluminum Cans	124	1.8%	4,960	10.8%	50
Tin Cans	324	4.8%	4,320	9.4%	150
PET Bottles	52	0.8%	2,600	5.6%	40
HDPE Bottles	56	0.8%	2,800	6.1%	40
Auto Batteries	32	0.5%	17	0.0%	3,750
TOTAL	6,717	100.0%	46,020	100.0%	292

Note: Cubic yards were calculated using in-truck densities for "lbs/cu.yds" conversion (See Appendix 2).

Cost of Recycling System

In 1992, the City spent a total of $1.3 million on the curbside collection program. Costs included $1.1 million for collection operations, $0.1 million for administration, and $0.1 million for promotion and education. The City received about $0.2 million in revenues from the sale of curbside collected materials. The net cost of the recycling collection program, after material sales, was $175 per ton collected.

Table B-2 details the cost components of Spokane's recycling collection system. Actual costs are presented, regardless of funding source. Thus, program costs have not been decreased to reflect the grant funding Spokane received for recycling program implementation. Actual "out-of-pocket" City expenses were somewhat lower than shown due to grant funding.

Table B-2. RECYCLING SYSTEM: SPOKANE - Residential Curbside (1992)

	Recycling System Component Costs		
Cost Components	Total Costs (000)	Costs Per Ton	Distribution of Costs
Collection	$1,100	$163.76	82.4%
Overhead	$234	$34.87	17.6%
Total Cost	$1,334	$198.63	100.0%
Less: Revenues	($158)	($23.55)	
Net Cost	$1,176	$175.08	

Note: Recycled materials are sorted curbside by the driver and "marketed" off-the-truck at the end of each route to one of two local processing and marketing contractors who prepare the materials for resale to end-use markets.

The City's contract with the processing vendors shares commodity market risk. Material prices paid to the City vary in relation to published market indices. The processors are not allowed to charge the City for accepting recyclables, even if prices become negative. In 1992 average commodity prices per ton received by the City were:

Newspaper	$ 14.31
Cardboard	16.07
Glass Containers	5.72
Tin Cans	9.00
Aluminum Cans	581.73
PET Bottles	127.05
HDPE Bottles	24.13
Auto Batteries	71.28

Although Spokane is distant from Seattle-area markets, this has not proven to be an impediment to receiving substantial revenues from the sale of recyclable commodities. Regional markets for ONP, OCC, aluminum, and plastics exist in eastern Washington, allowing cost-effective transportation to relatively nearby markets for many commodities.

Table B-3. RECYCLING SYSTEM: SPOKANE - Residential Curbside (1992)

		Costs Per Material – Allocated By Tons			
Materials	Total Costs (000)	Costs Per Ton	Revenue Per Ton	Net Cost Per Ton	Distribution of Tons
Newspaper	$847	$198.63	$14.31	$184.32	63.5%
Corrugated Cardboard	$23	$198.63	$16.07	$182.56	1.7%
Glass Containers	$348	$198.63	$5.72	$192.91	26.1%
Aluminum Cans	$25	$198.63	$581.73	($383.10)	1.8%
Tin Cans	$64	$198.63	$9.00	$189.63	4.8%
PET Bottles	$10	$198.63	$127.05	$71.58	0.8%
HDPE Bottles	$11	$198.63	$24.13	$174.50	0.8%
Auto Batteries	$6	$198.63	$71.28	$127.35	0.5%
Total/Average	$1,334	$198.63	$23.55	$175.08	100.0%

Note: Tons are sorted at the curb by the collection route truck driver. Collection costs are alocated among materials using distribution of tons. Because materials are sorted at the curb, contaminants can be left in the household's recycling container. Thus there is no adjustment to costs for contaminants.

		Costs Per Material – Allocated By Cubic Yards			
Materials	Total Costs (000)	Costs Per Ton	Revenue Per Ton	Net Cost Per Ton	Distribution of Cu. Yds
Newspaper	$668	$156.71	$14.31	$142.40	50.1%
Corrugated Cardboard	$73	$644.26	$16.07	$628.19	5.5%
Glass Containers	$166	$95.05	$5.72	$89.33	12.5%
Aluminum Cans	$144	$1,159.67	$581.73	$577.94	10.8%
Tin Cans	$125	$386.56	$9.00	$377.56	9.4%
PET Bottles	$75	$1,449.59	$127.05	$1,322.54	5.6%
HDPE Bottles	$81	$1,449.59	$24.13	$1,425.46	6.1%
Auto Batteries	$0	$15.46	$71.28	($55.82)	0.0%
Total/Average	$1,334	$198.63	$23.55	$175.08	100.0%

Note: Tons are sorted at the curb by the collection route truck driver. Collection costs are alocated among materials using distribution of cubic tons. Because materials are sorted at the curb, contaminants can be left in the household's recycling container. Thus there is no adjustment to costs for contaminants.

Recycling Cost By Material

Table B-3 provides materials-specific recycling cost data when total curbside program costs are allocated according to either weight or volume for the materials recycled by Spokane's program. As with cost allocations presented for Seattle's northend program, costs vary with material density and allocation method. Negligible contamination is experienced in the Spokane's system due to on-route sorting. Thus, all materials are assigned the same per ton costs when total costs are allocated according to tons collected.

The least dense materials, OCC, aluminum cans and plastic bottles, have the highest per ton costs when total costs are allocated according to collection volumes. ONP and auto batteries, on the other hand, are the most dense and have the lowest per ton costs under volume-based cost allocations.

3 Solid Waste Disposal System

Weight and Volume

Table B-4 shows 1992 residential and commercial waste quantity collected for disposal in the city of Spokane. Collection of waste from smaller businesses is integrated with residential collection routes in Spokane. Waste from larger businesses is collected on separate routes, but to date no separation of disposal quantities from the combined total has been attempted by the City or the Project.

Table B-4 also shows distribution of disposed waste by materials type for 22 categories of waste materials. Included in the categories are all the materials collected for curbside recycling (except auto batteries), so that material specific costs of curbside collection for recycling can be compared to costs of collection for disposal of these same materials.

The distribution of waste among materials shown in Table B-4 is an estimate of residential waste composition based on surveys conducted in 1987 for Ecology's Best Management Practices Study. The main use for disposed waste composition data in this study is to allocate disposal costs among materials. Because recycling costs are for residential curbside, residential disposed waste composition is more appropriate for these cost comparisons, even though total disposal quantity in Table B-4 includes business waste.

It is important to note that these composition estimates are based on limited samples in the mid 1980s, and more importantly, are "pre-curbside" compositions. As the city of Seattle has found in successive waste composition samples, the removal of curbside-collected recyclables from the disposed waste stream can cause a substantial change in composition of the remaining waste stream. The Spokane residential waste stream disposed in 1992 probably contained fewer recyclables, and a higher proportion of yard waste and non-recyclables than indicated by the 1987 composition study. Since updated waste composition data was not available for this report, the 1987 Ecology composition data was used, with the caveat that actual 1992 composition could be quite different.

Cost of Disposal System

Table B-5 shows total system and system component costs for collection and disposal of residential and commercial waste. The costs listed are that portion of Solid

Waste Disposal Project costs allocated to the City's residential and commercial solid waste stream on a relative weight basis. Because costs for collecting waste from businesses as well as residences are included in Table B-5, it should be noted that these costs are not necessarily reflective of a system serving solely residential customers. Collection of larger amounts of refuse at each collection stop generally lowers average collection costs per ton. Per ton collection costs shown in Table B-5 probably understate the average costs of collecting residential waste in Spokane.

Capital cost of the WTE facility and associated improvements to the transfer system was $131.5 million. A large portion of this cost, $60 million, was funded through the Department of Ecology Referenda 26/39 grant program. Consequently, the City and the Project incurred no out of pocket costs for $60 million of facility costs. To reflect the opportunity cost of these funds, and to provide an estimate of disposal cost that includes all expenditures necessary to construct and operate the WTE facility, transfer and incineration costs in Table B-5 include annual amortization of both Project and grant funded capital costs over 30 years at 9%. In practice, since a significant portion of the Spokane disposal system was grant funded, net costs paid by the City each year are substantially lower.

In Table B-5, both system costs and revenues are shown. Unlike most landfill-based disposal systems, Spokane's energy-recovery-based system generates electricity sales revenues to offset some of the costs of WTE facility operation.

Costs for residential waste collection accounted for about 47% of total disposal system costs. Costs for the City's transfer operations accounted for 4% of costs. Incineration and landfill of ash plus bypass waste made up 45% of total cost. Billing, administration, and publicity/education accounted for the remaining 4% of costs.

Spokane's residential and commercial waste disposal system cost an estimated $34.5 million in 1992, $198 per ton of waste disposed. After taking into account City revenues of about $10 per ton from electricity sales to Puget Power, the net cost of waste disposal in Spokane in 1992 was $188 per ton.

Table B-4. DISPOSAL SYSTEM: SPOKANE - Residential and Commercial Collection (1992)

Materials	Tons (Actual)	Distribution of Tons	Volumes: Cubic Yards (Calculated)	Distribution of Cu.Yds	Conversion Lbs/Cu.Yds
Newspaper	9,959	5.7%	22,131	3.5%	900
Kraft/Corrugated	8,387	4.8%	55,910	8.8%	300
Office Paper	699	0.4%	1,747	0.3%	800
Mixed Paper	24,461	14.0%	81,536	12.8%	600
Other Paper	9,784	5.6%	32,614	5.1%	600
Glass Containers	12,230	7.0%	24,461	3.9%	1,000
Other Glass	349	0.2%	699	0.1%	1,000
Aluminum Cans	1,398	0.8%	13,978	2.2%	200
Tin Cans	4,368	2.5%	29,120	4.6%	300
Other Ferrous Metals	1,223	0.7%	3,763	0.6%	650
Other Non-Ferrous Metals	524	0.3%	2,097	0.3%	500
PET Bottles	699	0.4%	6,989	1.1%	200
HDPE Bottles	874	0.5%	8,736	1.4%	200
Other Bottles	1,660	1.0%	16,598	2.6%	200
Plastic Packaging	8,561	4.9%	57,075	9.0%	300
Other Plastics	2,097	1.2%	13,978	2.2%	300
Food	19,044	10.9%	38,089	6.0%	1,000
Yard Waste	38,963	22.3%	155,850	24.5%	500
Other Organics	11,357	6.5%	25,237	4.0%	900
Wood	2,097	1.2%	9,318	1.5%	450
Construction Debris	1,048	0.6%	2,097	0.3%	1,000
Miscellaneous	14,851	8.5%	33,003	5.2%	900
Total (1)	174,720	100.0%	635,027	100.0%	550
Memo: Disposal Data (from above) for Materials Also Recycled Curbside:					
Newspaper	9,959	5.7%	22,131	3.5%	900
Corrugated Cardboard	8,387	4.8%	55,910	8.8%	300
Glass Containers	12,230	7.0%	24,461	3.9%	1,000
Aluminum Cans	1,398	0.8%	13,978	2.2%	200
Tin Cans	4,368	2.5%	29,120	4.6%	300
PET Bottles	699	0.4%	6,989	1.1%	200
HDPE Bottles	874	0.5%	8,736	1.4%	200
Auto Batteries	0	0.0%	0	0.0%	3,750

Notes: (1) Disposal quantities include commercial refuse; distribution is based on residential waste composition.

(2) Cubic yards were calculated using "lbs/cu.yds" conversion. Distribution of tons based on Northeast Waste Generation Area residential waste composition data from 1987 Recycling and Waste Stream Survey, Volume 1, Best Management Practices Analysis for Solid Waste, Washington State Department of Ecology, Publication No. 88-33A, p. 134.

Table B-5. DISPOSAL SYSTEM: SPOKANE - Residential and Commercial Collection (1992)

	Disposal System Component Costs		
Cost Components	Total Costs (000)	Cost Per Ton	Distribution of Costs
Collection	$16,063	$91.94	46.5%
Transfer	$1,361	$7.79	3.9%
Incineration	$12,674	$72.54	36.7%
Bypass Landfill	$1,016	$5.82	2.9%
Ash Landfill	$1,893	$10.83	5.5%
Overhead	$1,541	$8.82	4.5%
Total Cost	$34,548	$197.73	100.0%
Less: Revenues	($1,664)	($9.52)	
Net Cost	$32,884	$188.21	

Note: (1) Transfer and incineration costs include amortization of capital (including $60 million state grant) over 30 years at 9%.
(2) City of Spokane costs in this table account for 60% of total disposal costs incurred by the Project.

Disposal Cost By Material

Table B-6 shows disposal system costs allocated to each waste material on both a weight basis and an in-compactor-truck cubic yard basis. Allocation of disposal costs to specific materials based on distribution of cubic yards is dependent on estimates for each material's density, as given in the right-hand column of Table B-4. The sources for these estimates for materials that are both recycled and disposed are given in Appendix 2.

Lightweight aluminum cans, plastic bottles and corrugated cardboard absorb relatively more disposal system cost on a volume basis than they do on a weight basis. Aluminum cans and plastic bottles at $535 per ton are the most costly on a volume basis, compared with a flat $188 for all materials on a weight basis.

The right-hand column in Table B-6 shows the distribution of tons and cubic yards for disposal quantities of materials recycled curbside in Spokane. For all materials but auto batteries, these distributions provide the basis for allocation of total costs according to relative weights or relative volumes, as shown in the left-hand column of Table B-6. Auto batteries cannot be legally disposed in residential waste. However, to provide a disposal cost for use in comparing the costs of recycling versus disposal, $188 is shown in Table B-6 as the per ton cost of auto battery disposal for both weight and volume allocations of disposal costs.

Since the Spokane system is based on energy recovery incineration, energy sales will offset some of the costs for each material. Since the energy value of each material varies, electricity revenue could also vary by material. For example, newspaper generates relatively high energy per ton burned. Glass containers generate no energy, other than from their paper or plastic labels, and may actually decrease energy generation. However, WSI guarantees the Project that at least 505 kWh will be generated for each ton of waste burned. This guarantee makes the connection between a material's heating value and Project energy sales revenues rather indirect.

As explained in the introduction to this chapter, a drastic change in average heating value of disposed waste might lead to an eventual change in energy revenue to the Project. But WSI's guarantee insulates the Project from shifts in heating value that are caused by changes in the composition and quantity of materials recycled in Spokane's curbside collection. Thus, the Project's average per ton energy revenue is assigned to each commodity in Table B-6.

Table B-6. DISPOSAL SYSTEM: SPOKANE - Residential and Commercial Collection (1992)

Recyclable Materials	Total Costs (000)	Costs Per Material – Allocated By Tons Costs Per Ton	Revenue Per Ton	Net Cost Per Ton	Distribution of Tons
Newspaper	$1,969	$197.73	$9.52	$188.21	26.3%
Corrugated Cardboard	$1,658	$197.73	$9.52	$188.21	22.1%
Glass Containers	$2,418	$197.73	$9.52	$188.21	32.3%
Aluminum Cans	$276	$197.73	$9.52	$188.21	3.7%
Tin Cans	$864	$197.73	$9.52	$188.21	11.5%
PET Bottles	$138	$197.73	$9.52	$188.21	1.8%
HDPE Bottles	$173	$197.73	$9.52	$188.21	2.3%
Auto Batteries (1)	$0	$197.73	$9.52	$188.21	0.0%
Total/Average	$7,497	$197.73	$9.52	$188.21	100.0%

Notes: (1) Auto battery disposal costs included for comparison purposes only. Auto battery disposal not allowed.
(2) Only materials in recycling program are shown. Tons are "collected." Total costs are allocated among materials using distribution of tons.

Recyclable Materials	Total Costs (000)	Costs Per Material – Allocated By Cubic Yards Costs Per Ton	Revenue Per Ton	Net Cost Per Ton	Distribution of Cu.Yds
Newspaper	$1,204	$120.90	$9.52	$111.38	13.7%
Corrugated Cardboard	$3,042	$362.69	$9.52	$353.17	34.7%
Glass Containers	$1,331	$108.81	$9.52	$99.29	15.2%
Aluminum Cans	$760	$544.04	$9.52	$534.52	8.7%
Tin Cans	$1,584	$362.69	$9.52	$353.17	18.1%
PET Bottles	$380	$544.04	$9.52	$534.52	4.3%
HDPE Bottles	$475	$544.04	$9.52	$534.52	5.4%
Auto Batteries (1)	$0	$197.73	$9.52	$188.21	0.0%
Total/Average	$8,777	$231.49	$9.52	$221.97	100.0%

Notes: (1) Auto battery disposal costs included for comparison purposes only. Auto battery disposal not allowed.
(2) Only materials in recycling program are shown. Cubic yards are "collected." Total costs are allocated among materials using distribution of cubic yards.

4. Comparison of Recycling and Disposal Costs

Table B-7 shows recycling and disposal system costs per ton for the materials currently recycled through Spokane's curbside recycling system. Recycling system costs in total are reported in the "Recycling Total Cost Per Ton" column of Table B-7. Including a credit against total costs for revenues obtained from the sale of recycled materials gives the figures reported in the "Recycling Cost Net of Revenue" column of Table B-7. The column "Disposal Cost Net of Revenue" in Table B-7 gives disposal system net cost per ton after deducting energy revenues from total disposal costs.

For costs allocated according to weight collected, recycling in Spokane in 1992 was less expensive than disposal for all materials except glass containers and tin cans. On average recycling cost $13 less per ton than disposal.

When costs are allocated according to collection truck volumes, all materials other than glass containers and auto batteries were more expensive to recycle in Spokane in 1992 than they were to dispose. However, because the materials collected curbside were much lighter and more bulky than the average for disposed materials, disposal cost on a volume basis was almost $34 more per ton than on a weight basis. Thus, on a volume basis recycling was actually cheaper on average than disposal by about $47 per ton, even though most materials had volume-based recycling costs that were greater than their disposal costs.

This somewhat anomalous result should again provide caution in using the per material recycling or disposal costs to make claims about which materials should or should not be included in a curbside recycling program. As indicated earlier in this report, if the "true" cost of recycling or disposal for each material were available, it probably would lie in between the weight- and volume-based costs estimated herein.

Table B-7. RECYCLING vs. DISPOSAL SYSTEM COSTS: SPOKANE - Residential Curbside (1992)

	Costs Per Material – Allocated By Tons			
Recyclable Materials	Recycling Total Cost Per Ton	Recycling Cost Net of Revenue	Disposal Cost Net of Revenue	Recycling Cost Difference
Newspaper	$198.63	$184.32	$188.21	$3.89
Corrugated Cardboard	$198.63	$182.56	$188.21	$5.65
Glass Containers	$198.63	$192.91	$188.21	($4.70)
Aluminum Cans	$198.63	($383.10)	$188.21	$571.31
Tin Cans	$198.63	$189.63	$188.21	($1.42)
PET Bottles	$198.63	$71.58	$188.21	$116.63
HDPE Bottles	$198.63	$174.50	$188.21	$13.71
Auto Batteries	$198.63	$127.35	$188.21	$60.86
Total/Average	$198.63	$175.08	$188.21	$13.13

	Costs Per Material – Allocated By Cubic Yards			
Recyclable Materials	Recycling Total Cost Per Ton	Recycling Cost Net of Revenue	Disposal Cost Net of Revenue	Recycling Cost Difference
Newspaper	$156.71	$142.40	$111.38	($31.03)
Corrugated Cardboard	$644.26	$628.19	$353.17	($275.02)
Glass Containers	$95.05	$89.33	$99.29	$9.95
Aluminum Cans	$1,159.67	$577.94	$534.52	($43.42)
Tin Cans	$386.56	$377.56	$353.17	($24.38)
PET Bottles	$1,449.59	$1,322.54	$534.52	($788.02)
HDPE Bottles	$1,449.59	$1,425.46	$534.52	($890.94)
Auto Batteries	$15.46	($55.82)	$188.21	$244.03
Total/Average	$198.63	$175.08	$221.97	$46.88

Note: The difference between recycling and disposal costs per ton may not be indicative of the actual cost decrease or increase when tonnage recycled increases or decreases.

C. Bellingham

1. Overview

Bellingham is a city with a population of 55,000 situated on Bellingham Bay in Whatcom County, in northwestern Washington. Bellingham is the County seat and contains approximately 40% of the County population.

The City's solid waste management system features contracted residential garbage and recycling collection. Disposal services are also contracted through a private disposal firm. In 1988, the City entered into a 10-year contract with Sanitary Service Company and Recycling Services, Inc. (a sister company to Sanitary Service), for residential garbage and recycling collection services.

Sanitary Service Company bills residents directly for combined garbage and recycling collection services. Collection charges are reviewed and approved by the City annually. Charges are based on the costs of the combined collection systems and a regulated profit to the contractors. Contractor expenses are reviewed yearly to verify actual costs from the previous year and develop adjusted expense and revenue forecasts for the upcoming year. Rates are then adjusted, if necessary, to meet the forecast revenue requirements for the garbage and recycling collection system.

The residential garbage collection system is based on the use of 60- or 90-gallon wheeled carts (Toters) with weekly, biweekly, or monthly collection. The residential recycling collection system is based on the use of three stacking bins, and accepts newspapers, mixed waste paper, cardboard, glass containers, aluminum cans, tin cans, motor oil, and scrap metals. Recycling collection is provided weekly, on the same day as garbage collection. The collected recyclables are processed at Northwest Recycling, Inc., a local recycling firm.

Commercial and multifamily garbage collection and multifamily recycling collection in Bellingham is provided by Sanitary Service Company. The Washington Utilities and Transportation Commission regulates their service, not the City. Multifamily collection services in Bellingham are directed through Whatcom County's Service Level Ordinance. Yard waste collection is not offered at this time.

Bellingham's waste is processed and incinerated under contract at a facility owned and operated by Recomp of Washington, Inc. The facility is located in Ferndale, a few miles north of Bellingham. All waste is delivered directly to the Recomp's facility. No intermediate transfer stations are used in Bellingham.

Recomp's corporate predecessor, Thermal Reduction Corporation, had operated an incineration system for the City since 1974. In 1985, Bellingham and Thermal Reduction Corporation amended their disposal contract to provide for a major upgrade and expansion of the incineration facility. The earlier incinerators were removed and a new facility featuring two 50 ton per day Consumat incinerators, a 1.2 megawatt energy recovery system, and a new tipping floor was constructed. Major pollution control upgrades occurred in 1990, including the installation of an acid gas scrubber and the construction of a temporary ash storage facility.

Recomp of Washington, Inc. purchased the Thermal Reduction Corporation facility in 1990 and developed a MSW composting and waste export system to handle the portion of Whatcom County's waste stream that had previously been landfilled at the County's Cedarville Landfill. After the completion of the upgraded facility, financial difficulties for Recomp's parent company forced the bankruptcy sale of the facility. A group of investors and creditors currently own the facility, which includes the incineration capacity contracted to the city of Bellingham.

Description of Solid Waste Disposal System

Residential garbage collection in Bellingham is mandatory, although enforcement is limited by the nature of the billing system. Sanitary Service Company bills residents directly, making punitive action against non-subscribers difficult for the City. Although Census reports indicate over 15,000 single through four-plex households in the City, Sanitary Service Company reports indicate approximately 13,500 accounts. The difference may be attributed to non-subscribers, vacancies, and multiple dwellings using one account (e.g. duplexes).

Garbage collection charges are designed to provide waste reduction and recycling incentives while simultaneously generating sufficient revenue to cover contractor expenses. At the end of 1992, monthly garbage collection rates were:

Service Frequency	60 Gallon Cart	90 Gallon Cart
Weekly	$22.50	$33.60
Every-other-week	12.28	19.53
Monthly	6.86	12.02

A "super recycler" rate of $4.76 per month is available for those generating only one 32 gallon of waste per month.

Rates fund costs for collection, disposal, recycling, and containers, both garbage and recycling , as well as contractor's profits. The City levies a 2.5% utility tax on these rates to fund City management costs. A portion of this tax is used by the City to administer its recycling and disposal system contracts.

In mid-1992, approximately 30% of Bellingham households subscribed to weekly collection service, 51% subscribed to biweekly, 18% subscribed to monthly, and the remaining 1% were "super recyclers."

Collected solid waste is delivered to Recomp, where it is processed and incinerated. In 1992, 10,153 tons of residential waste were collected in Bellingham and disposed at Recomp.

Bellingham's contract with Recomp provides a base fee payment, currently about $38 per ton of waste accepted, regardless of volume. The base fee is modified annually, based on changes in the Consumer Price Index. In 1988, the City directed Thermal Reduction Company (Recomp's predecessor) to make certain pollution control upgrades. These upgrades included the installation of an acid gas scrubber/bag house and the construction of a temporary ash storage facility. The total capital cost of the acid gas scrubber/bag house improvement was $1.6 million. The temporary ash storage facility consisted of an impervious surface and a leachate collection system constructed over a previously-closed ashfill to contain incinerator ash for later off-site disposal. The temporary ash storage facility also cost $1.6 million, bringing the combined cost of pollution control improvements to $3.2 million. The costs of these upgrades were intended to be amortized over a four year period through a disposal surcharge. Although the pollution control surcharge is nearing the end of its intended term, a surcharge will likely be retained to fund the costs of disposing incinerator ash stockpiled since 1990.

The 1992 tipping fee of $90.94 per ton comprises a base tipping fee of approximately $38 per ton, a pollution control surcharge of approximately $42 per ton, a County overhead surcharge of $9 per ton (shown as part of the disposal fee charged to the City), and health department permitting fees of approximately $2.75 per ton. The portion of the pollution control surcharge related to capital improvements is expected to expire in mid- to late-1993. According to Recomp, the ongoing operating costs of the pollution control equipment and ash disposal are expected to add approximately $46 per ton to the base tipping fee, increasing the total tipping fee in the near future to $100 per ton.

Although the City's contract with Recomp is based on the operation of the company's two incinerators in 1992, Bellingham's waste is not necessarily all incinerated. All waste entering Recomp's facility is handled through a prioritized process defined by the County's flow control ordinance. Waste entering Recomp's facility is first screened to reject any oversized or unprocessable materials, which are directed to the waste export system for long hauling to the Roosevelt Regional Landfill in Roosevelt, Washington. Processable waste then enters a processing system designed to recover some recyclables (primarily metals), and screen out contaminated materials (e.g., oil filters and household hazardous waste) and other materials inappropriate for composting or incineration. Remaining waste is separated into two streams. The first stream consists of screened materials less than 8" in size, not all of which are biodegradable, which are then loaded into Recomp's MSW composting digesters. The second stream, which consists of a light fraction over 8" in size, is directed toward the energy recovery incinerators.

Compost operation was in testing mode in 1992 and did not have Health Department permit. As a result, material from the composter was long-hauled to landfill.

Finally, it should be noted that while Bellingham's disposal system is contractually based on incineration, it is operationally part of a larger system that accepts waste county-wide and includes mechanical processing and recycling, MSW composting, and waste export.

Description of Recycling System

Bellingham's curbside collection program is operated by Recycling Services, Inc. (RSI), a sister company to Sanitary Service Company. RSI serves as a subcontractor to Sanitary Service Company, providing recycling collection services in areas served by the garbage collection company, including Bellingham.

In Bellingham, the company uses three 23 cubic yard trucks (plus one backup truck) to collect newspapers, mixed waste paper, cardboard, glass containers, aluminum cans, tin cans, motor oil, and scrap metals. The trucks have four dividers providing three 4.6 cubic yard compartments for newspaper, mixed waste paper, and cardboard, and a 9.2 cubic yard compartment for commingled glass and cans. Side racks are used to store boxed scrap metal and bottled motor oil.

All city households were provided a set of three stacking blue, red, and white bins at the time the program started in 1989. No sign-up system was necessary, since all residents were provided bins. The blue bin is used for commingled glass and cans, the red bin is used for newspaper, and the white bin is used for mixed waste paper. Residents are asked to bundle and stack cardboard next to the bins. Motor oil is placed in sealed clear jugs, and placed next to the bins. Boxed scrap metal may also be placed next to the bins for collection. Collection is offered weekly throughout the city.

Collected recyclables are delivered to Northwest Recycling, located in the center of Bellingham. Northwest Recycling is the only facility in the Bellingham area equipped to handle the curbside-collected materials. The independent processor either pays for the delivered materials or charges a tipping fee. Northwest Recycling's prices are not established by contract with either the City or the collection contractor, but are based on local processing and shipping costs and prevailing commodity prices. In 1992, an average of $25 per ton was charged for each ton of curbside materials delivered to Northwest's facility.

Essentially all materials from the residential collection program are recovered for marketing. Careful screening at the curb, efficient handling at Northwest Recycling, and intensive sorting of commingled containers serve to minimized rejected materials and unmarketable glass. A negligible amount of contaminants and mixed color glass cullet are disposed.

In 1992, 3,623 tons of materials were collected from the city's 15,000 households, of which about 13,500 participate in recycling, diverting approximately 26% of the residential waste stream.

2 Recycling System

Market risk for Bellingham's curbside collection system is borne by the ratepayers. Commodity charges and revenues are added or subtracted, respectively, from the annually calculated revenue requirement. At the end of each 12-month accounting period, actual revenues and expenses are compared with the previous year's forecast. Forecasts for the following year are then adjusted to "true up" actual expenses and revenues for the previous year. If commodity values for a previous year were less than expected, causing a revenue shortfall, the total revenue requirement for the succeeding year is adjusted upward to allow Sanitary Service Company and Recycling Services Inc. to recoup their losses. Conversely, if commodity quantities and values for the previous year were more than expected, the revenue requirement forecast would be adjusted downward to reimburse ratepayers.

In this way the collection system in Bellingham operates as a combined public/private utility system, offering no risk to the Contractor. Risks due to varying commodity values, changing collection costs, and changing service revenues due to shifting service levels are all mitigated by the annual rate adjustment process and the "look back" provisions used to correct revenue shortfalls or surpluses.

In theory, this system should offer low collection costs due to the elimination of the contractor's need to hedge against financial risk. In practice, the system requires a fair amount of management and oversight on the City's part to assure that all costs are fair, just, and reasonable.

<u>Weight and Volume</u>

Table C-1 gives tonnage and cubic yards, in total and by material type, for the city of Bellingham's curbside program in 1992. A total of 3,623 tons of recyclable materials were collected, processed, and marketed. A negligible, but unknown, amount of collected material was rejected during processing. As discussed previously, the collection and processing system minimizes material loss due to breakage and contamination.

Based on the conversion factors for material densities given in Table C-1, over 28,000 cubic yards of material were recycled in Bellingham in 1992. Because corrugated cardboard is separated from residential mixed waste paper in the

Bellingham curbside program, residential MWP has a higher in-truck density than it does in Seattle's northend curbside collection. MWP represents about the same relative proportion of cubic yards and tons in Bellingham's curbside, because its density it about the same as the average density of all recycled materials combined.

Newspapers, glass containers, scrap metal and used oil are more dense than the average, so their relative proportion of cubic yards is less than their proportion of tons. The opposite is true for the light and bulky recyclables, corrugated cardboard, aluminum cans, and tin cans. Bellingham does not at present collect any plastic bottles in its curbside program.

Table C-1. RECYCLING SYSTEM: BELLINGHAM - Residential Curbside (1992)

	Volumes				
Materials	Tons (Actual)	Distribution of Tons	Cubic Yds (Calculated)	Distribution of Cu.Yds	Conversion Lbs/Cu.Yds
Newspaper	1,094	30.2%	5,914	20.8%	370
Corrugated Cardboard	255	7.0%	5,667	20.0%	90
Mixed Paper	1,050	29.0%	8,400	29.6%	250
Glass Containers	981	27.1%	3,216	11.3%	610
Aluminum Cans	84	2.3%	3,360	11.8%	50
Tin Cans	131	3.6%	1,747	6.2%	150
Scrap Metal	10	0.3%	62	0.2%	325
Used Oil	18	0.5%	25	0.1%	1,414
TOTAL	3,623	100.0%	28,390	100.0%	255

Note: Cubic yards were calculated using in-truck densities for "lbs/cu.yds" conversion (See Appendix 2).

Cost of Recycling System

Cost data was derived from Sanitary Service Company's June 1992 proforma budget for the period July 1992 through June 1993. Actual commodity charges and volumes for 1992 were combined with projected collection costs to provide an financial overview of Bellingham's system.

In June 1992, the annual costs of the curbside recycling collection program for the next year were forecast to be $361,774, including both operating and amortization expenses. Collection vehicles and recycling containers are amortized over the ten year contract period. In this forecast, total commodity charges of $33,575 were anticipated. Actual commodity charges during the calendar year 1992 were $90,819, $57,244 higher than forecast. Thus, the combination of forecast operating costs and actual commodity charges yields an approximate program cost of $419,000 for 1992.

Table C-2 details cost components for Bellingham's recycling collection system. Sanitary Service provides billing services for both the garbage and recycling components of the overall collection systems. All billing costs are reflected in the collection component of disposal system costs detailed later in this section.

Table C-2. RECYCLING SYSTEM: BELLINGHAM - Residential Curbside (1992)

	Recycling System Component Costs		
Cost Components	Total Costs (000)	Costs Per Ton	Distribution of Costs
Collection	$328	$90.59	78.3%
Processing	$91	$25.06	21.7%
Overhead	NA	NA	NA
Total Cost	$419	$115.65	100.0%
Less: Revenues	$0	$0	
Net Cost	$419	$115.65	

Note: Recycled materials are "marketed" off the truck at the end of each route to a local drop-off/buy-back operation. Processing cost is the average commodity charge by the drop-off/buy-back operation. Commodity charges exceeded prices paid by the processor, so average revenue is shown as zero. NA = no available estimate for overhead costs.

Recycling Services, Inc. paid almost $91,000 in commodity charges to Northwest Recycling in 1992. Prices charged for mixed glass and cans and mixed waste paper rose throughout the year. At the beginning of 1992, Northwest Recycling charged $25 per ton to accept mixed glass and cans and $50 per ton to accept mixed waste paper. By the end of the year, Northwest Recycling charged $45 per ton for mixed glass and cans and $65 per ton to accept mixed waste paper. Average 1992 per ton prices/(charges) for each of the recycled materials were:

Newspaper	$ 10
Cardboard	$ 23
Mixed Waste Paper	$(61)
Mixed Glass, Tin Cans, Aluminum Cans	$(36)
Average	$(25)

Scrap metal and used motor oil generated no revenues during 1992.

Northwest Recycling's charges reflect the company's processing and shipping costs as well as profit. The breakdown of these categories is not available. However, as Bellingham is approximately 90 miles from Seattle, the increase in transportation costs due to Bellingham's distance from markets could be calculated.

In 1992, the costs of Bellingham's recycling collection system averaged $116, including commodity charges. Over three quarters of the cost was for collection, with 22% of the cost covering processing.

Recycling Cost By Material

Table C-3 provides materials specific recycling cost data when total curbside program costs are allocated by weight and by volume for the materials recycled by Bellingham's program. As with the cost allocation presented for Seattle's northend program, costs vary with materials density and allocation method. Contamination in the Bellingham program is negligible. Marketable tons are therefore equal to collected tons. And, all materials are assigned the same per ton costs when total costs are allocated according to the tonnage of each material recycled.

Table C-3 also shows the local recycler's fee for processing and marketing Bellingham's curbside recycled materials. Northwest Recycling charged $36 per ton for commingled glass and metal containers. Mixed paper was the most expensive, costing an average $61 per ton in 1992. ONP and OCC had a positive price at Northwest Recycling during 1992. Recycling Services was paid an average of $10 per ton for ONP and $23 per ton for OCC.

When costs are distributed according to cubic yards collected, the bulky materials absorb a greater proportion of total costs and their per ton collection costs rise. For example, aluminum cans are the most expensive recycled material with a collection cost of $462 per ton. Because Northwest Recycling charges $36 per ton for commingled containers delivered to its processing facility off the Bellingham curbside recycling routes, aluminum cans also have the highest net cost per ton at $498, based on collection costs allocated by material volume in the recycling truck.

Table C-3. RECYCLING SYSTEM: BELLINGHAM - Residential Curbside (1992)

		Costs Per Material – Allocated By Tons			
Materials	Total Collection Costs (000)	Collection Costs Per Ton	Processor Charge Per Ton	Net Cost Per Ton	Distribution of Tons
Newspaper	$99	$90.59	($10.00)	$80.59	30.2%
Corrugated Cardboard	$23	$90.59	($23.00)	$67.59	7.0%
Mixed Paper	$95	$90.59	$61.00	$151.59	29.0%
Glass Containers	$89	$90.59	$36.00	$126.59	27.1%
Aluminum Cans	$8	$90.59	$36.00	$126.59	2.3%
Tin Cans	$12	$90.59	$36.00	$126.59	3.6%
Scrap Metal	$1	$90.59	$0.00	$90.59	0.3%
Used Oil	$2	$90.59	$0.00	$90.59	0.5%
Total/Average	$328	$90.59	$25.06	$115.65	100.0%

Note: Tons are collected and "sold" to a processor, typically at a negative price called a "commodity charge." Collection costs are allocated among materials using distribution of tons. Because materials are sold unprocessed off-the-truck, there is no adjustment to costs for contaminants.

		Costs Per Material – Allocated By Cubic Yards			
Materials	Total Collection Costs (000)	Collection Costs Per Ton	Processor Charge Per Ton	Net Cost Per Ton	Distribution of Cu. Yds
Newspaper	$68	$62.49	($10.00)	$52.49	20.8%
Corrugated Cardboard	$66	$256.90	($23.00)	$233.90	20.0%
Mixed Paper	$97	$92.48	$61.00	$153.48	29.6%
Glass Containers	$37	$37.90	$36.00	$73.90	11.3%
Aluminum Cans	$39	$462.41	$36.00	$498.41	11.8%
Tin Cans	$20	$154.14	$36.00	$190.14	6.2%
Scrap Metal	$1	$71.14	$0.00	$71.14	0.2%
Used Oil	$0	$16.35	$0.00	$16.35	0.1%
Total/Average	$328	$90.59	$25.06	$115.65	100.0%

Note: Tons are collected and "sold" to a processor, typically at a negative price called a "commodity charge." Collection costs are allocated among materials using distribution of cubic yards.

3. Solid Waste Disposal System

Weight and Volume

Table C-4 shows 1992 residential disposed waste in total and by materials type for 22 categories of waste materials. The materials collected for curbside recycling (except for used oil) have been segregated at the bottom of the table, so that material specific costs of curbside collection for disposal can be compared with recycling.

The composition used in Table C-4 is based on surveys conducted in 1987 for the Washington State Department of Ecology's Best Management Practices Analysis for Solid Waste. It is important to note that these composition estimates are based on limited samples taken in the mid 80s before citywide curbside recycling was initiated. The city of Seattle has found that removal of curbside-collected recyclables from the waste stream substantially changes the composition of the remaining waste. The Bellingham waste stream in 1992 probably contained far fewer recyclables, and a higher proportion of yard waste and non-recyclables than indicated by the 1987 composition study. Since updated waste composition data was not available for this report, the 1987 Ecology composition data was used, with the caveat that actual 1992 composition could be quite different.

In 1992 Bellingham disposed of slightly over 10,000 tons of residential waste. Almost a quarter of this was yard and garden debris. Paper accounted for over 30% of waste in 1992, well over half of it being ONP, OCC and MWP that could have been recovered in the curbside recycling program.

Cost of Disposal System

Table C-5 shows total system and system component costs for collection and disposal of residential waste. In total, excluding the city of Bellingham's overhead costs for contract administration, residential waste collection and disposal cost approximately $1.8 million in 1992. City contract administration activities are funded by a portion of the City's 2.5% utility tax assessment. However, these administration costs are not included in disposal system costs shown in Table C-5. The City does not maintain accounting records that separately track contract administration costs for either recycling or disposal systems.

The mechanics of the revenue requirement forecasting and rate adjustment process were described previously. As with recycling, 1992 disposal costs were based on Sanitary Service Company's June 1992 budget proforma, as adjusted by actual 1992 disposal volumes and costs. According to the June 1992 proforma, Sanitary Service Company's collection operations were expected to cost approximately $918,000. Disposal was forecast to cost approximately $890,000. Actual 1992 disposal costs were $923,000, based on the disposal of 10,153 tons at $90.94 per ton. Thus, combined forecast collection and actual disposal costs for 1992 were $1.8 million.

Payments to the garbage collection contractor to cover refuse containers and collection route costs amounted to about 50% of total disposal system costs, about $90 per ton of residential waste disposed. Payments to Recomp to cover disposal of residential waste accounted for the other half of disposal system costs, almost $91 per ton of residential garbage.

Table C-4. DISPOSAL SYSTEM: BELLINGHAM - Residential Curbside (1992)

Materials	Tons (Actual)	Distribution of Tons	Volumes Cubic Yards (Calculated)	Distribution of Cu.Yds	Conversion Lbs/Cu.Yds
Newspaper	579	5.7%	1,286	3.5%	900
Kraft/Corrugated	487	4.8%	3,249	8.8%	300
Office Paper	41	0.4%	102	0.3%	800
Mixed Paper	629	6.2%	2,098	5.7%	600
Other Paper	1,361	13.4%	4,535	12.3%	600
Glass Containers	711	7.0%	1,421	3.9%	1,000
Other Glass	20	0.2%	41	0.1%	1,000
Aluminum Cans	81	0.8%	812	2.2%	200
Tin Cans	254	2.5%	1,692	4.6%	300
Other Ferrous Metals	71	0.7%	219	0.6%	650
Other Non-Ferrous Metals	30	0.3%	122	0.3%	500
PET Bottles	41	0.4%	406	1.1%	200
HDPE Bottles	51	0.5%	508	1.4%	200
Other Bottles	96	1.0%	965	2.6%	200
Plastic Packaging	497	4.9%	3,317	9.0%	300
Other Plastics	122	1.2%	812	2.2%	300
Food	1,107	10.9%	2,213	6.0%	1,000
Yard Waste	2,264	22.3%	9,056	24.5%	500
Other Organics	660	6.5%	1,467	4.0%	900
Wood	122	1.2%	541	1.5%	450
Construction Debris	61	0.6%	122	0.3%	1,000
Miscellaneous	863	8.5%	1,918	5.2%	900
Total	10,153	100.0%	36,901	100.0%	550

Memo: Disposal Data (from above) for Materials Also Recycled Curbside

Newspaper	579	5.7%	1,286	3.5%	900
Corrugated Cardboard	487	4.8%	3,249	8.8%	300
Mixed Paper	629	6.2%	2,098	5.7%	600
Glass Containers	711	7.0%	1,421	3.9%	1,000
Aluminum Cans	81	0.8%	812	2.2%	200
Tin Cans	254	2.5%	1,692	4.6%	300
Scrap Metal	102	1.0%	341	0.9%	605
Used Oil	0	0.0%	0	0.0%	1,414

Note: Cubic yards are calculated using in-truck densities for "lbs/cu.yds" conversion (See Appendix 2). Distribution of tons based on Northwest Waste Generation Area residential waste stream composition from Best Management Practices Analysis for Solid Waste, Volume 1, 1987 Recycling and Waste Stream Survey, Washington State Department of Ecology, Publication No. 88-33A, p. 104.

