AN ECONOMIC EVALUATION OF THE POTENTIAL FOR RECYCLING WASTE MATERIALS IN ANCHORAGE, ALASKA

NSTITUTE OF SOCIAL AND ECONOMIC RESEARCH
UNIVERSITY OF ALASKA
Fairbanks • Anchorage • Juneau

AN ECONOMIC EVALUATION OF THE POTENTIAL FOR RECYCLING WASTE MATERIALS IN ANCHORAGE, ALASKA

By

William E. Nebesky
Institute of Social and Economic Research
University of Alaska

Final Report to the
House Finance Committee
of
The Alaska State Legislature

May 1, 1980

TABLE OF CONTENTS

LIST OF TABLES

List of Tables (Cont.)

List of Tables (Cont.)

LIST OF FIGURES

EXECUTIVE SUMMARY

This study reports on an economic analysis of the potential for recycling waste material in Anchorage, Alaska. The purpose of the study is to assist the House Finance Committee of the Alaska State Legislature and other interested parties in the development of public policy to strengthen private and public sector involvement in material recovery for recycling. Funding for this research was made available by the House Finance Committee.

The analysis of recycling potential encompasses three broad questions:

1. How much waste material is available for recycling in Anchorage?
2. What is the current extent of Anchorage-based recycling?
3. What are the economic effects of expanding current levels of recycling?

The results of the analysis are then used to highlight the potential effects of several public policy proposals to increase recycling.

The scope of the analysis is limited to Anchorage for two reasons. First, the nature of the study requires considerable detail regarding the source, quality, composition, and market for specific materials consumed in a community or local economy. In many instances, data was missing or inaccurate and had to be estimated. Thus, in order to retain a manageable level of detail, the analysis is confined to a single location and to a specific set of materials, including: tin and aluminum cans, glass, and several grades of waste paper. Second, Anchorage comprises a substantial portion of statewide economic activity and compared with most Alaska cities is located nearest to "stateside" secondary materials markets. Thus, if recycling potential is marginal in Anchorage, it would be unlikely elsewhere in Alaska.

I conservatively estimate the annual quantity of secondary tin, aluminum, glass, and paper available for recovery and recycling in Anchorage to be 30 thousand tons. This compares by weight to about one-fifth of total mixed solid waste generated and thrown away from residential and commercial sources. The determination of the quantity of recoverable secondary materials takes into account factors such as contamination and limited accessibility.

Each ton recycled reduces by an equivalent amount the quantity of waste that must be collected, processed, and disposed in the municipal landfill. In 1979, total waste management costs for 160 thousand tons of municipal refuse was $9.8 million, or $61 per ton. For the purpose of calculating the impact of recycling on the cost of waste management, I estimate that 20 percent of total waste management cost is variable and therefore affected by quantity reductions. This amounts to less than 12 dollars per ton and assumes that the frequency and, therefore, cost of collection is unchanged.

Backhaul rates for southbound community movement from Anchorage to Seattle are not likely to be reduced by carriers. Southbound container movement is 90 percent unused. Thus, revenues from forward commodity movement cover 80 percent of backhaul shipping expenses. Lower southbound rates would further shift the backhaul deficit on forward commodity movement unless southbound commodity movement increased somewhat dramatically in response to southbound tariff reductions.

On average, only 2 percent of the annual quantity of available secondary materials is actually recovered and shipped to stateside secondary materials markets. Private sector involvement in Anchorage-based collection for recycling is composed of small-scale operations that specialize in a narrow range of commercially desirable secondary materials. The Alaska Center for the Environment Recycle Center (ACERC) represents an exception to the above structure in that it recovers a "full line" of secondary materials including newsprint, computer print out (CPO), IBM tabulating cards (tab cards), tin and aluminum cans, used motor oil, and worn-out car batteries. Also, ACERC is nonprofit and depends partly on public funds to cover expenses. Data from the first three months of operations suggest that, in order to break even, ACERC's recovery would have to increase five-fold from 18-to-90 tons of newsprint, CPO, and tab cards per month. However, this required break-even quantity represents only 3 percent participation in waste separation and recovery by Anchorage residents and commercial institutions.

Several factors limit recycling potential in Anchorage:

Instate recycling potential. Prospects for instate production of recycled commodities are limited by factors identical to those that limit the potential for the development of a broader-based manufacturing sector in Anchorage. In general, these include relatively high labor and capital costs, confined local market demand, and high freight costs for in- and outbound commodity movement.