Table C-5. DISPOSAL SYSTEM: BELLINGHAM - Residential Curbside (1992)

	Disposal System Component Costs		
Cost Components	Total Costs (000)	Costs Per Ton	Distribution of Costs
Collection	$918	$90.39	49.8%
Disposal	$923	$90.94	50.2%
Overhead	NA	NA	NA
Total Cost	$1,841	$181.33	100.0%
Less: Revenues	NA	NA	
Net Cost	$1,841	$181.33	

Note: NA = no available date for overhead costs or for revenue. Electricity sales are reflected in $90.94 tipping fee at Recomp.

Disposal Cost By Material

Table C-6 shows disposal system costs allocated to each waste material on both a weight basis and an in-compactor-truck cubic yard basis. Allocation of disposal costs to specific materials based on distribution of cubic yards is dependent on estimates for each material's density, as given in the right-hand column of Table C-4. The sources for these estimates for materials that are both recycled and disposed are given in Appendix 2.

The lightweight metal containers and corrugated cardboard absorb relatively more disposal system cost on a volume basis than they do on a weight basis. Aluminum cans at $499 per ton are the most costly on a volume basis, compared with a flat $181 for all materials on a weight basis. The right-hand column in Table C-6 shows the distribution of tons and cubic yards for disposal quantities of materials recycled curbside in Bellingham. For all but used oil, these distributions provide the basis for allocation of total costs according to relative weights or relative volumes, as shown in the left-hand column of Table C-6. Used oil cannot be legally disposed in residential waste. However, to provide a disposal cost for use in comparing the costs of recycling versus disposal, $181 is shown in Table C-6 as the per ton cost of used oil disposal for both weight and volume allocations of disposal costs.

4. Comparison of Recycling and Disposal Costs

Table C-7 shows recycling and disposal system costs per ton for the eight materials currently recycled through Bellingham's residential curbside recycling system. Recycling system collection costs are reported in the "Recycling Collection Cost per Ton" column of Table C-7. Including the processor's charge, or in the case of ONP and OCC the credit, in collection costs for recycled materials gives the figures reported in the "Recycling Cost Net of Revenue" column of Table C-7. Total waste disposal system costs per ton are reported in the "Disposal Total Cost Per Ton" column.

For each recycled material, the last column in Table C-7 shows the difference between average per ton costs of recycling and disposal. The top half shows average costs when total costs are allocated according to the distribution of collected tons, the bottom half shows averages when total costs are allocated on the basis of collected cubic yards. For all materials under both cost allocation methods, average costs of recycling are less than for disposal.

Recycled mixed paper has the lowest margin versus disposal on a weight-based allocation of costs, and the second lowest margin under volume-based allocation of costs. For costs allocated according to relative usage of collection truck cubic yard capacity, aluminum has the lowest margin for recycling versus disposal. The low margin is a result of the high market value for recycled aluminum being distributed across all glass and metal containers in Northwest Recycling's processing charge of $36 for each ton of commingled containers delivered. So the relatively light and bulky aluminum cans absorb more collection costs on a volume basis than do tins cans and glass containers, but get "sold" off-the-truck for the same negative price as the other containers with which they are commingled in the collection vehicle.

5. Additional Comments

The nature of Bellingham's collection and disposal contracts allow the city ratepayers to capture much of the benefit of reduced waste volumes. Savings in disposal charges accrue directly to Bellingham ratepayers, as collection contractor costs are reduced. Theoretically, reductions in waste volume could allow the collection contractor to continually optimize collection routes to maximize garbage collection savings. The City's disposal contract with Recomp of Washington contains no "put or pay" provisions that may cause disincentives for reduced waste volumes. However, the fixed cost recovery for past pollution control improvements could possibly increase tipping fees if a significant reduction in waste volume is experienced.

Table C-6. DISPOSAL SYSTEM: BELLINGHAM - Residential Curbside (1992)

Recyclable Materials	Total Costs (000)	Costs Per Material – Allocated By Tons: Costs Per Ton	Revenue Per Ton	Net Cost Per Ton	Distribution of Tons
Newspaper	$105	$181.33		$181.33	20.4%
Corrugated Cardboard	$88	$181.33		$181.33	17.1%
Mixed Paper	$114	$181.33		$181.33	22.1%
Glass Containers	$129	$181.33		$181.33	25.0%
Aluminum Cans	$15	$181.33		$181.33	2.9%
Tin Cans	$46	$181.33		$181.33	8.9%
Scrap Metal	$18	$181.33		$181.33	3.6%
Used Oil (1)	$0	$181.34		$181.34	0.0%
Total/Average	$515	$181.33		$181.33	100.0%

Notes: (1) Used oil disposal costs included for comparison purposes only. Disposal of used oil is prohibited.
(2) Only materials in recycling program are shown. Tons are "collected." Total costs are allocated among materials using distribution of tons.

Recyclable Materials	Total Costs (000)	Costs Per Material -- Allocated By Cubic Yards: Costs Per Ton	Revenue Per Ton	Net Cost Per Ton	Distribution of Cu.Yds
Newspaper	$64	$110.87		$110.87	11.8%
Corrugated Cardboard	$162	$332.61		$332.61	29.8%
Mixed Paper	$105	$166.30		$166.30	19.3%
Glass Containers	$71	$99.78		$99.78	13.0%
Aluminum Cans	$41	$498.91		$498.91	7.5%
Tin Cans	$84	$332.61		$332.61	15.5%
Scrap Metal	$17	$167.33		$167.33	3.1%
Used Oil (1)	$0	$181.34		$181.34	0.0%
Total/Average	$544	$191.29		$191.29	100.0%

Notes: (1) Used oil disposal costs included for comparison purposes only. Disposal of used oil is prohibited.
(2) Only materials in recycling program are shown. Cubic yards are "collected." Total costs are allocated among materials using distribution of cubic yards.

Table C-7. RECYCLING vs. DISPOSAL SYSTEM COSTS: BELLINGHAM - Residential Curbside (1992)

	Costs Per Material – Allocated By Tons			
Recyclable Materials	Recycling Collection Cost Per Ton	Recycling Cost Net of Revenue	Disposal Total Cost Per Ton	**Recycling Cost Difference**
Newspaper	$90.59	$80.59	$181.33	**$100.74**
Corrugated Cardboard	$90.59	$67.59	$181.33	**$113.74**
Mixed Paper	$90.59	$151.59	$181.33	**$29.74**
Glass Containers	$90.59	$126.59	$181.33	**$54.74**
Aluminum Cans	$90.59	$126.59	$181.33	**$54.74**
Tin Cans	$90.59	$126.59	$181.33	**$54.74**
Scrap Metal	$90.59	$90.59	$181.33	**$90.74**
Used Oil	$90.59	$90.59	$181.34	**$90.75**
Total/Average	$90.59	$115.65	$181.33	**$65.68**

	Costs Per Material -- Allocated By Cubic Yards			
Recyclable Materials	Recycling Collection Cost Per Ton	Recycling Cost Net of Revenue	Disposal Total Cost Per Ton	**Recycling Cost Difference**
Newspaper	$62.49	$52.49	$110.87	**$58.38**
Corrugated Cardboard	$256.90	$233.90	$332.61	**$98.71**
Mixed Paper	$92.48	$153.48	$166.30	**$12.82**
Glass Containers	$37.90	$73.90	$99.78	**$25.88**
Aluminum Cans	$462.41	$498.41	$498.91	**$0.50**
Tin Cans	$154.14	$190.14	$332.61	**$142.47**
Scrap Metal	$71.14	$71.14	$167.33	**$96.19**
Used Oil	$16.35	$16.35	$181.34	**$164.99**
Total/Average	$90.59	$115.65	$191.29	**$75.64**

Note: The difference between recycling and disposal costs per ton may not be indicative of the actual cost decrease or increase when tonnage recycled increases or decreases.

D. Vancouver

1. Overview

Vancouver is a city of 47,000 located across the Columbia river from Portland, Oregon, in the southwest region of Washington. Vancouver is the largest city in Clark County and contains approximately 20% of the County's population. Vancouver is surrounded by an extensive densely populated urban fringe. The majority of the County's population reside in the greater Vancouver area.

Solid waste collection within the city of Vancouver is contracted. The Disposal Group's (TDG) contract with the City to provide residential and commercial solid waste collection expires in July 1995. Minican, one can, and two can collection service levels are offered to residential customers. The city has 14,068 single-family (one through four units) residences.

In 1991 the City separately contracted with Waste Management of Oregon (WMO), a Waste Management, Inc. subsidiary, to provide curbside recycling collection over a five year period. The curbside recycling service is part of a coordinated effort between the City and County to offer uniform recycling services throughout the urban service area. Both the City and County contract for identical services (provided at the same price) from WMO. WMO provides collection services only, with collected materials owned by the County and marketed by Columbia Resources Company (CRC).

Solid waste disposal, recycling processing and marketing are handled through an interlocal agreement with Clark County. The County contracts with CRC, a sister company of Tidewater Barge Lines, for the transfer, transportation, and landfill disposal of waste at the Company's landfill in Boardman, Oregon. The 1992 tipping fee at CRC's facilities was $71.45 per ton of waste delivered, including a County overhead surcharge of $9.00 per ton. CRC's transfer station on River Road also serves as a recycling processing center for City and County curbside collected recyclables.

The City provides customer billing through combined utility bills and pays TDG and WMO for solid waste collection and disposal, and curbside recycling, respectively.

The City and Clark County are currently in the process of implementing a pilot yard debris collection program. The pilot area will include the entire city of Vancouver as well as some unincorporated areas within the Urban Service Area. The collection program will be subscription based, with only those who specifically subscribe for yard debris collection charged. The service is expected to start in May 1993. The implementation of the pilot is expected to provide for the diversion of a portion of the waste currently handled by the City's garbage collection and disposal system. The potential financial effect of the future diversion on the residential disposal system is unknown.

The City and County are also in the process of implementing a multifamily recycling collection program throughout the Urban Service Area. The program will accept the same materials collected by the single-family program, and will target multifamily buildings with five or more apartment units. Phased-in collection will start in May of 1993. Collection services should be available to all multifamily units within the Urban Service Area by the end of Summer, 1993.

Description of Solid Waste Disposal System

Residential garbage collection in Vancouver is mandatory. The City uses a combined utility billing systemthat includes water, sewer, garbage and recycling.

Garbage collection charges are designed to provide waste reduction and recycling incentives while simultaneously generating sufficient revenue to cover City overhead expenses and the costs of contracted services. Residential recycling is billed as a separate line item of $3.10 a month per household. Three rate classifications are used: regular curb service, carryout service, and handicapped or elderly and low income carry out (HELICO). At the end of 1992, monthly garbage collection rates were:

Service Level	Regular/Curb	Carryout	HELICO	Recycling
Minican-weekly	$8.75	$14.40	$8.15	$3.10
Minican-every-other-week	7.15	9.75	6.55	3.10
Standard One Can	9.75	15.40	9.15	3.10
Standard Two Can	18.65	29.80	18.05	3.10

At present, 1.1% of Vancouver residences subscribe to every-other-week minican service, 3.2% subscribed to weekly minican service, 88.0% subscribe to standard one can service, and the remaining 7.7% subscribe to two can service.

In 1992 the City received $2.3 million in residential solid waste revenues. Solid waste collection services and disposal cost $1.4 million, recycling collection services cost $0.4 million, and the City had $0.3 million in expenses. City expenses included $45,000 for Spring cleanup activities and $103,000 in contract administration and billing expenses, and $110,000 in general solid waste planning, waste reduction program, and landfill closure expenses.

Collected solid waste is delivered to CRC's River Road transfer station and Material Recovery Center, where it is loaded onto barges and transported to CRC's Boardman, Oregon landfill. In 1992, a total of 10,143 tons of single-family residential waste were collected and disposed at the River Road transfer station.

CRC operates the disposal system under a 20-year contract with Clark County. The contract provides for CRC's operation of two transfer sites within Clark County, a minimum of 20% recycling of the incoming waste stream through a combination of source separation opportunities and mechanized recovery from mixed waste delivered to the transfer stations, and the transportation of remaining wastes to the Tidewater Barge Line's Finley Buttes Landfill in Morrow County, Oregon.

The $71.45 per ton tipping fee charged in 1992 at the CRC facilities includes $62.45 per ton for waste transfer and export, and $9.00 per ton for County solid waste management activities – planning, waste reduction, and groundwater pumping and treatment at the landfill used prior to the development of the waste export system.

Description of Recycling System

Vancouver's curbside recycling collection program is operated by Waste Management of Oregon. The City and Clark County issued at joint RFP in 1991 for Urban Service Area curbside recycling services. The Urban Service Area includes approximately 50,000 single-family (1-4 unit) households, including 14,000 in the city.

Once the contract negotiation process was complete, the City and the County executed separate contracts for their respective jurisdictions.

WMO uses 31 cubic yard capacity recycling trucks to collect newspaper, mixed waste paper, cardboard, glass containers, tin and aluminum cans, motor oil, PET and natural HDPE plastic bottles, and polycoated milk/juice containers (Tetrapak™and gabletop). All materials are contained within the truck body with the exception of motor oil, which is placed in jugs on sideracks. In 1992, 3,062 tons of recyclables were collected through the curbside collection program.

All city households were provided a set of three stacking bins during the startup period in January and February, 1992. The company collected bins from customers rejecting the recycling collection program. One bin is used for newspaper; one for mixed waste paper; and one for glass, aluminum and tin cans, plastic bottles and polycoated containers. Cardboard can be set out in 3-foot square stacks next to the bins. Used motor oil can be set out in lidded plastic milk jugs.

Under the City's contract, WMO provides only collection services. The ownership of the collected materials is retained by the County. Collected recyclables are directed to the CRC processing site on River Road. Recycling processing occurs as a integral component of the County's larger waste export contract. CRC processes and markets curbside collected recyclables for the local governments. The capital cost of the equipment and facilities required to process the recyclables is funded through the general solid waste tip fee. The operating costs of processing recyclables are subtracted from the overall revenues received from marketing materials, and 85% of the remaining "profits" are returned to the County. Revenues attributable to materials collected by the City's program are directed to the City to offset collection costs.

During 1992, CRC was in the process of completing its River Road waste transfer and recycling processing site which opened January 1993. As an interim measure, curbside collected recyclables were directed to an affiliated company in Portland. The ability of this facility to efficiently process the volumes of materials recovered by the City/County program was limited, resulting in higher than expected contamination rates and processing losses. Now that processing has shifted to the River Road site, contamination losses should be reduced. In 1992, approximately 0.2% of the mixed waste paper and 37.7% of the glass collected in the City/County curbside programs was rejected during processing.

2 Recycling System

The City's contract with WMO features a per-ton payment to WMO for collected materials delivered in acceptable condition to CRC's processing site. In 1992, WMO's fee was $128.50 per ton. The collection expenses were partially offset by the City's portion of material marketing revenues. At the time this draft report was prepared, the City's commodity payment had not been determined. It is expected to average approximately $6 per ton for the 3,062 tons collected.

Market risk is shared by CRC and the County (City), to the extent that net profits from the sale of recyclables are split. Marketing revenues are higher than would normally be expected since the capital costs of the recycling processing center are funded through the disposal system tipping fees. Thus, revenues from the sale of recovered materials need only cover the operating expenses of the recycling processing before "profit" is generated. This differs from the Spokane and Bellingham systems described in this report, where both capital and operating costs must be covered by commodity sales before "profits" are available to the operator or jurisdiction.

Weight and Volume

Table D-1 gives tonnage and cubic yards, in total and by material type, for the city of Vancouver's curbside program in 1992. A total of 3,062 tons of recyclable materials were collected and processed. Based on the distribution of tonnage collected throughout the Urban Service Area, 45% of recycled material collected in Vancouver was newspaper, only 0.1% was polycoated containers, 31% was mixed waste paper, 17% was glass, 1% was aluminum cans, 4% was tin, 0.5% was PET bottles, 1% was HDPE bottles, and 1% was used motor oil. Mixed waste paper and glass volumes have been reduced to reflect contamination rates of 0.18% and 37.7%, respectively.

As with the other recycling programs examined in this report, the distribution of recycled material volumes is quite different than the distribution of weight. Distributions for both tons and cubic yards among the nine materials collected curbside in Vancouver are shown in Table D-1.

Table D-1. RECYCLING SYSTEM: VANCOUVER - Residential Curbside (1992)

			Volumes		
Materials	Tons (Actual)	Distribution of Tons	Cubic Yds (Calculated)	Distribution of Cu.Yds	Conversion Lbs/Cu.Yds
Newspaper	1,380	45.1%	7,459	27.7%	370
Polycoat Containers	3	0.1%	56	0.2%	100
Mixed Paper	949	31.0%	12,653	47.0%	150
Glass Containers	505	16.5%	1,656	6.2%	610
Aluminum Cans	31	1.0%	1,224	4.5%	50
Tin Cans	119	3.9%	1,592	5.9%	150
PET Bottles	15	0.5%	735	2.7%	40
HDPE Bottles	30	1.0%	1,485	5.5%	40
Used Oil	30	1.0%	43	0.2%	1,414
TOTAL	3,062	100.0%	26,903	100.0%	228

Note: Cubic yards were calculated using in-truck densities for "lbs/cu.yds" conversion (See Appendix 2).

Cost of Recycling System

The WMO contract specifies a payment of $128.50 per ton of acceptable material. If materials are delivered to CRC's processing site in a contaminated condition, WMO is charged the regular solid waste disposal tipping fee instead of receiving the contracted recycling collection payment. In 1992, all delivered materials were considered acceptable. The delivery of contaminated materials has not been a problem, although additional measures are being considered to reduce glass breakage during collection.

Table D-2 details the cost components of Vancouver's recycling collection system. In addition to the contract fee paid to WMO, a portion of the $102,800 administration and billing expense incurred by the City is allocated to the recycling collection program in proportion to the relation between tons of residential waste recycled through the curbside program in Vancouver versus tons disposed.

As described previously, recycling revenues to the City are based on a share of commodity revenues, after operating costs are subtracted. Material marketing revenues and processing costs are currently being calculated by CRC and the County. The current estimate is that Vancouver will receive an average $6 per ton after processing charges by CRC. No split between processing costs and gross revenues, or allocation of revenues and costs among the recycled materials is currently available. Estimated revenue net of processing charges of $6 per ton is shown in Table D-2 as revenue from the sale of recycled materials.

Table D-2. RECYCLING SYSTEM: VANCOUVER - Residential Curbside (1992)

	Recycling System Component Costs		
Cost Components	Total Costs (000)	Costs Per Ton	Distribution of Costs
Collection	$393	$128.50	94.0%
Processing (1)	NA	NA	NA
Overhead	$25	$8.23	6.0%
Total Cost	$419	$136.73	100.0%
Less: Revenues (1)	($18)	($6.00)	
Net Cost	$400	$130.73	

Notes: (1) NA = no available information on processing costs. Revenue is estimated and net of processing cost.

(2) Collected materials are delivered to a processor that prepares them for market. The revenue from material sales is shared bewteen the City and the processor. At present only the net of processing cost and market revenue has been calculated. The City and the processor are currently calculating separate processing costs and market revenues for each recycled material.

Recycling Cost By Material

Table D-3 provides material specific recycling cost data when total curbside program costs are allocated according to either weight or volume for the materials recycled by Vancouver's program. Costs vary with material density and allocation method. The amount of cost allocated to light, but voluminous materials goes up dramatically when in-recycling-truck density rather than tonnage collected is used to allocate recycling costs among the nine materials.

Table D-3. RECYCLING SYSTEM: VANCOUVER - Residential Curbside (1992)

		Costs Per Material -- Allocated By Tons			
Materials	Total Costs (000)	Costs Per Ton	Revenue Per Ton	Net Cost Per Ton	Distribution of Tons
Newspaper	$189	$136.73	$6.00	$130.73	45.1%
Polycoat Containers	$0	$136.73	$6.00	$130.73	0.1%
Mixed Paper	$130	$136.73	$6.00	$130.73	31.0%
Glass Containers	$69	$136.73	$6.00	$130.73	16.5%
Aluminum Cans	$4	$136.73	$6.00	$130.73	1.0%
Tin Cans	$16	$136.73	$6.00	$130.73	3.9%
PET Bottles	$2	$136.73	$6.00	$130.73	0.5%
HDPE Bottles	$4	$136.73	$6.00	$130.73	1.0%
Used Oil	$4	$136.73	$6.00	$130.73	1.0%
Total/Average	$419	$136.73	$6.00	$130.73	100.0%

Note: Tons are collected and delivered to a processor. Ownership of the materials is retained by the City. At the end of 1992 the City and the processor began a negotiation process to determine processing cost and sales revenue for each material. A portion of the City's sales revenue is shared with the processor. Collection and processing costs are allocated among materials using distribution of tons.

		Costs Per Material -- Allocated By Cubic Yards			
Materials	Total Costs (000)	Costs Per Ton	Revenue Per Ton	Net Cost Per Ton	Distribution of Cu. Yds
Newspaper	$116	$84.10	$6.00	$78.10	27.7%
Polycoat Containers	$1	$311.19	$6.00	$305.19	0.2%
Mixed Paper	$197	$207.46	$6.00	$201.46	47.0%
Glass Containers	$26	$51.01	$6.00	$45.01	6.2%
Aluminum Cans	$19	$622.38	$6.00	$616.38	4.5%
Tin Cans	$25	$207.46	$6.00	$201.46	5.9%
PET Bottles	$11	$777.97	$6.00	$771.97	2.7%
HDPE Bottles	$23	$777.97	$6.00	$771.97	5.5%
Used Oil	$1	$22.01	$6.00	$16.01	0.2%
Total/Average	$419	$136.73	$6.00	$130.73	100.0%

Note: Cubic yards are collected and delivered to a processor. Ownership of the materials is retained by the City. At the end of 1992 the City and the processor began a negotiation process to determine processing cost and sales revenue for each material. A portion of the City's sales revenue is shared with the processor. Collection and processing costs are allocated among materials using distribution of cubic yards.

3. Solid Waste Disposal System

Weight and Volume

Table D-4 shows 1992 residential disposed waste in total and by material type for 22 categories of waste materials. Included in the categories are all the materials collected for curbside recycling (except for polycoated paper containers and used motor oil) so that material specific costs of curbside collection for recycling can be compared to costs of collection for disposal of these same materials.

The residential waste composition data reported in Table D-4 are from the relatively old Department of Ecology Best Management Practices Analysis for Solid Waste, as were composition data for Spokane and Bellingham. Thus, the caveats described in the sections for Spokane and Bellingham also apply to these composition estimates for Vancouver.

Cost of Disposal System

Table D-5 shows total system and system component costs for collection and disposal of residential waste. In total, including a share of the city of Vancouver's overhead costs for contract administration and billing, residential waste collection and disposal cost approximately $1.6 million in 1992. The portion of 1992 ratepayer revenue that was directed to the City's general fund has been subtracted from City administrative and billing cost charges to more accurately portray actual current disposal system costs. Similarly, the portion of 1992 ratepayer revenues paid to cover taxes and reserves also has been subtracted from City administrative costs to maintain consistency with other surveyed cities.

Therefore, 1992 City expenses for residential garbage collection were $0.7 million; waste disposal expenses (at $71.45 per ton) were $0.7 million; and City management, billing, and spring clean up costs were $0.1 million. In total disposal of Vancouver's residential waste in 1992 cost $1.6 million[11], or about $156 per ton. Collection costs accounted for 46% of the total, disposal for 46% and City overhead for 8% of disposal system costs.

Disposal Cost By Material

Table D-6 shows disposal system costs allocated to each waste material on both a weight basis and an in-compactor-truck cubic yard basis. Allocation of disposal costs to specific materials based on distribution of cubic yards is dependent on estimates for each material's density, as given in the right-hand column of Table D-4. The sources for these estimates for materials that are both recycled and disposed are given in Appendix 2.

The lightweight metal and plastic containers absorb relatively more disposal system cost on a volume basis than they do on a weight basis. Aluminum cans and plastic bottles at $429 per ton are the most costly on a volume basis, compared with a flat $156 for all materials on a weight basis.

The right-hand column in Table D-6 shows the distribution of tons and cubic yards for the disposed quantities of materials recycled curbside in Vancouver. For all but used oil, these distributions provide the basis for allocation of total costs according

[11] Separate collection, disposal and overhead costs do not add to $1.6 million due to rounding.

to relative weights or relative volumes, as shown in the left-hand column of Table D-6. Used oil cannot be legally disposed in residential waste. However, to provide a disposal cost for use in comparing the costs of recycling versus disposal, $162 is shown in Table D-6 as the per ton cost of used oil disposal for both weight and volume allocations of disposal costs.

Table D-4. DISPOSAL SYSTEM: VANCOUVER - Residential Curbside (1992)

			Volumes		
Materials	Tons (Actual)	Distribution of Tons	Cubic Yards (Calculated)	Distribution of Cu.Yds	Conversion Lbs/Cu.Yds
Newspaper	578	5.7%	1,285	3.5%	900
Kraft/Corrugated	487	4.8%	3,246	8.8%	300
Office Paper	41	0.4%	101	0.3%	800
Mixed Paper	629	6.2%	2,096	5.7%	600
Other Paper	1,359	13.4%	4,531	12.3%	600
Glass Containers	710	7.0%	1,420	3.9%	1,000
Other Glass	20	0.2%	41	0.1%	1,000
Aluminum Cans	81	0.8%	811	2.2%	200
Tin Cans	254	2.5%	1,691	4.6%	300
Other Ferrous Metals	71	0.7%	218	0.6%	650
Other Non-Ferrous Metals	30	0.3%	122	0.3%	500
PET Bottles	41	0.4%	406	1.1%	200
HDPE Bottles	51	0.5%	507	1.4%	200
Other Bottles	96	1.0%	964	2.6%	200
Plastic Packaging	497	4.9%	3,313	9.0%	300
Other Plastics	122	1.2%	811	2.2%	300
Food	1,106	10.9%	2,211	6.0%	1,000
Yard Waste	2,262	22.3%	9,048	24.5%	500
Other Organics	659	6.5%	1,465	4.0%	900
Wood	122	1.2%	541	1.5%	450
Construction Debris	61	0.6%	122	0.3%	1,000
Miscellaneous	862	8.5%	1,916	5.2%	900
Total	10,143	100.0%	36,865	100.0%	550

Memo: Disposal Data (from above) for Materials Aslo recycled Curbside

Newspaper	578	5.7%	1,285	3.5%	900
Polycoat Containers	50	0.5%	167	0.5%	600
Mixed Paper	629	6.2%	2,096	5.7%	600
Glass Containers	710	7.0%	1,420	3.9%	1,000
Aluminum Cans	81	0.8%	811	2.2%	200
Tin Cans	254	2.5%	1,691	4.6%	300
PET Bottles	41	0.4%	406	1.1%	200
HDPE Bottles	51	0.5%	507	1.4%	200
Used Oil	0	0.0%	0	0.0%	1,414

Note: Cubic yards are calculated using in-truck densities for "lbs/cu.yds" conversion (See Appendix 2).
Distribution of tons based on Southwest Waste Generation Area residential waste stream composition from Best Management Practices Analysis for Solid Waste, Volume 1, 1987 Recycling and Waste Stream Survey, Washington State Department of Ecology, Publication No. 88-33A, p. 116.

Table D-5. DISPOSAL SYSTEM: VANCOUVER - Residential Curbside (1992)

Cost Components	Disposal System Component Costs		
	Total Costs (000)	Costs Per Ton	Distribution of Costs
Collection	$734	$72.40	46.4%
Disposal	$725	$71.45	45.8%
Overhead	$123	$12.12	7.8%
Total Cost	$1,582	$155.97	100.0%
Less: Revenues			
Net Cost	$1,582	$155.97	

4. Comparison of Recycling and Disposal Costs

Table D-7 shows recycling and disposal system costs per ton for the nine materials (excluding OCC) currently recycled through Vancouver's curbside recycling system. Recycling system costs in total are reported in the "Recycling Total Cost per Ton" column of Table D-7. Including a $6 per ton credit against total costs for net revenues obtained from the sale of recycled materials after deduction for processing costs at CRC gives the figures reported in the "Recycling Cost Net of Revenue" column of Table D-7.

Because Clark County and CRC have not yet completed their joint determination of processing costs and market revenues in total and for each recycled material, the comparison between recycling and disposal system costs on a volume collected basis is somewhat misleading. When final figures are available, the more valuable materials such as aluminum cans and plastic bottles will not show a recycling cost that exceeds their disposal cost by such a wide margin. The cost comparisons for other materials will also change, so most comment on Table D-7 is premature at present.

Table D-6. DISPOSAL SYSTEM: VANCOUVER - Residential Curbside (1992)

Recyclable Materials	Total Costs (000)	Costs Per Material -- Allocated By Tons: Costs Per Ton	Revenue Per Ton	Net Cost Per Ton	Distribution of Tons
Newspaper	$90	$155.97		$155.97	24.2%
Polycoat Containers	$8	$155.97		$155.97	2.1%
Mixed Paper	$98	$155.97		$155.97	26.3%
Glass Containers	$111	$155.97		$155.97	29.7%
Aluminum Cans	$13	$155.97		$155.97	3.4%
Tin Cans	$40	$155.97		$155.97	10.6%
PET Bottles	$6	$155.97		$155.97	1.7%
HDPE Bottles	$8	$155.97		$155.97	2.1%
Used Oil (1)	$0	$155.97		$155.97	0.0%
Total/Average	$373	$155.97		$155.97	100.0%

Notes: (1) Used oil disposal costs included for comparison purposes only. Used oil disposal is prohibited.
(2) Only materials in recycling program are shown. Tons are "collected." Total costs are allocated among materials using distribution of tons.

Recyclable Materials	Total Costs (000)	Costs Per Material – Allocated By Cubic Yards: Costs Per Ton	Revenue Per Ton	Net Cost Per Ton	Distribution of Cu.Yds
Newspaper	$55	$95.36		$95.36	15.3%
Polycoat Containers	$7	$143.04		$143.04	2.0%
Mixed Paper	$90	$143.04		$143.04	25.0%
Glass Containers	$61	$85.83		$85.83	16.9%
Aluminum Cans	$35	$429.13		$429.13	9.7%
Tin Cans	$73	$286.09		$286.09	20.2%
PET Bottles	$17	$429.13		$429.13	4.8%
HDPE Bottles	$22	$429.13		$429.13	6.1%
Used Oil (1)	$0	$155.97		$155.97	0.0%
Total/Average	$360	$150.32		$150.32	100.0%

Notes: (1) Used oil disposal costs included for comparison purposes only. Used oil disposal is prohibited.
(2) Only materials in recycling program are shown. Cubic yards are "collected." Total costs are allocated among materials using distribution of cubic yards.

Table D-7. RECYCLING vs. DISPOSAL SYSTEM COSTS: VANCOUVER - Residential Curbside (1992)

	Costs Per Material – Allocated By Tons			
Recyclable Materials	Recycling Total Cost Per Ton	Recycling Cost Net of Revenue	Disposal Total Cost Per Ton	Recycling Cost Difference
Newspaper	$136.73	$130.73	$155.97	$25.24
Polycoat Containers	$136.73	$130.73	$155.97	$25.24
Mixed Paper	$136.73	$130.73	$155.97	$25.24
Glass Containers	$136.73	$130.73	$155.97	$25.24
Aluminum Cans	$136.73	$130.73	$155.97	$25.24
Tin Cans	$136.73	$130.73	$155.97	$25.24
PET Bottles	$136.73	$130.73	$155.97	$25.24
HDPE Bottles	$136.73	$130.73	$155.97	$25.24
Used Oil	$136.73	$130.73	$155.97	$25.24
Total/Average	$136.73	$130.73	$155.97	$25.24

	Costs Per Material – Allocated By Cubic Yards			
Recyclable Materials	Recycling Total Cost Per Ton	Recycling Cost Net of Revenue	Disposal Total Cost Per Ton	Recycling Cost Difference
Newspaper	$84.10	$78.10	$95.36	$17.26
Polycoat Cardboard	$311.19	$305.19	$143.04	($162.14)
Mixed Paper	$207.46	$201.46	$143.04	($58.41)
Glass Containers	$51.01	$45.01	$85.83	$40.81
Aluminum Cans	$622.38	$616.38	$429.13	($187.24)
Tin Cans	$207.46	$201.46	$286.09	$84.63
PET Bottles	$777.97	$771.97	$429.13	($342.84)
HDPE Bottles	$777.97	$771.97	$429.13	($342.84)
Used Oil	$22.01	$16.01	$155.97	$139.96
Total/Average	$136.73	$130.73	$150.32	$19.59

Note: The difference between recycling and disposal costs per ton may not be indicative of the actual cost decrease or increase when tonnage recycled increases or decreases.

3. SYSTEM COSTS: COMPARISONS AMONG CITIES AND OUTLOOK

This chapter summarizes and compares recycling and disposal system cost data developed in Chapter 2 for the four cities examined in this report. The impact of management expertise and waste management system configuration on costs is analyzed. In particular the impacts of collection strategies, materials targeted for recycling, and disposal methods on system costs and recycling diversion levels are reported. This chapter also examines factors that will influence future costs for recycling versus disposal.

A. Comparisons Among Cities

This section compares and contrasts recycling and disposal system costs for Seattle, Spokane, Bellingham and Vancouver, based on the detailed system cost information developed in Chapter 2. Material specific costs for Seattle are also discussed and the impact of weight-based versus volume-based allocation of costs is highlighted. The two methods of allocating system costs to specific materials are exhibited to indicate the range within which actual recycling and disposal costs for each material are likely to fall.

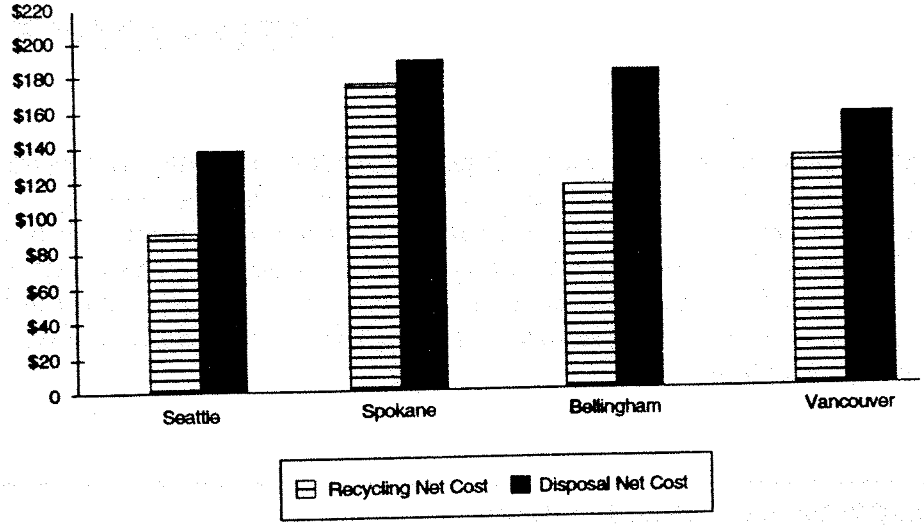
Possible explanations for Seattle's lower recycling and disposal costs are discussed in some detail. The section ends with an analysis of who pays for recycling and disposal in the four cities, and the use of incentive rates for garbage collection and disposal to fund system costs.

1. Recycling Vs. Disposal System Costs

Figure A-1, **Recycling vs. Disposal Net Costs Per Ton (1992)**, is a bar graph showing the net cost of recycling and the net cost of disposal for each of the four cities. As is apparent from the graph, **average net cost for recycling in 1992 was lower than for disposal in all four cities.** Disposal costs exceeded recycling costs by a range of $13 per ton in Spokane to $65 per ton in Bellingham, with Vancouver and Seattle in between at $25 and $47 per ton, respectively.

One caveat should be noted regarding this comparison of recycling versus disposal. **It cannot be assumed that any city's 1992 recycling versus disposal cost difference per ton would be sustained by shifting additional tons from disposal to recycling or vice versa.** These costs are based on currently in place recycling and disposal systems for these cities at a particular point in time, and depend on specific tonnage, operating methods, materials collected, market conditions, fixed costs and other factors. Thus, it is not possible to determine solely from these data what cost changes per ton would actually result from shifting additional tonnage between the two systems.

Figure A-1
Recycling vs. Disposal Net Costs Per Ton (1992)



2 Allocation of System Costs by Material

Figure A-2, Recycling vs. Disposal Net Costs Per Ton by Material (1992), Seattle - Weight Based, and Figure A-3, Recycling vs. Disposal Net Costs Per Ton by Material (1992), Seattle - Volume/NSWMA Based, compare system net costs for the materials recycled in Seattle's northend curbside program. As shown by material specific costs given in Chapter 2 for the four cities, density of the material collected has significant impacts on collection system costs. For weight-based cost comparisons, recycling and disposal costs were allocated among materials based on tons sold for recycling and tons collected for disposal. For volume-based materials costs comparisons, system costs were allocated among materials based on volume (proportionate to density) each material occupies in the collection truck for recycling and disposal. In addition, Seattle's recycling processing costs were adjusted to reflect material specific MRF costs as calculated in the National Solid Wastes Management Association's MRF cost study.

Figure A-2
Recycling vs. Disposal Net Costs Per Ton by Material (1992)
Seattle – Weight Based

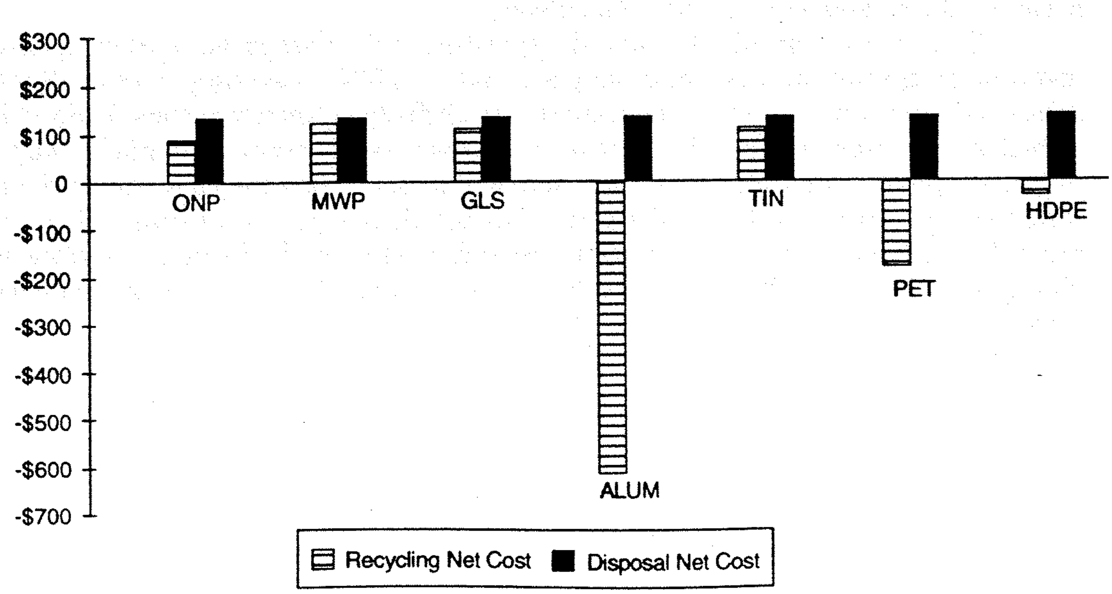
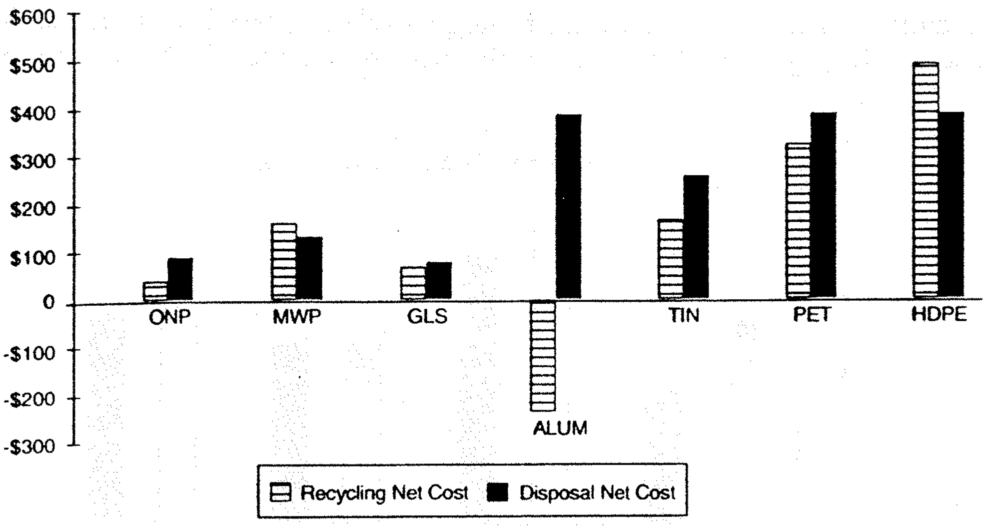


Figure A-3
Recycling vs. Disposal Net Costs Per Ton by Material (1992)
Seattle – Volume/NSWMA Based



In the case of weight-based costs, all seven materials recycled in Seattle have an average recycling net cost per ton below their disposal cost. In the case of aluminum cans and PET and HDPE plastic bottles, revenues obtained from selling these recycled materials exceed their collection and processing costs, resulting in a negative net cost.

For volume/NSWMA-based costs, mixed wastepaper and HDPE bottles have recycling net costs per ton above disposal costs in 1992. Also, per ton costs of both recycling and disposal systems for light weight, but bulky materials such as plastic bottles and aluminum cans are much higher when costs are allocated according to volume.

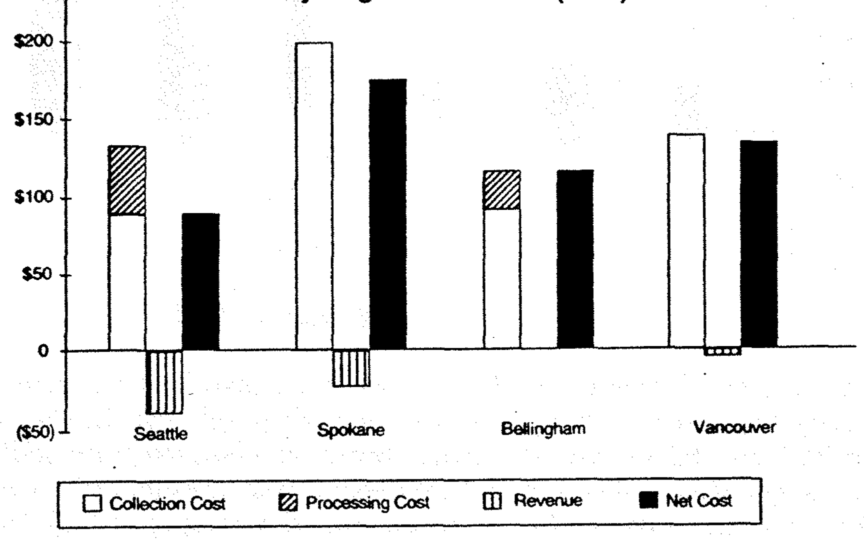
Both these results indicate the potential costs of inefficiencies in collecting low density materials. Discussions on cost of curbside recycling of low density materials, especially plastic containers, however, often neglect to consider that many of the same problems and inefficiencies are encountered in curbside collection of those materials for disposal as well.

Finally, the average cost of collecting mixed paper is about the same for recycling and disposal under either cost allocation method. This does not necessarily imply that one should be indifferent between recycling or disposal. Whether mixed paper is economical to recycle depends not only on its markets, but also on how collection routes for both recycling and disposal might change when a large quantity of this low density material is moved from one collection system to the other. If large quantities of mixed paper can be recycled, then there may be substantial opportunities to restructure garbage collection routes and reduce garbage collection costs when that material is one of the items targeted for curbside recycling. There also may be opportunities for reduced per ton recycling collection costs when mixed waste paper is picked up at each participating household on a curbside recycling route.

3. Recycling System Cost Comparisons

Figure A-4, **Recycling Costs Per Ton (1992)**, is a bar graph that summarizes recycling system costs for the four cities examined in Chapter 2. The first of the three bars shown on the graph for each city depicts total recycling cost broken down into collection (including overhead) and processing costs. The middle bar below the line shows revenues ("negative costs") from selling recycled materials to processors, brokers or end users. The right-hand bar shows the net cost of recycling, i.e., the difference between total cost and revenue.

Figure A-4
Recycling Costs Per Ton (1992)



For Seattle and Bellingham material revenues are less than processing costs. In Seattle estimated processing costs at Recycle America's MRF in 1992 slightly exceeded actual revenues. In Bellingham, where materials are sold off the recycling truck to a privately-owned recycling operation, charges by the local recycler for accepting mixed paper and commingled containers outweighed positive prices for ONP and OCC. The resultant charge for the average ton of recyclables delivered to this recycler is shown as Bellingham's processing cost, with material revenues shown as zero.

For Spokane and Vancouver material revenues in 1992 exceeded processing costs at the processing operations where materials are delivered and, in effect, sold off the truck. For both of these cities, processing costs are, thus, shown as zero, and the revenue bar below the line depicts the average price received for a ton of recyclables delivered from a curbside collection route.

Collection Costs

With the exception of Spokane, **curbside recycling collection costs per ton appear to fall gradually as population rises.** This relationship may not hold for Spokane because more processing is done on-route than in the other three cities. For the other three cities this inverse relationship would suggest economies of scale. However, a recycling truck route should cost roughly the same in any city, assuming that there are no severe differences in street topography, participation and set out rates, or truck crew efficiency. A bigger city would have more truck routes than a smaller city, but costs per household for a route should not differ by city size.

Some scale economy could be found in the fixed amount of administrative and overhead costs required to run a curbside recycling system, regardless of its size. However, the information gathered on recycling systems in the four towns suggests other factors also may explain Seattle's lower collection costs.

• **Seattle attempts to maintain competition among providers of recycling and refuse collection services** by dividing the city into sectors and contracting with multiple providers. The City selects at least two different curbside recycling contractors, two yard waste collection contractors and two refuse collectors. Perhaps because of their smaller populations, Bellingham and Vancouver each have a single contractor providing collection for recyclables from single-family residences. Spokane has municipally owned and operated collection services.

• **Seattle is the only city of the four in which the curbside recycling contractor determines its own choice of collection bin and distribution, degree of household sorting of recyclables, type of collection vehicle and route size, type of materials processing facility, effectiveness of material preparation for market, and the market in which each material is sold.** In the other three cities, one organization manages collection, and another, often a local private recycler, cleans, processes and markets materials.

• Seattle is the only city of the four in which a substantial professional staff (including Ph.D.'s in economics) and time are committed to analyzing the cost effectiveness of the various recycling programs conducted in the city, calculating recycling and disposal system costs separately for single-family, multifamily and commercial waste generators and analyzing historical and projected prices for the materials selected for recycling collection.

• **Seattle has taken care to write its contracts for recycling and disposal so that as much as possible of its payments are variable, i.e., paid on a per actual ton basis.** This is the opposite of a put-or-pay type of contract in which a city pays a fixed cost to its contractor, regardless of the actual tonnage handled. This is important because a put-or-pay type contract for disposal prevents a city from realizing savings when materials are diverted from disposal into recycling.

Spokane **has substantially higher collection costs, in part because sorting of recyclables is done by the truck driver collecting the materials**. At each household on the curbside collection route, the driver sorts recyclables into seven compartments on the truck -- one each for newspapers, corrugated cardboard, flint glass, amber glass, green glass, metal cans, and plastic bottles. As a result of on-route sorting Spokane realizes higher prices for materials sold off the truck than if materials were more commingled. In the other three cities, the driver dumps materials from presorted bins into the appropriate truck compartment. In these three cities, separation of materials and removal of contaminants is done at the processing facility, rather than on route.

Collection costs per ton also are significantly influenced by the amount collected at each stop. Within limits, extra weight can be collected without significantly increasing the time to stop the truck and pick up a household's recyclables.

Spokane's higher cost per ton collected may be because Spokane does not include mixed waste paper in its curbside program. Residential mixed wastepaper plus corrugated cardboard accounts for 31% to 37% of the tonnage in the other three cities, while corrugated cardboard accounts for only 2% of tonnage in Spokane. Spokane collected about 225 pounds per household during 1992. This is only one third of Seattle's curbside collection rate of 650 pounds of recyclables per household, less than 50% of Bellingham's 1992 rate of 485 pounds, and slightly over 50% of Vancouver's rate of 435.

Processing Costs and Revenues

The other two elements of recycling system net cost shown in Figure A-4 are processing costs and revenues from the sale of recycled materials. Recycle America was willing to divulge the prices they received for each type of material collected in Seattle's northend curbside program. Processing costs and revenues, thus, are shown separately for Seattle on Figure A-4.

However, the processors that take delivery of curbside materials in each of the other three cities do not reveal the revenue they get for selling processed materials. Thus, the only information available in Spokane and Bellingham is the net charge incurred or price paid for each material delivered by a curbside collection truck to the processor. In Vancouver even information on individual material charges or prices was not available, only the average price received per ton of delivered recyclables.

As a result of on-route sorting of recyclables, Spokane was able to sell its materials off the collection route truck to two private recyclers for a positive $24 per ton during 1992. This is shown in the revenue bar below the line for Spokane on Figure A-4. Processing costs are shown as zero. In fact, however, a portion of the costs reported for collection should be included in processing costs for Spokane.

Bellingham also sells its recyclables off the collection route truck, but had a negative average price of $25 for 1992. Bellingham residents do not separate glass from metal containers, or color sort glass. Thus, Bellingham pays the processor $36 for every ton of commingled glass and metal (including aluminum) containers, while Spokane received $6 per ton for glass, $9 for tin and $582 for aluminum. Furthermore, Bellingham paid $61 for each ton of mixed paper delivered to the processor. Bellingham did receive a positive price of $10 per ton for newspapers and $23 for corrugated cardboard. But total charges for mixed paper and commingled containers were greater than revenues for ONP and OCC. As a result, Figure A-4 shows a processing cost for Bellingham, and no revenue for the average ton of curbside recyclables.

By contrast, Seattle's northend recycling program sold mixed paper at the contractor's MRF dock for $5 per ton in 1992. Overall, Seattle's northend program averaged $42 in processing costs per ton recycled versus $41 in material revenues, almost break-even.

Vancouver's net revenue for delivered recyclables was about $6 per ton. This is depicted on Figure A-4 by the revenue bar below the line, with processing costs shown as zero.

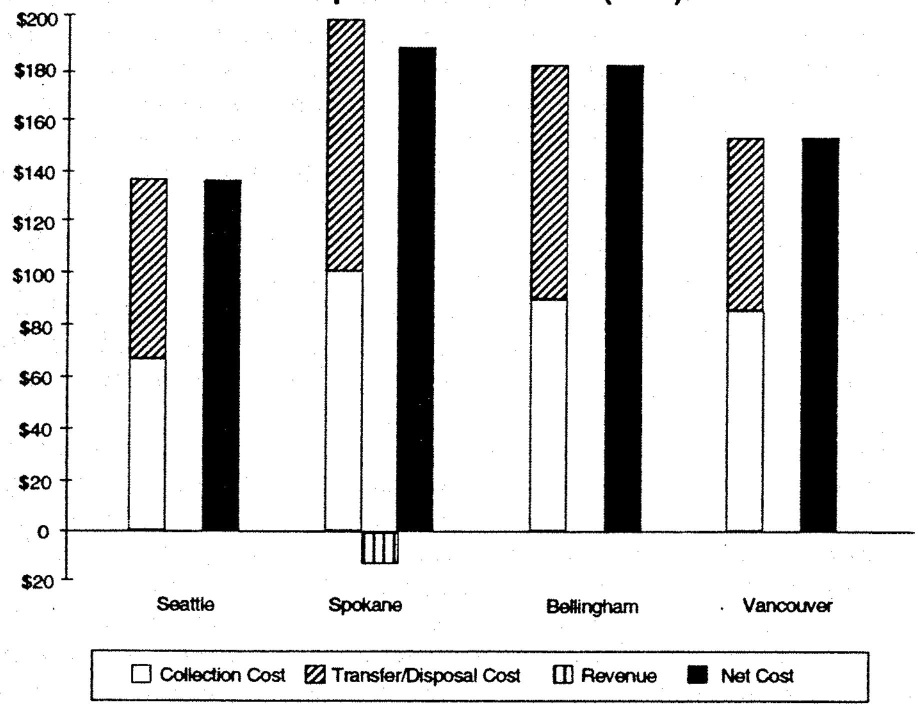
It is worth noting again that Seattle's **northend curbside program is managed from collection bin to material market by a single contractor, Recycle America.** The contractor is paid a pre-determined amount per ton collected and sold to market. In addition, **the contractor keeps whatever market revenue it can generate. Thus, Recycle America has substantial incentive to efficiently collect clean materials,** process them into a condition that makes them readily marketable, and find the highest value markets in which to sell materials.

In the other three cities the collector's incentive to maximize cleanliness and marketability of materials is not as clear cut. While processors can refuse to accept delivery if a load of recyclables is too contaminated, there appears to be little incentive for collectors to reduce contamination further below the rejection level for delivered loads.

4. Disposal System Cost Comparisons

Figure A-5, **Disposal Costs Per Ton (1992)**, is a bar graph that summarizes disposal system costs for each of the four cities. The first of the three bars shown on the graph for each city depicts total disposal system costs broken down into collection (including overhead) and transfer/disposal costs. The middle bar below the line for Spokane shows revenues ("negative costs") from selling electricity generated in Spokane's waste-to-energy plant. The other three cities do not receive any of the revenues that may be generated by disposal facilities which process their residential garbage, so revenues for those cities are shown as zero. The right-hand bar shows the net cost of disposal, i.e., the difference between total cost and revenue.

Figure A-5
Disposal Costs Per Ton (1992)



As with recycling system costs, Spokane has the most expensive disposal system, on both a total and a net cost basis. Collection and transfer/disposal cost each exceed costs for those components in the three other cities. However, **Bellingham's transfer/disposal cost is almost as great as Spokane's, perhaps because both depend on incineration for some or all of their disposal.** Spokane's total disposal system costs per ton are reduced by about $10 from revenue obtained by selling electricity generated by incinerating their waste.

Collection costs for refuse in Spokane are closer to those for the other cities than were their collection costs for recycling. However, Spokane does not track residential collection separately from commercial for refuse. As a result, their residential costs probably are understated since refuse collection costs usually run less per ton for commercial than for residential.

Seattle's collection costs again come in below costs in the other three cities. Many of the factors that reduce Seattle's recycling collection costs also keep garbage collection efficient. That is, **by maintaining competition among collection service providers, spending time and money for professional staff who can provide analytical and contract management skills, and negotiating cost effective and flexible payment contracts**[12]**, the City appears to be able to make any resulting additional administrative costs pay off with lower overall system costs.**

5. Who Pays for Recycling and Disposal System Costs?

In all four cities almost all curbside recycling or disposal system costs are paid by residents through rates charged for mandatory garbage collection. The main exception is that $60 million of the City and County of Spokane's WTE disposal system capital costs were paid by a state grant funded out of a special levy on state taxpayers. In addition, state funds on occasion have been used to purchase curbside collection containers.

Because refuse collection is mandatory, recycling costs can be and are included in garbage collection rates. Thus, there is no additional direct charge to a household that uses curbside recycling versus one that doesn't. However, **households that use curbside recycling may be able to divert enough material from disposal to subscribe to lower volume or reduced frequency garbage collection.**

All four cities use incentive rate structures for their garbage collection fees. That is, collection charges vary according to the size container used and, in Bellingham and Vancouver, the collection frequency to which the household subscribes. Seattle and Spokane households have mandatory weekly collection, but can subscribe to have a smaller size container picked up at a lower collection charge than for a larger container. In Vancouver a household also can reduce their garbage collection frequency to every other week, while Bellingham residents can subscribe to weekly, biweekly or monthly garbage collection.

Seattle has linear, volume-based garbage collection rates for many of its collection volume options. For example, a Seattle household subscribing to two can weekly collection service pays double what a single can household pays. Bellingham has nearly linear rates for many collection service options, e.g., the 90 gallon toter costs 49% more than the 60 gallon toter for weekly collection. Vancouver is not quite as linear with two can service costing 91% more than one can service. On the other hand, Spokane sets garbage collection rates for additional cans based on disposal costs for the incremental amount of garbage rather than setting incentive rates for reduction and recycling. Thus, Spokane's two can collection cost is only 54% more than one can service.

In all four cities minican or super recycler service is offered, but at a less than proportionate decrease in cost versus standard one can weekly service. Presumably this is due to wanting minican users to cover more of their recycling and disposal system costs than would be the case under strictly linear rates for minican service.

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[12] Seattle has a variable cost disposal contract and 50% variable cost refuse collection contracts.

B. Systems Cost Outlook

This section examines a variety of factors that will impact future recycling and disposal system costs. An indication of the direction various system component costs are likely to move is given. There are several factors that will determine future costs for recycling versus disposal. These factors are discussed in this section and include:

- Collection strategies.
- Recycling processing costs.
- Landfill capacity and disposal costs.
- Incineration disposal costs.

1. Collection Strategies

Essentially all household recycling and yard debris collection programs in Washington State feature the use of separate collection vehicles.[13] The use of two (garbage and recycling) or three (garbage, recycling, and yard debris) collection vehicles to service each household each week can result in high diversion, but also results in financial and environmental costs associated with doubling or tripling total collection vehicle mileage.

During the past 10 years the collection industry has made significant advances in refining the collection vehicles used for separate recycling collection. Most pioneering curbside recycling collection programs used relatively low technology low capacity collection vehicles ranging from 15 to 25 cubic yards of capacity. These lower capacity vehicles had a limited range, both in number of commodities handled efficiently and in number of households that could be collected before unloading at a processing facility. Now many collection vehicles feature compaction of one or more materials, the ability to empty wheeled carts (semi-automatic), and capacities of up to 38 cubic yards.

However, continued refinement in recycling vehicle technology does not reduce the economic and environmental costs of using a separate, additional, truck for recycling collection. Two opportunities exist for reducing these costs: dual collection and reduced collection frequency.

<u>Dual Collection Systems</u>

Dual collection systems can be divided into two broad categories: (1) combined collection or bag systems (often called "Blue Bag" collection systems because of the use of a disposable or recyclable blue colored bag to hold commingled recyclables), and (2) multipurpose vehicles. Neither are common in Washington State or in the rest of

[13] Pullman, Washington uses a "blue bag" recycling collection system in which recyclables are placed in specially purchased blue bags and collected simultaneously, commingled with garbage. The bags are later recovered from the mixed solid waste at the County's landfill, and the recyclable materials processed and marketed.

the nation. Dual collection systems have been used only to a limited degree in various parts of the country up to the present time.[14]

Bag systems generally feature the source separation of recyclable materials into specially colored bags (usually blue) that are either provided to residents or sold at local stores. The residents place the bagged recyclables either in or next to their garbage. Both garbage and recyclables are collected by the same packer truck and delivered to a transfer station. The recoverability of the bags is sometimes increased by reducing compaction and/or placing the blue bags in one side of the packer truck during collection. The blue bags are then manually removed from the collected garbage, and processed to recover recyclables.

Blue bag collection systems allow the collection of two solid waste streams (garbage and recyclables) in one vehicle, thereby reducing the route costs that would be otherwise incurred by adding a recycling truck. Although the savings in route costs are significant, the additional costs of consuming non-reusable bags, separating bags from mixed solid waste, opening bags, and processing commingled recyclables have tended to approach or exceed the cost savings realized by not using a separate recycling truck.

Multipurpose vehicles, on the other hand, are designed to collect two or more material streams on the same route without combining the separated materials. Most multipurpose collection vehicles developed to date have been designed to collect both garbage and recyclables on one truck, although dual compaction trucks capable of collecting both garbage and yard debris have also been developed.

The most common type of multipurpose truck is based on stretching the frame length of a standard rear loading packer truck, downsizing the packer body, and adding dumping compartments behind the cab of the truck. As many as six or seven categories of commodities can be handled in the two or three compartments added to these trucks. Residents use bins or bags to contain recyclables, which are then emptied into recycling compartments on the combined garbage/recycling truck.

Although the use of both blue bag collection and multipurpose vehicles is increasing in North America, their applicability to the high-diversion programs present in Washington State is questionable. Many curbside recycling programs in Western Washington achieve diversion rates of 20 to 25 percent. This diversion has been attributed to the inclusion of a wide range of materials, rate incentives, and the high visibility of bin collection systems.

Essentially all major blue bag recycling programs (e.g. Chicago, Houston, Omaha, Pittsburgh) achieve less than ten percent diversion. The lower diversion rate may be due to varying demographic factors, incentives, and regional attitudes, but may also be due to the inherent nature of blue bag programs. They require the consumption of single-use containers (contrary to waste reduction objectives) and may encourage residents to see recyclables as "garbage."

Many of the Northwest's current curbside recycling programs were developed prior to the availability of blue bags. Thus, little experimentation has been done regionally with combined collections. Cities and collection companies have substantial investment in containerized (three bin and wheeled cart) separate collection systems, and are unlikely to consider shifting to a blue bag system soon, at least not until currently used equipment and containers are depreciated. As existing collection

[14] Institute for Local Self-Reliance, *Co-collection of Recyclables and Mixed Waste: Problems and Opportunities*, (September 1992), is an informative source for survey information on co-collection systems.

contracts expire in the mid-90s, some municipalities and collection companies may review blue bag alternatives.

Multipurpose vehicles may be more directly applicable to the containerized recycling systems common in the Northwest. The primary limitation of combined garbage/recycling trucks is the lack of space to handle a wide range of recyclable commodities. The use of these trucks is common in areas that focus on relatively few recyclables such as newspaper, glass, and cans. Since many Northwest curbside recycling programs also accept mixed waste paper, cardboard, plastic bottles, and scrap metals, the use of multipurpose vehicles is not necessarily practical at this time.

One area for achieving potential collection efficiencies is the combined collection of garbage and yard debris. Both garbage and yard debris require compaction, so they are suitable candidates for combined collection on packer trucks. Split compartment rear loading packer trucks are available that may allow the simultaneous collection of garbage and yard debris. The development and use of these trucks is recent, and different versions are currently being tested throughout North America. If these trucks prove reliable, some collection companies and cities in the Northwest may be able to combine garbage and yard debris collection.

Less Frequent Collections

Another opportunity for decreasing collection system costs is reduced collection frequencies. Weekly garbage collection is the de-facto standard collection frequency in Washington State. Some jurisdictions, notably Bellingham and Whatcom County, and Vancouver and Clark County, have collection systems and rates that vary both with container size and frequency. However, fixed weekly collection with varying container sizes is much more common.

Recycling collection programs in Washington are split between weekly and every-other-week collection, with south Seattle's monthly wheeled cart program an exception. Yard debris collection programs throughout the state are also split between weekly and every-other-week collection.

Participation and diversion in weekly recycling and yard debris collection programs may be somewhat higher than biweekly collection. Lower diversion in every-other-week programs could result from less convenience, confused collection days, or limitations on the size of containers. However, every-other-week collection can offer substantial savings by cutting weekly route mileage in half. The resulting economic and environmental benefits are the primary impetus behind biweekly collection.

The rationale for every-other-week recycling and yard debris collection may also be applied to garbage collection. In areas with high diversion recycling and yard debris programs, up to fifty percent reduction of waste for disposal may be achieved. In these areas, a large majority of customers are on minican or 1-can garbage collection service. These reduced volumes of waste may warrant serious consideration of biweekly garbage collection. The primary barriers to implementation of biweekly garbage collection are health department regulations and customer acceptance. If these concerns can be addressed, significant savings may be achieved.

In the future, an optimized solid waste collection system may be possible by combining multi-purpose vehicles with every-other-week collection. For example, garbage and yard debris collection could be provided every-other-week by one truck. Recyclable materials could be collected every-other-week on the "off weeks" by a separate truck. The net effect of this system would be the collection of three separate streams of materials, with only one truck passing by a particular residence each week.

Thus, separate every-other-week garbage, recycling, and yard debris collection could be offered at a cost roughly equivalent to the previous cost of weekly garbage collection alone. Because the costs of processing and handling recyclables and yard debris are usually lower than waste disposal tipping fees in this region, total system net costs would be lower than the cost of garbage collection alone.

2 Recycling Processing Costs

Material recovery facilities (MRF's) for sorting, cleaning and packaging curbside collected recyclables for market come in all shapes and sizes. Sorting and packing equipment configuration and amount of hand sorting in a MRF are dependent on a number of factors. Of chief importance are the number of curbside collection routes being serviced by the MRF, the variety of materials collected on those curbside routes, and the extent of source and/or on-route separation of materials. Given the variety of influences on MRF configuration, anticipating future costs for processing recyclables is quite difficult.

On the regulatory front little has been done by either federal or state agencies to set emissions standards for recyclables processing facilities, especially for those that process only the standard curbside materials. Facilities that handle used oil, batteries or appliances in some states are subject to hazardous waste management facility rules. However, in Washington State curbside programs that collect household batteries, vehicle batteries, used oil or scrap metal as yet have not been subject to regulations that apply to hazardous waste transporters. Nor have the processing facilities to which these curbside materials are delivered been subject to hazardous waste management facility regulations.

Requirements for design and operation of MRFs in Washington State are set forth in WAC 173-304-300. In addition, local governments and/or health departments may impose requirements on recycling processors.

Worker safety is coming under scrutiny by the federal Occupational Safety and Health Administration (OSHA). New England CRInc. and RRT, two of the biggest operators of MRF's, have had visits by OSHA inspectors at all their facilities.[15] New federal standards on worker ergonomics are expected later this year. These standards may force significant changes in MRF operations, and may cause increases in operating costs. Head-on sorting stations may begin to replace stations set alongside the conveyor belt. Enclosed sorting stations and air ventilating equipment that allows numerous air changes per hour may also become more standard.

In terms of capital equipment costs, newly constructed material recovery facilities will tend to employ more automated, less labor intensive sorting systems using advanced separation technologies such as eddy current separators and optical plastics sorters. People will continue to be replaced by equipment, but facility size will need to be tailored to regional needs.[16]

- Larger MRFs should be able to take advantage of economies of scale, but rural areas may find smaller, less automated facilities more cost-effective.
- Eddy current separators, often used to separate aluminum cans from steel containers, have been available for some time but are now finding increasing acceptance in MRFs.

[15] Powell, Jerry, "The MRF report: the continuing evolution of commingled recyclables," *Resource Recycling*, May 1993, p.28-9.

[16] Phone conversation with Chaz Miller, NSWMA, May, 1993.

- Although few automated sorting systems currently in operation can separate plastics by color and/or resin, this type of system may see increased use in the near future. The payback period for such equipment is projected by one author to be as little as one year.[17]

In general MRF costs per ton processed tend to rise as more materials are targeted by curbside recycling programs. In addition, higher value materials markets tend to be more competitive and require more cleaning and packaging operations at the MRF. However, there is a trade off between collection costs and MRF costs associated with the degree to which collected materials are separated in the home or on route versus being collected commingled and separated at the MRF. Thus, rising MRF costs may not necessarily signal an increase in overall recycling system costs.

3. Landfill Capacity and Disposal Costs

The number of landfills in the U.S. has been decreasing for many years, mainly because costs for older, smaller landfills to attain compliance with disposal facility regulations are too high relative to the tipping fees they can charge. *Waste Age* magazine reported that 18,539 sanitary landfills and open dumps were in operation nationwide in 1974. By 1984 only 10,467 solid waste landfill disposal facilities were in operation, and by 1986 only about 6,000. The trend towards fewer operating landfills continues into 1993.

Open dumps and burning areas in the past were located close to each waste generating community. Siting this type disposal facility used to be relatively simple. Capital and operating costs associated with open dumps were low compared with the costs of long hauling waste. Then in 1979, the U.S. Environmental Protection Agency (EPA) began to force the closing of the many open dumps not in compliance with its new waste management regulations. More recent state and federal regulations, such as the new Resource Conservation and Recovery Act (RCRA) Subtitle D requirements discussed below, continue to add to the cost of construction, operation/maintenance, and closure of solid waste landfills.

Yet, despite the decreasing number of open landfills, total landfill capacity increased nationwide by 4% between 1980 and 1986. Recent sitings of large, regional scale landfills in Washington and Oregon also suggest that disposal capacity in the Northwest will not decrease in the near future.

Cost Implications of New RCRA Subtitle D Regulations

The Washington Department of Ecology is currently in the final stages of updating the State's Minimum Functional Standards (MFS) to comply with recent federal Resource Conservation and Recovery Act Subtitle D requirements.[18] The new State standards are expected to result in a significant increase in environmental protection costs experienced by local government and private operators of small to medium-sized landfills.

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[17] Broughton, A.C.,"MRFs Go High-Tech," *Recycling Today*, March 1993.

[18] 40CFR Part 258. States have the option of developing their own regulations for implementation by October 1993. If a state does not have Subtitle D regulations implemented by the October date, federal regulations based on Subtitle D will apply to landfills in those states. The Washington State Department of Ecology has proceeded with drafting regulations on the assumption that they will be effective by the October EPA cutoff date.

The new MFS [Chapter 173-351 WAC] will replace the older, current, MFS [Chapter 173-304 WAC] which were last updated in 1985. As of mid-1993, public comments had been received on the new draft MFS, and the MFS were being modified accordingly. Formal rulemaking (the process by which new regulations are promulgated) is expected to commence in early summer, with the new MFS expected to be in effect by October, 1993, EPA's deadline for Subtitle D compliance.

The new MFS have five areas of significant change from previous State standards[19]:

(1) The handling of financial assurance reserve funds will be changed. The previous standards featured relatively flexible requirements for financial assurance. Although financial assurance reserve funds were required, site operators were allowed some flexibility to determine the total amount and funding rate for the reserves. The new MFS will require that operators base closure funds on worst-case corrective action scenarios and on the performance of closure and post closure work by third-parties. These assumptions can be expected to raise the amount of financial assurance reserves required of operators. Funding higher reserve balances through tipping fees will raise user fees, particularly at sites with limited remaining capacity.

(2) The post-closure monitoring period will change from 20 years to 30 years. The extension of the monitoring period by 10 years will result in increased long-term costs incurred by site operators and a corresponding increase in required post-closure reserve fund balances.

(3) New design criteria have been included in the MFS. The EPA's standard composite liner design will be required to meet the new design standards. Landfills not currently meeting these design standards will need to make the capital improvements necessary for compliance.

(4) Ground water monitoring requirements have been expanded to include a boarder array of testing parameters and additional statistical analysis of testing results. These expanded testing requirements will increase both operating costs for open landfills and long-term post-closure costs for landfills closed under the new MFS.

(5) Specific corrective actions are required if contamination is detected.

The Department of Ecology is also making other changes to the MFS, such as streamlining permitting requirements, that are not specifically required by Subtitle D.

Cost Impacts of New Regulations on Small Versus Large Scale Landfills

As costs for compliance with landfill regulations increase, siting and construction of large scale regional landfills may mitigate rising landfill costs and associated tipping fees:

[19] Phone conversation with James Pendowski, Department of Ecology, Olympia, May 1993.

• Fixed costs of landfill design and construction may be borne by more users and greater disposal volumes in larger landfills, thus decreasing the amount each user has to pay.

• Larger operations often can use labor and equipment more efficiently.

Because the disposal cost per ton or cubic yard tends to be lower for larger facilities, each community wishing to dispose of waste may be willing to pay somewhat more now than previously to have its trash hauled to a more distant site. As long as increased transport costs do not exceed the cost advantages of larger disposal sites, regionalized landfills help communities minimize the costs associated with solid waste management.

According to a national survey conducted by *Waste Age*, tipping fees rose 52 percent between 1986 and 1987, and 32 percent between 1987 and 1988.[20] A National Solid Wastes Management Association (NSWMA) survey found that tipping fees increased 17% nationwide between 1988 and 1990.[21] The NSWMA results were based on a different sample of landfills than the *Waste Age* survey, so comparing results from the two surveys is not necessarily valid. However, unless one or the other surveys picked a particularly unrepresentative sample, results from the two surveys, as well as recent sitings of regional scale landfills, suggest that the rapid increase in landfill tipping fees experienced in the 1980s may be moderating in the 1990s on a nationwide basis.

Although regional scale landfills help to mitigate the costs of new regulations, landfill costs in the Northwest may still continue to rise. In the two year period ending 1990, the West Region (Washington, Oregon, Idaho, Nevada, and California) had the highest average percentage increase in tipping fees (up 32 percent) of all regions nationwide.[22] Limited 1991 data suggests that prices in the West have not yet hit their peak.

Furthermore, a source at the Washington Utilities and Transportation Commission(WUTC) believes that upward pressure on tipping fees will continue to be exerted by factors not directly related to landfill capacity.[23] Another source provided an example of one such factor. As communities emphasize what presently may be less profitable waste management alternatives such as source reduction and recycling over incineration or landfilling, publicly owned companies such as Waste Management and Browning-Ferris will be under pressure to maintain profitability. This may lead them to solicit waste from out-of-region generators for their regional landfills, thus increasing pressure on landfill capacity and, consequently, on landfill tipping fees.[24]

However, if regional scale landfills begin to compete for waste, the impact on average landfill tipping fees will depend on whether total disposal capacity substantially changes as old landfills close and new landfills are sited. The implementation of new MFS will affect landfill disposal patterns, but not capacity, in Washington State. Of the

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[20]Buell, D., Kevin Dietly, Ron Burke, Patricia Robertson, Sara Rasmussen, "Economic Incentives and Trends for Regionalization of Municipal Solid Waste Landfills," *Proceedings of the First U.S. Conference on Municipal Solid Waste Management*, June 13-16, 1990.

[21]Sheets, S.K., and Repa, E.W., "1990 Landfill Tipping Fee Survey", National Solid Wastes Management Association, Washington D.C.

[22]Sheets and Repa, op. cit.

[23]Phone conversation with Kathy Anderson, Washington Utilities and Transportation Commission, May 25, 1993.

[24]Bari, M., and Lache, R., "Pollution Control: Are Solid Waste Stocks Hazardous to Your Portfolio?," Mabon Securities Corp., New York, NY, March 22, 1993.

45 active municipal solid waste landfills operated in 1991 in Washington State, 19 are expected to close prior to implementation of the new MFS.[25] Although the number of landfills in Washington will decrease, the impact on statewide disposal capacity will be limited, due to the substantial remaining capacity at Rabanco's Regional Landfill in Roosevelt, Washington. The remaining *permitted*[26] capacity of this site, at 119 million tons, dwarfs anticipated capacity loss from closure of existing landfills due to the new MFS.

U.S. capacity from new regional landfills also appears to compensate at present for landfill closures due to the impact of new Subtitle D regulations. Smaller community-based facilities are the landfill type most likely to close in response to Subtitle D. One source estimates that landfills will increase in size and decrease in number for the next 20 years, as present landfills close and new regional landfills open up.[27] As an additional factor mitigating the cost impacts of new regulations, many of the sites that will eventually close due to Subtitle D requirements will receive extensions past the October, 1993 compliance deadline.[28]

Eventually, as states (including Washington State) implement new standards to comply with RCRA Subtitle D requirements, numerous smaller landfills throughout the U.S. will close rather than meet new standards. Little composite data is available on the "average" cost of upgrading existing landfills to the new Subtitle D requirement, due to the highly variable and site specific nature of costs. However, recent estimates of meeting Subtitle D standards indicate cost can approach $200,000 per acre of active landfill, *excluding* planning, siting, permitting, land acquisition, technical studies, infrastructure, and general site development costs that would be incurred to site new landfill acreage.[29] Other estimates, from the Midwest, indicate average costs of about $150,000 per active acre.[30]

A variety of factors affect costs and must be taken into account when computing a tipping fee for a given disposal facility. These include:

- Closure.
- Post closure care(including leachate treatment).
- Ongoing or expected contingency action. Possible examples of needed corrective action include groundwater remediation, liner repair, cover erosion and/or settlement, collection pipe collapse, and gas migration control.
- Liner/leachate collection systems.
- Operations and maintenance, including monitoring and leachate treatment.
- Capital costs, including land, equipment, hydrogeologic study and site preparation.

Of these, operations and maintenance costs (including amortization of capital costs) are the largest expected contributor to landfill costs and tipping fees needed to cover those costs. Corrective action costs vary widely and can also be an important

[25] Washington State Department of Ecology, *Solid Waste in Washington State - First Annual Status Report*, January 1993, Page vi.

[26] The physical capacity of Rabanco's site may exceed the currently permitted capacity.

[27] Buell, et al, op. cit.

[28] Bari and Lache, op. cit.

[29] "Calculating the Real Cost of Landfill Disposal," *World Wastes*, June 1992, pp. 30-33.

[30] Phone conversation with James Pendowski, Department of Ecology, Olympia, May 1993. Mr. Pendowski previously worked on Subtitle D issues for the State of Illinois. The $150,000/active acre estimate is based on his previous work in the Midwest.

contributor to landfill costs.[31] Furthermore, landfill regulations have a substantial impact on both capital and operations costs. For example, the National Solid Wastes Management Association (NSWMA) concludes that "there appears to be a relationship between average tip fee and the level of environmental protection provided at landfill facilities." [32]

High costs of developing landfills under the new regulations create strong "economies of scale" for landfill development. According to one source the unit costs of landfill operation increase sharply under 170-200 tons of daily capacity.[33] In general, it appears that the operation of small landfills under the new MFS will be economically difficult. Thus, export of waste to regional landfills will likely accelerate with implementation of new MFS.

Finally, cost impacts of the new MFS on existing and planned regional landfills in Washington and Oregon are expected to be negligible. These regional landfills meet or exceed the new Subtitle D regulations. In addition, regional scale landfills have lower unit costs, and to some extent have the ability to stabilize disposal costs over time. These considerations suggest that in the short run at least, increased costs due to new regulations will be experienced primarily by smaller local landfills that operate past October 1993.

Cost Impacts of Landfill Siting and Transport

There are two other factors likely to have important effects on future landfill tipping fees - (1) difficulties siting regional scale landfills; and (2) regulations on, and costs for, long haul transport of solid waste. In certain circumstances siting difficulties and restrictions on interstate transport of waste could cause significant increases in landfill tipping fees, despite the current existence of substantial regional scale landfill capacity.

There are substantial uncertainties regarding future siting of near or remote landfills. There is an inherent limit on the availability of large tracts of land that will meet current and future landfill siting and operating criteria. Also, local community opposition to disposal facilities serving remote populations is unlikely to decrease. For both these reasons, there is value in conserving current landfill capacity. One effective measure for preserving capacity is to charge high tipping fees.

In terms of interstate waste transport, solid waste is considered to be a commercial product. The terms of the Interstate Commerce Clause of the U.S. Constitution, therefore, limit the ability of states to regulate or limit solid waste import or export. However, this situation could change drastically, depending on the outcome of various bills before Congress. If states do gain the right to restrict waste imports, then for waste exporting states or regions the mitigation of upward pressure on landfill tipping fees provided by regional scale landfill capacity would be substantially reduced.

Finally, costs for long hauling solid waste can be expected to rise over time. Costs common to all forms of transportation (fuel, maintenance, new government regulations) will exert upward pressure on prices charged for hauling waste. The main countertrend would be cost savings associated with switching from truck to rail as the transport method of choice.

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[31] Halbach, M.M., "Financial Assurance for Land Disposal Facilities," *Proceedings of the North Dakota Solid Waste Symposium*, October 1990.

[32] Sheets and Repa, op. cit.

[33] "Calculating the Real Cost of Landfill Disposal," op. cit.

Cost Impacts of Waste Reduction and Recycling Programs

Diversion of waste from disposal through unit-based pricing for solid waste services, as well as the provision of convenient, often free, recycling and composting alternatives to disposal also impact the demand for landfill disposal capacity. To the extent that these measures divert waste from disposal, pressures on landfill tipping fees are correspondingly reduced.

In addition, the 1989 Waste Not Washington Act prohibited banning of products or packages. However, this "Ban on Bans" provision will expire in July 1993. If the Ban on Bans is allowed to expire as scheduled, communities may begin to use taxes and fees to provide incentives for manufacturers to generate less waste. This may lead to reduced demand for landfill capacity in Washington State.

It is unlikely that rates charged for waste collection and hauling will fall. Furthermore, counties and cities often add surcharges on to rates set by the WUTC. Revenues from these surcharges are used to fund waste reduction, recycling and general waste management programs. Surcharges currently range from as low as 2% in Eastern Washington to as high as 40% in Western Washington.[34] Also, haulers must recoup the costs of providing state mandated recycling programs.

All these aspects of waste reduction and recycling programs and policies in Washington State will serve to moderate future landfill tipping fee increases in the state.

4. Incineration Disposal Costs

With the siting and construction of large regional landfills in the Northwest, the attractiveness of waste incineration as a method for reducing the volume of waste landfilled has been sharply curtailed. Efficiently managed solid waste incinerators can reduce waste volume up to 90%, leaving an ash residue that occupies as little as 10% of the landfill space initially required by uncompacted, not yet biodegraded refuse. Solid waste can be combusted in an incineration facility that has equipment to recover a portion of the energy released from burning the organic fraction of refuse. These waste-to-energy (WTE) incinerators can sell steam and/or electricity to generate revenue to offset a portion of the facility's operation and maintenance costs.

However, compared with the costs of rail, barge or truck long haul disposal at one of the available regional landfills, incineration, even with energy recovery, is more costly at the present time. For example, Seattle's rail long haul disposal cost $70 per ton in 1992, and Vancouver's barge long haul disposal cost $71, both including transfer costs. By comparison, Spokane and Bellingham paid $87 and $91, respectively, per ton in 1992, including transfer costs, for disposal at WTE facilities. However, future energy revenues and/or regulatory changes could alter the relationship between landfill and incineration disposal costs.

As is the case with landfill costs, future incineration costs depend on interactions among a number of complex influences. Given its current cost disadvantage versus long haul landfill and the potential that an improperly sized facility could restrict waste reduction and recycling opportunities, incineration is unlikely to replace landfill disposal, even in those communities choosing to close their landfills rather than upgrading to new RCRA subtitle D requirements. For that reason

[34] Phone conversation with Kathy Anderson, Washington Utilities and Transportation Commission, May 25, 1993.

the analysis of future incineration costs in this report is less detailed than the discussion of future landfill costs. Two factors affecting future incineration costs are (1) new regulations on operations, emissions and ash disposal; and (2) future electricity prices.

Potential Regulatory Cost Impacts

Combustion of solid waste produces air emissions, wastewater discharges, and both bottom and fly ash. Air pollutants generated include particulates, carbon monoxide, oxides of nitrogen, and sulfur dioxide, as well as dioxins, furans, heavy metals, and acidic gases.[35] Many of these pollutants can be successfully controlled. Acid gas scrubbers can neutralize sulfur dioxide gases. Baghouse fabric filtration systems can control many particulates. Denox equipment can minimize the release of nitrous oxides.

However, mercury is of particular concern among the heavy metals because it vaporizes at temperatures attained in the exhaust gas stream produced from combusting solid waste and can escape through some heavy metal particulate control devices. Recent amendments to the 1990 Clean Air Act direct EPA to set mercury emissions limits, but these limits have not yet been set. Control systems for mercury emissions are commercially available. Because mercury emissions standards have not been established, currently operating solid waste incinerators are not generally designed to control mercury.[36]

An acid gas scrubber/fabric filter combination with continuous emissions monitoring (CEM), nitrogen oxide controls, and mercury controls, has been identified by EPA as the maximum available control technology for solid waste incineration plants with 250 TPD or greater capacity.[37] New WTE facility construction will typically include these control technologies. After a grace period, older solid waste incineration facilities often are required to meet new emissions regulations. Some existing incineration facilities have ceased operations because of an inability to meet current emissions standards.

In addition, Best Available Control Technology (BACT) for air pollutants under the Clean Air Act may come to be defined to include recycling to control certain emissions. Under the previous administration EPA had completed the public process for establishment of New Source Performance Standards (NSPS) for municipal solid waste incineration facilities, and was about to promulgate a rule requiring front end processing of solid waste prior to its incineration. Those NSPS for solid waste incinerators were overturned by the previous administration's economic competitiveness council chaired by then Vice President Quayle.

In incineration facilities where wastewater is discharged, it may be regulated by state or federal agencies. Water can be and is used in a number of combustion facility processes, for example, to process waste, produce steam, transport ash, clean flue gases and assist with plant maintenance. Wastewaters resulting from these processes may be

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[35] Bonneville Power Administration, "Draft 1992 Resource Program: Technical Report," Portland, OR, February, 1992.

[36] Nebel, K.L., and White, D.M., "Mercury Control Systems - Tested and Ready to Go," Solid Waste & Power, September/October 1992.

[37] Kiser, J.V.L., "Municipal Waste Combustion in North America: 1992 Update," *Waste Age*, November 1992.

contaminated by heavy metals. Water use, contamination, and wastewater treatment vary by plant and water availability.[38]

Ash is the other main output of solid waste incineration that attracts regulatory concern. Bottom ash consists of the inorganic and unburned residual material left after the combustion process is completed. Fly ash consists of both gases and particulate matter collected in the air emissions control equipment. Depending on both feedstock and combustion technology used, bottom and fly ash may contain heavy metals and toxic compounds such as dioxins.

Regulations affecting management of incinerator ash are still in development. On the federal level, former EPA Administrator William Reilly ruled that ash from solid waste incinerators need not be managed as hazardous waste under RCRA Subtitle C.[39] However, current legal proceedings or the change of administrations may result in a new classification for ash.

The Washington State Department of Ecology has ruled that solid waste incinerator fly ash may either be classified as dangerous or hazardous waste, while bottom ash may be classified as dangerous, special or solid waste. Washington State's Special Incinerator Ash Management Standards (173-303 WAC) specify that ash resulting from refuse combustion must be tested to determine if it qualifies as a dangerous waste.