Just as the extra cost of shipping commodities into Alaska creates an incentive for local commodity production, the cost of shipping secondary materials to external markets for recycling represents an economic stimulant for instate production of recycled commodities from locally generated secondary materials. The freight factor from Anchorage to Seattle typically absorbs 25 percent of revenue potential and places Alaska recyclers at a substantial competitive disadvantage in relation to recyclers located in closer proximity to end-use markets.

Nevertheless, the high incidence of commodity imports into Alaska suggests that the higher costs of local commodity production generally outweigh the transportation disadvantage felt by outside producers. The same conditions apply to local production of recycled commodities; that is, the high cost of local recycled commodity production from secondary materials outweighs the cost disadvantage of transporting materials to "stateside" markets.

Although the potential for local recycling is important from the standpoint both of energy and resource conservation and of development of local industrial capacity, this report focuses on the economic feasibility of Anchorage-based recycling recovery systems that collect, sort, compact, and market secondary materials to existing end-use markets in Seattle.

Externalities. Steady patterns of rising secondary materials prices suggest that recognition of energy savings from recycling is becoming more widespread and, as a result, demand for secondary materials is on the increase.

Despite the effect of rising demand, secondary materials continue to be undervalued as a consequence of the narrow interpretation of costs and benefits in private sector markets.

If we broaden the definition of costs and benefits to include non-market factors such as savings from landfill diversion, then additional "external" benefits arise outside the private sector that have the potential to compensate for private sector losses.

Until these external benefits are reflected in prices explicitly, secondary materials will continue to be underutilized. Equivalently, by passing up the opportunity to recycle, extra unnecessary waste management costs (equal to foregone benefits) are imposed on both resident and commercial sectors of the Anchorage economy.

Economies of scale and citizen participation. The scale of material recovery is largely a function of residential and commercial participation in waste separation. Thus, the degree of citizen participation is a principal determinant of economies of scale to the recycler.

Although the recycler is able to influence participation through buy-back programs, advertising, and educational campaigns, the level of material recovery and, therefore, the quantity of marketable supply is not under the recyclers' direct control.

I apply two criteria to evaluate the economic feasibility of expanding material recovery beyond current levels. The first criterion, designated "commercial feasibility," employs market prices and assumes customary commercial financing for all plant and equipment without government intervention or assistance. In the second criterion, designated "social feasibility," I quantify several "external" benefits and costs and use them to adjust private benefits and costs subsumed under commercial feasibility. Social feasibility reflects the combined effect of benefits and costs in both private and public sectors of the economy.

To illustrate the economic significance of factors not reflected in market prices, we construct two competing definitions of social feasibility. In the pessimistic definition, I interpret time and effort in household waste separation as an "opportunity" cost that is equal to the value of foregone leisure or employment. Household waste separation of newsprint, glass, and tin and aluminum cans requires about one hour per month, or about $100 annually for participating households.

The optimistic definition ignores this effect under the assumption that waste separation may be easily integrated into routine household functions and, in fact, creates compensating benefits from reduced household garbage disposal.

Both interpretations of social feasibility recognize reduced waste management costs from processing and disposing less refuse and extra savings from delayed expenditures on new landfill site development. In the optimistic interpretation of social feasibility, I assume further that recycling would reduce the frequency of municipal refuse collection and therefore create additional (though modest) savings in the overall waste management system.

I ignore the effect of environmental amenities from litter and pollution reduction in both interpretations of social feasibility and therefore understate the level of external benefits from recycling.

I apply the feasibility criteria to three expanded recycling scenarios constructed from specific assumptions or product mix and profit orientation. All scenarios assume that 25 percent of Anchorage households and commercial institutions regularly engage in waste separation of specific materials for delivery to or collection by the recycle center.

The basic recycling scenario depicts a nonprofit, full-line recycle center that depends on secondary material donations by household residents and commercial institutions. In the buy-back scenario, the recycle center is profit-oriented and offers to pay consumers for specific secondary materials. The basic and buy-back scenarios are distinguished mainly by the profile of materials they recover. Commercially unprofitable materials are omitted from the buy-back scenario. The office-collection scenario modifies conditions in the buy-back scenario by introducing a comprehensive program in high-grade ledger paper separation and collection from state office buildings.

Several important observations emerge from the feasibility analysis of alternate, expanded recycling scenarios. They are:

1. None of the recycling scenarios were able to satisfy the criteria for commercial feasibility. Recycling under the modified-product mix in the buy-back scenario would be profitable only under conditions in which recyclables are donated by residents and commercial groups.