The State's regulatory definition of dangerous waste is "comparable" to the RCRA definition of hazardous waste. In order to show that the ash is not dangerous, it must be tested for heavy metals, pH, carbon content, and animal and fish toxicity every three months for a year. If, at the end of this time, the ash passes these tests, it may then be classified as a special waste or a solid waste, depending on the specific test results.[40]

Whether ash from combusting solid waste is classified as a dangerous, special or solid waste affects the costs of managing incinerator ash. If ash is classified as a dangerous or a special waste, it must be landfilled in a double-lined ash monofill built in accordance with 173-306 WAC. These monofills often charge more for disposal than do regular municipal solid waste landfills.

Future Electricity Prices

The energy produced by waste combustion may be used to produce steam. In turn, generated steam can be used to run a turbine and produce electricity, can be transported to an adjacent industrial plant to provide production line power, and can provide building heat for the incineration facility itself.

Electric utilities are required under the Public Utility Regulatory Policies Act of 1978 (PURPA) to pay "avoided cost" prices, i.e., the price the utility would have to pay to produce the same amount of power on its own, for power produced by qualifying facilities. Solid waste incinerators are qualifying facilities under PURPA. The required minimum purchase price may vary according to time of day and season during which the power is transmitted to the utility.[41]

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[38] Bonneville Power Administration, op. cit.

[39] Kiser, op. cit.

[40] Colville, E.E., and McFeron, N.J., "Skagit County Waste-To-Energy Facility Front End Materials Recovery."

[41] Kiser, J.V.L., and Burton, B.K., "Energy from Municipal Waste: Picking Up Where Recycling Leaves Off," *Waste Age*, November 1992.

H.R. 776, passed by Congress in October 1992, allows independent power producers to sell electricity outside of their immediate markets. In addition, the WUTC has ruled that privately owned electric companies must use a competitive bidding process to acquire new generation sources.[42]

WTE facilities, thus, have a guaranteed market for electricity they generate. However, the price utilities or independent power producers currently pay for alternative power sources in the Northwest is low relative to the costs of combusting solid waste. For example, the Spokane Regional Solid Waste Disposal Project received only $0.024 per kWh from Puget Power for electricity produced by their WTE facility in 1992. After the facility operator Wheelabrator took its share, Spokane's revenue was under $10 per ton of solid waste incinerated. This compares with incineration disposal costs in Spokane of $97 per ton.

Whether electricity prices will rise faster than the costs of operating solid waste incineration facilities in the Northwest is uncertain. In terms of operating costs, conventional electrical generation facilities and WTE plants both tend to be capital intensive technologies. Their costs are, thus, less dependent on wages and taxes that might increase rapidly in the short run. This limits the extent to which short-run wage or tax increases might cause electricity prices to outpace incineration cost increases. Long term contracts such as the one negotiated between Spokane and Puget Power also limit short run escalation in electricity revenues.

Long-run demand for disposal capacity, whether it be landfill or incineration, is uncertain because of the increasing emphasis on waste diversion methods for managing solid waste. Similarly, the long-run demand side for electricity is also rapidly changing due to competition from potentially lower cost conservation measures and alternative on-site energy sources. Thus, increasing electricity prices caused by rapid growth in electrical energy demand cannot reliably be expected to decrease the net cost of solid waste disposal during the remainder of this decade.

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[42] R.W. Beck and Associates, in association with Elway Research, Inc., "Washington State Solid Waste Management Plan Issue Paper No. 8: Regionalization of Solid Waste Management and Facilities," January 1991.

4. MATERIALS AND PRODUCTION COSTS: RECYCLED VS. VIRGIN [HIGH VALUE MARKET APPLICATIONS]

This chapter provides an analysis of comparative costs and benefits of using recycled versus virgin materials to produce marketable products. As explained in Chapter 1, the methodology was to find final products which are produced using either recycled materials or their virgin substitutes, and compare costs incurred in using the two types of materials. Ideally, final products chosen for examination are actually produced with both 100% recycled and 100% virgin content. In addition, recycled-content products chosen are ones whose producers are willing to pay the best market prices for recycled materials incorporated in their products.

For old newspapers (ONP) the final product chosen for analysis was newsprint. For recycled glass containers the final product was glass containers. For high density polyethylene (HDPE) milk jugs the final product was HDPE plastic grocery sacks and shopping bags. For polyethylene terephthalate (PET) beverage containers two products were examined - polyester carpet fiber and two liter beverage containers. For yard waste the final product was residential soil amendments.

The main difficulty in determining relative costs for manufacturing with recycled versus virgin materials is that cost data are both proprietary and extremely variable. Age of plant and equipment, location relative to material sources and product markets, and skill of the labor force are just three of the many factors that influence actual costs incurred by any particular manufacturer. Variations in total cost caused by a switch from virgin to recycled material feedstocks include costs of production equipment modifications, production efficiency changes, and additional or reduced labor requirements. Specific data on such costs, or cost impacts of the switch to using recycled feedstocks, are almost always proprietary.

The following analysis compensates for such difficulties by focusing on market prices for recycled versus virgin materials that have been sufficiently processed to be used as production feedstocks. The analysis takes into account any differences in productivity between recycled and virgin material inputs.

Recycled versus virgin materials price comparisons in this chapter's analysis of manufacturing costs are based on 1992 average prices. Those price comparisons, thus, represent only a snapshot of the historical relationship between recycled and virgin materials prices. To provide perspective this chapter also includes price index data showing movements in materials prices over the past five or ten years. In addition, this chapter discusses for each recycled material whether the relationship in 1992 between recycled and virgin materials prices is likely to persist in the future.

Price index data are exhibited on graphs showing separate indices for recycled and virgin materials. When examining these price index graphs and comparing indices for recycled materials versus virgin materials, the reader is cautioned to remember that a price index shows how price levels for a given material move up and down over time, i.e., each index measures changes in price levels *relative to a base period price for the material itself*.

A price index, thus, shows movement in a material's price *relative* to its base period price, but cannot be used to compare *absolute* prices for two different materials.

When two price indices are plotted on the same graph, the fact that one index lies above the other does not mean that one material's *absolute price* is greater than the other's. It only means that one material's price versus its base period price is relatively higher than the other material's price versus its base period price.

A. Newspapers (ONP)

1. Recycling Overview

Old newspapers recycled in Washington go to a variety of end users for manufacturing into consumer products. A high value end use for recycled newspapers is to remanufacture newsprint, the product whose use generated newspaper waste. This fact is reflected in market prices for the various grades in which ONP is marketed. The best price for ONP is typically as grade (8) **Special News De-ink Quality**, the grade required by recycled newsprint mills for deinking and repulping to remanufacture newsprint. Number 8 is defined by ISRI as:[43]

"Consists of baled sorted, fresh dry newspapers, not sunburned, free from magazines, white blank, pressroom over issues, and paper other than news, containing not more than the normal percentage of rotogravure and colored sections. This packing must be free from tare.

Prohibitive materials.......................... None permitted
Total Out throws may not exceed............ 1/4 of 1%"

This top grade of ONP is often referred to as **Number 8 News** or **Deinking News**. "Prohibitives" are non-paper materials such as broken glass, plastic bags or tin can lids. "Out throws" are paper types that are not allowed in the grade such as kraft grocery bags, window envelopes or telephone books.

Recently constructed deinking systems often use flotation cell equipment in the deinking process. Flotation cell technology actually requires and benefits from the clay content on newspaper inserts or on old magazines (OMG). The clay helps to gather ink droplets floated off old newspapers in the repulping slurry. The stronger fibers in OMG also help strengthen the recycled-content newsprint, replacing virgin kraft pulp which otherwise may be added to the deinked ONP pulp. These newer flotation cell deinking operations mix ONP and OMG, typically in proportions ranging between 70/30 and 80/20.

Older style deinking operations use a washing system in which too much clay can cause production problems. Magazines and newspaper inserts typically have a clay coating to brighten printing from colored inks. To avoid clay contamination, out throws, including OMG, are limited to 1/4 of 1%.

The other main grade for marketing ONP is ISRI grade (6) **News**, which[44]:

[43] Institute of Scrap Recycling Industries, Inc. (ISRI), *Scrap Specifications Circular 1991, Guidelines for Ferrous Scrap, Nonferrous Scrap, Paper Scrap, Plastic Scrap* , p.28. When referencing paper grades, this publication is often referred to as the PS-91, or Paper Stock-91, guidelines.

[44] Ibid, p. 28.

"Consists of baled newspapers containing less than 5% other papers.

Prohibitive materials may not exceed....... 1/2 of 1%
Total Out throws may not exceed.......................... 2%"

This grade is often sufficient for remanufacturing ONP into boxboard, gypsum wallboard facing, molded pulp products, and other paper or paperboard products that do not require that the recycled paper be deinked. It is also used in producing cellulose insulation products.

For recycling programs that collect newspapers commingled with other papers such as junk mail or boxboard, the resultant mix of ONP and other paper fiber types can be marketed without further sorting as ISRI grade **(1) Mixed Paper**, defined as a paper mix, which:[45]

"Consists of a mixture of various qualities of paper not limited as to type of packing or fiber content.

Prohibitive materials may not exceed.................... 2%
Total Out throws may not exceed......................... 10%"

Mixed paper is the lowest of over 75 grades of paper classified by ISRI. The market price for mixed paper almost always reflects this fact, rarely rising above single digits in recent years, and often selling at a negative price, depending on the part of the U.S from which the grade is being sold. Net revenue to the seller is lower in eastern parts of the country, where transportation costs to Asian markets increase costs.

Actual and planned additions of in-state deinking are increasing local demand for deinking grade ONP – e.g., Inland Empire (Millwood), North Pacific Paper (Longview), Daishowa (Port Angeles), and Boise Cascade (Steilacoom). Oregon and British Columbia also have large scale ONP deinking operations on line at Smurfit Newsprint (Newberg and Oregon City, OR) and Newstech Recycling (Coquitlam, BC).

ONP that does not meet deinking grade quality has a number of local markets – e.g., Container Corporation of America (Tacoma), Paperboard Industries Corp. (Burnaby, BC), Keyes Fiber Co. (Wenatchee), Sonoco Products Co. (Sumner), and Michelson Packaging Co. (Yakima).

Exports to Pacific Rim nations of both deinking and lower grade ONP also provide substantial demand for newspapers recycled in Washington state. Recycle America relies on exports and Smurfit Newsprint's mills in Oregon to market the deinking grade ONP it produces from the materials recycled in Seattle's northend curbside program.

2 Newsprint Market

Production and Feedstocks

Virgin Materials

Virgin-content newsprint manufacture is a technology and energy intensive process. Turning pulpwood or wood chips into pulp for use on the newsprint machine typically involves the application of both mechanical and thermal processes. The pulp

[45] Ibid, p. 28.

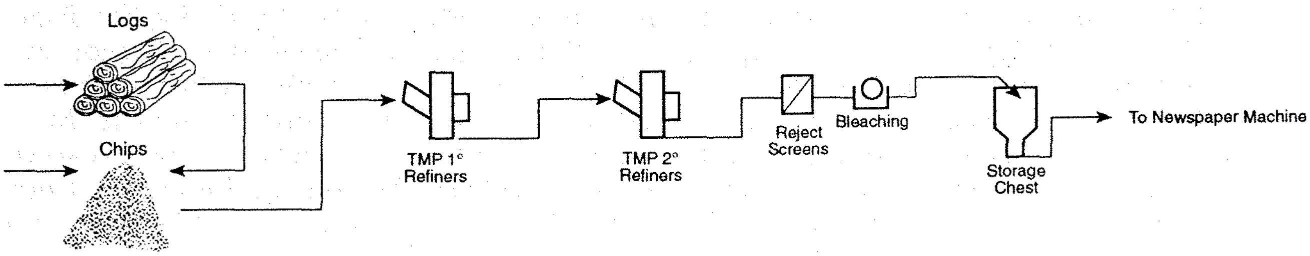
for newsprint is generally termed mechanical pulp, with subcategories such as stone groundwood and thermomechanical pulp (TMP).

A generic schematic for the TMP pulping process is shown in Figure A-1. An actual newsprint plant would be more complicated, but the diagram shows the basic functions performed to turn logs into a pulp which in turn can be made into newsprint. Logs themselves are mechanically chipped at the newsprint mill, or else chips are purchased on the open market. The chips are softened by preheating under pressure and then sent through pressurized primary and secondary refining stages. These thermomechanical refining operations yield a slush pulp slurry. Screening out reject material and bleaching to desired brightness complete the pulping operation. The TMP at this point is piped into a storage chest to await pumping to the newsprint machine, where it is discharged onto the machine's wire for forming into newsprint.

Approximately 90% of incoming woodchip fiber on a bone dry weight basis ends up in the newsprint pulp. This leaves about 10% by weight as residue from the typical TMP newsprint process. This residue is made up of suspended solids that can be removed at a primary treatment facility, as well as dissolved organic material that can be treated in a secondary effluent management process.

In many cases the TMP newsprint manufacturing process also involves the addition of bleached softwood kraft market pulp to strengthen the resultant newsprint sheet, especially in Southeastern U.S. locations.[46]

Figure A-1. TMP Pulping Process Schematic



Recycled Materials

Recycled-content newsprint manufacture avoids the process of turning trees into pulp, but substitutes the complexity of having to remove/screen inks and other undesirable materials that may have been collected and baled with ONP. Almost all ONP deinking operations for newsprint manufacturing are integrated with one or more papermaking machines to produce newsprint on the same site. Most of these recycled-content mills also contain virgin pulping operations. The Smurfit Newsprint plant (formerly Golden State Paper) in Pomona, CA is one West Coast facility that relies solely on deinked pulp and produces a 100% recycled-content newsprint.

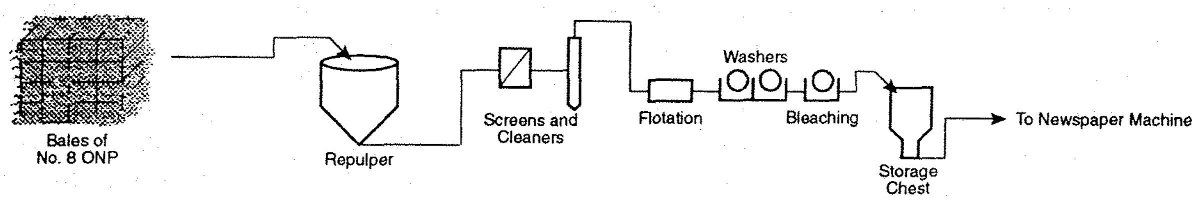
[46]Pesonen, Kari V., "Recycled Vs. Virgin - Energy and Manufacturing Cost Differentials: Four Hypothetical Case Studies," Proceedings of Focus '95+, Landmark Paper Recycling Symposium, (Atlanta: Tappi Press, 1991), p. 253.

Newstech Recycling is the only existing North American producer of deinked ONP pulp for resale. Newstech produces a wet lap pulp (i.e., 50% water content) under contract to nearby newsprint mills in British Columbia belonging to Fletcher Challenge at Crofton and MacMillan Bloedel at Powell River and Port Alberni. These mills buy in deinked ONP pulp to combine with their 100% virgin-content pulp to meet recycled-content requirements.

Figure A-2 provides a generic schematic for a newspaper deinking operation to produce a slush pulp suitable for manufacturing newsprint. Turning ONP into slush pulp begins as a simple process which involves blending unbaled newspapers with water in a hydrapulper in combination with chemicals such as caustic soda (sodium hydroxide) to help break up the paper sheets, and then adding sulfuric acid as a stabilizing agent to the resultant pulp slurry. A spinning rotor in the bottom of the pulper tears the ONP into small pieces which, as they rub against each other, break down further into separate fibers.

Then come the harder parts of the process – screening out undesirable materials such as paper clips, staples, and stickies (globs of insoluble glues that melt on the newsprint machine as the paper web is being dried and can leave a hole or weak spot in the newsprint), and removing inks. A series of screens and centrifuges or cyclones are used to clean out contaminants.

Figure A-2. Deinked ONP Pulping Process Schematic



The cleaning stage can be followed by, or include as an integral element, the deinking stage, which in Figure A-2 consists of a flotation cell and washing operations. Flotation is a chemi-mechanical process designed to separate ink particles from recycled fiber by floating them to the surface, where they can be skimmed off for dewatering and disposal. In this process, small air bubbles are injected at the bottom of flotation cells. As they rise, these bubbles collect ink particles and form a froth on the surface. A soap solution applied in the mixing tanks at the front of the deinking lines ensures that paper fibers do not stick to the air bubbles.

In Figure A-2, the flotation stage is followed by washing, a mechanical process of rinsing ink, ash and dirt particles from pulp. In this process ink particles are separated from the wash water by flotation in a separate clarifier.

Finally a bleaching stage, typically using hydrogen peroxide or sodium hydrosulfite as the bleaching agent, is used to return the slush pulp to the brightness desired for unprinted newsprint.

From 85% to 88% of incoming ONP material actually is incorporated into newsprint during production. The remaining 12% to 15% ends up as repulping/deinking residue with some amount also being discharged to wastewater treatment. The review of Newstech Recycling's prospectus conducted by British Columbia's Ministry of Environment (MOE) estimates that 87.5% of incoming ONP/OMG will end up in the newsprint pulp; about 9% will consist of ash (clay), carbon black (inks), adhesives, plastics, and wood fiber sludge that may be compostable; and about 2% will be solid waste composed of staples, paper clips, glass and plastics. The remaining 1.5% of incoming material that does not end up in newsprint pulp is not directly addressed, but by implication this material must be discharged with process wastewater or as particulate matter into the air.[47]

Materials Prices

Interviews with a number of pulp and paper industry personnel, published literature, and published price indices and price data provided a good data base for cost analysis of producing newsprint from recycled ONP versus virgin woodchips.

Table A-1, **Manufacturing System: Newsprint**, summarizes raw material cost and newsprint revenue for 100% recycled-content versus 100% virgin newsprint manufacture. The bottom part of Table A-1 indicates estimated 1992 market value of newsprint producable from a ton of Number 8 News. That part of the table also shows the materials cost in 1992 for a ton of Number 8 News versus 94% of a ton of Douglas fir residual woodchips necessary to produce the same output tonnage of newsprint.

According to *Pulp & Paper Week*, the 1992 West Coast list price for standard 30 pound newsprint was $630 per metric ton, or $572 per short ton. Actual transaction prices, however, were estimated to average about $430 per metric ton, or $390 per short ton, with discounting occurring below that price.[48]

To verify the accuracy of *Pulp & Paper Week* price estimates, their estimated transaction prices in 1987 were compared with U.S. Census Bureau data from the 1987 Survey of Manufacturers, the most recent year in which manufacturing census data is available. The *Pulp & Paper Week* transaction price averages for 1987 are $502 per short ton delivered on the West Coast and $517 on the East Coast. The 1987 Survey of Manufacturer's average revenue for newsprint produced by U.S. manufacturers in 1987 was $474 per ton, net of discounts, allowances, freight charges, and returns.[49] At a delivered cost equal to the *Pulp & Paper Week* price averages of $502 to $517 per short ton, $474 in net revenue would leave about $25 to $45 per ton to cover freight, returns and discounts, which seems within reason. The fact that the *Pulp & Paper Week* price data for 1987 matched the 1987 Census data, plus the confidence that industry personnel expressed for this publication, motivated use of their estimated price of $390 per ton, or $430 per metric ton, as the average market price for newsprint in 1992.

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[47]Steering Committee of the Major Project *Review Process, Review of Prospectus for Newstech Recycling Inc.'s De-inking Plant*, Co-published by MOE, August 1990, pp. 2-5.

[48]"Price Watch: Paper and Paperboard," *Pulp & Paper Week*, various 1992 issues. A metric ton or tonne is 2204.6 pounds; a short ton or ton is 2000 pounds, 90.72% of a tonne.

[49]Price data for 1987 from *Pulp & Paper* 1992 North American Factbook, (San Francisco: Miller Freeman Inc., 1992), p. 159. Value of shipments data from 1987 Census of Manufacturers, Industry Series MC87-I-26A, Pulp, Paper, and Board Mills, Industries 2611, 2621 and 2631, Table 6C. Short tons shipped data for 1987 from Current Industrial Reports, Pulp, Paper and Board, MA26A(87)-1, 1987, Table 13.

Table A-1. MANUFACTURING SYSTEM: NEWSPRINT (1992 Averages)

	Recycled vs. Virgin Materials Cost (Per Metric Ton Finished Product)		
FACTORS/PRICES	Recycled Materials	Virgin Materials	Recycled Materials Cost Difference
Cost of Material (Per ton)	$62	$84	$22
Tons of Material (Per metric ton of product)	1.30	1.22	
Cost of Materials (Per metric ton of product)	$80	$103	$22
COST STRUCTURE			
Newsprint Price	$430	$430	$0
Materials Cost (Incl.Transportation)	$80	$103	$22
Net Available for Manufacturing, Profit, etc.	$350	$327	$22

	Recycled vs. Virgin Materials Cost (Per Ton of Recycled Material or Equivalent)		
FACTORS	Recycled Materials	Virgin Materials	Recycled Materials Cost Difference
Short Ton/Metric Ton Ratio	0.91	0.91	
Yield of Finished Product (Per ton of materials)	85.0%	90.0%	
Virgin Material Equivalent (Of one ton of recycled material)		0.94	
COST STRUCTURE			
Newsprint Value	$332	$332	$0
Materials Cost (Incl.Transportation)	$62	$79	$17
Net Available for Manufacturing, Profit, etc.	$270	$252	$17

A ton of Number 8 News has a yield of 85% to 88% in repulping and deinking for production of recycled-content newsprint. A ton of Douglas fir residual woodchips has a yield in TMP for newsprint of about 90%.[50]

Based on an 85% yield from ONP and a 90% yield from Douglas fir residue chips, a ton of Number 8 News would produce $332 worth of newsprint at the 1992 transaction price of $390 per ton of newsprint sold. A ton of Douglas fir residual chips would produce $351 in newsprint revenues.

The cost in 1992 for Number 8 News delivered to recycled newsprint mills in Longview and Millwood, WA, and Newberg and Oregon City, OR was estimated by a major Oregon broker to be about $62 per ton, including $17 average shipping costs and a $45 revenue to the shipper at the shipper's dock. This is very close to Recycle America's average revenue of $42.30 at their Seattle MRF.

The manager for a major packing plant in Oregon reported that shipping point prices for Number 8 News averaged $35 to $45 during 1992. Waste Age's *Recycling Times* reported end-user prices on the West Coast during the first half of 1992 in the range $55 to $75. Miller Freeman's *Paper Recycler* reported Los Angeles/San Francisco area seller's dock prices in the range $30 to $50 for Number 8 News in 1992. All these price estimates are consistent with the estimate that North Pacific Paper, Smurfit Newsprint and Inland Empire paid an average $62 per ton to get Number 8 News to their recycled newsprint mills during 1992.

Table A-1, thus, shows $62 as cost per ton of Number 8 News that a typical Northwestern U.S. recycled newsprint mill had to pay for recycled material inputs in 1992. That left $270, or 81% of revenue, to cover the cost of other materials, as well as for value added in 1992, out of the $332 worth of newsprint produced by a ton of Number 8 News. This $270 amount is shown at the bottom of Table A-1 as the net available for manufacturing, profit, etc.

A $270 or 81% margin after paying ONP furnish cost may be a conservatively low estimate for two reasons. First, recycled-content newsprint mills may get better than an 85% yield from Number 8 News furnish. Second, many of the newer deinking operations are equipped with flotation cells, and some may use OMG as part of their furnish. Currently, prices for OMG are significantly below prices for Number 8 News. OMG has a yield of only about 75% in newsprint production, but to the extent that this lower yield is more than offset by lower OMG prices, the newsprint manufacture may be able to reduce furnish costs. On the other hand, limited quantities of Number 8 News may also force a newsprint producer to buy OMG even when it increases overall furnish costs.

By contrast, in 1992 the 100% virgin newsprint producer had to pay between $90 and $110 at Longview, WA, and from $95 to $110 in Eugene/Springfield, OR for a bone dry unit of Douglas fir residual chips. A bone dry unit of chips is 2400 pounds of wood fiber, so that the cost for one ton of newsprint quality woodchips in 1992 was about $84. As shown in Table A-1, 94% of a ton of woodchips, at a cost of $79, produces the same amount of newsprint as one ton of Number 8 News. This leaves $252 to cover

[50] Estimate of 90% yield from woodchips from 02/16/93 conversation with Steve Storms, Process Evaluation Staff, Pulp, Paper and Paperboard Manufacturing, Weyerhaeuser Company. A 90% yield estimate for TMP is also given in *Pulp & Paper* 1992 North American Factbook, op cit, in a table titled General Description of Commercial Processes for Pulping Wood. Estimate of 85% ONP yield from 01/20/93 meeting with Steve Storms. The 88% estimate is from Review of Prospectus for Newstech Recycling Inc.'s De-inking Plant, op cit, p. 2.

manufacturing costs, profits and other items, $17 less than the margin provided by using Number 8 News.

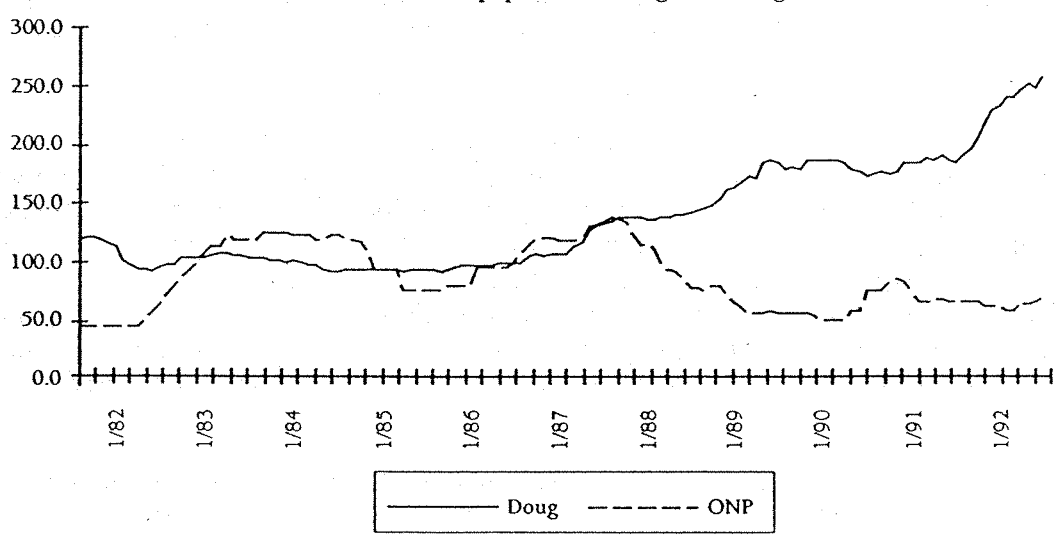
Historical Prices: ONP vs. Woodchips

Figure B-1, **Recycled and Virgin Materials Price Indices (1982-1992), Old Newspapers and Douglas Fir Logs**, shows a monthly price index (base December 1986 = 100) for recycled old newspapers in the western U.S. states for January 1982 through December 1992. The graph shows the substantial volatility in market prices for recycled newspapers, as well as the fact that prices since 1989-90 for the most part have been near their ten-year low. The prolonged economic recession on the demand side, and the increased rate at which newspapers have been recycled on the supply side, are the primary causes of the fall in ONP's market price since 1989.

Figure B-1 also shows a monthly price index (base December 1986 = 100) for Douglas fir logs, bolts and timbers. Because TMP newsprint manufacturers in the Northwest use woodchip residues from Douglas fir lumber production, prices for these woodchips should tend to follow movements in prices for virgin logs, bolts and timbers. Virgin Douglas fir prices have risen over the past five years, and those price increases accelerated during 1992. Export demand and restrictions in logging on federal lands are two important causes for the rise in timber prices.

During 1992 old newspapers had lower prices than Douglas fir residual woodchips for use in manufacturing newsprint. This price relationship is a recent occurrence. Prior to 1988 or 1989 old newspapers cost more than virgin woodchips for use in manufacturing newsprint. However, based on the price trends shown on Figure B-1, one would expect recycled newspapers to remain cheaper than Douglas fir woodchips in the foreseeable future.

Figure B-1
Recycled and Virgin Materials Price Indices (1982-1992)
Old Newpapers and Douglas Fir Logs



Source: U.S. Dept. of Labor, Bureau of Labor Statistics, *Producer Price Indexes* 12/86=100

Cost of Newsprint Production

The cost of producing newsprint, whether with recycled ONP or virgin woodchips, at any particular newsprint manufacturer is highly proprietary and quite dependent on both financial and cash costs. Financial costs depend on age and sophistication of the technology used, as well as the amount of borrowing versus equity used for capitalization of the business. Cash costs depend on such factors as location of the operation, the extent to which the producer must buy woodchips or ONP from the open market versus relying on its own fiber sources, transportation costs to bring in fiber and ship out finished newsprint to market, and the degree to which the facility is mechanized and uses less labor than another operation.

One forest products industry expert recently completed a confidential study of the costs of newsprint production in 16 mills in western North America.[51] While most of this study is proprietary, certain results are available, i.e., cost ranges and cost rankings for recycled- versus virgin-content newsprint manufacturers. On the basis of a metric ton (tonne) of newsprint delivered to the largest West Coast market, Los Angeles, total cost varied from $400 to $530. On a short ton delivered basis, this is a cost range of $363 to $481, with a midpoint of $422.

Similar cost data are reported by another source. The *Pulp & Paper 1992 North American Factbook* reported per ton delivered costs for newsprint of $391 in 1989, $411 in 1990 and $427 in 1991, based on a detailed cost study conducted for the years 1985-89 by the Forest Sector Advisory Council of Canada.[52]

Compared with estimated 1992 transaction price for delivered newsprint of $390 per ton, newsprint manufacturing in the western part of North America apparently was not very profitable in 1992.

Of course, a portion of total cost is financial and unrelated to current levels of output, so newsprint manufacturers would choose to maintain production and not shut down as long as the $390 covered their variable or cash costs. Older mills with lower financial or fixed costs due to more of their plant and equipment being fully amortized, might or might not have a better bottom line in this time of depressed product price. While older mills generally have lower fixed costs, they have higher variable costs due to lower efficiency of their older technology production machinery.

Comparison – Recycled vs. Virgin Costs

In the confidential study mentioned above, mills were ranked from lowest cost to highest cost. In an existing mill many factors affect cost besides whether it is using virgin or recycled furnish. Other factors of importance include mill location compared to source of fiber and location of markets, equipment age, technological sophistication of machinery, and skill and experience of workers.

Thus, recycled content is not a clear key to high or low cost. When ranked according to cost per ton of newsprint produced, the three lowest cost mills manufacture a minimum 40% recycled-content newsprint and are all located in the

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[51] The mills in alphabetical order are: Alberta Newsprint (Whitecourt, Alberta), Boise Cascade (Steilacoom, WA), Canadian Pacific Forest Products (Gold River, BC), Finlay (Mackenzie, BC), Fletcher Challenge Canada (Crofton, BC and Campbell River, BC), Howe Sound Pulp and Paper (Port Mellon, BC), Inland Empire (Millwood, WA), MacMillan Bloedel (Port Alberni, BC and Powell River, BC), North Pacific Paper (Longview, WA), Ponderay Newsprint (Usk, WA), Smurfit Newsprint (Newberg, OR; Oregon City, OR; and Pomona, CA), and Stone Container (Snowflake, AZ).

[52] Pulp & Paper 1992 *North American Factbook*, p. 165.

U.S. The next three lowest cost (numbers four, five and six in the cost ranking) are 100% virgin. Number seven is recycled, number 8 is virgin, number 9 is recycled, number 10 virgin, numbers 11 and 12 are recycled, number 13 is virgin, number 14 is recycled, number 15 is virgin and number 16, the highest cost mill, is recycled.

Other details available from this cost study are that the two mills using deinked market pulp[53] were among the higher cost mills. They buy recycled-content pulp from Newstech Recycling, and must pay to have the recycled pulp shipped. Newstech presses the pulp to reduce water content to 50% before the resultant wet lap pulp is shipped. In addition, these mills must pay a price that covers Newstech Recycling's profit. They also are farther from the bigger newsprint markets.

In general, the old mills in this proprietary study are less competitive because cash (variable) costs tend to outweigh financial (fixed) costs. For example, North Pacific Paper (NorPac) is a very efficient, state of the art, newly equipped mill. Its supplier of recycled ONP is Weyerhaeuser's Quality Sort Center in Portland. Smurfit Newsprint's plant at Pomona, CA, (formerly Garden State Paper) is 100% recycled, close to both a large ONP source and the large Los Angeles newsprint market, making it one of the lower cost mills. On the other hand, Inland Empire in Millwood (Spokane), WA, is relatively small. Its labor costs per ton are higher due to lower scale economies; it also has to pay more freight to ship newsprint to the large Los Angeles market.

For newsprint mills in similar locations with similar scale and age equipment, there may be certain cost savings associated with recycled-content newsprint manufacture. Besides the fact that virgin furnish costs were higher than recycled furnish for newsprint manufacture in 1992, virgin newsprint requires more energy. In fact, a recent study by Pesonen estimated that power requirements for virgin newsprint in the southeastern US and in eastern Canada are over three times the power needs for recycled newsprint production.[54] In that study energy savings amount to enough to offset costs for the substantial extra use of chemicals in deinking and the additional cleaning required when repulping ONP.

In addition, one user of recycled ONP and OMG noted that their mill was able to reduce its use of chemical kraft pulp, and may eventually eliminate it completely, due to the fiber characteristics of the recycled furnish. Beyond the headbox (the equipment for mixing and discharging slush pulp onto the newsprint machine's wire), costs for recycled and virgin newsprint manufacture are estimated to be virtually identical.

Pesonen's generic comparative cost study concluded that in the southeastern U.S. cost savings total about $70 per ton of newsprint produced. In eastern Canada cost savings are estimated at about $27 per ton. Lower energy costs and greater costs of acquiring ONP furnish in eastern Canada reduce the cost advantage of recycled over virgin newsprint manufacture.[55]

On the other hand, according to the quality control manager at a major Northwest newsprint mill, one example of extra cost on the recycled side is additional chemicals usage, e.g., surfactants needed to separate inks from recycled paper fibers and bleaching agents needed to re-brighten recycled-content pulp. Also, stickies and other imperfections in the recycled news sheet are expected to cause at least a 1%

[53] These must be Newstech Recycling's only two customers Fletcher-Challenge at Crofton and MacMillan Bloedel at Powell River or Port Alberni, BC.

[54] Pesonen, op cit, p, 253.

[55] Ibid, p. 253 and Figures 2 and 3, p. 258.

efficiency loss during their first year of using recycled fibers in this plant, even though substantial money was spent on better showering equipment for the felt and wire on the newsprint machine. This same source said that drying newsprint made from recycled fiber was more difficult, requiring extra energy costs beyond the headbox.

However, on balance this mill expected to save $40 per ton for their 40% recycled-content versus 100% virgin-content newsprint, due to savings in energy costs prior to the newsprint machine's headbox, less usage of kraft pulp, and reduced woodchip costs. This mill gets half its chips from company sawmills, but woodchips purchased on the open market cost more than in-house chips and have been rising in price.

A representative of another major West Coast newsprint manufacturer, one more experienced with running recycled-content newsprint, confirmed the generalization that energy and furnish cost savings from recycled outweigh the extra chemical costs. He also asserted that the 55% to 60% recycled-content product his two mills produce is competitive with virgin in terms of performance on their newsprint machines.

Although recycled may now be cheaper to produce than virgin, given current costs for Number 8 News versus woodchips[56], the cost difference would not by itself support the major investment required to install a repulping and deinking plant costing, roughly, $50 million, and at the same time shut down an existing virgin newsprint pulping plant.[57] Thus, in the absence of recycled-content requirements or customer demand, new recycled furnish use would be added only as capacity expansion is required.

Referring again to Table A-1, recycled newsprint has an edge of 5 percentage points, 81% of revenue versus 76% for virgin to cover non-furnish materials, labor, energy and financial costs. On the basis of 1992 prices of $390 per ton for newsprint, this extra 5% represents $20 more per ton to pay for costs other than fiber furnish. In addition, one mill's representative suggested that reduced energy costs and lowered kraft market pulp content may save the recycled newsprint producer an additional $20, even after paying costs for deinking chemicals.

Finally, a major British Columbia newsprint manufacturer buying in deinked ONP/OMG pulp from an outside supplier gave a ballpark estimate of cost to his headbox of $400 per metric ton for repulped secondary fiber, roughly the same cost as the virgin TMP pulp his integrated pulp mill produced internally. Deinked pulp costs include transportation and a profit margin for the pulp's producer. The fact that it still

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[56] It is important to bear in mind that only a few years ago ONP furnish cost was greater than woodchips. For example, in an article published in 1989, furnish cost for 100% ONP was estimated to be over 35% greater than for virgin pulp. (Fred D. Iannazzi, "The economics are right for U.S. mills to recycle old newspapers, " *Resource Recycling*, v8, n3 (Jul 89), p. 35.) This compares with the estimate in this study that ONP furnish is over 20% cheaper in 1992. Furthermore, at those times when overseas countries drastically increase their ONP orders, or when a domestic building boom causes production of cellulose insulation to surge, prices for ONP can jump $30 or more per ton in a few weeks or months. Such a surge could easily wipe out the current cost advantage for ONP in newsprint production. Price trends for ONP and woodchips are discussed in Chapter 5.

[57] For example, a 250 ton per day (TPD) deinking retrofit to an existing newsprint mill could cost $50 million. At a savings of $40 per ton, the retrofit would earn about $3.7 million per year. At this annual rate of savings, the payback period for the investment in deinking equipment would be over 13 years. Estimate of investment cost for a deinking retrofit from Ed Sparks, "Recycled newsprint production in North America, " *Resource Recycling*, v9, n4 (Apr 90), p.52.

costs the same to the integrated mill's headbox confirms that deinked pulp was competitive with virgin TMP on the West Coast of North America in 1992.[58]

Although recycled-content pulp may produce more newsprint machine downtime for operators inexperienced with making a recycled-content news sheet, for some producers there appear to be savings in using ONP in place of woodchips in 1992's West Coast market conditions. However, the fact the 16 mill cost study found no significant correlation between recycled-content and relative cost ranking suggests that no general conclusion for all newsprint producers is possible at present.

[58] Drying and shipping costs for market pulp in the U.S. are probably $40 to $50 per short ton. Unlike market pulp, however, deinked ONP wet lap pulp is pressed to a 50% water content, rather than being thermally dried to the 10% water content for market pulp. Thus, due to its high water content, shipping wet lap pulp still incurs a significant cost. (Meeting on 01/20/93 with Steve Storms, Weyerhaeuser Company; also see Judy Usherson, "Recycled office paper: why it costs more, " *Resource Recycling*, v11, n11 (Nov 92), p. 56.)

B. Glass Containers (Cullet)

1. Recycling Overview

Glass collected for recycling in the Puget Sound region of Washington is first sorted by color – at the point of collection or at a processing facility – then delivered either to Fibres International in Seattle or to Owens-Brockway, a glass container manufacturer in Portland. Fibres crushes the glass and removes contaminants, including caps, neck rings, and labels, then sells most of this material, called furnace-ready "cullet," to Ball Incon, a glass container manufacturer in Seattle. Some furnace-ready cullet from Fibres benefication process has also been shipped to a glass plant in California. Owens-Brockway has their own benefication process that includes equipment to remove both ferrous and non-ferrous metals from cullet.

Owens-Brockway and Ball Incon use color-sorted cullet along with virgin materials in manufacturing glass containers. This is the largest current use for recycled glass food and beverage containers that cannot be cleaned and refilled. In the Northwest, flint (clear) and amber (brown) color cullet currently command a better market price than does green. This is mainly due to importation of beer and wine in green containers. When these imported green beer and wine bottles are recycled along with domestically produced green containers, there is an excess supply of green cullet in the Northwest, because of the relatively lower amount of green containers manufactured in this area. Some green can be mixed with amber in manufacturing amber containers, but the amount that can be used is quite small relative to the excess supply of green cullet.

Glass breakage during collection and processing can result in large quantities of glass fragments which are too small to cost-effectively sort by color. The resulting "mixed-color cullet" is difficult to use in container manufacturing and typically has difficulty finding a market. The proportion of glass breakage during curbside collection, delivery to a MRF, and processing can be quite high. For example, about 25% of glass containers recycled through Recycle America's northend Seattle curbside collection are broken into mixed color pieces by the time the other 75% leaves its MRF for market as color-sorted cullet. Glass breakage can be even higher, at times up to 50%, for Recycle America curbside routes outside of Seattle, due, for example, to unloading collected containers at a transfer point to combine loads for more efficient delivery to Recycle America's MRF in south Seattle.

2. Glass Container Market

Production and Feedstocks

Virgin Materials

Glass container manufacturing is an integral part of glass production. Once molten glass is formed it is molded directly into a container. The principal virgin materials used in manufacturing glass containers are sand (which is 99% silica oxide), soda ash (sodium carbonate), and lime (often as limestone, i.e., calcium carbonate).

The typical raw material composition of a 100% virgin-content glass container is 70% sand, 15% soda ash, 12% lime and 3% other materials, a major portion of which is often feldspar.[59]

The typical glass plant measures appropriate portions of each raw material and transports them to a mixer where recycled glass cullet that has been crushed also is added to the batch of glassmaking material. This mixed batch of materials is continuously fed to a furnace where it is melted under extremely high temperatures. After being completely melted, a second section of the furnace gradually lowers the temperature of the molten glass and then refines it to remove crystalline materials and gas bubbles.

Then the molten, refined glass is cooled a bit further to a temperature suitable for forming into glass containers.

Recycled Materials

Historically, cullet has been added to virgin materials in making glass. Cullet substitutes directly for a portion of the virgin materials batch mix, rather than for any single material. Older technologies generated substantial in-house scrap that was returned to the furnace as cullet. As glassmaking technology improved less in-house scrap was generated, creating more opportunities to use recycled post-consumer glass cullet.

End users need to guard against contaminants that can be introduced into the glassmaking furnace with post-consumer recycled cullet. Metals, ceramic and stone do not melt at the 2600 degree Fahrenheit temperature at which the batch mix of raw materials and cullet is first melted. These contaminants remain intact, can damage the glass-melting furnace, and sometimes become incorporated into the glass walls of new containers.

A glass batch can also be damaged if the wrong color cullet is added. Flint glass has the lowest tolerance for color contamination; it must be at least 97% flint with no more than 1% green. Amber must be at least 95% amber. Green glass has the highest tolerance for color contamination; it must be 85% green, with no more than 10% flint.[60] Green and amber can be combined in limited quantities, however they react chemically when melted.

As a result of having higher tolerance for color contamination, green glass has the highest recycled content, followed by amber, then flint. Recycled content for flint containers also is often limited by available supplies of flint cullet. Certain standard specialty greens require higher virgin content. An additional advantage of manufacturing with green cullet arises from the fact that imported beverages are more often in green glass containers; leading to supply significantly in excess of demand for green glass cullet, and recently much lower prices than flint or amber cullet.

Technically, glass containers can be made with 90% to 95% recycled content. This is the practical limit on recycled content because a certain amount of virgin material allows better control of batch chemistry and melting characteristics. Difficulty in getting an assured supply of color-consistent, contaminant-free cullet has been a barrier to ongoing large-scale manufacturing with maximum recycled content.

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[59] CSG/Tellus Packaging Study, Volume II, p. 4-1. These percentages also agree with information supplied by the Glass Packaging Institute in Washington, D.C.

[60] Gibboney, Douglas L., "Closing the Loop with Glass Recycling," *Biocycle*, Apr 90, p. 91.

Materials Prices

The term "batch cost" refers to the aggregate cost of the mixture of materials used as inputs to the glass manufacturing process. Batch cost for 100% virgin raw material inputs is estimated to be between $38 and $60 per ton of input material. Batch cost for the virgin materials inputs includes mining, transportation, and mixing. The upper end of this range came from various individuals in the glassmaking business who estimated costs to be $45 to $60.[61] The lower end of the range comes from the weighted average of separate prices for the raw material inputs themselves. That is, 70% sand at $20-$30 per ton, 15% soda ash at $115-$140,12% limestone at $20-$25, and 3% other materials at $150-$200 results in a batch cost per ton of $38 to $51.[62]

The differences among the sources in these estimates of virgin batch cost could be due to variations in the exact batch mix being quoted, as well as differences in time period, since price estimates are for various years 1987 through 1992. For purposes of comparing costs of recycled versus virgin materials, batch cost for 100% virgin inputs is estimated to be $55, based on conversations with Seattle and Portland glass container manufacturers.

For recycled cullet, Fibres International estimates that their costs to purchase, process, and deliver clean cullet to Ball Incon include the following:

Recycled Glass Color	Flint	Amber	Green
Purchase Price	$33-40	$33-40	$0-10
Processing Costs*	10-15	10-15	10-15
Other Costs**	10	10	10
TOTAL	$53-65	$53-65	$20-35

*Processing costs include labor, power, equipment repair and depreciation.
**Other costs include land, building, and inventory.

Fibres' purchase prices for recycled glass containers had dropped by the end of the third quarter of 1992 to $33 for flint and amber and $0 for green. Up until then they had paid $40 for flint and amber, and $10 for green.

During 1992, Ball Incon in Seattle bought cullet from Fibres International for between $50 and $60 per ton, for all colors. But by the end of the year Ball Incon stopped taking all the green cullet that Fibres produced. Fibres International then had to ship green cullet to a glass market in California at a price, net of transportation costs, of $10 to $15 per ton.

Owens-Brockway, on the other hand, paid $40 for flint, $20 for amber and $10 for green during 1992. However, they do their own benefication, while Ball Incon relies on Fibres to prepare furnace ready cullet.

Cost estimates for furnace ready cullet used in Table B-1 for comparison with virgin materials cost are $55 per ton for flint and amber, and $33.75 for green. These

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[61] Roger Hecht, Bassichis Company estimated $45-$50; Fred Spicer, Ball Incon, Seattle, estimated $55-$60; and Ron Sprague, Owens-Brockway, Portland, estimated $55 per ton of input material.

[62] These material costs represent ranges based on data from personal communications with Fred Spicer, Plant Engineer, Ball Incon-Seattle; text of a speech given by Roger Hecht, Bassichis Company, at First National Symposium on Recycled Glass, Los Angeles, CA, June, 1991; and 1987 U.S. Census of Manufacturers, Industry Series 3221, Glass Containers, Table 7. All price quotes were adjusted as necessary to represent prices F.O.B. Seattle.

costs are based on Ball Incon's purchase costs for flint and amber cullet. The discounted purchase cost for green is intended to reflect excess supply conditions as they developed during 1992. Even though Ball Incon paid $50 to $60 for green cullet purchased from Fibres throughout 1992, by the end of the year they had stopped taking a significant portion of Fibres green cullet. Given low market prices for green cullet, Ball Incon could have taken advantage of the opportunity for significant cost savings in their purchases of green cullet.

Recycle America's average selling price for recycled glass during 1992 was $24 per ton. However, the price for green cullet fell dramatically between January and December of 1992. By the end of 1992, Recycle America was selling flint and amber to Fibres International at $33 per ton and green at $0. For recycled glass that can be color sorted, Recycle America's average distribution is about 50% flint, 30% amber and 20% green. However, a significant portion of the glass Recycle America collects curbside ends up as mixed color cullet which cannot be color sorted. Mixed color cullet has little to no market value at the present time. As an example of how low prices for recycled glass and high amounts of mixed color cullet can interact to depress average revenue, Recycle America in December sold 17.1% flint, 10.3% amber, 17% green and 55.7% mixed-color for an average of just $9 per ton, at $33 per ton for flint and amber and $0 for green and mixed. This $9 average price, however, may have been partially caused by Recycle America selling inventoried mixed color cullet in December that had been stockpiled earlier in 1992.

There are many material costs in addition to batch cost that are incurred in glass container manufacture. The 1987 U.S. Census of Manufacturers data for the glass container industry shows that batch mix material inputs, both virgin and recycled, accounted for only 33% of all materials consumed. Other material input categories include paperboard boxes and containers (32%), plastic film and sheet (3%), industrial molds (4%), and other unspecified materials (28%). However, these other material input costs are mostly independent of a company's choice of recycled versus virgin batch mix materials for glass container manufacturing.

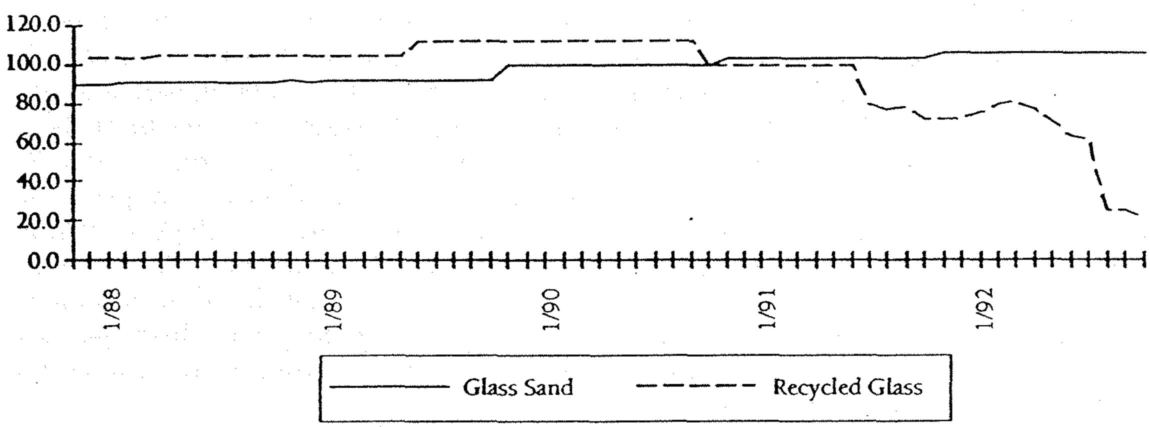
Historical Prices: Cullet vs. Sand

Figure B-2, **Recycled and Virgin Materials Price Indices (1988-1992), Recycled Glass Cullet and Glass Sand**, shows a monthly price index (base December 1990 = 100) for recycled glass cullet sold by Recycle America out of their Seattle MRF. The graph indicates that glass recycled in Seattle had a stable market price until the last half of 1991. Then recycled glass prices began a sharp plunge to a level at the end of 1992 only one fourth as high as they were in 1990. While prices for flint and amber have declined since 1991, it is mainly the lack of value for green cullet and mixed color cullet that caused the precipitous drop in prices at Recycle America's MRF. Furthermore, their practice of storing mixed color cullet until buyers can be found means that any particular month's average revenue per ton can be adversely impacted by large shipments of low value cullet.

Figure B-2 also shows a monthly price index (base December 1990 = 100) for sand used in glassmaking. Because sand comprises about 70% of the batch mix of virgin materials used in glassmaking, price movements in sand provide a strong indicator for changes in the cost of virgin materials used to manufacture glass containers. As shown on Figure B-2, glass sand prices exhibited a slight upward trend during the period from 1988 through 1992.

During 1992 glass cullet was cheaper than virgin materials for manufacturing new glass containers. Based on recent price decreases for recycled glass and the likelihood that the supply of recycled glass will continue to increase in the Northwest, one would expect recycled glass to remain cheaper than virgin materials for glassmaking throughout the next few years.

Figure B-2
Recycled and Virgin Materials Price Indices (1988-1992)
Recycled Glass and Glass Sand



Sources: 1) U.S. Dept. of Labor, Bureau of Labor Statistics, *Producer Price Indexes*
2) Seattle Solid Waste Utility data on prices received for materials recycled through Northend curbside program

12/90=100

Cost of Glass Container Production

Besides actual prices paid for material inputs, operational costs also vary depending on the level of recycled cullet versus virgin materials. A major operational difference is in energy use. Cullet melts at a lower temperature than the virgin materials for which it substitutes, so less energy is consumed in gas furnace glassmaking. One estimate is that energy savings range from $3 to $10 per ton, depending on utility rates. Pacific Northwest utility rates are generally below national averages, so this savings in Seattle would be about $5 per ton. However, actual energy savings in Ball Incon's electric furnace glassmaking process may be less than savings attained in a gas furnace when recycled cullet is substituted for virgin raw material, due to difficulties involved in using more than a limited amount of recycled content in electric furnace glassmaking.

Owens-Brockway in Portland stated that their plant saves 2.5% to 3% on energy costs for each 10% increase in cullet usage above a baseline of 20%. Owens-Brockway uses gas furnaces, as do most glass container manufacturers in the U.S.

Other operational differences include longer furnace life, both because of lower temperature required to melt cullet versus sand, soda ash and limestone, and because of higher throughput.

Offsetting these operational cost savings associated with using recycled cullet is a higher rejection rate for finished containers due to incorporation of metallic or ceramic contaminants in glass containers made from post-consumer recycled cullet. Automated non-ferrous metal detection during benefication can substantially reduce non-ferrous contamination for those benefication operations such as Owens-Brockway in Portland that have invested in this type of equipment. However, ceramic contamination remains a significant problem, leading to lower pack rates for finished recycled-content versus virgin-content glass containers. For example, Owens-Brockway estimates that, on an ongoing basis, 2% or 3% more recycled-content glass containers are rejected during quality inspection of finished product than would be rejected if only virgin materials were used.

Ball Incon and Owens-Brockway manufacture a wide range of products for sale to the food and beverage industry. Estimates of the average prices for these products can be derived from the 1987 U.S. Census of Manufacturers, which provides product type data for the glass container industry. In 1987, the industry shipped 4.78 billion dollars worth of goods. The total number of units shipped was 279 million gross, or 40.1 billion units. Several sources use 0.5 lb. per container as an average unit weight. Applying this conversion factor, total shipments in 1987 weighed approximately 10.03 million tons and were valued at an average of $477 per ton.

A separate estimate was given by Ron Sprague of Owens-Brockway. Their plant in Portland is a "general line" factory, which makes a range of products representative of the industry as a whole. Mr. Sprague calculated average value for all products sold to be $440 per ton in 1992.

The color distribution of finished products for the industry as a whole is estimated to be 67% flint, 25% amber, and 8% green.[63] The distribution of Owens-Brockway's Portland plant products in 1992 was 50% flint, 30% amber, and 20% green.

Comparison – Recycled vs. Virgin Costs

Table B-1, **Manufacturing System: Glass Containers**, shows relative recycled glass and virgin materials costs, benefication costs (including any gain or loss from buying recycled glass from a MRF and selling furnace-ready cullet to a glass container manufacturer), and sales value for glass containers. As shown on Table B-1, cost per ton for furnace-ready flint or amber cullet in 1992 averaged about $55, about the same as for virgin materials. On the other hand, green cullet was substantially cheaper at $34 per ton, in part due to the current excess supply. In addition to recycled versus virgin materials cost, there are numerous engineering considerations to take into account in determining the appropriate level of post-consumer cullet to use in glassmaking. For example, increased post-consumer cullet use increases the potential for contamination, which can cause structural weakness as well as cosmetic flaws. This may increase reject rates and/or decrease throughput, which obviously has a negative economic impact.

As shown in the top portion of Table B-1, revenue from selling a ton of glass containers, regardless of color or recycled versus virgin content, is estimated to have averaged about $440 in 1992. After deducting for cost of materials required to make one ton of glass containers, virgin glassmakers had $376 to cover other material and energy costs, as well as contribute to value added. Using recycled flint or amber cullet increases the net available to pay these other costs and contribute profit to $384 per ton. Using green glass cullet leaves over $400 from sales revenue free to cover other costs and contribute profit.

[63] Phone conversation with Chaz Miller, National Solid Wastes Management Association.

Table B-1. MANUFACTURING SYSTEM: GLASS CONTAINERS (1992)

	Recycled vs. Virgin Materials Cost (Per Ton Finished Product)				
	Recycled Flint/Amber Cullet	Recycled Green Cullet	Virgin	Recycled Materials Cost Difference Flint/Amber	Recycled Materials Cost Difference Green
FACTORS/PRICES					
Cost of Material (Per ton)					
Virgin Batch Mix			$55		
Beneficated Cullet	$55	$34		$0	$21
Tons of Material (Per ton of finished product)	1.03	1.03	1.17		
Cost of Materials (Per ton of finished product)	$56	$35	$64	$8	$30
COST STRUCTURE					
Glass Containers Price	$440	$440	$440	$0	$0
Materials Cost (Incl.Transportation)					
Crushed Glass from MRF	$37	$5			
Benefication (cullet)*	$19	$29			
Total Materials Cost	$56	$35	$64	$8	$30
Net Available for Manufacturing, Profit, etc.	$384	$405	$376	$8	$30

	Recycled vs. Virgin Materials Cost (Per Ton of Recycled Material or Equivalent)				
	Recycled Flint/Amber Cullet	Recycled Green Cullet	Virgin	Recycled Materials Cost Difference Flint/Amber	Recycled Materials Cost Difference Green
FACTORS					
Benefication Yield (Per ton of crushed glass from MRF)	0.98	0.98			
Yield of Finished Product (Per ton of beneficated or virgin materials)	0.98	0.98	0.86		
Virgin Material Equivalent (Of one ton of recycled material)			1.11		
COST STRUCTURE					
Glass Containers Value	$418	$418	$418	$0	$0
Materials Cost (Incl.Transportation)					
Crushed Glass from MRF	$37	$5			
Benefication (cullet)*	$17	$28			
Total Materials Cost	$54	$33	$61	$7	$28
Net Available for Manufacturing, Profit, etc.	$365	$385	$357	$7	$28

* Includes actual benefication costs plus gain or loss from selling furnace-ready cullet.

The top and bottom parts of Table B-1 differ in that the top portion reflects costs on the basis of one ton of manufactured glass containers, while the bottom part represents costs on the basis of one ton of recycled glass sold from the MRF. The cost figures in the top and bottom parts of Table B-1 are different because one ton of recycled glass does not yield one ton of marketable new glass containers. Although recycled glass leaving the typical MRF is relatively clean, the benefication process still sorts out 2% to 3% contaminants. Even then containers are produced that don't pass product quality inspection. Owens-Brockway in Portland estimates their manufacturing reject rate is from 2% to 3% higher than if the plant used 100% virgin materials. More thorough benefication can lower these reject rates for finished glass containers.

Based on a benefication loss of 2.5% and a reject rate for finished containers of another 2.5%, a ton of recycled glass that is shipped from a MRF in 1992 would produce about $418 worth of new marketable glass containers, as shown in the bottom part of Table B-1. Because of the 15% to 17% fusion loss in melting virgin materials to manufacture glass containers, about 1.11 tons of virgin materials must be purchased to produce $418 worth of new containers. Measuring material costs on the basis of MRF output, then, recycled flint or amber cullet costs about $7 per ton less than virgin materials, and green cullet about $28 less. Thus, material cost savings from using recycled instead of virgin materials for glassmaking is essentially the same, whether measured per ton of finished glass containers or per ton of recycled glass sold at a MRF. Whichever way material cost savings are measured, if the glassmaker uses gas fired furnaces additional savings may accrue due to needing less energy to melt cullet versus virgin batch mix materials.

C. High Density Polyethylene (HDPE) Plastic Bottles

1. Recycling Overview

A majority of high density polyethylene (HDPE) containers collected by recycling programs in Washington state are exported. However, a significant number also are reprocessed in the region, i.e., cleaned, sorted, ground, and perhaps pelletized. Northwest reprocessors for post consumer HDPE in Washington include Interstate Plastic Inc. and Partek in Vancouver, The Molen Company Inc. and Northwest Plastics in Kent, Sepco in Spokane. Denton Plastics Inc. in Portland, OR regrinds post consumer HDPE. Merlin in Vancouver, B.C. is another reprocessor for HDPE in the Northwest.

Pelletized HDPE is marketed nationally to manufacturers that extrude film for merchandise and grocery bags, blow-mold containers for non-food products, injection-mold recycling and compost bins, extrude pipe, and injection-mold sign posts and sign blanks. FDA consideration and approval for post-consumer HDPE in food-grade applications is expected by 1995, according to some reports.

The Society for the Plastics Industry (SPI) developed the coding system widely used to label plastic packaging materials. The SPI code system was voluntarily adopted by the majority of plastic container manufacturers. SPI's system labels all HDPE containers with code number 2.

Since adoption of the SPI codes, however, it has become apparent in certain instances that the codes do not meet many of the needs of reprocessors and end users of post-consumer plastics. The main difficulty is that the coding system lacks sufficient detail to adequately sort and identify various sub-categories within particular code numbers. For example, the two basic types of HDPE plastic are extruded grades and injection grades. The latter types of HDPE have a much higher melt index than extrusion grade HDPE. That is, the injection grades become liquid more readily and are much less stiff than extrusion grades.

Blow-molding is a specific form of extrusion. Blow-molded containers are narrow-necked products such as milk jugs and detergent bottles. As a result of their differences in melt index, blow-molded containers cannot provide much recycled-content for injection-molded products. With processing equipment modifications and/or use of blending additives, recycled blow-molded HDPE can be blended with injection grade in concentrations up to 10 or 20%. Otherwise the injection molding equipment becomes clogged with sticky and stiff extrusion grade HDPE. Blow-molded HDPE containers can be remanufactured into extruded products such as HDPE grocery and general merchandise bags or subsequent generations of blow-molded containers.

Injection-molded containers typically are wide-mouthed products such as yogurt and margarine containers. Injection-molded containers cannot be recycled into blow-molded bottles. The high melt index of injection grade HDPE can cause the bottle bubble to break in the manufacture of blow-molded containers.

Injection-molded HDPE containers, as well as extruded film grade HDPE bags, are post-consumer HDPE materials that have much less recycling infrastructure in place than exists for blow-molded milk jugs and other blow-molded containers. Plastics processing presently is done by hand, and separating non-HDPE plastics from HDPE films or injection-molded containers is much more time consuming. A worker sorting blow-molded HDPE does not have to pick up every milk jug and look for the

SPI code number on the bottom to be sure that a milk jug is number 2. However a sorting line worker processing HDPE bags or injection-molded containers would have to handle virtually every item and check its code to do a thorough job of separating out items with codes other than 2.

For these reasons, the form of HDPE that is most widely recovered is blow-molded containers, especially natural colored milk jugs. The highest prices are paid for natural blow-molded containers, and one of the most profitable uses of this type of recycled HDPE at present is to manufacture grocery bags, merchandise bags and other general film extrusion products. Thus, the economic analysis in this report for recycled versus virgin HDPE concentrates on recycled natural HDPE used to manufacture HDPE grocery and general merchandise bags.

2 HDPE Bag Market

Production and Feedstocks

The two basic types of plastics are thermosetting plastics and thermoplastics. Thermosetting plastics are cured or hardened into a permanent shape from which they cannot be remelted to a liquid flowable state. Thermoplastics, on the other hand, do not cure or set, and so can be remelted and rehardened a number of times.

Thermosets are used primarily in durable goods and account for less than 20% of U.S. plastics sales. Thermoplastics account for over 80% of plastics sales, including most packaging uses. Packaging uses account for about one quarter of all plastics sales.

There are a number of polymers that are used in plastic packaging products, but seven account for over 90% of plastic packaging products. These seven, in order of packaging sales, are HDPE, low density polyethylene (LDPE), polystyrene (PS), linear low density polyethylene (LLDPE), polypropylene (PP), polyethylene terephthalate (PET), and polyvinyl chloride (PVC).

Crude oil and natural gas are the basic raw materials for plastics production. Ethane and propane are the main hydrocarbons from natural gas processing that are used to manufacture plastics. Crude oil refining provides liquified petroleum gases (LPG – propane and butane), naptha, and gas oil. In turn, ethane, propane, LPG, naptha, and gas oil are processed into organic chemicals used as plastic feedstocks – ethylene, propylene, benzene, and paraxylene. The manufacture of PET, PS or PVC requires further processing of these plastic feedstocks. PVC also requires chlorine, a feedstock not manufactured from petrochemicals.

The manufacture of plastics, polymerization, involves linking individual molecules, monomers, into molecular chains of the same monomer. Additives can be mixed in before, during or after polymerization to give the polymer specific qualities such as flame resistance, flexibility, color or resistance to ultraviolet light degradation. Compounding is the term used when additives are mixed in after polymerization. After compounding the resultant plastic resin is formed into a final product through extrusion, including blow molding, or injection molding. Some additives can be used even during formation of the packaging product.

Virgin Materials

HDPE is polymerized from the monomer ethylene at relatively low pressure, 300 to 700 pounds per square inch (psi), and at a relatively low temperature of about 200 degrees Fahrenheit. Virgin HDPE is marketed in pellets which can then be purchased by a container manufacturer for use in their production process.

Recycled Materials

Recycled HDPE that has been reprocessed and extruded into pellets competes with virgin pellets. The risk for the purchaser of recycled HDPE pellets is in not knowing the degree of resin purity: whether the pellets are extruded from 100% blow-molded HDPE containers, 100% injection-molded HDPE containers, other plastic containers, or a mixture; and the degree of contamination with other materials, e.g., aluminum neck rings or paper labels. Tests for various forms of contamination exist, but they are time consuming and expensive.

Furthermore, resin manufacturers spend a great deal of time and money differentiating their resins from one another on the basis of such characteristics as glossiness, rigidity, or processability. Recycled resin can not help but be a blend of all these properties without being able to claim consistent attainment of any particular one.

Materials Prices

Despite the existence of published prices for clean, flaked recycled HDPE, no practical market exists for flake. Flake is too variable in size and is neither as homogeneous nor as clean as recycled HDPE that has been extruded into pellets. The processing steps for converting baled HDPE bottles from a MRF into pelletized HDPE are unbaling/sorting, grinding, washing/drying, and extruding/pelletizing. Pellets are also the form in which virgin HDPE is sold, so pelletized recycled HDPE is a direct substitute for these virgin pellets in manufacturing merchandise and grocery bags.

Table C-1, Manufacturing System: HDPE Bags, shows the $195 per ton price Recycle America received for recycled natural colored HDPE bottles processed through its MRF into bales and sold during 1992.

Table C-1. MANUFACTURING SYSTEM: HDPE BAGS (1992 averages)

	Recycled vs. Virgin Materials Cost (Per Pound Finished Product)		
FACTORS/PRICES	Recycled Materials	Virgin Materials	Recycled Materials Cost Difference
Cost of Material (Per pound of pellets)	$0.34	$0.34	$0.00
Pounds of Material (Per pound of product)	1.00	1.00	
Cost of Materials (Per pound of product)	$0.34	$0.34	$0.00
COST STRUCTURE			
HDPE Bag Price	$1.00	$1.00	$0.00
Materials Cost (Excl.Transportation)			
Baled Jugs	$0.10		
Cleaning/Flaking	$0.14		
Pelletizing*	$0.10		
Total Materials Cost (Pellets)	$0.34	$0.34	$0.00
Net Available for Manufacturing, Profit, etc.	$0.66	$0.66	$0.00

	Recycled vs. Virgin Materials Cost (Per Ton of Recycled Material or Equivalent)		
FACTORS	Recycled Materials	Virgin Materials	Recycled Materials Cost Difference
Yield of Finished Product (Per ton of pellets)	1.00	1.00	
Yield of Pellets (Per ton of baled HDPE milk jugs)	0.96		
Virgin Material Equivalent (Of one ton of recycled material)		0.96	
COST STRUCTURE			
HDPE Bag Value	$1,920	$1,920	$0
Materials Cost (Excl.Transportation)			
Baled Jugs	$195		
Cleaning/Flaking	$269		
Pelletizing*	$195		
Total Materials Cost	$659	$653	($6)
Net Available for Manufacturing, Profit, etc.	$1,261	$1,267	($6)

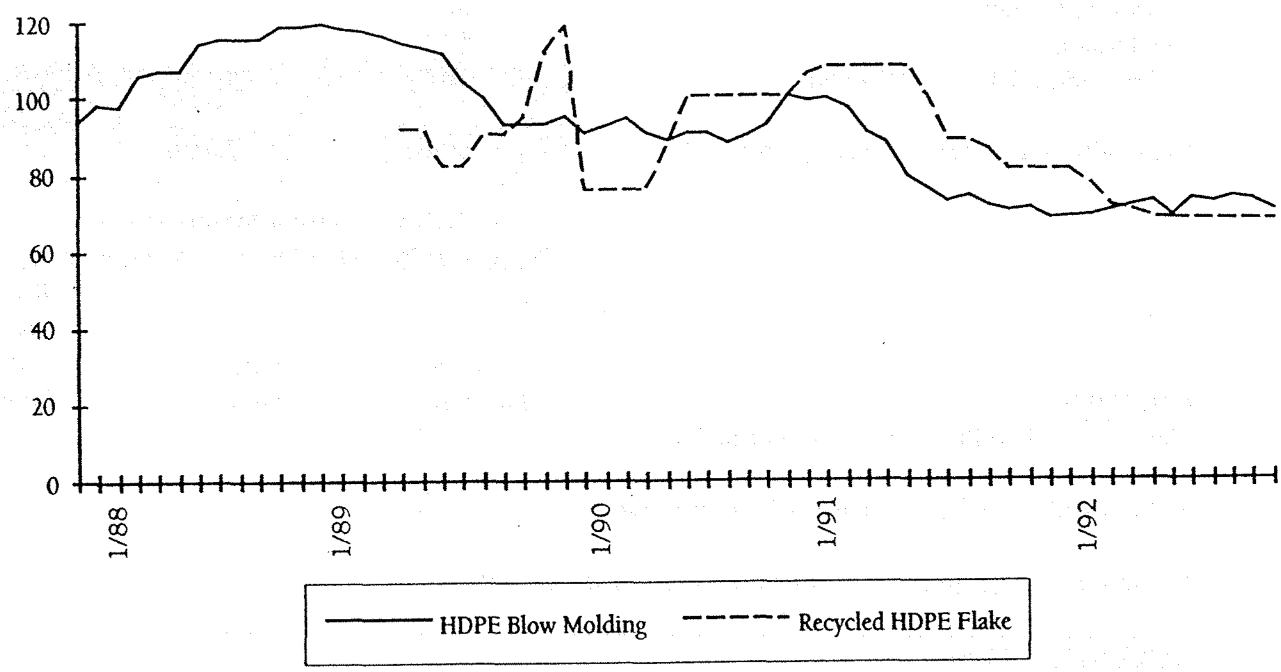
* Includes actual pelletizing costs, as well as gain or loss from buying baled jugs and selling pellets.

Historical Prices: Milk Jugs vs. HDPE

Figure B-3, **Recycled and Virgin Materials Price Indices (1988-1992), Recycled Natural Flake and Virgin Blow Molding Grade HDPE** shows a monthly price index (base December 1990 = 100) for natural colored recycled HDPE (i.e., mainly milk jugs) that has been cleaned and ground into flake. Price data for pelletized recycled HDPE is not available for as long a period, but, as will be seen on Figure B-4 discussed below, recycled flake and pellet prices move together. Thus, price movements portrayed in the graph for recycled natural flake on Figure B-3 would be similar to movements in recycled-content HDPE pellet prices.

Figure B-3 also shows a monthly price index (base December 1990 = 100) for virgin HDPE blow molding grade resin for the period 1988 through 1992. The price indices for recycled and virgin HDPE are strikingly similar, and indicate the extent to which recycled HDPE prices probably follow virgin prices.

Figure B-3
Recycled and Virgin Materials Price Indices (1988-1992)
Recycled Natural Flake and Virgin Blow Molding Grade HDPE

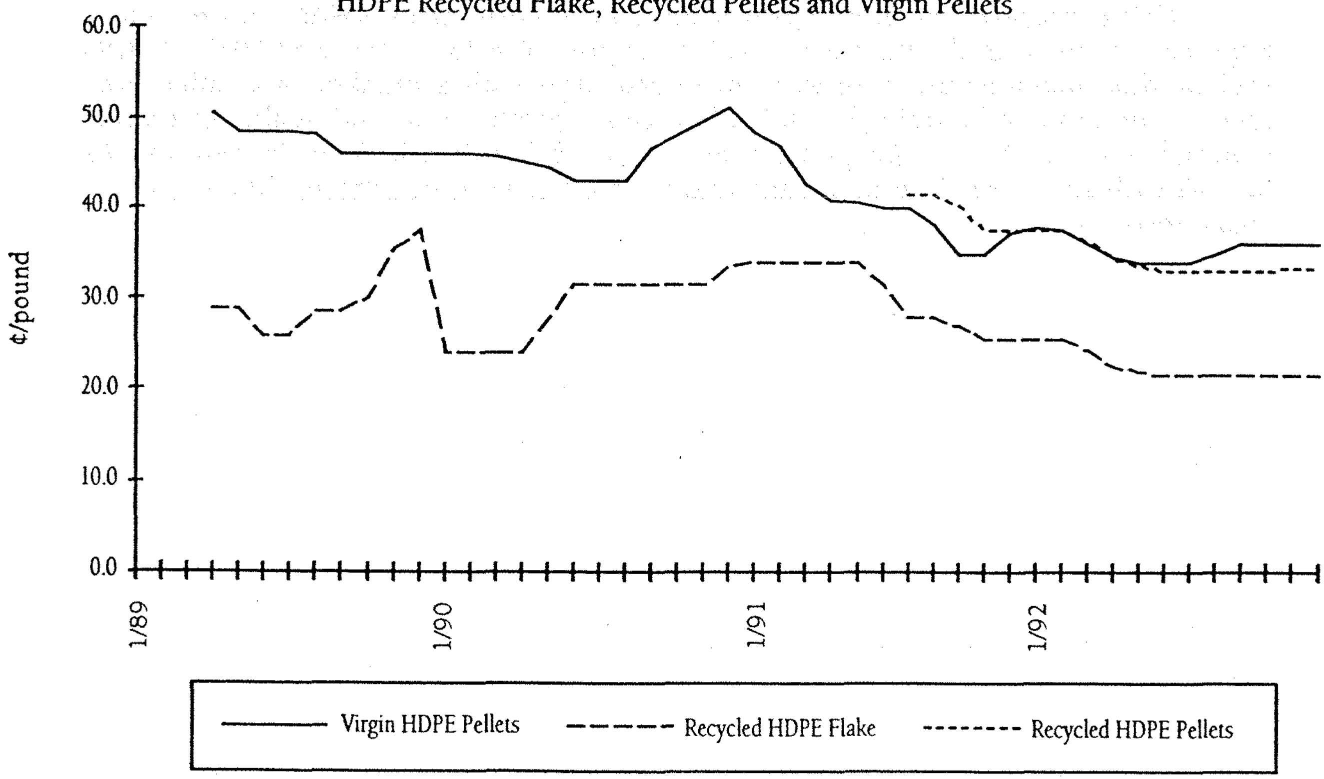


Source: 1) U.S. Dept. of Labor, Bureau of Labor Statistics, *Producer Price Indexes* 12/90=100
2) *Plastic News*

Figure B-4, **Recycled Vs. Virgin Materials Prices (1989-1992), HDPE Recycled Flake, Recycled Pellets and Virgin Pellets** shows absolute prices for recycled natural HDPE flake and pellets, as well as virgin HDPE pellets. As indicated by the graph, recycled flake and pellet prices appear to follow movements in virgin pellet prices. Furthermore, recycled pellets have tended to be priced at almost the same level as virgin pellets during the year and a half ending December 1992.

Recycled and virgin HDPE materials cost for manufacturing plastic bags were within 1% of each other during 1992. Based on the relatively stable relationship between recycled and virgin HDPE prices exhibited on Figures B-3 and B-4, one would not expect recycled HDPE to be available at prices significantly below virgin HDPE prices in the near future. In fact, the downward trend in virgin prices shown on both graphs suggests that recycled HDPE will be hard pressed to remain competitive with virgin grade HDPE in the next few years. Recently constructed capacity for manufacturing virgin HDPE resin will also continue to exert downward pressure on both recycled and virgin HDPE prices.

Figure B-4
Recycled and Virgin Materials Prices (1989-1992)
HDPE Recycled Flake, Recycled Pellets and Virgin Pellets



Source: *Plastic News*

Cost of HDPE Bag Production

In 1992 sorting, grinding, washing and pelletizing a baled ton of recycled HDPE milk jugs at a reprocessor upgraded the value of the ton to $659. About 4% of ton, or 80 pounds, is lost due to contaminants such as caps and labels which are sorted out during reprocessing. The market price in 1992 for natural color recycled HDPE in pellet form averaged $0.343 per pound, or $686 per ton. Thus, the 96% of a ton of pellets produced from a bale of recycled HDPE milk jugs was worth $659.

At an average estimated 1992 price of $1.00 per pound for HDPE merchandise and grocery bags, the 1,920 pounds of pellets are worth $1,920 when remanufactured into HDPE bags.

Comparisons – Recycled vs. Virgin Costs

By comparison, virgin pellets cost about $0.34 per pound in 1992, or $680 per ton, and produced an estimated average of $2,000 in revenue when manufactured into merchandise bags.[64] The virgin pellet user had a margin of 66% to cover other material costs as well as valued added costs and value added profit. The recycled pellet user had a margin of just under 66%. Thus, as shown at the bottom of Table C-1, recycled- and virgin-content HDPE bag producers had materials costs that differed by only $6 per ton, with the virgin producer enjoying the slight cost advantage.

Using recycled entails higher transaction costs than using virgin pellets. Reprocessors must deal with many small generators of bales of recycled HDPE bottles. End product manufacturers, in turn, must also deal with a number of smaller firms, each of whom must be trained to provide precise specifications and quality of recycled material desired. The virgin pellet user, on the other hand, buys in railroad car quantities from a virgin resin manufacture who can be quite precise about product characteristics.

[64] Prices for recycled and virgin pellets are from *Plastics News*; prices for HDPE bags are based on information from both buyers and sellers. HDPE bags sell in the price range from $0.80 to $1.50 per pound, with $1.00 as an estimated average price. Contaminant estimate of 3% to 5% in bales of recycled HDPE bottles is based on conversations with Caroline Rennie, Marketing Manager, Envirothene.

D. Polyethylene Terephthalate (PET) Plastic Bottles

1. Recycling Overview

Most PET collected for recycling in Washington state is marketed by O'Neill and Company through their plant in Tacoma. O'Neill ships the consolidated PET containers to Pacific Rim export markets, South Carolina, Agra in Edmonton, Alberta, and until recently, Sepco in Spokane. Northwest Container Corporation in Tumwater, WA is a large end user of recycled food grade PET, which is at present being purchased from out-of-state PET reprocessors.

SPI's code system labels all PET containers with code number 1.

The main manufacturing use for recycled PET containers has been in producing polyester fiber for use in carpets, insulation and other polyester fiber applications. PET that has been cleaned and ground is often shipped to California or the Southeast for remanufacture. However, recent FDA approval for both Coca Cola and Pepsi Cola to use repolymerized post-consumer PET in their beverage bottles provides a substantial opportunity for firms that repolymerize PET, as well as a new market for collectors and reprocessors of PET containers. Hoechst Celanese Fibers and Film Group in Charlotte, NC is currently the main producer of repolymerized PET resin. Other firms are expected to enter the market, e.g., Eastman Chemical Company recently began repolymerizing PET in Kingsport, TN. Entry of new firms and use of new processing, pelletizing and repolymerization technologies could improve the economics of recycled PET beverage bottle manufacturing. Decreased cost for repolymerized PET could in turn increase recycled content levels in beverage containers beyond their current level of 20% to 30%..

Most virgin PET is used for beverage bottles, but a substantial amount is also used for bottles and wide-mouthed jars containing cosmetics, toiletries, pharmaceuticals and foods. Unlike HDPE, PET narrow-necked bottles and wide-mouthed containers can be reprocessed and remanufactured together. However, at present PET bottles containers cannot be recycled with film plastics made from PET, PET containers with handles, PET plastics items such as microwave trays, or PET cups that are made from sheeting that contains nesting agents to allow the cups to be separated after stacking. Repolymerization, on the other hand, may be a more forgiving technology and allow mixing of some of these other types of PET with recycled PET beverage containers.

2. Polyester Fiber Market

The general process for manufacturing plastic packaging materials was described in the technology review for HDPE production. Only those unique aspects of PET polymerization and package forming are discussed in the following section.

Production and Feedstocks

Virgin Materials

PET is polymerized from the monomer bis(2-hydroxethyl) terephthalate (BHET), which itself is produced from ethylene glycol and dimethyl terephthalate (DMT) or terephthalic acid (TPA). Manufacture of PET is, thus, a two step process, requiring esterification of BHET from ethylene glycol and either DMT or TPA. If DMT is the feedstock, methanol is a byproduct of the esterification process.

BHET is then fed through polycondensation reactors to polymerize PET. The PET can then be extruded into chips, or else turned into fiber by means of fiber spinnerets.

Recycled materials

The technology for recycling PET into products such as polyester carpet fiber involves remelting clean, flaked PET. More demanding applications such as bottle forming require recycled PET that has been extruded into pellet form.

The particular quality of the PET polymer is often defined by its intrinsic viscosity (IV). By one account, after about six recycling cycles PET loses enough IV and suffers enough stress cracking to require depolymerization. This methanolysis process is currently quite expensive and results in pellets priced at $0.08 per pound above virgin.[65]

Materials Prices

Recycle America received $320 per ton at their MRF for baled PET bottles recycled from the Northend Seattle program in 1992. Johnson Controls has been paying a guaranteed $0.16 per pound for recycled PET for a few years, but that price support is being discontinued gradually throughout 1993. Without that price support recycled PET would have sold in the range $0.06 to $0.10 per pound based on prices reported during 1992 in *Recycling Times*. The midpoint of this price range, $0.08, is used in Table D-1 to compare the materials cost of manufacturing carpet fiber from recycled versus virgin PET.

Historical Prices: Pop bottles vs. PET

Figure B-5, **Recycled and Virgin Materials Price Indices (1989-1992), Recycled Clear Bottle Flake and Virgin PET Pellets** shows a monthly price index (base December 1990 = 100) for recycled clear PET bottles that have been cleaned and ground into flake. Price data for pelletized recycled PET is not available for as long a period, but, as will be seen on Figure B-6 discussed below, recycled flake and pellet prices move together. Thus, price movements portrayed in the graph for recycled PET flake on Figure B-5 would be similar to movements in recycled-content PET pellet prices.

Figure B-5 also shows a monthly price index (base December 1990 = 100) for virgin-content PET pellets during the period 1989 through 1992. The price indices for recycled and virgin PET are very similar, and indicate the extent to which recycled PET prices appear to follow virgin prices.

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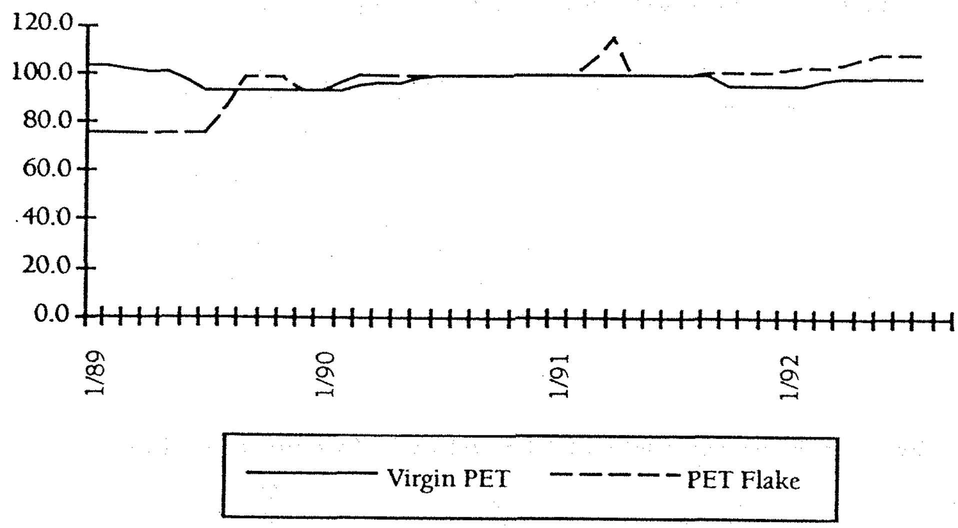
[65] Phone conversation 02/11/93 with Floyd Flexon, Director, Governmental Relations & Environmental Affairs, Johnson Controls.

Figure B-5
Recycled and Virgin Materials Price Indices (1989-1992)
Recycled Clear Bottle Flake and Virgin PET Pellets

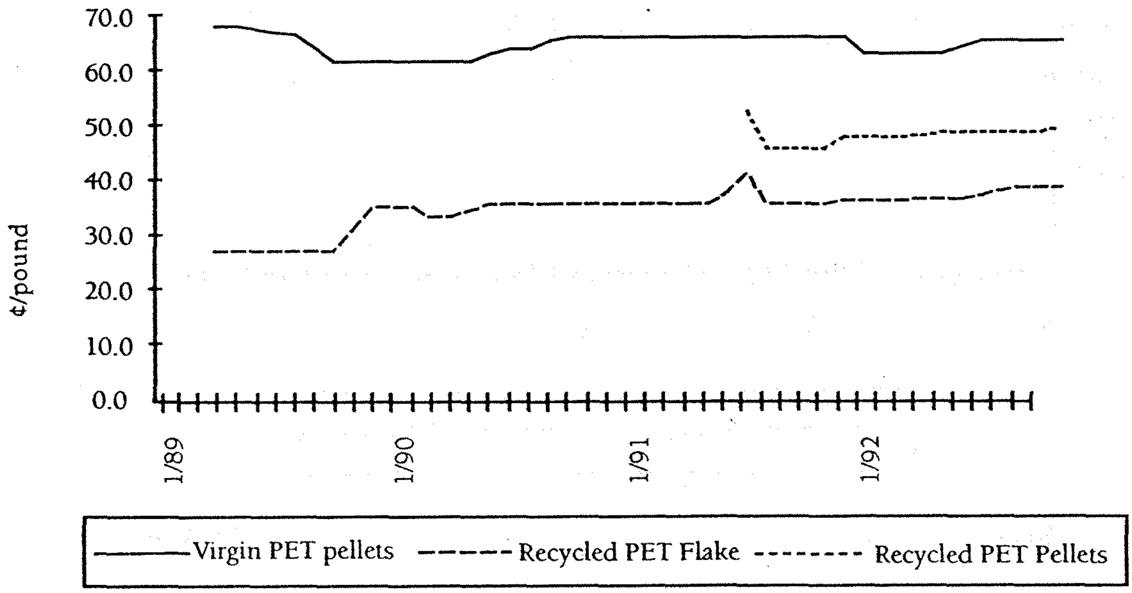


Source: *Plastic News* 12/90=100

Figure B-6, **Recycled Vs. Virgin Materials Prices (1989-1992), PET Recycled Flake, Recycled Pellets and Virgin Pellets** shows absolute prices for recycled clear PET bottle flake and pellets, as well as virgin PET pellets. As indicated by the graph, recycled flake and pellet prices and virgin pellet prices have quite similar patterns over time, probably because recycled prices follow virgin prices and the differential between recycled flake and pellets reflects the relatively constant cost of producing extruded pellets from flake. Furthermore, recycled pellets have been priced $0.16 to $0.20 cents per pound below virgin pellets during the approximately year and a half ending December 1992 for which recycled and virgin pellet prices are available.