2. None of the recycling scenarios were able to satisfy the criteria for social feasibility under the pessimistic interpretation of external costs and benefits. The public cost of household separation, evaluated at the average wage rate in Anchorage, outweighs direct savings in waste management, resulting in net external costs which compound commercial losses in the private sector.

3. All of the recycling scenarios satisfy criteria for social feasibility under the optimistic interpretation of external

benefits in which the cost of household waste separation is negligible.

4. Economies of scale (i.e. savings in money outlays due to efficiencies inherent in larger scale operations) as a result of increased participation would be substantial. However, even under conditions in which community participation in material recovery is 25 times greater than estimates of current Anchorage participation (less than 1 percent), commercial feasibility would not be obtained under basic scenario assumptions.

Thus, in addition to community participation in waste separation and recovery, the product mix is itself an important determinant of commercial feasibility. Individually, the cost of collecting, processing, and shipping glass, mixed scrap paper, and corrugated containers (CC) would exceed revenue potential. However, in contrast to mixed scrap and CC, glass exhibits greater external benefits for each ton recovered than commercial losses per ton. Thus, from the standpoint of social feasibility, glass recycling under 25 percent participation in the basic scenario would be socially desirable.

A prominant, Seattle-based waste paper dealer recently commented that, "The city is a forest to be harvested daily for its fiber content" (Sid Shapiro, President, Paper Fibres Corportion). The preceding analysis suggests that substantial untapped reserves of several types of secondary materials are available for recovery in Anchorage. Further, the analysis of existing circumstances in Anchorage's recycling recovery sector suggests that it would be socially desirable to expand the scope of material recovery, but commercially prohibitive to do so under many circumstances. Legislative initiative is therefore required to stimulate private and public sector involvement in material recovery for recycling.

Several policy options are available to the state, including those that are directed toward the recycling recovery sector (i.e. collectors and recyclers) and those that affect community participation directly.

Direct subsidy. At one extreme, the subsidy could consist of a large grant to a single recipient. The major reasons for a subsidy of this type are to concentrate funds to allow for a larger, more efficient scale of recovery and, more importantly, to provide financial support for materials that are socially beneficial but commercially unprofitable to recover. The grant could be made contingent upon the recycle center's acceptance of a carefully specified product mix. A policy of this type, however, discriminates against the independent, unsubsidized collector and potentially displaces private investment.

To reduce (but not eliminate) the discrimination problem, the state could issue smaller grants to several local operations. A small-grants program, however, may not provide the financial relief required to achieve cost-effective scale economies in less profitable materials. Thus, a program of this type may increase the aggregate level of recovery without altering the mix of materials to include less profitable grades.

Central recovery wholesaler. As an alternative to direct subsidization, the state could fund a publicly operated, central processor/wholesaler that intermediates between local, independent collectors and "stateside" secondary materials dealers and specializes in processing (i.e. shredding, crushing, baling, and compacting) and in shipping large quantities. Although scale economies from consolidating recovery are not likely to compensate for the recovery wholesaler's ongoing operating expenses, a subsidized and stabilized price level would improve commercial prospects for local collectors and, therefore, stimulate additional recovery effort.

Tax relief. Depletion deductions and tax credits provide indirect financial incentives to recyclers and help to counter-balance existing tax regulations that encourage over-production of virgin resources at the expense of available secondary materials. Tax regulations do not discriminate among recyclers and may be designed to integrate all or some of the anticipated net social benefits. As in the case of dispersed subsidies, however, tax relief would most likely stimulate additional recovery of secondary materials that already exhibit profits and not address the equally important problem of socially beneficial but commercially unprofitable material recovery. Tax relief may best be used as an ancillary proposal in conjunction with other more direct recycling policies.

Community participation. The success or failure of recycling depends ultimately on the degree of residential and institutional participation in separation of recyclable materials from nonrecyclable waste. While "buy-back" policies (cash rebates) provide direct incentives for consumers to recycle, the overall effect on the rate of participation is unclear. For example, Seattle Recycling, Inc., (SRI) and Portland Recycling Team (PRT) are relatively large, full-line recyclers with comparable volume and composition of material recovery. In contrast to SRI, which operates under a comprehensive buy-back policy, PRT depends on consumer donations and on average achieves a compatible rate of participation.