Figure B-6, thus, indicates that recycled PET prices provide a margin versus virgin PET prices which does not exist for recycled versus virgin HDPE. This margin can provide support for the manufacturer that wants to switch to using recycled PET and needs some protection from potential increased costs due to buying materials from many suppliers, none of whom can certify the exact specifications of their recycled PET as precisely as a virgin PET supplier.

Figure B-6
Recycled and Virgin Materials Prices (1989-1992)
PET Recycled Flake, Recycled Pellets and Virgin Pellets



Source: *Plastic News*

Cost of Polyester Fiber Production

For use in polyester fiber production, baled PET bottles must be upgraded through cleaning and grinding into flake at a reprocessor. In 1992 flaked post consumer PET sold for an average of $0.37 per pound for clear, and $0.295 for green color bottles.

Comparison – Recycled vs. Virgin Costs

Virgin grade PET in pellet form sold in 1992 for $0.65 per pound. Non-integrated producers of polyester fiber would have had to pay $0.65 per pound to buy virgin PET for processing into fiber. Of course the integrated manufacturer that polymerized PET directly into fiber would save the costs involved in pelletizing virgin PET and then turning it back into fiber. According to one source, the cost of virgin PET fiber feedstock for making polyester fiber is just $0.40 per pound.

Based on this cost of virgin fiber feedstock for an integrated polyester fiber manufacturer, recycled clear flake at $0.37 per pound and green at $0.295 provide a substantially cheaper feedstock for manufacturing carpet fiber.

Table D-1. MANUFACTURING SYSTEM: POLYESTER CARPET FIBER (1992 averages)

	Recycled vs. Virgin Materials Cost (Per Pound Finished Product)				
				Recycled Materials Cost Difference	
FACTORS/PRICES	Recycled Clear	Recycled Green	Virgin Materials	Clear	Green
Cost of Material (Per pound)					
Virgin Fiber			$0.40		
Recycled Flake	$0.37	$0.30		$0.03	$0.11
Pounds of Material (Per pound of product)	1.00	1.00	1.00		
Cost of Materials (Per pound of product)	$0.37	$0.30	$0.40	$0.03	$0.11
COST STRUCTURE					
Polyester Fiber Price	$0.70	$0.70	$0.70	$0.00	$0.00
Materials Cost (Excl.Transportation)					
Baled Bottles	$0.11	$0.11			
Cleaning/Flaking*	$0.26	$0.19			
Total Materials Cost	$0.37	$0.30	$0.40	$0.03	$0.11
Net Available for Manufacturing, Profit, etc.	$0.33	$0.41	$0.30	$0.03	$0.11

	Recycled vs. Virgin Materials Cost (Per Ton of Recycled Material or Equivalent)				
				Recycled Materials Cost Difference	
FACTORS	Recycled Clear	Recycled Green	Virgin Materials	Clear	Green
PET Flake Yield (Per ton for baled PET bottles)	0.75	0.75			
Yield of Finished Product (Per ton of flake/pellet)	1.00	1.00	1.00		
Virgin Material Equivalent (Of one ton of recycled material)			0.75		
COST STRUCTURE					
Polyester Fiber Value	$1,050	$1,050	$1,050	$0	$0
Materials Cost (Excl.Transportation)					
Baled Jugs	$160	$160			
Cleaning/Flaking*	$395	$283			
Total Materials Cost	$555	$443	$600	$45	$158
Net Available for Manufacturing, Profit, etc.	$495	$607	$450	$45	$158

* Includes costs of cleaning and flaking baled PET bottles, revenue from selling polypropelene caps and HDPE based cups, plus gain or loss from buying baled bottles and selling flake.

3. Two Liter Pop Bottle Market

Production and Feedstocks

Virgin Materials

The general process for polymerizing PET was covered in the discussion of the polyester fiber market for recycled PET bottles. Once PET is polymerized from virgin materials it can be injection molded into pre-forms or "slugs" for marketing to beverage bottlers. Many bottling operations that fill PET bottles with their product, also blow mold the bottles themselves from these slugs. One source at Containers Northwest estimated that two liter bottle slugs cost $98 to $106 per thousand.[66] Given that a two liter PET bottle weighs about two ounces, this is a cost of $0.78 to $0.85 per pound. By comparison virgin bottle-grade PET pellets sold for $0.65 per pound in 1992.

Recycled materials

Demanding applications for PET, such as bottle forming, require recycled PET material that has been extruded into pellet form. In addition, to remanufacture recycled PET into beverage containers, the recycled material must be repolymerized. As discussed in the coverage on the PET polyester fiber market, methanolysis is currently quite expensive and results in pellets priced at $0.08 per pound above virgin. Given a price for clear virgin pellets of $0.65 per pound, repolymerized recycled PET would cost about $0.73 per pound in pellet form. This compares with an average price in 1992 for recycled clear PET pellets of $0.482, and a price for clear recycled flake of $0.37 per pound.

Assuming that turning recycled pellets into slugs requires the same $0.13 to $0.20 margin as exists for virgin slugs versus virgin pellets, repolymerized recycled PET slugs would cost $0.86 to $0.93 per pound, with a midpoint in this range being $0.895. The cost for recycled PET slugs used to make 100% recycled-content two liter pop bottles used in the calculations for Table D-2 is, thus, $0.895 per pound.

Materials Prices

Table D-2 shows the estimated $160 per ton, or $0.08 per pound, unsubsidized price paid for baled PET bottles recycled in 1992. Virgin grade PET in pellet form sold in 1992 for $0.65 per pound, and pop bottle slugs are estimated to have cost on average about $0.815 per pound.

Cost of Two Liter Pop Bottle Production

For use in producing two liter pop bottles, baled recycled PET bottles must be upgraded through cleaning and grinding into flake, pelletization, repolymerization and injection molding into bottle slugs. The cleaning and flaking stage results in discarding or reselling about 25% by weight of each incoming bale due to contaminants, labels, HDPE base cups, neck rings, caps and other materials that are

[66] Phone conversation with Mel White, Containers Northwest, March 1993.

not bottle-grade PET.[67] There is also a 2% to 3% loss when PET flake is extruded into pellets.

In 1992 flaked post consumer clear PET sold for an average of $0.37 per pound, and clear recycled pellets sold for $0.482. Repolymerized PET pellets cost an estimated $0.73 per pound, and the bottle slugs produced from repolymerized PET are estimated to cost $0.895. Subtracting these prices for recycled PET between successive stages of processing gives the estimated costs (including profit or loss) shown in Table D-2 for the four processing steps necessary to remanufacture PET bottles into two liter pop bottles – cleaning/flaking the bales of recycled PET bottles, pelletization, re-polymerization, and bottle slug production.

Comparison – Recycled vs. Virgin Costs

Table D-2 shows that in 1992, two liter pop bottles manufactured from 100% recycled PET would have an additional materials cost of about $117 per ton of recycled PET bottles than using 100% virgin material to produce an equivalent quantity of two liter bottles. However, one source at Johnson Controls estimated that recycled-content PET pop bottles would sell for about $1.61 per pound (per eight bottles weighing two ounces each), versus $1.60 for virgin bottles.[68] This price advantage offsets some of the input materials cost differential.

Due to the extra cost of repolymerized recycled PET compared with virgin, two liter bottles at present have only about 25% recycled-content. The figures in Table D-2 compare 100% recycled-content with 100% virgin-content bottles, and show a 100% recycled-content bottle costing $0.01 more than a 100% virgin-content bottle (at 8 two liter bottles to the pound). A 25% recycled-content bottle would have only 25% of the materials cost disadvantage shown in Table D-2, i.e., about $0.0025 per two liter soda bottle.

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[67] In the Northwest HDPE base cups on PET beverage bottles are becoming less common as use of one-piece PET bottles increases. Recovery rates for PET from baled bottles, thus, may improve from current 75% levels. A base cup accounts for about 25% of the weight of two liter soda bottles. Of course, single serving size beverage bottles have no base cup and have always accounted for a significant portion of recycled PET bottles.

[68] Phone conversation with Chuck Breithaupt, Johnson Controls, Tacoma, March 1993.

Table D-2. MANUFACTURING SYSTEM: TWO LITER POP BOTTLES (1992 averages)

	Recycled vs. Virgin Materials Cost (Per Pound Finished Product)		
FACTORS/PRICES	Recycled Clear	Virgin Materials	Materials Cost Difference
Cost of Material (Per pound for bottle slugs)	$0.90	$0.82	($0.08)
Pounds of Material (Per pound of product)	1.00	1.00	
Cost of Materials (Per pound of product)	$0.90	$0.82	($0.08)
COST STRUCTURE			
Two Liter Pop Bottle Price (Per pound)	$1.61	$1.60	$0.01
Materials Cost (Excl.Transportation)			
Baled Bottles	$0.11		
Cleaning/Flaking*	$0.27		
Pelletizing**	$0.10		
Repolymerization	$0.25		
Slug Production	$0.17		
Total Materials Cost	$0.90	$0.82	($0.08)
Net Available for Manufacturing, Profit, etc.	$0.72	$0.79	($0.07)

	Recycled vs. Virgin Materials Cost (Per Ton of Recycled Material or Equivalent)		
FACTORS	Recycled Clear	Virgin Materials	Recycled Materials Cost Difference
Pet Flake Yield (Per ton of baled PET bottles)	0.75		
Pellet Yield (Per ton recycled flake)	0.98		
Virgin Material Equivalent (Of one ton of recycled material)		0.73	
COST STRUCTURE			
Two Liter Pop Bottle Price	$2,355	$2,340	$15
Materials Cost (Excl.Transportation)			
Baled Bottles	$160		
Cleaning/Flaking*	$395		
Pelletizing**	$150		
Repolymerization	$363		
Slug Production	$241		
Total Materials Cost	$1,309	$1,192	($117)
Net Available for Manufacturing, Profit, etc.	$1,046	$1,148	($102)

* Includes costs of cleaning and flaking baled PET bottles, revenue from selling polypropelene caps and HDPE based cups, plus gain or loss from buying baled bottles and selling flake.

**Includes actual pelletizing costs, as well as gain or loss from buying flake and selling pellets.

E. Yard Waste

1. Composting Overview

Yard waste collected for processing and composting in Washington state is generally delivered to a composting site that is relatively close to the community where the material is collected. Before, during or after the composting process, yard waste can be mixed with a wide variety of other organic materials, such as soil, mushroom compost, bark dust, sawdust, animal manures, sewage sludge, or food waste.

Residential use of compost from yard waste as a soil conditioner and mulch is probably the single largest market for the material at present in Washington state. Landscaping contractors and institutional uses such as for landscaping roadsides or public buildings are other markets for yard debris compost.

2. Residential Soil Conditioner Market

Yard waste is somewhat different than the other recycled materials discussed in this report in that after processing and composting it is ready for marketing as an end-use product. This section, thus, discusses prices at which yard waste compost and some competing soil conditioners are sold. These comparative prices determine the competitiveness of yard waste compost versus more conventional, sometimes virgin-resource-based, soil conditioners. Some information on yard waste processing and composting costs is also reported.

Prices (Cost) for Compost and Competing Materials

Compost is typically sold by the cubic yard. Compost from Seattle's curbside collected yard waste is sold wholesale in bulk by Cedar Grove for $8.00 per cubic yard; retail for $10.00 per yard. Quantity discounts are available at Cedar Grove on a bid basis or for large volume customers (price breaks are at 1,000 and 5,000 yards). Delivered orders over 10 cubic yards also get a price break. Discounts can be as high as 25%, and discounted orders account for a large proportion of sales. Cedar Grove yard waste compost is also sold in bags at many retail grocery or garden stores.

Iddings Recycling sells a compost made from yard waste, horse manure and stall shavings, food waste and paper pulp from Boeing at $12.95. Sawdust Supply sells compost made from sawdust and sewage sludge, its GroCo brand, at $12.95. Pacific Topsoil sells its Pacific Garden mulch at $10.00 per cubic yard.

Prices during 1988-89 for fir bark or hemlock bark were $11 to $12, and yard debris compost was sold at $8.80 and $10.00 at two compost and bark dealers in the Portland, Oregon area.[69] Comparable prices for peat are somewhat difficult to obtain due to wide variations in the weight of peat sold in a cubic yard, but prices probably range from $15 up.

[69]Metropolitan Service District and Northwest Economic Associates, "An Estimate of the Processing and Market Capacity for Yard Debris Compost Products in the Portland Metro Area," December, 1989.

Based on this cursory examination of the prices for pure yard waste compost, a variety of compost blends, and virgin materials such as bark and peat, yard waste compost is sold at a price that is competitive in existing markets.

Cost of Yard Waste Compost Production

Facilities that compost yard waste are reluctant to disclose their processing costs. Based on a variety of sources, processing and composting costs for yard waste collected by residential curbside programs are in the range of $15 to $35 per ton of yard debris collected. Because a ton of yard waste produces about a cubic yard of yard waste compost, input tons and output cubic yards are approximately equal units for measuring compost facility throughput. Based on yard waste compost selling in the range $8 to $10 per cubic yard, approximately $7 to $25 of the costs of composting each ton of collected yard waste are not covered by market revenues.

Processing contract fees and tipping fees at a variety of facilities accepting yard waste confirm these net cost data. For example, Seattle pays Cedar Grove $12.50 per ton of yard debris delivered from its curbside collection in that part of the city that lies north of Yesler Avenue. On the other hand, Cedar Grove charges a tipping fee of $26.50 per ton for mixed yard debris delivered by other collectors or private parties.

Valley Topsoil charges $8.50 per cubic yard for mixed yard debris, which converts to $34 per ton, using a density of 500 pounds per cubic yard. Iddings charges $4.50 per cubic yard ($18 per ton), while Pacific Topsoil charges $10 ($40 per ton). MaFarlane's in Portland charges a tipping fee of $35 per ton.

King County currently has four permitted private sector composting operations. Competition among these composters may be driving the price for yard waste processing down. A recent King County contract for yard waste processing received bids in the range of $14.90 to $20.67 per ton. A recent low bid received by Tacoma from a King County processor was $13.75 per ton. By contrast, Snohomish County received bids in 1992 to process its yard waste into compost that varied from a low of $19 or $20 per ton from Bassett Western and Cedar Grove to a high of $65 from Pacific Topsoils.

On the other hand, Pierce County has a publicly owned yard waste composting facility that is privately operated by LRI. Pierce County pays $28 per ton of yard waste it delivers to the facility. LRI keeps the first $4 of revenue from each ton of yard waste compost it sells, and shares equally with the County any revenue in excess of $4 per ton.

Comparison – Recycled vs. Virgin Costs

Market prices for yard waste compost are competitive with other products that can be used as residential soil amendments. But just as many recycled materials do not sell for prices that cover all the costs of preparing them for use in manufacturing, yard waste compost does not sell for enough to cover its processing and composting costs. Based on market price, processing cost and tipping fee data, from 50% to 75% of the costs of composting yard waste cannot be covered by its present price. In addition, none of the costs of collecting yard debris from residences and delivering it to a processing and composting site are covered by the market price for yard waste compost.

5. MATERIALS AND PRODUCTION COSTS: SUMMARY AND OUTLOOK

This chapter draws conclusions from data in Chapter 4 on prices and costs of recycled materials use, developing any generalizations that emerge from the commodity markets and materials uses examined. Promising market trends and barriers to increased use of recycled feedstocks are also enumerated

A. Materials and Production Summary

This section highlights the main conclusions that can be drawn from investigating recycled versus virgin materials prices and costs for four recycled materials used to manufacture five products, and for yard waste used to produce a compost for application as a residential soil conditioner.

1. Manufacturing Use

Chapter 3 examined the use of four recycled materials in the manufacture of five products -- newspapers in newsprint, glass containers in new glass containers, PET bottles in carpet fiber, PET bottles in new two liter soda bottles, and HDPE milk jugs in plastic bags. A few generalizations can be drawn from the markets and products examined for these four recycled materials.

• **Prices for virgin materials appear to set a loose upper limit in feedstock markets for recycled materials prices.** Manufacturing with recycled material feedstocks entails certain risks in terms of material contamination and variability in production characteristics that are not encountered when using virgin feedstocks. Also, suppliers of recycled materials tend to operate at a smaller scale than virgin material producers. The manufacturer using recycled feedstocks, thus, in general must arrange to purchase these materials from more suppliers and accept greater uncertainty than would be the case if using virgin materials. For these reasons, manufacturers are reluctant to pay a premium to use recycled materials as feedstocks.

Among the recycled materials and manufactured products investigated for this report the only exception to this general rule was in the case of recycled-content PET soda bottles. Repolymerization of recycled PET results in bottle manufacturing preforms (or slugs) that cost substantially more than 100% virgin preforms.

• **Prices for recycled content products vary little, if at all, from prices for virgin content products.** In newsprint there appears to be no price difference, although one source did suggest that 100% recycled-content newsprint was sometimes sold at a slight discount from 100% virgin-content. New glass containers are sold at a market price that is apparently the same regardless of the amount of recycled content. The market for polyester carpet fiber does not appear to care whether the fiber is recycled or virgin. One source did suggest that two liter PET soda bottles with recycled content sell at a small price premium, about 0.5%, versus 100% virgin-content bottles, to cover a portion of the extra costs involved in repolymerizing recycled PET for use with food or beverage contact. Finally, while HDPE plastic bags have widely variable market prices depending on the purchaser's requirements for shape, printing and order quantity, no evidence was found that recycled-content bags are being sold at a discount or premium versus virgin-content HDPE bags.

• **Even when manufacturing with recycled materials is cheaper, producers may not switch from virgin materials if it means investing in new recycled materials handling equipment and abandoning virgin production capacity.** This is especially true in times of slow growth in demand for a product.

• **Purchase of recycled or virgin feedstocks for manufacturing products required between 8% and 57% of final product revenues**. The low end 8% is for green glass cullet used to manufacture glass containers. Due to supply exceeding demand at present in the Northwest, recycled green glass prices have recently fallen to zero. Manufacturers can buy green cullet at a price that need only cover costs of processing recycled glass from a MRF into furnace-ready cullet. For flint and amber cullet, or for virgin glassmaking materials, feedstock costs require in the neighborhood of 15% of revenue obtained by selling new glass containers.

Feedstocks for making newsprint cost nearly 20% of newsprint revenue in 1992 in the case of recycled newspapers, and nearer to 25% for Douglas fir woodchips. Recycled and virgin HDPE feedstocks in plastic bag manufacturing required nearly 35% of product revenue to cover their purchase cost.

The highest feedstock costs relative to product revenues were for recycled and virgin PET feedstocks. Recycled PET flake required between 42% and 53% of carpet fiber revenue, for green and clear recycled flake respectively. Virgin flake, on the other hand, would use 57% of carpet fiber sales revenue. In two liter soda bottle production, 100% recycled-content preforms would require 56% of revenue from selling two liter bottles, while 100% virgin-content preforms would need about 51% to cover their purchase costs.

2. Compost

As in manufacturing feedstock markets, virgin materials such as peat or bark appear to set an upper bound for the price of compost and mulch made from recycled yard waste. In Seattle average processing costs to clean and prepare recycled materials for market were almost covered by average revenues from their sale as manufacturing feedstocks. By contrast, **costs of cleaning and composting yard waste are two to four times the price at which compost is sold in the metropolitan Seattle area.** Thus, a dramatic increase in market prices is needed to make yard waste compost self supporting and allow municipalities to stop paying composters to take yard waste.

B Outlook for Use of Recycled Materials

This section describes promising market trends and important barriers to increased use of recycled materials in manufacturing and other productive end uses.

1. ONP

A number of factors suggest continued success in recycling old newspapers into productive uses in the coming years.

• **Increasing recovery rate:** Since 1980, national ONP recovery rates have almost doubled, increasing from 29% to 52%.[70] In Oregon and Washington recovery rates are now close to 60%. Analysts believe recovery rates as high as 65% to 80% may eventually be possible.[71]

• **Increasing newsprint deinking capacity, enough to balance new supply:** By 1995, the annual consumption of old newspapers by U.S. and Canadian newsprint mills is predicted to increase by 3 million tons or 55% over the 5.4 million tons consumed in 1991.[72] If capacity to use ONP in newsprint continues to expand at its current pace of 600,000 tons of new deinking capacity per year, total deinking capacity will probably be capable of using new supply through the end of 1995, without any progress in other market sectors.[73]

• **Increasing use in other products:** In 1991, less than one third of recycled ONP went into newsprint.[74] Most ONP was used to make products such as paperboard, insulation, tissue and, increasingly, animal bedding. While newsprint will consume a greater overall percentage of ONP in the future, other uses also will probably consume greater volumes.

• **Increasing ONP utilization rate in newsprint:** The utilization rate for ONP in newsprint manufacture is rising. At 25% in 1988, utilization is projected to rise to 37% in 1995, and then to 45% in 2000.[75]

• **Continuing relative strength of Northwest market.** West Coast market prices for ONP continue to be relatively strong in comparison to other regions of the country as a result of proximity to major export markets and a rapid increase in recycled newspaper use by local manufacturers.

• **Advancing technology:** Newsprint manufacturers have achieved a number of equipment breakthroughs which facilitate the switch to recycled fiber. For example, more development in deinking technology has occurred in the last few years than in the previous history of paper recycling.

• **Increasing domestic newsprint production:** Demand for recycled-content newsprint is promoting greater U.S. domestic newsprint production. In 1947, 80% of U.S. newsprint consumed in the U.S. came from Canada; in 1992 only about 50% came from Canada.[76]

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[70]"Paper—Foundation Of Waste Reduction," *The Biocycle Guide to Maximum Recycling*, edited by the staff of BioCycle, The JG Press, Inc., Emmaus, Pennsylvania, 1993, p. 194 (8).

[71]Apothecker, Steve, "Market trends for old newspapers" *Resource Recycling*, Vol. XI, No. 7, (July 92) p. 25 (9).

[72]Iannazi, Fred D. and Strauss, Richard, Changing markets for recycled paper," *Resource Recycling*, Vol. XI, No. 4, (Apr 92) p. 81 (12).

[73]Apothecker, op. cit.

[74]"Paper—Foundation Of Waste Reduction," *The Biocycle Guide to Maximum Recycling*, edited by the staff of BioCycle, The JG Press, Inc., Emmaus, Pennsylvania, 1993, p. 194 (8).

[75]Ince, Peter J. and Alig, Joanne T., "Waste paper recycling and the future timber market" *Resource Recycling*, Vol. XI, No. 4, (Apr 92) p. 123 (8).

[76]Apothecker, op. cit

However, there are still significant barriers and challenges to use of ONP in manufacturing.

- **Increasing importance of quality:** To maintain newsprint quality, higher rates of ONP utilization in newsprint will cause increased attention to cleanliness and consistency of ONP supplies. Efficiency of cleaning technologies must increase as utilization rates increase.[77] Some mills have begun to accept only source separated ONP or only sorted material in loose form.
- **Stalling of market price increases:** While the recovery rate for ONP improved, its market prices have not yet recovered from their fall after peaking in early 1988. Cheap and abundant supplies of virgin fiber, decreased newspaper advertising, and falling exports contributed to the stall in price recovery. Recently installed deinking operations have brought some increase in demand and prices for No. 8 Deinking News to Northwest producers. Other regions have not seen as great an impact, however. Demand for No. 6 News appears to remain weak, even in the Northwest.
- **Increasing shipping distances:** New deinking mills, concentrated in the Northwest, South and East, have to source much of their ONP from suppliers hundreds of miles away.[78] To reduce transport costs, railroads are expected to provide shipment from regions with excess ONP supply to regions such as the Northwest which have excess demand.
- **Flooding in export markets:** Wastepaper exports declined in 1992 for the first time in a decade due to growing volumes of recovered paper from European countries and decreased demand in Pacific Rim countries brought about by the world-wide recession.[79] Slow exports continue into 1993, with export prices reaching the lowest some West coast marketers have seen.

2 Glass Cullet

A number of factors suggest continued success in recycling glass food and beverage containers into manufacture of new glass containers as well as other productive uses.

- **Increasing utilization of cullet by container industry:** The proportion of cullet (including both plant scrap and post-consumer recycled glass) used in manufacturing container glass increased from 25% in 1989 to 33% in 1992. With batches averaging about 60% recycled content, the Owens-Brockway plant in Portland is a leader in manufacturing glass containers from recycled cullet.[80]
- **Increasing demand through legislative action:** New laws may help alleviate cullet gluts. For example, California now recycles more glass containers. due to legislation mandating recycled content for glass containers and fiberglass on the demand side, and container redemption price support legislation (AB2020) on the supply side. Local glass processors have shipped green glass to California where green cullet now fetches higher prices than in the Northwest.

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[77]Ibid.

[78]Iannazi, and Strauss, op. cit.

[79]Miller, Chaz, "Europeans Flooding Asian Waste Paper Markets," *Recycling Times*, Vol. 5, No. 9, may 4, 93).

[80]"New Uses for Glass Cullet, op. cit.

• **Improving alternative markets:** Feasibility is being demonstrated for use of recycled glass cullet in asphalt and unbound construction aggregates. Such applications are increasingly attractive due to drops in the price of cullet. These low-value applications could absorb substantial quantities of cullet on the market in the Northwest.[81] Other applications, such as fiberglass or electromagnetic water filtering, could provide additional markets for cullet conforming to stricter specifications.

• **Finding other solutions for excess supply:** If a wine bottle washing operation were to locate in the state, it could reduce the excess supply of green glass 25%. Encore!, which operates in Richmond, California and annually washes nine million bottles for reuse, could provide a model.[82]

• **Finding market development opportunities:** The benefication plant operated by Fibres International is scaled for twice the amount of cullet needed by its major customer, Ball Incon. This gives Fibres incentive to seek out and develop new markets for recycled glass.[83]

Significant barriers and challenges still remain to increased use of recycled glass cullet in manufacturing in the Northwest.

• **Continuing downward pressure on prices:** To cover increased costs from shipping cullet to more distant furnaces that can use green and amber glass, processors in excess supply regions have reduced prices paid to collectors of recycled glass

• **Limited export options:** Exporting Washington cullet incurs substantial shipping costs and may not be viable in the long run as collection programs in other states provide more local material. Overseas exports have been, and probably will continue to be, ruled out due to prohibitive shipping costs.[84]

• **Marketing strategies add to green glass oversupply:** Foreign manufacturers continue to export and market beer to the U.S. in green bottles, while packaging the same beer in brown bottles for domestic consumption., Washington and European wineries have begun to switch from green to yellow green ("dead leaf") bottles which can use only 15% green cullet.[85]

• **Local market limits:** While they have increased their cullet use over the last several years, Ball Incon in Seattle is using less recycled content than Owens-Brockway in Portland due to constraints imposed by Ball Incon's electrically heated glassmaking furnaces.[86]

• **Limiting cost pressures:** Faced with substantial competition from makers of lighter, less expensive food and beverage containers, glassmakers are hesitant to add any significant costs to their process. Widespread conversion to color coating or other

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81 Clean Washington Center, [Description of] "Feedstock Study" and phone conversation with Bob Kirby, May, 1993.

82 "New Uses for Glass Cullet, op. cit.

83 C2S2 Group, *Market Assessment for Use of Recycled Tires, Oil, and Glass*, prepared for State of Washington Committee for Recycling Markets and The Department of Trade and Economic Development, (Oct 90).

84 Ibid

85 "New Uses for Glass Cullet, op. cit.

86 "Ibid.

new technologies is unlikely unless the industry finds ways to decrease costs, e.g., by reducing container weight.[87]

3. Recycled HDPE and PET Plastic Bottles

Several general factors will positively impact markets for recycled HDPE and PET bottles.

• **Increasing demand for recycled resins:** Domestic markets for sorted PET bottles and HDPE milk jugs, and to a lesser degree for sorted pigmented HDPE, have grown dramatically in the last five years. Large manufacturers of HDPE plastic, such as Sonoco Graham, have opened new scrap processing plants to satisfy increasing demand for recycled-content bottles for oil and household products. Wellman Inc., the largest PET reclaimer in North America, has substantially expanded its capacity for processing bottles into polyester carpet fiber, blanket fiber and other products. Wellman plans to expand capacity at its South Carolina plant from 1992 processing levels of 110 million pounds per year to 200 million pounds per year by 1994.[88] Other manufacturers such as Image Carpets in Rome, GA, and UltraPac in Minnesota are also producing post consumer recycled-content PET products.

• **Improving color sortation technologies:** Several firms, including Wellman, have developed automated color-sorting systems for PET and HDPE.[89] Some analysts believe that this will allow collection of all PET and HDPE containers in the near future.[90] However, it may be several years before color sorting technologies are efficient enough to be economical in commercial applications.

• **Increasing efficiencies in processing and transporting recycled bottles:** Plastics recyclers and processors have identified a variety of opportunities which could cut the price of post-consumer resin by $.06 to $.08 per pound, allowing it to compete more effectively with virgin resin.[91] Opportunities for greater efficiency include improving automatic sorting techniques and reducing the number of sorts required; flaking and bulk-handling material in or near to the MRF to eliminate extra shipping and transportation steps; using more powerful compacting processes and more efficient loading techniques; increasing shipment of scrap by rail; moving to single-layer bottle construction by using recycled-virgin blends; increasing use of long term contracts between suppliers, processors and manufacturers; and vertically integrating reclamation of materials with production of end products to reduce broker handling and marketing costs. The recycling industry is already on the road to making many of these improvements.[92] However, few firms have implemented more than a few of these improvements.

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[87]Phone conversation with Bob Kirby, Clean Washington Center glass commodity specialist, May, 1993.

[88]Marley, Michael, "Wellman exec dispels plastic recycling myths," *American Metal Market*, v100, n32 (17 Feb 92): p. 8 (2).

[89]Powell, Jerry, "The common recyclable: the growth in plastic bottle recovery," *Resource Recycling*, vol. X, no. 1, (Jan 91), p. 37 (6).

[90]Burnett, Robert, "Moving plastics to the next level," *Resource Recycling*, vol. XI, no. 5, (May 92), p. 136 (2).

[91]Rattray, Tom, "Fixing plastic recycling," *Resource Recycling* (May 93) p. 65 (7).

[92]"Materials handling improvements reduce final cost of reclaimed resin," *Modern Plastics* (May 93) p. 77 (3)

Factors that exert a positive influence specifically on markets for recycled HDPE are, as follows:

• **Growing household product packaging markets:** A national market for recycled HDPE bottles and milk jugs emerged in 1989 when Proctor & Gamble began using post-consumer HDPE to bottle several of their products.[93] Traditional uses such as pipe, plastic lumber, and shower accessories will continue to provide markets for HDPE, but the greatest growth is taking place in household and industrial chemical bottles and plastic bags.[94]

• **Expanding HDPE colored bottle recycling:** Almost 78 million pounds of HDPE were recycled in 1990, over 60% consisting of milk and water bottles.[95] HDPE recycling in some regions is expanding beyond natural colored water and milk jugs to include all forms of HDPE bottles.[96]

Factors that exert a positive influence specifically on markets for recycled PET are, as follows:

• **Expanding and mature infrastructure:** Wellman has been buying scrap PET bottles for fiber production since 1979. The supply of scrap bottles generated by bottle bill legislation in 10 states enabled a national market to develop for post-consumer PET resin by 1990. Expansion of curbside PET bottle collection has further increased the supply of PET bottles available to plastic reprocessors and manufacturers. According to the National Association for Plastic Container Recovery (NAPCOR), 27% of post-consumer PET bottles were recycled in 1992. The number of pounds of PET collected in 1992 increased 28% over 1991. There is also expanding use of PET as a substitute for PVC.

• **Expanding uses for PET bottles:** While fiber markets such as carpet and fiberfill absorb the majority of recycled PET, household products and food and beverage containers are using an increasing portion. As an example of new PET recycling endeavors, Procter & Gamble is test marketing 100% recycled-content PET bottles for Spic and Span and using 20-30% recycled-content bottles for Tide and other laundry products. Possibly the most significant development occurred in 1991 when the FDA accepted the safety of newly developed PET repolymerization technologies for use in manufacturing recycled-content packaging for foods and beverages.[97] In addition, multi-layer PET containers have also been approved for use with food contact. Multi-layer bottles eventually will be cheaper to manufacture than repolymerized PET bottles, but at present technology does not exist to produce them as quickly as existing single-layer bottles can be produced. The FDA's acceptance of the repolymerization technology allowed Pepsi Cola and Coca Cola to begin making and selling 25% recycled-content PET bottles in several states. By 1992, a dozen

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[93]The Matrix Management Group, et. al, *Plastics Recycling in Washington and the Northwest: An Assessment of Market Opportunities*, prepared for The Washington State Committee for Recycling Markets (1990).

[94]Glenn, Jim, "An industry shapes up for recycled plastics," *Resource Recycling*, vX, n1 (Jan 91): p. 38 (6).

[95]"Processing and Marketing Plastic, "*The BioCycle Guide to Maximum Recycling*, edited by the staff of BioCycle, The JG Press, Inc. Emmaus, Pennsylvania (1993).

[96]Glenn, Jim, "An industry shapes up for recycled plastics," *Resource Recycling*, vX, n1 (Jan 91): p. 38 (6).

[97]Powell, Jerry, "The ups and downs in bottle-to-bottle plastics recycling," *Resource Recycling*, vol. XI, no. 5, (May 92), p. 98 (6).

manufacturers and bottlers were involved in PET scrap regeneration into bottles and thermoformed food applications such as fruit trays and pie and cake packaging materials. Twenty percent of Coke bottles nationwide now contain scrap resin.

The FDA's acceptance of PET packaging containing post-consumer content holds promise for Northwest PET markets. A large portion of the otherwise small packaging industry in the Northwest consists of food packagers. Most of the virgin plastic resin consumed by Oregon and Washington manufacturers is used in food applications, with PET bottles and milk jugs being the most common uses.[98]

There still are general barriers and challenges to expanded recycling of HDPE and PET containers.

- **Continuing inefficiencies in materials handling and processing:** Recycled plastic is shipped longer distances and passes through more hands than most other recycled materials. Recycled resin currently costs as much or from $.01 to $.07 per pound more than virgin resin. The major exception is recycled PET that has not been repolymerized. Until costs for most recycled resins come down, only legislation, price supports, or customer mandate will motivate packaging and container manufacturers to expand their use of recycled plastics.[99]
- **Continuing weakness in Northwest markets:** The Northwest's small population and lack of significant packaging and petrochemical industries put the region at a competitive disadvantage in attracting manufacturers which could provide markets for a plastics recycling industry.[100] A few manufacturers, such as Sonoco Products in Yakima, have started to use recycled plastic. But no substantial additions to recycled-content plastics manufacturing capacity are scheduled in the near future.
- **Fluctuating export markets:** In the late 1980s, strong overseas markets and low labor costs motivated West Coast recyclers to ship recycled plastics to China and other Pacific Rim countries. However, export market prices vary with world economic conditions, as well as conditions in the purchasing countries themselves. In 1992 slowdown in the world economy, among other factors, reduced value of plastic scrap exports by about 12% and volume by about 8% from 1991 levels. On the other hand, the low volume of exports vis-a-vis imports through West Coast ports provides shipping cost advantages that allow West Coast exporters to net 3-5 cents more per pound than East Coast counterparts for unpigmented HDPE.

There also are challenges specific to the recycling of HDPE bottles and containers related to the immaturity of HDPE processing and manufacturing markets. Mandatory soft drink container deposit laws in many states helped the collection infrastructure for PET to emerge early, even before curbside programs became prevalent. The infrastructure for HDPE developed later because HDPE recyclers had to rely on drop-off and curbside programs in individual communities, and had to deal with greater contamination problems than were found with containers subject to deposit laws. Also, HDPE bottles originally were not included in many curbside collection programs in Washington state. Now most curbside programs accepting plastic in the Northwest and across the nation are taking both HDPE and PET bottles. However, very few as yet collect injection-molded HDPE containers. Finally, recently

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[98]The Matrix Management Group, et. al, op. cit.

[99]"Materials handling improvements reduce final cost of reclaimed resin," *Modern Plastics* (May 93) p. 77 (3)

[100]The Matrix Management Group, et. al, op. cit.

constructed virgin HDPE capacity worldwide will continue to exert a downward pressure on HDPE resin prices. The scale and lead time for building virgin HDPE manufacturing capacity caused capacity additions to be planned ten years ago when demand outlook for virgin HDPE was good. The worldwide recession was well underway as that capacity has come on line.

Challenges specific to PET bottle recycling include questions about the long-term viability of bottle-to-bottle (closed loop) PET recycling. PET repolymerization technologies are very sensitive to contamination, and regenerated resin is more expensive than virgin resin. In 1992, Eastman Chemical reported that repolymerized PET resin was 25% to 30% more expensive than virgin resin. this translates into as much as $.01 more cost for a bottle with 25% reclaimed plastic. Cost is apparently the principal factor keeping bottlers from manufacturing bottles with greater than 25% recycled content.[101] The multi-layer PET bottle may eventually become commercially viable and eliminate this cost disadvantage versus virgin-content bottles in the U.S., as has already happened in Australia.

In 1993 Johnson Controls began to gradually remove the price support it has provided for recycled PET. The price is scheduled to fall by no more than 25% during each quarter of 1993 until it reaches market levels. Johnson Controls had formerly guaranteed $.16 per pound for bales of clean PET bottles.[102] The price will be 7-8 cents per pound by fall 1993 unless market conditions change unexpectedly. The elimination of the price support will make business more difficult for Northwest PET recyclers, and heighten pressure to find more cost-effective collection and handling systems.

4. Yard Waste Compost

A variety of factors could motivate increasing use of yard waste compost in the coming years.

• **Increasing scarcity of competing products:** High-quality topsoil, which was previously mined, is harder to come by. Whatcom County still has supplies of "virgin" topsoil, but other areas must "manufacture" most of their topsoil. This gives compost producers opportunities to move product into topsoil blends. On the flip side, because high-quality topsoil is in shorter supply, many landscape architects now direct contractors to simply amend the native soils with organic matter.

Compost also competes in the soil products marketplace with peat moss, which is mined from sensitive environmental areas in the northern US and Canada. Laws to provide greater protection for wetland areas will likely cause pressure on peat moss producing regions, increasing their production and marketing costs and possibly reducing total supplies.

Furthermore, compost competes with byproducts of the Northwest forest products industry, such as sawdust, bark, and wood chips. The increasing scarcity of these materials gives compost producers opportunities to develop and market alternative mulch products.

• **Increasing consumer awareness:** State and local efforts to enhance demand for composted products have helped develop awareness of and demand for these

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[101]Powell, Jerry, "The ups and downs in bottle-to-bottle plastics recycling," *Resource Recycling*, vol. XI, no. 5, (May 92), p. 98 (6).

[102]Phone conversation with Ron Grulich, CWC commodity specialist for plastics (May 93).

recycled products by public agencies, commercial users, and the general public. For example, many communities in the Northwest sponsor Master Composter-type programs to educate the public about compost and composting. Though their emphasis is on home composting, Master Composters help instill a general appreciation for compost in all its forms. This message comes from opinion leaders in gardening and horticulture as well. As a result, their readers and audiences hear from the "experts" that compost provides numerous benefits in a wide variety of gardening and landscaping applications.

Two areas of current popular interest in gardening and landscaping involve the use of more sustainable, less chemically dependent forms for fertilization and pest control and the use of drought-tolerant plants. This resurging emphasis on "organic gardening" and saving water means that the soil improvements and moisture-holding capacity provided by compost will be highly prized in years to come.

• **Stimulating use through public sector procurement rules:** Procurement legislation passed by the state legislature mandates increased use of compost and other products made from recycled materials by government agencies at all levels. As an example, the Washington Department of Transportation has responded by sponsoring tests of the use of compost in transportation-related construction and has moved in the direction of including compost in its specifications for soil products.

General barriers and challenges to marketing yard waste compost include:

• **Uncertainty about compost quality and consistency:** All compost products are not the same. Even those made by the same producer can vary slightly over time. This variability among compost products can confuse potential users. Add to the confusion the fact that many compost products are new to the marketplace, and one can begin to understand the barrier of uncertainty that must be overcome gradually through users' experience and education.

• **Process regulation increases costs:** Throughout the late 1980s and early 1990s; compost producers have been dealing with several types of regulations. Particular process-related regulations fall into three major categories:

o General facility and processing standards, including feedstock restrictions.

o Odor regulations.

o Surface and ground water regulations.

The Washington State Department of Ecology (DOE) is in the process of revising compost facility construction and processing standards. The new standards may require greater use of pavings and cover at many types of composting facilities, including those accepting source-separated yard debris.

Odor has been a concern at some composting facilities, particularly those in densely populated areas such as the Puget Sound region. The Puget Sound Air Pollution Control Agency (PSAPCA) regulates fugitive odors from composting facilities as an air quality issue. Responding to complaints from neighbors of some compost facilities, PSAPCA has required facility and process modifications to control odors.

Recently local and state water management agencies have begun investigating potential impacts to surface and ground waters from compost leachates.

The effect of most of the regulations currently proposed or under consideration will be to increase costs at yard waste composting facilities. Most yard waste processors appear convinced that costs will continue to increase in coming years due to various new facility regulations.

• **Product regulation threatens consumer confidence:** There is widespread concern among processors of yard debris and other recycled organic materials that product regulations and standards now under consideration by DOE will have a significant impact on their businesses by making consumers less confident of compost products.

• **Energy prices create competition for wood wastes:** Prices for all major forms of energy are trending upwards. As correspondingly higher prices are paid for hog fuel at any of dozens of facilities around Washington state, there will be increased competition for composting feedstock materials that can be converted to hog fuel. Though land clearing debris, brush, and urban wood waste are imperfect substitutes for many hog fuels, high energy prices could cause these materials to be bid away from compost producers.

6. SUMMARY AND CONCLUSIONS

This chapter provides a brief summary and conclusions based on the extensive data, information and analysis in this report. Manufacturing materials and product cost data are then combined with Seattle's system cost data to estimate the full costs of using a product. The intent is to compare product costs of recycling and manufacturing with recycled materials versus costs of manufacturing with virgin materials and disposing of used products.

A. Recycling vs. Disposal Systems

Curbside recycling is working in the four Washington State communities examined in this report. Recycling costs less per ton than disposal in all four cities. Curbside recycling programs also divert substantial quantities of material from disposal, especially in the three cities that collect mixed waste paper.

In most cities, under either weight- or volume-based cost allocation methods, curbside recycling of specific materials is cost effective versus home collection and disposal of those same materials in refuse.

In Seattle, recycling of mixed paper and HDPE bottles is more expensive than disposal of those two materials when costs are allocated according to collection truck volumes, but not when costs are allocated according to collection weights. All other materials are cheaper to recycle, regardless of the methodology used to allocate total costs to specific materials.

In Spokane recycling glass containers and tin cans is more expensive than collection for disposal when costs are allocated according to material weights. All materials except glass and auto batteries are more expensive to recycle than collect for disposal when material volumes are used to allocate costs. Even aluminum cans lose money in Spokane in this case.

In Bellingham all materials under either cost allocation methodology are cheaper to recycle. However, recycled aluminum cans have a cost advantage versus disposal of less than $1 per ton, the lowest among the recycled materials when cost allocations are volume based. This result is caused by Bellingham's having to pay $36 a ton to deliver commingled metal cans and glass to a local processor.

In Vancouver all materials are cheaper to recycle in the curbside program than they are to collect for disposal, under the assumption that costs should be allocated based on material weights. However, if cost allocations to materials are collection truck volume-based, then only newspapers, glass containers, and tin cans are cheaper to recycle.

These results suggest that extreme caution should be used when making calculations regarding which specific materials are, and which are not, profitable to recycle in an existing curbside recycling program. The real costs of handling specific materials probably depend on a weighted average of weight, volume and other factors such as time required to collect and load each material into the recycling truck. These weights likely will be different for different curbside programs due to variations in containers, truck types, number and type of

materials collected, and degree of commingling versus source or on-route separation.

Rather than using the calculations of material specific recycling costs in this report to determine which materials should be included or excluded from curbside recycling, a more productive use of the information is to note that light, bulky materials such as plastic bottles require a disproportionate share of collection vehicle capacity using current collection methods. This suggests that resources need to be invested in finding more efficient ways to collect and haul these materials, not that they should be removed from recycling programs.

The other major conclusion about recycling systems in the four cities is that recycling system costs appear to be influenced by disposal system costs. Although recycling is cheaper in all cities, the ones with more expensive disposal systems tend to have more expensive recycling systems. Seattle has the least expensive and Spokane the most expensive recycling and disposal systems. Bellingham has the second most expensive disposal system, and third most expensive recycling system. Vancouver has the third most expensive disposal system, and the second most expensive recycling system.

As discussed in Chapter 3, the low cost for recycling and disposal in Seattle cannot be explained by economies of scale in this the largest of the four cities. Seattle's careful management of collection, processing and disposal programs and contracts, its attempt to contract for waste management services of all kinds for a per ton fee rather than on a fixed annual payment basis, and its systems for tracking and analyzing costs for specific programs serving specific classes of waste generators, all seem to provide savings in recycling and disposal system costs.

B. Markets for Recycled vs. Virgin Materials

A major conclusion from examining five materials recycled (or composted in the case of yard waste) into six products is that virgin materials prices establish limits to the prices end users will pay for recycled materials. This should come as no surprise when virgin materials manufacturing has been developed over the course of two centuries in this country. Manufacturing products with recycled materials, on the other hand, has until recently only been of importance in times of national shortages in virgin materials such as during World War II.

Furthermore, for the products examined in this report, recycled-content products typically do not sell at a price premium versus the same products manufactured with virgin materials. There are some exceptions, such as the small price premium allowed on 25% recycled-content two liter PET soda bottles, or the occasional discounting of 100% recycled-content newsprint rumored to exist. But for the most part recycled-content products must sell at prices competitive with virgin-content products. This means that any additional costs incurred by the manufacturer in using recycled versus virgin feedstocks must be covered by savings in other costs or by lower prices for the recycled materials.

Finally, even when recycled materials cost less than virgin feedstocks and other production costs are not increased substantially by using recycled materials, a virgin manufacturer still may not find advantage in substituting recycled for virgin feedstocks. Especially if virgin capacity must be abandoned in favor of expensive new recycled capacity, the virgin manufacturer may choose to wait until product demand requires investment in additional capacity before buying equipment needed to use recycled feedstocks.

C. Costs of Product plus Disposal or Recycling

Prices for manufactured products cover only a portion of their costs. In the case of virgin-content products, disposal costs after products have been used are not included in product prices. These disposal costs are paid by communities, businesses and households through waste management fees and taxes. Similarly, for recycled-content products a portion of the cost of recycled feedstocks - collection costs and often some processing costs - are not covered by the manufacturers' selling price for the product.

This is not to say that prices for feedstock materials or product prices themselves should cover waste management system costs. However, it is instructive to use the data generated in this report to compare system versus materials costs of product use.

This section, thus, provides an estimate of product cost, including costs of managing the product after it has been used, as well as its materials feedstock cost. For recycled-content products these costs include the net cost for curbside recycling plus the price paid by the manufacturer to purchase recovered materials as feedstocks to make new products. For virgin-content products these costs include the price paid to purchase virgin raw material feedstocks plus waste management system costs incurred to dispose of used products.

The task of estimating both waste management and materials costs for a product's use is simplified by the fact that this study focused on products which in most cases are composed of simple material feedstocks. This avoids the complication of allocating waste management system costs to each of a number of waste materials generated when a complex product has been used and thrown in the waste stream. However, any comprehensive method of estimating recycling and disposal system costs for manufactured goods would need to deal with products that generate complex combinations of material wastes.

Furthermore, only costs monetized in current waste management system operations and in markets for feedstock materials are included in product use costs reported herein. For example, external environmental costs are not included in the system or materials cost figures developed for this report.[103] Or, as another example, energy cost differences between using recycled and virgin materials are not included in materials use cost estimates reported in this study, although there is some discussion in the report on energy savings for certain manufacturing operations.[104] Finally, equipment or labor cost differences required when manufacturing with recycled materials are not explicitly included in materials costs. These sorts of costs were

[103]See Tellus Institute, *CSG/Tellus Packaging Study - Assessing the impacts of production and disposal of packaging and policy measures to alter its mix*, for an example of the complexities involved in deriving quantitative cost estimates for external environmental impacts.

[104]See Morris and Canzoneri, "Comparative lifecycle energy analysis: theory and practice," *Resource Recycling*, vXI, n11 (Nov 92), for estimates of energy saved by manufacturing with recycled rather than virgin materials.

discussed on a qualitative basis for each material analyzed in Chapter 4, but reliable quantitative estimates for these other costs could not be developed within the scope of this study.

Product use costs are developed in this section for newsprint, glass containers and two liter PET bottles. In developing system costs for Chapter 2, costs of recycling versus disposal were obtained for old newspapers, used glass containers and used PET bottles. Those data can, thus, be combined with the material feedstocks data from Chapter 4 to estimate product use costs.

On the other hand, this report did not develop disposal costs for HDPE plastic bags and polyester carpet fiber, the other two manufactured products examined in Chapter 4. Recycled content for these products is not provided by closed loop recycling, i.e., by manufacturing the product with its own used product waste. This section, thus, does not provide product use cost estimates for these two products.

Finally, the system costs used in this section to develop an estimate of full product use costs are for Seattle in 1992. Any comprehensive estimate of product use costs would require a more representative calculation for system costs, as well as covering products not amenable to closed loop recycling. The information reported below should, thus, be used mainly for purposes of illustrating the relationships between product cost (price), material feedstock cost and waste management cost.

I. Product Use Costs for Newsprint

Figure C-1, **System, Materials and Product Cost for Newsprint (1992), Recycling Vs. Disposal**, is a bar chart showing the 1992 cost of newsprint, broken down into feedstock material costs and other costs/profit for 100% recycled- versus 100% virgin-content product. Figure C-1 also shows waste management system costs added on top of newsprint's product cost. The left-hand part of the graph shows per ton recycling and disposal system costs based on allocating system costs according to material weight. The right-hand side of the graph shows waste management system costs allocated according to material volume and the NSWMA MRF study.

Figure C-1
System, Materials and Product Cost for Newsprint (1992)
Recycling vs. Disposal

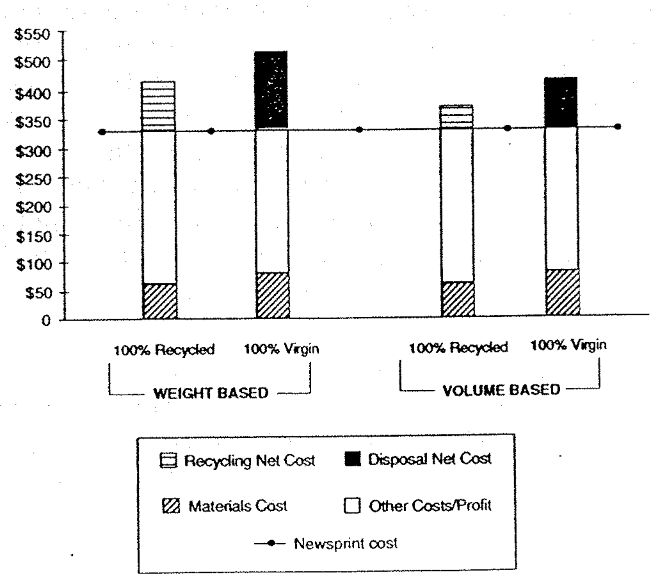


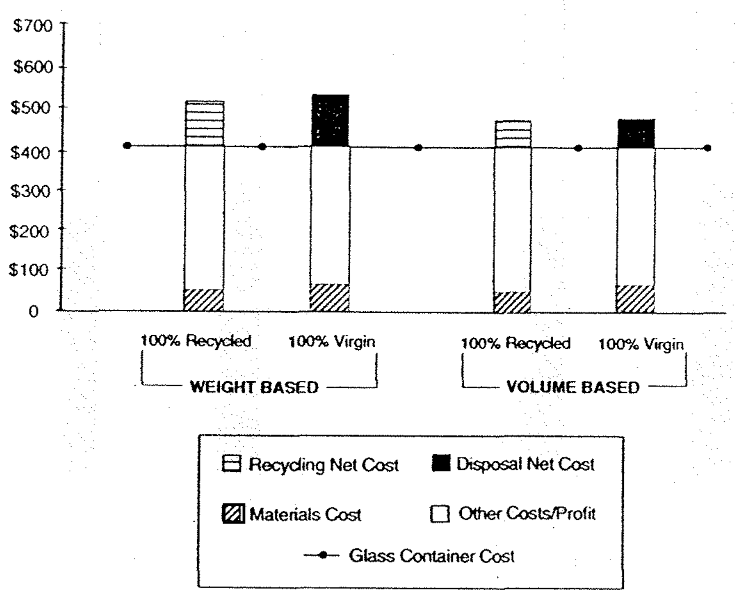
Figure C-1 shows that for newsprint production, recycling and disposal system costs in Seattle are of the same order of magnitude as recycled and virgin material feedstock costs, respectively. Whether system costs are lesser or greater than material costs depends in this case on whether actual system costs are closer to weight-based or volume-based cost estimates.

2 Product Use Costs for Glass Containers

Figure C-2, **System, Materials and Product Cost for Glass Containers (1992), Recycling Vs. Disposal**, is a bar chart showing the 1992 cost of new glass containers, broken down into feedstock material costs and other costs/profit for 100% recycled-versus 100% virgin-content product. Figure C-2 also shows waste management system costs added on top of product cost for glass containers. The left-hand part of the graph shows per ton recycling and disposal system costs based on allocating system costs according to material weight. The right-hand side of the graph shows waste management system costs allocated according to material volume and the NSWMA MRF study. Recycling system and materials costs are for recycled clear or brown glass, not green glass.

Figure C-2 shows that for clear or amber glass container production, recycling and disposal system costs in Seattle are greater than, but of the same order of magnitude as, recycled and virgin material feedstock costs, respectively. How much system costs exceed material costs depends in this case on whether actual system costs are closer to weight-based or volume-based cost estimates.

Figure C-2
System, Materials and Product Cost for Glass Containers (1992)
Recycling vs. Disposal

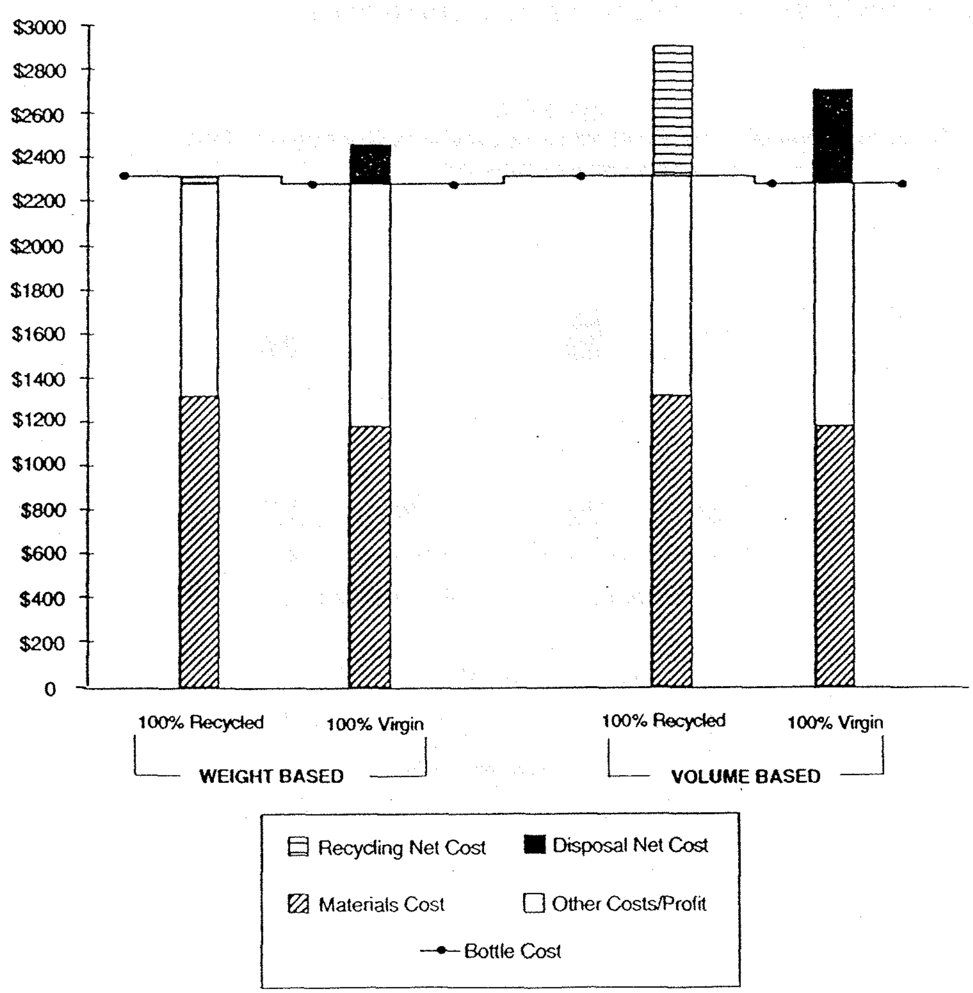


3. Product Use Costs for Two Liter PET Bottles

Figure C-3, **System, Materials and Product Cost for Two Liter PET Bottles (1992), Recycling Vs. Disposal**, is a bar chart showing the 1992 cost of new two liter PET soda bottles, broken down into feedstock material costs and other costs/profit for 100% recycled- versus 100% virgin-content product. Figure C-3 also shows waste management system costs added on top of product cost for PET soda bottles. The left-hand part of the graph shows per ton recycling and disposal system costs based on allocating system costs according to material weight. The right-hand side of the graph shows waste management system costs allocated according to material volume and the NSWMA MRF study.

Figure C-3 shows that for PET bottle production, recycling and disposal system costs in Seattle are substantially less than recycled and virgin material feedstock costs, respectively. In fact, for weight-based costs, recycling system costs in Seattle in 1992 were more than covered by the price received for selling baled PET bottles, even excluding the price support provided by Johnson Controls.

Figure C-3
System, Materials and Product Costs for Two Liter PET Bottles (1992)
Recycling vs. Disposal



Recycled materials costs for two liter soda bottle production include expenditures for cleaning and depolymerization, as well as for producing the preform from which the two liter bottle is eventually extruded. Virgin materials cost include production of the preform as well.

In the case of two liter bottle production, materials costs include essentially all materials preparation costs, as compared with newsprint production where the costs of additional materials processing, such as pulping newspapers or woodchips, were not included. The relationship between materials costs and waste management costs, thus, in some cases is dependent on the amount of materials processing already completed when the manufacturer purchases feedstock materials.

Finally, two liter PET bottles are the one example in this report of a product which has different market prices for recycled- versus virgin-content products. This is shown by the staggered product cost line on Figure C-3. Whether this price differential will persist in the long run is questionable since there apparently are no significant differences in product performance between recycled and virgin two liter PET bottles.

APPENDIX 1. ANNOTATED BIBLIOGRAPHY

A. Introduction

SRMG conducted a library and computerized database search to locate similar work done in the last three years (1990 through 1992) in Washington and elsewhere in the U.S. that might contain information, methods, models, or data sources that could be used in this project. Relevant information sources identified by this search were reviewed and are summarized in the annotated bibliography that follows.

B. Search Methodology

SRMG conducted a search of the following computerized databases at the University of Washington Libraries and the Seattle Public Library:

- o NTIS—Indexes U.S. government-sponsored research, development, and engineering reports distributed by National Technical Information Service.
- o ENVIRO/ENERGYLINE ABSTRACTS PLUS—Covers environmental and energy issues and includes journals, proceedings, technical reports, and other publications. Corresponds to the printed *Environment Abstracts*..
- o University of Washington On-Line Catalog—Lists holdings of U.W. libraries.
- o GPO—Computerized version of the U.S. Government Printing Office monthly catalog. Includes all catalogued documents of Congress and the executive agencies.
- o INFOTRAC—Features a General Periodicals Index which includes all periodicals held at the Seattle Public Library.

SRMG also consulted the *Environmental Periodicals Bibliography* and the *Journal of Economic Literature* to locate additional documents not indexed above.

Periodicals covered in our search included, but were not limited to:

American Metal Market
BioCycle
Business Week
Chemical Business
Journal of Environmental Economics and Management
Journal of Environmental Engineering
Journal of Environmental Management
Journal of Resources, Management and Technology
Management of World Wastes
Materials and Society

Pulp & Paper
Recycling Today (Municipal Market Edition and Scrap Market Editions)
Renewable Resources Journal
Resource Recovery
Resource Recycling
Resources, Conservation and Recycling
Tappi Journal (Technical Association of the Pulp and Paper Industry)
Waste Age
Waste Tech News

SRMG used different forms and combinations of the following key words to search the relevant databases and indexes: recycle, secondary material, virgin material, economics, price, cost, commodity, market, processing, manufacture, and remanufacture.

The sources listed in the bibliography are arranged in reverse chronological order. SRMG examined the most recent 1992 issues of *BioCycle* , *Resource Recycling,* and the *Journal of Environmental Economics and Management* to ensure that our search was up to date. While conducting our computerized search, we also discovered some particularly relevant articles published in 1989, which we also include in the bibliography.

Abbreviations used:

ABS—acrylonitrile-butadiene-styrene
HDPE—high density polyethylene
LDPE—low density polyethylene
MRF—materials recovery facility
OCC—old (i.e., waste) corrugated cardboard
OMG—old (i.e., waste) magazines
ONP—old (i.e., waste) newspaper
OWP—office waste paper
P & W—printing and writing
PET—polyethylene terephthalate
PP—polypropylene
PS—polystyrene
PVC—polyvinyl chloride
RMP—residential mixed paper
TPD—tons per day

C. Annotated Bibliography

I. Economics of virgin versus secondary materials

Andover International Associates, *Waste Printing and Writing Paper in North America: The Rapidly Changing Supply, Demand and Economics*, A Multiclient Report, Oct 90.

This report addressees the current supply and disposition of Printing and Writing (P&W) paper and projects the effects of markets, economics, and regulations on the reuse and recovery of waste P&W paper. Projections are made to 1995. Key findings include:

- Future increase in recovery of P&W paper waste must come from postconsumer office and home waste since preconsumer P&W waste is fully utilized.
- An office pack collection program would facilitate higher recovery rates and help meet projected increases in consumption of P&W waste paper.

The report evaluates the economics of office waste paper collection systems and calculates the price of office pack waste paper delivered to the mill: approximately $65 per ton/with a transport distance of 100 miles to $120 per ton with a transport distance of 800 miles.

The cost-effectiveness of manufacturing form bond paper from virgin pulp vs. a mixture of virgin pulp and post-consumer office pack paper depends upon pulping capacity. In mill situations requiring additional pulping capacity, a furnish of 40% office pack paper and 60% virgin fiber is more economical than a furnish made from 100% virgin fiber. Where there is adequate virgin pulping capacity on-site, installation of a new deinking facility is marginally attractive if the hardwood pulping facility continues operating at full capacity.

The cost to a municipality of delivering ONP/OMG to a mill is estimated at $72 per ton with a 300 mile haul to the mill and $88 per ton with a 600 mile haul. Assuming an avoided cost (tipping fee) of $60 yields a net delivered price to the mill of $12 per ton with the shorter distance and $28 per ton with the longer distance. The collection and use of OMG is closely tied to that of ONP. OMG collected separately would command a higher price and could become an established waste paper grade.

In analyzing the economics of ONP/OMG in newsprint furnish vs. virgin, the authors find that a new ONP/OMG deinking mill would cost less than a new virgin pulp mill. However, if no additional pulping capacity is needed, an investment in a new ONP/OMG deinking mill would rarely be economically prudent.

Collection of OMG is expected to rise as curbside ONP collection expands. If OMG is defined to include inserts, flyers, catalogs and magazines, the quantity collected will be greater than the quantity required for use with ONP in deinking for newspaper furnish. OMG and ONP will need to be collected in a source-sorted form in curbside programs to facilitate other uses of OMG grades and allow the market to absorb all of the paper collected. If this is done, the markets will readily absorb both household OMG as well as office pack papers from businesses.

Apotheker, Steve. "Market trends for old newspapers." Resource Recycling, vXI, n 7 (Jul 92): p. 25 (8).

During the first half of the 1980's, recovery rates for ONP were only about 30%. Recovery rates improved during the late 1980s and early 1990's due to increased demand by a few recycled newsprint mills, a developed export market, and new uses such as animal bedding. The American Paper institute estimated a national ONP recovery rate of 52% for 1991 and recovery rates in Oregon and Washington are close to 60%. ONP recovery rates should continue to improve as new collection programs begin, with a practical limit between 65% and 80%.

While recovery rates have improved, market prices for ONP have continued to deteriorate since their collapse in early 1989. Prior to 1989, there was a national ONP market price which fluctuated from $30 to $55 per ton, with markets in the West commanding an average price about $5 to $10 higher than the price prevailing in other regions. This has been replaced with a regional pricing structure in which the gap between the highest prices in the West and the lowest in the Northeast widened to $30 per ton. West Coast markets were able to maintain relatively strong prices (e.g., $30 to $40 per ton in San Francisco) due to 1) continued strength of export markets, 2) mills' need to contain material costs as habitat protection drove up the price of wood chips, and 3) passage of legislation in California requiring newspapers to increase recycled content.

Consultants are predicting that ONP prices will begin increasing by late 1993 or 1994, as newsprint and directory mills add deinking capacity. A No. 8 grade suitable for deinking could bring $60 per ton by the end of 1993. No. 8 grade ONP will bring $10 to $20 more per ton than regular (No. 6) news grade. Assuming ONP recovery continues at it's current pace, North American mills will add enough deinking capacity to balance new supply through 1993 without any progress by other end use market sectors. In order to build and maintain a strong market, the level of contamination in ONP feedstock will need to be kept low as recovery rates rise, and railroads will need to help connect new supply with existing demand.

British Columbia Ministry of Regional and Economic Development and Ministry of Environment. *Review of Prospectus for Newstech's Recycling Inc.'s Deinking Plant.* (Victoria, B.C.: 90) 128 p.

Newstech Recycling Inc. is proposing to establish Canada's first newsprint deinking facility in Coquitlam, B.C. The proposed newsprint plant will use 140,000 metric tons of ONP from western provinces to produce 122,500 metric tons of recycled fiber suitable as a replacement for virgin fiber. Newstech's submitted a prospectus in April, 1990 for the project addressing its potential environmental and socioeconomic impacts. This report reviews that prospectus and summarizes public and government comments.

Bishop, Robert and Hoffman, Michael. "Package projections." *Beverage World* v108, n1451 (Jul 91): p. 198 (3).

This article discusses raw material costs, industry capacity, environmental considerations and other factors that will impact the packaging mix for soft drink bottlers and brewers in the 1990s. Prices and industry capacity for aluminum (both ingot and container sheet), PET, and glass are discussed. Virgin raw material costs are expected to hold flat or decline from the high levels of the late 80's.

Consumers' environmental concerns and bottler economics will favor metal cans over plastic and glass. Local governments are exerting strong pressure on the industry to use recycled materials. As the largest user of containers, the soft drink industry has been criticized because of the low recycling rates of the containers utilized—particularly plastic bottles. Continued pressure by local governments, through imposition of mandatory recycling rates and packaging taxes, will influence soft drink bottlers to alter the packaging mix and include more recycled material. The underlying economics of recycling will further encourage a shift by soft drink bottlers to aluminum cans. Aluminum can makers are likely to benefit for at least two reasons 1) the infrastructure for recovery of aluminum cans is already in place; and 2) the re-smelting of aluminum provides a very large (95%) energy cost savings compared with virgin aluminum production. The energy savings for glass recycling is less (about 60%), while these authors assert that plastic beverage bottles cannot be recycled back into beverage containers.

Cesar, Mary, "The role of fiber substitution in scrap paper recovery," *Resource Recycling*, vXI, n1 (Jan 92): p. 56 (7).

Paper companies are increasingly investing in scrap paper processing facilities. As the recovery of different grades of scrap paper approaches maximum practical rates, regional imbalances of supply and demand will likely occur. Increasing demand for recycled content paper will tighten supplies of scrap paper, and some analysts are predicting shortages of old corrugated containers, old magazines and old newspaper in the near future. Fiber substitution will help ensure that future supply and demand for various grades of scrap paper be met. The fiber substituted can be secondary fiber for virgin fiber, virgin fiber for secondary fiber, or one grade of secondary fiber for another grade of secondary fiber.

In order to forecast the future balance of supply and demand for specific paper grades, one must understand how the properties (e.g., brightness, strength, smoothness, and cleanliness) provided by various grades of secondary fibers compare to those of different virgin grades subjected to different pulping processes. Properties associated with specific scrap grades, including mixed paper, old newspapers (ONP), office waste paper (OWP) are discussed. OWP is generally not a suitable furnish for manufacturing paper requiring high strength and cleanliness due its hardwood fiber content and to the use of laser and other permanent forms of printing. Tissue paper, and coated No. 3 and 4 grades are its current end uses. Due to its heterogeneous nature, mixed paper is generally confined to manufacture of lower grades of paper and paperboard, such as chipboard and roofing felts.

Understanding the economics of paper recycling also requires understanding the flexibilities and capabilities of individual mills and types of mills to substitute specific grades of scrap for virgin fiber. Examples are provided illustrating how box board mills and uncoated free sheet mills can achieve similar product properties using different furnish mixes.

Edgren, John A., and Kemper W. Moreland, "An Econometric Analysis of Paper and Wastepaper Markets," *Resources and Energy*, v11, n3 (Mar 90): p. 299(21)

This paper develops a statistical economic analysis of the paper industry and wastepaper markets. Data are first presented on real prices for wastepaper and virgin wood pulp for 1947 through 1985. Wastepaper exhibits substantial price volatility, its real price index varying between 41 and 286, with a coefficient of variation of 40.5. The real price index for wood pulp, by contrast, was relatively stable over the 1947-85 period, varying between 94 and 162, with a coefficient of variation of 15.

The paper then presents data for 1939 through 1985 showing that, despite substantial variation in relative price for wastepaper versus wood pulp, wastepaper recycling fell steadily from World War II rates near 40%, until it leveled at about 23 or 24% around 1970, where it remained through 1985.

Using annual data from 1952 through 1981, the authors next estimated an econometric model for paper industry output and wastepaper and pulpwood inputs, as well as capital and labor. The model's estimated coefficients suggest that the paper industry's demand elasticity for wastepaper is quite low, as is the elasticity of substitution between wastepaper and pulpwood.

Based on this evidence, the authors conclude that price subsidies would not substantially change utilization of wastepaper in the paper industry.

Environmental Defense Fund, *Developing Markets for Recycling Multiple Grades of Residential Paper*,: A Report to the Northeast Recycling Council and the U.S. Environmental Protection Agency, July 92.

In this report, John Ruston and his associates at EDF analyze the capability of the North American paper industry to recycle components of the residential mixed paper (RMP) stream—e.g., magazines, catalogs, direct mail, bags, and box board packaging. The report aims to provide a foundation for market development planning by local and state agencies and concludes with a series of 12 policy recommendations.

About 45 town and city residential collection programs include RMP. Most RMP is exported. In 1989, Seattle sold over 11,000 tons at $6 to $25 per ton (baled). RMP commingled with ONP collected in New York was sold loose to a processor at $15 per ton.

Some individual components of RMP, such as magazines, are highly marketable when separated, but less marketable when commingled. The report assumes that these paper types will be sorted at least twice (first by households an then by processors) before delivery to a manufacturer.

The report details the economics of sorting RMP at a MRF. Currently, paper processors cite costs at $15-40 per ton. Including baling puts RMP processing costs at the high end of the range. Some mills near populated areas are encouraging municipalities to deliver paper loose to cut down on processing costs. Large, heavy identifiable materials like OCC are most feasible to sort. Costs rise rapidly as other paper types are added to sortation. Mechanical sorting and contaminant removal has potential to increase the efficiency of processing operations.

Contamination and fiber mixing/unpredictability present the greatest economic challenges to mills. Technical solutions exist, but their use will not be economical if higher grades of recycled fiber are available at low cost.

The report assesses the potential for RMP to be used in 29 different products. Categories of products analyzed are printing and writing paper, tissue and toweling, newsprint, coated groundwood, linerboard and corrugating medium, and recycled boxboard. (Findings on these markets are summarized in the January 1992 *Resource Recycling* article by Ruston, also included in this bibliography.)

Installing fiber cleaning equipment at existing mills and developing techniques for using RMP to replace wood fiber in products like construction board are crucial strategies for developing markets.

The report lists different RMP subgrades according to their potential marketability. In this hierarchy, corrugated is rated highest, newsprint 2nd, and paper bag 3rd. Magazines and catalogs are rated next and will find expanding markets in recycled newsprint. Markets for direct mail and household ledger grades, which fall lower in the hierarchy, will depend upon successful contaminant removal.

E.H. Pechan & Associates, Inc., *Survey of Deinking Research and Development in the North American Paper and Paperboard Industry,* prepared for The City of New York Department of Sanitation, Nov 90.

This survey of recycling technologies was conducted to assist the Department of Sanitation plan for expanded collection of RMP including ONP, OCC and OMG. The survey addressed both current and planned paper recycling and deinking research and development activities in North America. Appendices include a database of research and development activities surveyed and a bibliography.

The discussion on deinking includes information on current technologies, capital and operating costs, material inputs, and waste products. Printing variables affecting the ease of deinking are examined and typical deinking systems described.

As of June 1990, 82 North American wastepaper processing projects had been announced. The authors found that cost estimates cited in the literature ranged widely: from $3.5 million to add deinking capacity to more than $200 million to build a state-of-the-art deinking and papermaking facility. Among the variables affecting costs are the nature of the end product; mill location, capacity and configuration; and waste paper price, quality and availability.

The authors site Arthur Veverka's article (also abstracted in this bibliography) as the most comprehensive discussion of economics of recycled paper manufacture. Veverka concludes that mills producing recycled paper can realized considerable savings ($110 per ton) over mills not using recycled furnish. A study conducted by Resource Information Systems, Inc. entitled "Production Costs and Profitability for a North American Newsprint Mill" finds that recycled newsprint is less costly to produce than virgin paper in terms of fiber, energy and labor expenditures but most costly with regards to chemicals and depreciation.

Erkenswick, Jane L., and Paul Hood, "Recycled market pulp mills: explosive development in the '90s," *Resource Recycling*, vXI, n11 (Nov 92): p. 57(9).

This article reports on the growth of recycled market pulp production capacity and offers some reasons for this growth. Since 1990 the number of recycled market pulp mills has doubled, and production capacity has increased over 280%. Recycled market pulp mills buy recovered paper, remove much of the inks and other contaminants, repulp the recovered paper, and sale wet lap (i.e., 50% moisture content) pulp to paper mills that cannot produce deinked pulp. Recycled market pulp mills typically do not have a paper machine. The early recycled pulp mills developed because they had a cost advantage versus virgin pulp, as much as $100 per ton according to the president of Ohio Pulp, a firm that as early as the 1960s was already reclaiming polycoated food and beverage board.

The recent growth in recycled market pulp is due to demand for recycled-content paper, the threat of minimum-content standards, and technological innovations that facilitate cleaning of xerographic, laser-printed and fax papers. The James River printing & writing paper and towel & tissue mill uses this newer type cleaning equipment to process mixed office papers. However, some types of papers found in the office, e.g., unbleached papers and manila file folders, still cannot be managed very readily in the James River deinking process.

This article provides a list of existing and planned North American recycled pulp manufacturers, including capacity, recycled paper types used, and type of paper mill customers. The article also reports that deinking produces a sludge containing 20-30% by weight of the input waste papers, which is sometimes expensive to dispose. One company has completed a patent for making a deinked pulp from sludge waste produced at paper mills, but this technology has not been commercially implemented for either virgin or recycled pulp mills.

Espe, Carl, "Solid Waste Issue Creates Boom in Recycled Fiber Capacity Growth," *Pulp and Paper,* v64, n9 (Sep 90): p. 78 (3).

More than a dozen states have or are considering laws mandating increased use of recycled fiber in newsprint. This has changed the nature of the scrap fiber market and has led to a boom in secondary fiber expansion projects and proposals. Tables are presented describing over 60 projects, ranging from new deinking capacity for newsprint and tissue mills to wastepaper processing projects for containerboard and boxboard. Planned Northwest facilities include, but are not limited to, a new newsprint machine with deinking capacity at Longview, Washington for North Pacific Paper Corp. and a deinked pulp plant to be built by Newstech Recycling in Coquitlam, B.C. The latter will be the first deinking facility in western Canada.

While there is an excess supply of virgin newsprint, there could be a shortage of recycled newsprint over the next few years. Virtually all North American newsprint producers not currently using secondary fiber are considering using recycled newsprint, including producers that are far away from newsprint sources.

Frey, James, "Newsprint production, consumption and recovery: switching to recycled fiber," *Resource Recycling* vX, n7 (Jul 91): p. 33 (8).

New newspapers contained an average of less than 10% recycled ONP fiber in 1990, but the switch to use of ONP is well underway. Although an oversupply of newsprint in general is expected due to slowing demand, the demand for recycled newsprint is strong and growing. More than 90% of new capacity added by the end of 1992 is expected to use recycled fiber.

Policy makers who want to further facilitate the switch to recycled ONP need to consider the factors that have driven the transition so far.

Insight can be gained by examining the potential for profit and the value added at each stage (production, consumption, and recovery) of the newspaper industry system. This assessment shows that publishers are the dominating force in most business interactions. Over 75% of value added by the industry occurs at the publishing stage (value added summary is presented in Figure 2). As the dominant actors, publishers have virtually 100% control over the decision to switch. An example of the way publishers have institutionalized their dominance, is the fact that publishers commonly take equity interests (sometimes controlling interests) in mills to reduce vulnerability to price increases.

Government efforts to motivate newspaper mills to switch to recycled ONP with market development tools such as investment tax credits have been misdirected. Only strategies, such as minimum content legislation, targeting publishers have been successful. Such legislation has been motivated by the temporary glut of ONP on the market and the need to increase demand to raise prices for recovered fiber. Publishers have responded positively to this legislation, partly due to political expediency and public relations concerns. Newsprint manufacturers have responded rapidly to publishers' demand for recycled fiber. Fortunately, newsprint manufacturers have also achieved a number of equipment breakthroughs, making it less costly for them to make the switch.

Glenn, Jim, "An industry shapes up for recycled plastics," *Resource Recycling*, vX, n1 (Jan 91): p. 38 (6).

The most commonly recycled resin is polyethylene terephthalate (PET). Major markets for recycled PET include carpets and fiberfill, industrial strapping, and automotive products. Reclaimed PET is increasingly being used in bottles for non-food household products. While markets for recycled high-density polyethylene (HDPE) are less mature than for PET, HDPE is poised to become the most commonly recycled plastic resin. This is due to both large production numbers and the promise of potential markets. HDPE is used more than twice as often as PET in packaging. Many firms are beginning to use HDPE in household and industrial chemical bottles and plastic bags. Use of recycled low density polyethylene (LDPE), polystyrene, and polyvinyl chloride (PVC) is also increasing. The recycling effort is discussed for each type of plastic and the leading firms involved are highlighted. Table 1 (page 40) presents prices for these and other resin types according to how they have been processed (baled, reground, or pelletized). Pelletized scrap commands the highest price and baled commands the lowest. Prices estimated for PET range from 7-8 cents per pound for green, baled, to 42-45 cents per pound for clear, pelletized scrap. Prices estimated for HDPE range from 5-8 cents per pound for mixed color, baled, to 32-39 cents per pound for pelletized, natural color scrap.

Plastics recycling is increasing rapidly, but is far from reaching its full potential. Sorting mixed plastics into individual types increases the volume of the material, but is yet to be proven both technically and economically. This suggests that more mixed plastics will need to be processed into products such as lumber, car stops and benches, as about a dozen firms are doing currently.

Hemphill, Thomas A., Institute of Scrap Recycling Industries, "Glass Outlook," *Scrap Processing & Recycling*, v49, n1 (Jan-Feb 92): p. 113 (3).

Recycled glass prices are down slightly from 1991 and are expected to remain relatively stable in 1992, ranging from $50 to $55 per ton. Industry representatives expect cullet consumption to grow by 25% in 1992, provided supply, price and quality factors remain good. Glass containers provide the largest and highest-value market for cullet. Recycling cullet into glass containers can be economical because glass cullet can be melted and reformed at lower temperatures than required to combine virgin materials from which glass is formed. Contamination presents challenges and will become a more critical obstacle as a greater percentage of cullet is used to manufacture glass containers. Processors will need to invest in new technologies to reduce contamination. Use of recycled glass in asphalt can also help municipalities save landfill disposal costs. States are leading the federal government in sponsoring glass recycling initiatives. States will likely expand tax credit programs to encourage the use of glass cullet in new glass containers.

Hegberg, Bruce A, et al, *Post-Consumer Mixed Plastics Recycling* (Chicago: University of Illinois, 1991).

Recycling of plastic discards is one method of reducing municipal solid waste. Due to its heterogeneous nature and the amount of contaminants present, separation of post-consumer mixed plastic waste is most difficult. This report identifies the compositions of plastics in municipal solid waste and in curbside recycling programs. Costs of plastics collection and end uses for reprocessed post-consumer plastics are discussed.

A relatively small amount of plastic is recycled on an annual basis in the U.S. in comparison to the production levels of plastics or the amount landfilled. About half of recycled plastic consisted of PET bottles (including HDPE base cups) and most of the remainder came from HDPE bottles, PET x-ray film and PP car battery cases.

Plastic recycling costs depend upon the equipment used, collection methods, collection frequency, materials collected and other variables. Generally, the cost of weekly curbside recycling ranges from $12 to $30 per household served per year. Collecting weekly costs 10 to 35% more than collecting biweekly. Little information exists on the incremental costs of collecting different types of plastics. One pilot project found that adding collection of clear HDPE and PET bottles to a 50,000 household program would cost $.70 to $1.40 annually per household served. (These are collection costs only and do not reflect processing costs or material revenue.) The cost of baling sorted plastic is estimated at 3 to 4 cents per pound. The cost of processing commingled plastic containers at a sorting and baling/grinding facility is estimated to be 10 to 12 cents per pound.

The market outlook for recycled plastics is strong. Overall demand for recycled plastic resin is expected to be 3.5 times that of 1990 levels. The price of baled post-consumer plastic is currently 7 to 12 cents per pound. The price of sorted, cleaned and flaked post-consumer plastic is 20 to 30 cents per pound. Pelletized recycled resin ranges from 20 to 25 cents per pound.

Changes in packaging design are taking place to reduce the cost associated with waste plastic processing and include more collected plastic in products.

Hunt, Robert G., Franklin Associates, "A New Look at Recycling Subsidies: Part 2," *Resource Recycling,* v8, n3 (Jul 89): p. 30.

The probable responses of profit-motive recycling businesses to broad-based raw material subsidies intended to increase recycling from solid waste are explored. Subsidies would lower prices of recycled materials and may motivate manufacturers to substitute recycled inputs for virgin inputs. However, the historical record shows that low recycled material costs have never driven significant replacements of virgin material. This is due to lack of consumer demand for and awareness of recycled products.

A sample calculation is made assuming unitary price elasticity of demand for recycled products. This is viewed as an optimistic assumption since historical economic data shows that a given percent decrease in price usually results in a lower percent increase in sales. Even in this optimistic scenario, raw material tonnage subsidies will likely not increase recycling, but instead will provide increased profits for investors and stockholders The company will benefit more from simply retaining the subsidy as profit than lowering prices charged to consumers.

Iannazzi, Fred D., "The economics are right for U.S. mills to recycle old newspapers," *Resource Recycling*, v8, n3 (Jul 89): p. 34(5).

This article estimates that operating costs, excluding investment related costs, for virgin and 100% recycled ONP content newsprint are, respectively, $387 and $315 per metric ton. The author claims that it is not economic to dry and ship pulp for newsprint, so that all U.S. newsprint mills are integrated.

The main reason why there is not more ONP deinking capacity, the author claims, is that the North American newsprint industry has excess capacity relative to current demand. So that while recycled content costs less, it is still not economic to shut down an existing virgin plant and invest in new deinking capacity.

Iannazzi, Fred D., and Richard Strauss, "Municipal solid waste and the paper industry: the next five years," *Resource Recycling*, vIX, n4 (Apr 90): p. 70(7).

This article provides data on 1988 production, consumption and recovery of newsprint and corrugated containers. The data and graphics outline type of fiber inputs in production, split between exports and domestic use of production, and disposal versus recovery of the used newsprint or corrugated containers. Based on these data and an analysis of potential uses in papermaking for old newspapers and old corrugated cardboard, the article suggests that nothing needs to be done to stimulate corrugated recycling, and that there is no current use for newspapers other than in newsprint that offers significant growth opportunities.

The municipal solid waste "crisis" has resulted in recycled-content legislation for newspapers and has depressed the cost of old newspapers to deinking mills. Both effects are expected to stimulate usage of newspapers as feedstock fiber for making newsprint. Because newer newspaper deinking processes not only permit but benefit from mixing up to 33% old magazines into the pulping plant feedstock, the extraction of magazines from waste will increase with the increased recycling of newspapers.

The article also examines the potential for recycling printing & writing (P&W) papers, and sites several significant barriers:

- Recycled P&W is extremely varied as papermaking feedstock because it contains everything from coated free sheet to uncoated groundwood.
- P&W paper waste is generated in small amounts from geographically scattered sites.
- Contamination levels in recycled P&W can vary dramatically from office generator to office generator.

Marley, Michael, "Wellman exec dispels plastic recycling myths," *American Metal Market*, v100, n32 (17 Feb 92): p. 8 (2).

Harry R. Benson, manager of market development for N.J.-based Wellman Inc., the largest plastics recycler in the U.S., spoke at a solid waste policy conference regarding plastics recycling. Benson said that avoidance of disposal costs, not profit from recycled materials, is the context within which plastics recycling should be viewed. The sale of collected material will help offset recycling collection programs but will rarely carry programs entirely. Benson believes that recyclers should seek to recover only those plastics that have a viable market as Wellman does. Wellman has targeted post consumer PET bottles since 1979 and HDPE jugs since 1988. Wellman uses plastic wastes to manufacture products such as polyester fibers and plastic resins.

Matrix Management Group, *et al*, *Poly-Coated Bleached Paperboard Feasibility Study*, draft final report prepared for The Department of Trade and Economic Development - Clean Washington Center, (Nov 92).

This draft report discusses the technical feasibility of collecting and processing polycoated paperboard packaging (milk cartons, drink boxes, ice cream containers, paper cups, and other food packaging), the economic viability of polycoated paperboard recovery and re-pulping, and the possibilities for development of commercial scale capacity in the Northwest. The report reviews prices that paperboard mills have paid since 1980 for northern bleached softwood kraft (NBSK) market pulp, as well as prices paid for hard white shavings (shavings or sheets of untreated white bond ledger papers with no printing and no groundwood content), which is a pulp substitute, and computer printout, which is a high grade deinking feedstock. These three products would need to be displaced by a pulp produced from recycled polycoated paperboard.

The draft report estimates that the margin between the price paid to recyclers of polycoated paperboard waste and the market price at which a recycled polycoated paperboard pulp could be sold is between $100 and $380 per ton. Estimated capital costs for a deinking plant to handle post consumer polycoated paperboard feedstock are between $135 and $413 per ton of deinked market pulp produced, depending on pulping plant scale and whether the feedstock is restricted to just gable tops, aseptic packages, and ice cream containers, or the feedstock is all polycoated materials.

Operation and maintenance costs are estimated at $43 to $86 per ton, depending on the same factors. Total costs per ton, thus, are estimated to be between $178 and $499, with the latter figure being so high due mainly to costs of sorting and

cleaning an unrestricted polycoated feedstock. Excluding the unlimited supply scenario and the less than 100 TPD capacity scenarios, cost of producing market pulp from recycled polycoated paperboard is estimated to be between $178 and $212 per ton.

"Price Restricts Markets for PET Copolymer," *Packaging*, v34, n6 (Apr 89): p. 31 (1).

Ira Stern, president of PET Polymers, Roosevelt, NY., has sought to interest molders of HDPE crates in switching to the impact-modified recycled PET made by his company. The company's recycled PET sells for 48 cents a pound and HDPE (article does not specify if this is recycled or virgin HDPE) sells for 54 cents a pound. However, crate molders are not willing to switch because of HDPE's better yield and the extra expense required to change molds to accommodate Stern's material. Stern is now concentrating on marketing his material as a replacement for ABS, which sells for 90 cents pound and is used for supports for padded toilet seats and other products.

"Profitability Problems Plague Plastics Recycling," *Chemical Business*, v12, n3 (Mar 90): p. 34 (2).

Plastics recycling is in its infancy but is a key element in reducing landfilled wastes. However, processing costs are high and profits are low for plastics recyclers. These costs include those related to energy, feedstock, cleaning and regrinding. Markets for end products are emerging, but are dependent on the availability of low-cost materials. These markets are described, as are various recycling operations.

Powell, Jerry, "The ups and downs in bottle-to-bottle plastics recycling," *Resource Recycling*, vXI, n5 (May 92): p. 98 (5).

While recycled PET has been used in the manufacture of new bottles for some time, this was limited to non-food, non-beverage applications up until 1991. This is partially due to food and beverage producers' concern that using recycled PET bottles will present liability problems, and their conclusion that the recycling technology used for other non-food product lines (conversion of PET scrap into pellets) cannot be assured to be yield contamination free containers. (While no federal law restricts use of recycled plastic in food and beverage containers, manufacturers generally will only use recycled packaging technology once the Food and Drug Administration has issued a "letter of non-objection.")

At the same time, concerted market demand has been exerted on the soft drink industry to begin using recycled content plastic bottles. Bottlers have turned to PET bottle scrap regeneration technology which breaks down PET scrap chemically into a pure monomer than can be used to produce contamination-free PET resin. Nearly a dozen companies have been involved in PET scrap regeneration since 1991, including four of the largest resin producers in the U.S. Coca-Cola, the leader in using recycled content PET bottles, has introduced soft drink bottles containing 25% regenerated PET in 13 states and the District of Columbia.

Despite this and other successes in using regenerated PET, critics point out four substantial concerns with regeneration technology: 1) it requires more energy than remelting cleaned scrap; 2) it generally requires very clean scrap; 3) it produces a

bottle resin that is 10% to 50% more expensive than virgin plastic resin; 4) it is not applicable to other resins.

Ruston, John, "Developing recycling markets for the components for residential mixed paper," *Resource Recycling,* vXI, n1 (Jan 92): p. 26 (8).

This article explores the potential of North American paper industry to absorb low grade secondary paper recovered from the residential mixed paper (RMP) stream. Material prices, sorting and processing costs, fiber characteristics and potential markets are discussed.

Mixed paper has usually sold for low market prices and is exported, but mixed paper composed 2.4 million of the 21 million tons of paperstock consumed by U.S. paper mills in 1989. In 1989, Seattle sold baled RMP at $6 to $25 per ton. In 1991, New York City transferred loose RMP commingled with ONP to a private processor at -$15 per ton.

Processors report that the cost of sorting, cleaning and bailing RMP grades falls close to $40 per ton. Sorting technology is fairly primitive and costs rise rapidly when workers are required to pull out light weight and sparsely distributed items such as envelopes.

Contamination and fiber mixing pose economic and technical challenges to recycling RMP. Technical responses are available, but their costs often outweigh their benefits to paper mills, especially if cleaner, higher grades of fiber are available at low prices.

RMP has the potential to be used in 29 different paper, paperboard, construction board, packaging, and agricultural products. The key to developing new markets for RMP is installation of fiber cleaning equipment and development of techniques for using RMP to replace wood fiber. Almost half of the scrap paper found in RMP could be recovered given existing market conditions; almost 90% could be recovered if fiber substitution frees up capacity in tissue and paperboard markets. RMP collection programs should avoid less specialized grades.

RMP could replace ONP and OCC in lower-end applications if higher grades, such as office paper, are pulled into higher uses.

Manufacturers of printing and writing paper are unlikely to become major RMP consumers. But these manufacturers may increase their use of recovered office paper and divert it from lower tissue and boxboard applications to provide markets for lower quality fibers.

Tissue mills are rapidly increasing investment in deinking equipment. While most recycled content tissue manufacturers' plan to use higher quality scrap fibers, some may begin using RWP if consumers can be convinced of the importance of recycled content.

The use of old magazines and old newspaper and magazines in paper suitable for commercial printing is lagging due to the need for very clean furnish, but increased consumer demand for recycled content and investment in new technology will eventually lead to increased use.

Paperboard producers are also learning how to use ONP, office paper, and RMP within their furnish mix. Boxboard is one of the most promising end uses for RMP.

Research and experiments on incorporating mixed paper into construction board projects, animal bedding, and molded pulp packaging are showing promising results.

Resource Integration Systems, Ltd. for The Oregon Department of Environmental Quality, *Current and Target Recovery Rates for Plastics Packaging in Oregon,* (Oct 90).

This study focuses on the generation and recovery of post-consumer plastic packaging manufactured from six common plastic resins. Included is information on current and projected recycling rates; economic, regulatory and technological trends; and collection and processing costs. The study will be used to develop recommendations on effective recycling rates for plastic resins for the years 1992 to 2000.

Chapter 4 "Collection and Processing Costs" presents observed and modeled costs of plastics collection for both curbside and drop-off systems and identifies cost factors (capital, labor and program design) that affect cost-efficiency. Costs are also presented for sorting, densification, and transportation to market. Manufacturing costs (including cleaning and pelletizing costs) are also estimated.

Siewert, Wolfgang H., "The use of wastepaper in tissue production," *Tappi Journal,* v72, n1 (Jan 89): p. 41 (5).

While objectives such as cleanness and uniformity are more favorably met through use of virgin raw material, the economic benefits of using wastepaper are sufficiently great to justify the use of wastepaper. When using virgin chemical pulp, raw material costs account for almost 95% of total costs. The use of wastepaper (grade(s) unspecified) can reduce this percentage to between 35 and 55%. While wastepaper requires more comprehensive and expensive processing systems, using wastepaper can reduce total manufacture costs to 65 to 85% of the costs paid by a manufacturer using virgin raw materials.

High quality tissue is currently being produced using high-speed machines from furnishes containing up to 100% wastepaper . Waste-paper preparation plants are becoming increasingly sophisticated. The use of wastepaper in tissue production is likely to increase, especially given the comparatively high cost of virgin raw materials.

Sorenson, Don, "Environmental Concerns, Economics Drive Paper Recycling Technology," *Pulp and Paper,* v64, n3 (Mar 90): p. 56 (2).

Recycled fiber is playing an increasingly important role in papermaking. Parts of the world with limited wood resources seek to maximize the volume of these resources and have higher recycled fiber utilization rates than the U.S. and Canada. In North American, quality and economics are the driving forces.

In North America, producers of high grades of paper are seeking to maintain quality at a reduced production cost, since further quality increases are unlikely to be noticed by consumers. Producers of lower-value paper are seeking to increase product quality while holding production costs constant. Producers of both grades are looking to recycled fiber to help meet industry challenges.

Concerns regarding scarcity of landfill space are also driving increased use of recycled fiber. The federal government has implemented procurement practices favoring recycled products and the states are adopting legislation to publishers to use newsprint with 25% to 50% recycled fiber content. Improvements in process technology (including defibering, contaminant and ink removal, and bleaching) are leading to better quality recycled newsprint. Research conducted by the American Newspaper Publishers Association also shows that mills close to large supplies of collected recyclables can gain an economic advantage by using ONP.

Sparks, Ed, "Recycled newsprint production in North America," *Resource Recycling*, vIX, n4 (Apr 90): p. 52(3).

This article reports estimated costs for ONP deinking operations. As a retrofit to an existing virgin newsprint mill, an ONP deinking plant costs about $200,000 per ton of daily capacity. Thus, a retrofit for a 250 TPD plant would cost $50 million. On the other hand, cost for a completely new deinking newsprint mill would be $500 to $600 million, and take five years to put into service. The author also observes that much of the North American newsprint industry is located near the far northern forests in Canada, where freight costs of delivering ONP from the urban centers make a deinking retrofit to existing virgin newsprint mills financially prohibitive.

Stone, Robert F., and Nicholas A, Ashford, *Package Deal: The Economic Impacts of Recycling Standards for Packaging in Massachusetts*, Center for Technology, Policy and Industrial Development, Massachusetts Institute of Technology, (Mar 91).

This report examines, among other issues, the economics of recycling versus landfilling or incineration. Net benefits of recycling are calculated as the sum of:

(1) Revenues to recyclers from selling separated solid waste materials,

(2) Avoided subsidies to producers of virgin materials,

(3) Avoided disposal costs for that portion of the average ton of waste that is incinerated, and

(4) Avoided disposal costs for that portion of the average ton of waste that is landfilled; less

(5) the costs of collecting and separating materials for recycling.

The analysis provides quantitative estimates for Massachusetts of each of these five components of the net social benefit of recycling. The report also discusses the micro- and macro-economic impacts in Massachusetts of recycling standards for packaging. Impacts addressed include, in addition to the net social benefit of recycling calculated as given above, compliance and administrative costs, tax effects, and industry production and employment effects.

TAPPI, *Focus '95+: Landmark Paper Recycling Symposium*, Mar 19-21, 1991: Atlanta, Georgia, 415 pages.

This conference was jointly sponsored by the American Paper Institute, the Institute of Paper Science and Technology, the National Council of the Paper Industry for Air & Stream Improvement, the Paper Industry Management

Association, the Technical Association of the Pulp and Paper Industry, and the USDA Forest Products Laboratory. These proceedings incorporate each speaker's presentation as well as the following question and answer period. Presentations were given on a variety of topics. Several of these presentations discussed recycling economics and presented charts showing historic and projected prices for virgin and secondary fiber. The presentations most relevant to our project are listed below:

Young, Rodney L., President, Resource Information Systems, Inc., "Fiber Balance: The Dynamics of Recycling."

A dynamic market for wastepaper recycling is insured by several factors. As the cost of solid waste disposal continues to rise in the U.S., the economics of wastepaper usage in the paper and board industry will also continue to improve relative to the usage of virgin fiber. Industry will also be under increasing pressure from government and consumers to expand use of recycled paper. On the other hand, consumers will expect the same high quality, requiring makers of some grades to develop new technologies for incorporating wastepaper into their furnish. Includes graphs of historic prices for virgin pulpwood and ONP and projected wastepaper consumption per ton of output for several different paper grades.

Ince, Peter J., "Timber Market Implications of Recycling."

With increased wastepaper recycling, pulpwood consumption will grow more slowly. Much of the increase in wastepaper recycling will take place in grades now manufactured primarily from softwood pulp grown in the Southern U.S. Charts show projections for U.S. wastepaper utilization; lumber production and imports; and prices for softwood, hardwood and recycling futures.

Pesonen, Kari V., Vice President, Jaakko Poyry Consulting Inc., "Recycled vs. Virgin-Energy and Manufacturing Cost Differentials: Four Hypothetical Case Studies."

Reports research findings comparing the manufacturing costs of various pulp and paper grades and discusses the feasibility of manufacturing paper products from recycled fiber of different grades in different regions. The same research findings are covered in Ververka's article in *Pulp and Paper*, which is cited above.

Tellus Institute, *CSG/Tellus Packaging Study - Assessing the impacts of production and disposal of packaging and public policy measures to alter its mix*, vI and vII, prepared for The Council of State Governments, U.S. Environmental Protection Agency and New Jersey Department of Environmental Protection and Energy, (May 92).

This lengthy, two-volume document reports on a three-year study comparing production and disposal impacts of various product packaging choices. All major materials used in consumer packaging were analyzed: aluminum, glass, steel, five types of paper (bleached kraft paperboard, folding boxboard, linerboard, corrugating medium, and unbleached kraft paper), and six types of plastic (PET, HDPE, PVC, LDPE, PP, and PS). Where data was available, the study compared virgin and recycled production of the same material.

One of the controversial aspects of the study was the quantification of relative importance for different environmental impacts. Some pollutants were "priced" at the cost of currently required control measures. For many other major pollutants, however, emissions had to be evaluated based on their impacts on human health. After ranking toxic and carcinogenic substances on the basis of their health hazard, a price was placed on health hazards based on an estimated cost of $1600 per pound of lead removed through air pollution controls, and the quantitative relationship between lead's health hazard and the health hazard of any other substance emitted during packaging material production.

This report is a storehouse of potentially useful information on production processes and emissions associated with making a wide variety of materials. There are direct comparisons between virgin and recycled materials for producing folding boxboard, linerboard, corrugating medium, aluminum, and glass containers.

Steel cans require a steel quality that can only be achieved in the basic oxygen furnace (BOF), which, unlike the electric arc furnace, has very narrow tolerance for detinned steel can scrap. Thus, the comparison of virgin versus recycled is for 0% detinned scrap versus 12% detinned scrap, so that differences between the two processes for making steel cans are quite small.

Post-consumer plastics recycling is an infant industry for which the authors could not create a complete set of data to compare with virgin plastics production.

Usherson, Judy, "Recycled office paper: why it costs more," *Resource Recycling*, vXI, n11 (Nov 92): p. 52(4).

As its title suggests, this article analyzes the higher prices charged for recycled-content office papers, recently 2-50% more than virgin paper. The article suggests some reasons for the price difference:

- Excess virgin capacity relative to product demand due to the recession has resulted in virgin office papers selling for as much as 40% discount in late 1992 compared with previous years' prices.
- Increased demand for recycled-content papers has exerted price pull relative to small amount of production capacity for recycled content office papers; in fact, recycled provided only 3% of the business papers market in 1991.
- The tight control on furnish characteristics required for printing & writing papermaking, and the difficulty of maintaining that control in deinked pulp which can contain mixtures of papers made with sulfite and sulfate pulps, hardwood and softwood pulps, and Northern and Southern wood species pulp.
- Cost of adding recycled content to an integrated pulp and paper mills own supply of virgin pulp.

The latter point deserves discussion. The article estimates that an integrated mill can produce virgin-content pulp at a cost of about $300 per ton, excluding amortization charges for buildings and equipment. On the other hand, that same mill would have to pay $500 or more per ton for deinked market pulp (approximately the same price that it would have to pay for virgin hardwood market pulp). Thus, the mill's margin would decrease by $200 for each ton of deinked market pulp substituted for its own virgin pulp in order to produce office paper with some recycled content.

With large investments in virgin pulping capacity that is not being fully utilized, integrated mills are naturally reluctant to idle virgin pulp capacity to build deinking capacity or to buy deinked market pulp. To produce recycled-content office paper at a price competitive with virgin-content paper, very large-scale recycled pulping plant would need to be constructed on the same site as the already existing integrated virgin pulp and paper mill. This is summed up by a quote from a Georgia-Pacific planning director, "The cost estimates for producing a ton of recycled pulp are markedly higher than producing a ton of bleached hardwood kraft."

The article also provides two useful classifications for office paper mills. One according to origin of their fiber:

- Integrated mills are vertically integrated to own or control the source of fiber (trees or waste paper packer or broker), pulpmaking operations, paper manufacturing, and perhaps even the converting and finishing operations.
- Semi-integrated mills have limited pulping capacity and must purchase some of their pulp on the open market.
- Non-integrated mills have no pulping capacity and must use market pulp for all their papermaking.
- The other classification is according to papermaking efficiency (i.e., the width and daily production capacity of the papermaking machine):
- Commodity mills are typically integrated operations making one type of paper all the time (e.g., newsprint, linerboard, or copy paper); their papermaking machines are 225-300 inches wide, run at speeds up to 3000 feet per minute, and can produce 350-1000 tons per day per machine.
- Specialty mills make multiple types of printing & writing papers on 65-185 inch wide machines running at 800-2500 feet per minute.

Woodward, T.W., "Fiber Substitution with Pulper Deinking Reduces Furnish Costs," *Pulp and Paper*, v63, n3 (Mar 89): p. 138 (2).

Conventional deinking requires mechanical treatment following repulping for separating ink particles from fiber. Pulper deinking disperses inks in the pulper without further mechanical treatment. Pulper deinking allows mills using virgin pulp, unprinted pulp substitute, or lightly printed secondary fiber to use more heavily printed waste paper to cut furnish costs without investing in more expensive, conventional deinking systems.

For example, using lightly printed bleached sulfate in place of unprinted pulp substitutes yields an overall savings of $25 per ton of furnish to produce boxboard topliner. A substitution of lightly printed bleached sulfate for half of the pulp substitute furnish for tissue and toweling products yields a savings of $120 per ton of furnish.

Veverka, Arthur, "Economics Favor Increased Use of Recycled Fiber in Most Furnishes," *Pulp and Paper*, v64, n9 (Jan 92): p. 97 (7).

Between 1970 and 1988, demand for recycled paper fiber grew twice as fast as demand for virgin pulp on a worldwide basis. Recycled fiber demand will likely grow even more rapidly in the future. (However, in North America, the use of recycled fiber has grown only slightly more than the use of virgin fiber during the same period, suggesting significant potential to use more recycled fiber in this continent.) Currently, close to 85% of recycled-fiber furnish worldwide is used without deinking, mostly in the packaging grades. Increases are expected in the use of recycled fiber for manufacturing newsprint, writing paper and tissue products. Use of deinking grades is expected to rise, with more than half of deinked pulp used for newsprint.

Recovery rates will have to rise to meet forecasted worldwide demand for secondary fiber. Tables are presented comparing current and forecasted wastepaper recovery and utilization rates in different regions of the world. The U.S. is currently collecting more paper scrap than it uses. U.S. recovery rates are expected to go from 30.2% in 1988 to 44% just after 2000. Utilization rates in the U.S. and Canada will increase more slowly. North America is expected to double its offshore exports between 1988 and 2000.

Natural resource economics have historically driven use of recycled fiber, with wastepaper enabling counties with scarce forest resources to compete with those having greater access to virgin fiber. Improved technology has also encouraged use of secondary fiber. Legislation mandating use of recycled material is creating a new driving force, as well as further technological breakthroughs in recycled fiber handling.

Improved economics of recycled fiber are generally borne out in cost comparisons between mills using virgin versus recycled fiber. Cost comparisons are made and illustrated for hypothetical mills in different regions producing 1) newsprint, 2) printing and writing paper, 3) tissue, 4) linerboard, and 5) corrugated medium. Recycled furnishes varied depending upon the end product, but included ONP, old magazines, office waste paper, mixed paper, and OCC. The cost estimates were carried out using a computerized model developed by Jaakko Povry.

Cost comparisons show that using recycled fiber yields a definite cost advantage in the production of newsprint but not in the production of printing and writing paper. However, it is likely that recycled content printing and writing paper will be produced because of public concern for the environment. Recycled fiber lowers the cost of tissue products, but also lowers the quality slightly. Still, North American consumers are likely to accept the lower quality. Cost advantages for the use of recycled fiber in linerboard and corrugating medium are strong and favor the use of even more recycled fiber than currently used to produce these products.

Yang, Dori Jones; Symonds, William C. and Driscoll, Lisa., "Recycling is rewriting the rules of papermaking," *Business Week*, n3210 (22 Apr 91): p. 100H (2).

Weyerhaeuser Co. and other major wood products companies are incorporating new paper recycling facilities into their production processes. As much as $8 billion is expected to be invested in recycling ventures by 60 companies in the U.S. and Canada over the next decade. New investment in recycling capacity has been prompted mainly by state laws requiring the incorporation of recycled material into newsprint.

Savings in material costs gained by using ONP are not currently large enough to offset the capitol costs associated with adding deinkers and other recycling equipment, as well as associated process costs. When planning its new newsprint machine in 1988, Weyerhaeuser anticipated that using recycled paper would save up to 15% of production costs, but the economics of the using recycled fiber have been much less favorable than anticipated. (This has resulted due to tightening demand for ONP which caused the West Coast price for ONP to triple since 1988 to about $75, compared to $90 per ton for wood chips.)

In many cases it is more expensive to produce paper from recycled materials, as Weyerhaeuser has discovered. While finer grades of writing paper made from recycled fiber can command a premium price, recycled content newsprint does not. Paper companies are often only using recycled fiber because they're afraid they'll loose customers otherwise.

II. Economics of recycling versus disposal

Englehardt, James D., and Jay R. Lund, "Economic Analysis of Recycling for Small Municipal Waste Collectors," *Journal of Resource Management and Technology, v18, n2 (Oct 90): p. 84.*

This paper presents a benefit-cost analysis based on linear programming for financial evaluation, selection and planning of recycling measures for small public and private solid waste collectors that pay others for disposal of wastes they collect. A common example would be a municipality or private hauler which pays tipping fees for waste disposal in a large regional landfill facility, where the municipality or hauler need not concern itself with impacts of its recycling decisions on remaining landfill life.

High disposal costs or the value of waste as a secondary material are two motivations for recycling illuminated by this cost-benefit method. At the same time, high environmental costs can also motivate recycling through their financial impacts, for example, on insurance costs for disposal facility operations and/or closure.

International City Management Association, *Costs and Financing of Solid Waste Collection*, (Washington, DC.: ICMA, 1991).

This report provides solid waste collection cost information by city based on surveys mailed to 4,958 local government officials in municipalities with a population of 10,000 or more, and to a one-in-four random sample of municipalities with a population of 2,500 to 10,000. Surveys were also to all ICMA-recognized counties and to a random sample of one-in-four nonrecognized counties. The survey response rate was 29.5% Information for 23 Washington state communities is reported.

Information covered is population; 1987 general expenditures; number and costs for supervisors, drivers/handlers, and maintenance staff for solid waste collection; number of recycling, refuse and other trucks used in collection; payments for contract collection services; amounts spent on fuel, materials & supplies, and vehicle maintenance; program costs to operate curbside recycling, a hazardous waste collection event, and/or a recycling drop-off center; and the source of revenues to finance solid waste collection.

Lund, Jay R., "Least-Cost Scheduling of Solid Waste Recycling," *Journal of Environmental Engineering*, v116, n1 (Feb 90): p. 182(6).

This paper develops a simple linear programming method for evaluating and scheduling a given set of recycling measures proposed to extend the life of an existing landfill. Use of the method requires a description of the capital and operating costs for each recycling measure, and effectiveness at diverting waste volume from disposal. The model evaluates recycling purely on its ability to reduce total present value waste management costs by deferring landfill closure and future replacement costs (of landfills, incinerators, or other disposal facilities), while taking advantage of any secondary materials markets.

Disposal side costs include landfill operation, closure and replacement, and refuse collection. Recycling costs include collecting, processing and selling recycled materials, minus any revenues from their sale.

Minnesota Office of Waste Management, *Internalizing Waste Management Costs*, presented to the Legislative Commission on Waste Management, Jan 92

This purpose of this study was to discuss methods to determine costs for particular types of solid waste based on their impact on the waste stream and the environment; discuss methods to charge these specific costs to the sources of that waste; develop recommendations for a fee system; and discuss administrative and other costs that would be incurred in implementing the system. The study provides a general discussion of external costs and the means to "internalize" such costs in Minnesota's waste management systems and practices.

The study develops three recommendations:

1. For most products, the state should not pursue a tax or fee that internalizes environmental costs of solid waste disposal by charging those costs to sellers of products.
2. For generic solid waste, the state should continue its present policy of point-of-disposal pricing and visible billing.
3. The state should develop a more complete set of incentives, including regulations, deposits and pre-disposal fees, to ensure proper management for certain problem materials discarded by consumers. Examples of such incentives include bans on disposal of certain battery types, motor oil, major appliances and tires.

Maltezou, Sonia P. "Costs and Benefits of Recycling." *Journal of Clean Technology and Environmental Sciences,* v1, n1 (Jan 91): p81 (9).

This article analyzes the variables that affect private and public decisions to recycle. The incentive to recycle a material varies with the price of the corresponding virgin resource and the cost to recover and use the secondary material. The interplay and diversion between public and private sector interests regarding short term economic objectives and long term allocation and conservation of resources also affects recycling decisions. From a private sector viewpoint, recycling is not necessarily an optimal economic activity. However, public sector planning and action may be needed in order to promote recycling activities and help fulfill the needs of future generations.

Moore Recycling Associates, *Pennsylvania Municipal Recycling Costs: Eight Case Studies*, prepared for The Pennsylvania Department of Environmental Resources by the Pennsylvania Soft Drink Association, Nov 92.

This report documents actual program costs for municipal recycling programs. Profiling recycling costs in eight communities, this report seeks to address a representative diversity of recycling collection systems and strategies, community sizes, geographical locations and demographics. The report authors estimated recycling costs by summing recycling program operations, labor and administrative costs and subtracting material revenues, performance grants and other revenues applicable to the program. Where relevant, indirect costs associated with the operation and administration of solid waste programs were also considered.

The report finds that program costs range widely among the eight communities, reflecting the variety of collection scenarios employed. The appendix includes a chart summarizing per ton and per collection unit (i.e.., per household) costs—both with and without Department of Environmental Resources (DER) grants—for each community. (DER grants are performance based and are used as a credit against recycling costs.)

The highest cost per ton (about $712 without grants) is found in Pittsburgh, and the lowest is found in Wellsboro (about -$40). Per collection unit costs follow a somewhat similar pattern (annual cost per collection is about $20 in Pittsburgh and about -$15 in Wellsboro). After recycling grants from the state are subtracted from net recycling program costs, there is cost per collection unit spread of approximately $40 and a cost per ton spread of about $200. It is important to note that Pittsburgh's program is in an expansion phase and went city-wide in the last quarter of 1991.

The report notes that difference in costs among the eight communities reflect a variety of factors including differences between contract collection versus municipal collection, rural versus urban location, labor sources, and avoided costs. However, the report warns against comparing programs directly and solely on the basis of costs since each community's program has many different characteristics which can affect both costs and other success measures.

National Solid Wastes Management Association, *The Cost to Recycle at a Materials Recovery Facility*, 1992.

This study reports detailed processing cost data gathered from ten materials recovery facilities (MRF's) that processed 100 to 300 tons per day (TPD) of recyclables and were willing to provide three consecutive months of cost data. Four of the MRFs were in the Northeast, 3 in Florida, 1 in the Midwest, and 2 on the West Coast. Four were partially or completely publicly owned; all were privately operated. The facilities received, sorted and processed recyclables in a wide variety of ways, including different combinations of automated and hand-sorting systems.

Based on data gathered it costs $50 to process a ton of recyclables at a MRF, not counting revenues from materials sales. Individual material processing costs per ton were estimated to be $34 for ONP, $43 for OCC, $37 for mixed paper, $143 for aluminum cans, $68 for steel cans, $73 for clear glass, $111 for amber glass, $87 for green glass, $50 for mixed-color glass, $184 for PET and $188 for HDPE.

MRF processing costs were allocated to specific materials in a number of ways:

- directly for equipment or labor devoted exclusively to one material,
- on a pro-rated basis by material weight for equipment such as conveyors and rolling stock,
- on a time usage basis for equipment dedicated to different materials at different times, and
- on a volume basis for buildings and land, since space requirements are the main consideration in facility size.

Powell, Jerry, "Just the facts: relevant data on MRF operations and costs," *Resource Recycling*, vXI, n5 (May 92): p. 34 (5).

Summarizes data on technical operations, facility management and economics of commingled material recovery facilities (MRFs) from two reports (the *1992-93 Materials Recovery and Recycling Yearbook*, published by Governmental Associates of New York City and a research study entitled *Materials Recovery Facilities for Municipal Solid Waste* published by the U.S. Environmental Protection Agency's Office of Research and Development and prepared by Peer Consultants and Cal-Recovery Inc.). The article addresses the following topics:

Technical operations—production rates for glass crushers, ONP balers, and other equipment.

Facility management—material sorting rates and staffing requirements.

Costs—construction costs, equipment cost, and operating and maintenance (O&M) costs. Annual O&M costs are estimated to run $123 per ton of daily processing capacity for a MRF with a capacity of 10 tons per day (TPD), $74 per ton for a MRF with a capacity of 100 TPD and $48 per ton for a MRF with a capacity of 500 TPD. (O&M costs include debt service based upon an interest rate of 10% amortized over 20 years for equipment and facilities. Taxes and depreciation were not included.)

Reiter Northwest and Seattle Solid Waste Utility, *1991 Recycling Potential Assessment*, (Sep 91).

This study provides the 1991 update of the Recycling Potential Assessment (RPA) model originally developed in 1988 by the Seattle Solid Waste Utility (SWU) to evaluate the feasibility and cost-effectiveness of the City's many recycling options. The 1991 update addresses three major questions:

- What are current and projected levels of waste generation, recycling and disposal?
- How do current projections compare with those developed in 1988?
- Are programs planned in 1988 but not yet implemented sufficient to meet the City's 60% recycling goal by 1998?

The study projects estimated costs and benefits per ton for each year through 2014, and calculates the net benefit or cost per ton for each recycling program. Recycling program costs are defined to include direct costs of a recycling program plus cost of SWU staff in planning and supporting that program. Recycling program benefits are equated to the cost of waste processing activities that would have occurred in the absence of the program. Waste processing activities are grouped into four categories: collection, transfer, transport and disposal. The "avoided costs" of a recycling program, which are that program's benefits, depend on the quantity of collection, transfer, transport and disposal tons avoided through the program's activities.

In sum, recycling benefits (avoided costs) exceed recycling costs for nine of the ten SWU-sponsored programs, The one exception, apartment building recycling has costs only about $1 per ton higher than its benefits. However, these ten programs are not expected to meet the City's 1998 goal of 60% recycling. Commercial paper recycling and restaurant glass, metals, and food waste recycling are suggested as two programs to consider that would add enough recycling to meet the City's goal.

Schall, John, *Does the Solid Waste Management Hierarchy Make Sense? A Technical, Economic and Environmental Justification for the Priority of Source Reduction and Recycling,* (New Haven, CT: Yale University School of Forestry and Environmental Studies, Oct 92).

This paper provides conceptual discussion and preliminary empirical support for the solid waste management hierarchy. A full cost comparison of solid waste management techniques is attempted by estimating the monetary value of environmental impacts associated with collecting, processing, and disposing waste. Data from the New York City region is used in cost examples, with comparisons made first at the waste management level and then at the production (manufacturing) level.

Waste management level:

Source reduction saves 70% of the average cost of managing a ton of waste in the region's solid waste system. Environmental impacts prevented through waste reduction are almost twice as large as conventional cost savings.

Recycling and composting up to 50% of remaining waste costs no more than managing it through a system relying solely on disposal. This intensive recycling strategy also produces environmental impacts which are no greater, but *no less* than the disposal-only approach. This finding is due to the high environmental costs of recycling collection, which is five times that of garbage collection. (Generally, collection vehicles for recyclables do not compact their contents as garbage trucks do and stop at each collection point for a longer period of time than garbage trucks do.) Utilizing recycling facilities over landfills and incinerators, however, offsets the negative environmental effects of recycling collection.

Production level:

The greatest advantages of pursuing waste reduction and recycling occur at the production level. Using 50% of the waste stream as manufacturing feedstock instead of using virgin raw materials would reduce environmental impacts greatly—by almost $1 billion per year in the study region. This is technologically feasible and the economic costs of manufacturing with recycled materials does not appear prohibitive.

Smith, D. G. and Baetz, B. W., "A Comprehensive Costing Methodology for the Assessment of Solid Waste Management Alternatives," *Journal of Resource Management and Technology,* v19, n4 (Dec 91): p 140 8.

When engaging in solid waste management planning, it is essential to obtain a comprehensive cost estimate for each alternative solid waste management system considered. All significant costs need to be incorporated into the cost comparison, rather than simply being dismissed as too complex to quantify. In particular, the impact that implementation of one alternative may have upon the costs associated with operation of another alternative needs to be recognized.

A comprehensive methodology is presented for the identification of all cost components for recycling, energy-from-waste, and landfill developments. The methodology estimates the range of costs under current market conditions and with current environmental legislation, design standards and practices. The comprehensive costing methodology described is applied to the waste management system of the City of Catharines, Ontario, Canada to assess the costs of its curbside recycling program and landfilling activities. Waste collection and landfilling with recycling is determined to be somewhat more expensive per tonne than waste collection and landfilling without recycling, but increases landfill site life. It is difficult to determine whether the extension in landfill life is worth the additional cost of recycling. For example, the impact of fluctuating markets for recyclable material may alter the economics of recycling, or the cost of obtaining approvals for landfill sites may increase. There are also additional reasons to operate recycling programs, including natural resource and energy conservation benefits.

Tellus Institute, *A Cost Analysis of Municipal Waste Landfilling in California*, prepared for California Integrated Waste Management Board, (Apr 90).

This study estimates expected future costs of landfilling in California as current landfills with tipping fees that average $10 per ton close, and must be replaced with new sites and landfill construction and operations that meet current regulations. The current low tipping fees may be due to one or more of the following four missing or underestimated costs:

1. Cost of remediating environmental damages, especially those connected with ground or surface water contamination;
2. Depletion, or replacement costs, i.e., the premium users of a finite or severely restricted resource (landfill space) ought to pay in anticipation of its exhaustion and replacement by a more costly alternative (e.g., a new landfill , incinerator or recycling system);
3. The opportunity cost of land, i.e., income foregone by not renting or selling landfill sites for other purposes; and
4. Hidden subsidies of publicly-operated facilities by local governments.

The California Integrated Waste Management Board (IWMB) decided not to include item 2 in this study. Also, environmental remediation costs were limited to water degradation, and did not include, for example, air quality degradation from current landfill operations. However, estimates of environmental costs included do go beyond the closure/post-closure funds required by California law. Thus, costs account for remediation and control technologies that prevent degradation of water resources.

A representative sample of 27 landfills was used to estimate the costs listed in item 1, 3 and 4 to add to existing tipping fees that did not reflect such costs. The average comprehensive cost across all 27 sites was estimated to be $48 per ton. Economies of scale were estimated to yield a 13% cost savings for every doubling of landfill capacity. The addition of closure/post-closure costs and environmental remediation costs to capital and operating & maintenance costs is estimated to increase landfill costs at least 60%. Furthermore, comprehensive costs are on average 59% above current tipping fees.

Tellus Institute, *Disposal Cost Fee Study Final Report*, prepared for California Integrated Waste Management Board, (Feb 91).

This study evaluates the feasibility of a disposal fee on goods sold in California. Existing and proposed legislation in other states is surveyed and analyzed. The report develops a quantitative estimate of the full costs of waste management (including pollution costs) for different types of materials in waste that such a fee would need to cover, evaluates alternative fee systems, and recommends a fee system levied at the point of first sale in California. Depending on policy considerations, the fee could be set high enough to cover both the $123 estimated full cost of managing the average ton of non-hazardous waste, and the $1943 estimated cost for the average ton of household hazardous waste, generated in California.

In developing a methodology for allocating waste management and pollution costs to specific waste materials, costs for collecting recyclables or refuse were allocated based on in-truck volumes for each material, distances traveled to and from waste management facilities, and engine idling time. The actual allocation and amount of costs thus depend on a number of estimates and assumptions about collection efficiency, waste stream quantities, and participation levels.

Landfill costs were allocated to materials based on cubic yards of landfill capacity used. Tables 6.3, 6.4 and 6.9 provide respectively, estimated in-truck garbage densities, in-truck recyclables densities, and in-fill garbage densities for 22 categories of waste materials.

For incineration, full costs of operations and pollution generation were allocated based on material weight, except that ash disposal costs were allocated based on ash content and electricity revenues were allocated based on Btu content.

Recycling facility costs were allocated according to weight, and revenues were allocated according to specific material prices as well as weights.

VHB Research & Consulting Inc. and MacLaren Engineers Inc., *Cost Accounting Methods for Landfill*, prepared for Waste Reduction Advisory Committee, (Feb 91).

The purpose of this study was to review methods that can be used to estimate landfill costs, including internal financial costs, external financial costs, and external social and environmental costs. The dividing line between internal and external costs is defined by the accounting framework of the owner or operator of the landfill. Costs that the owner or operator includes are internal, costs that are not accounted for are external. Examples of internal costs given, among others, in this report are engineering and approval costs, initial construction costs, capital costs, operations and maintenance costs, closure and post-closure costs. Examples of external costs are permitting costs incurred by regulatory agencies or interveners; capital costs paid for by someone else, such as road construction done by the local municipality; regulatory agency monitoring; opportunity costs; costs of unmitigated environmental impacts; and indirect social costs, such as displacement of residents, traffic congestion and risk, and income loss due to concerns about safety of local farm products.

The conclusions of this study are:

- The cost of landfill is only about $60 (Canadian) per tonne, less than is widely believed, and less than the tipping fee at many landfills.
- The trend in recent years has been to "internalize" external social and environmental costs, by encouraging or requiring new landfills to mitigate impacts, to compensate residents and municipalities providing support infrastructure, and to use technologies that help minimize the risk of environmental damage.
- There are two available indicators of social costs: estimates of property value impacts (no more than 2% of total costs, and usually much less), and "host benefit" surcharges. Based on these measures, external social costs are not likely to exceed $12 per ton, and in most cases would be much less.

This study reviews methods of measuring or estimating "hard" landfill costs and social costs. The methods discussed for estimating "hard" costs are regional modeling, comparative costing and hypothetical costing. The methods reviewed for estimating social costs are hedonic price impact measurements, survey measurements of contingent valuation, measurements of time value, and environmental damages measurements.

Given a method for estimating "hard" landfill costs, the study goes on to evaluate the effect on costs of landfill size (scale economies), location and hydrogeologic setting, and landfill age. The study also argues that when making comparisons of costs for various waste management alternatives, costs included for each alternative should be measuring the same type of things. If landfill costs include estimates of environmental impact costs, then so should recycling costs, for example, noise, dust and odors at the MRF, as well as upstream benefits from less raw materials extraction.

APPENDIX 2. WASTE MATERIAL DENSITY

Waste Material Density (pounds/cubic yard)

	In Recycling Truck									In Garbage Truck					
MATERIALS	A	B	C	D	E	F	G	H	I	A	B	D	F	G	H
Newspapers	450	365	365	500	600	500	600	500	369	583.9	900	900	1000		
Corrugated Cardboard	75	100				120		100	80	335	300				250
Office Paper	200	300		500		500		400		430	800	900			
Mixed Paper	150	150		150	103			150	270	399.2	600	700			
Container Glass	600	610	610	400	498	600	600	600		1446	1000	1000	1000	1000	1000
PET Containers	30	40	40	40		35		34		155	200	300	261		
HDPE Containers															
Milk Jugs		25	25			25							350		
All	35			24				30		158.1	200	300			
Lawn & Garden Debris	200	500		415	120	450		296		700	500	415	600		
Scrap Metal	150	325								347	575				

SOURCES

A - Tellus Institute, *Disposal Cost Fee Study Final Report*, prepared for California Integrated Waste Management Board, (Boston, 1991) p. 6-18/6-19.

B - Sound Resource Management Group, Inc., *Rhode Island at the Recycling Crossroads*, prepared for War on Waste Steering Committee (Seattle, 1993), Appendices 3&4.

C - Department of Environmental management and Rhode Island Solid Waste Management Corp., *City of Providence Planning Study*, (Providence, 1989) p. V-2.

D - Matrix Management Group, *Best Management Practices Analysis for Solid Waste*, vol. III, prepared for Washington State Department of Ecology, (Seattle, 1989) Table C-1.

E - Peer Consultants, *Materials Recovery Facilities for Municipal Solid Waste*, prepared for united States Environmental Protection Agency, (Washington, 1991) p. 2-26.

F - Oregon Department of Environmental Quality, *Handbook for Commercial and Institutional Recycling*, p. 9.

G - New Jersey Office of Recycling, *Conversion of Volume to Weight for Recyclable Materials*, handout.

H - Steve Apotheker, "Volume-to-weight factors: recycling's manifest destiny," *Resource Recycling*, November 1991.

I - Volume-to-weight measurement for five recycling truck loads with separate compartments for newspapers, corrugated cardboard and mixed paper. Mixed paper density is for compartment loads that are "stomped" by the truck driver. Unstomped mixed paper is less the 200 pounds per cubic yard. Cardboard was separated on route from rest of residential mixed waste paper and "stomped."