Compulsory measures may be combined with economic incentives to further stimulate material recovery. For example, the office paper collection scenario in Part IV demonstrates that a comprehensive program in separation and collection of high-grade ledger paper from state and municipal offices would release significant reserves of high-value waste paper, reduce municipal waste management costs, provide supplemental income to offices, and be well-received by local collectors. In addition to important economic advantages in both the private and public sectors, a program in office paper separation would demonstrate positive intent on the part of the state (and the municipality) to get involved in recycling and would be an example that would precipitate involvement elsewhere in the community.

Returnable beverage container legislation (RBCL) establishes a mandatory deposit on most beverage bottles and cans and requires distributors and grocers to redeem, from customers, beverage containers which they normally handle. The effect of RBCL depends in part on the existing structure of a community's recycling recovery system. For example, in Washington State, where RBCL is not in effect, revenues from refillable bottles and cans represent the economic foundation on which the decentralized system of independent, full-line recyclers depends. The Washington State Recyclers Association (WSRA) claims that RBCL similar to Oregon's "bottle bill" would redirect important revenue-generating bottles and cans away from independent, full-line recyclers. Recent trends in Oregon's recycling recovery system suggest that RBCL encourages large-scale, specialized recovery that focuses exclusively on bottles and cans.

In Alaska, where proximity and handling constraints prohibit commercial glass recovery by smaller, independent collectors and recyclers, RBCL would provide an institutional framework that would encourage the development of more efficient techniques in handling and processing glass.

The public policy response to a large, unexploited reserve of secondary materials must be tailored to circumstances and problems unique to Alaska and to the domestic recycling industry as a whole. Distant proximity to secondary materials markets is the primary constraint to the development of recycling recovery systems in Alaska. On a broader scale, the domestic recycling industry is sensitive to events which create even slight changes in technology and in the relative value of secondary materials. Therefore, policies must be carefully designed to avoid regulatory and institutional impediments that compete with and discriminate against independent recyclers in the private sector.

Also, factors that are not readily expressed in economic terms, such as aesthetics from litter and pollution reduction, should not be overlooked as important qualifications to economic criterion for feasibility analysis and for public policy evaluation.

INTRODUCTION

The purpose of this study is to assist the House Finance Committee of the Alaska State Legislature and other interested parties in the development of public policy to strengthen private and public sector involvement in recycling. Funding for this research was made available by the House Finance Committee.

A bill for an act related to ". . . Comprehensive Recycling and Litter Reduction. . ." (HB 5) is under consideration in the 1980 session Alaska State Legislature. The bill is intended to initiate programs in litter prevention and to encourage private and public recycling efforts. The bill calls for the creation of a state agency to "encourage, organize, and coordinate" public and private involvement in litter reduction, source separation, and recycling. The bill would also establish an advisory council consisting of seven members to be appointed by the Governor. The council would be responsible for furnishing guidance and encouraging the participation of industry, labor, federal, state, and local government agencies and the general public in recycling.

In its present form, the only definite actions taken in HB No. 5 are to establish litter prohibitions and to create an anti-litter symbol. The remaining contents call for expansion of state bureaucracy to "coordinate" and to "encourage" litter prevention and recycling participation. Yet, a well-defined task outline or institutional framework to achieve these goals is not specified.

To some extent, the lack of specificity of HB no. 5 reflects a shortage of information regarding recycling feasibility and options for stimulating litter reduction and recycling. In order to develop positive, uniform legislation to achieve higher rates of material recovery, further information regarding the potential for recycling waste products is needed.

The intent of this research is to develop an understanding of the problems and constraints in Alaska's urban economic environment and in the recycling industry as a whole that are responsible for the relatively negligible public and private sector participation in recycling exhibited in Alaska.

The format of this research is divided into four analytical parts, followed by a discussion of policy options. Part I presents a general overview of the United States' recycling industry structure and highlights technical and institutional factors that influence the market value of recyclable materials and the extent to which recycling takes place.

In Part II our attention focuses on recycling potential in Anchorage. I estimate how much waste material is feasibly recoverable from the total quantity of a selected range of commodities that enter the Anchorage economy for final consumption. Important features of market demand are presented for specific secondary materials (i.e., used materials that may be recycled as substitutes for primary raw materials) in order to determine the compatability of recoverable supply and demand. Part II also includes a description of the structure and cost of solid waste management in the Anchorage municipality. We are particularly interested in the effect of recycling on the cost of solid waste management.

Note that an in-depth analysis of the supply and demand for recycled commodities must focus on specific materials within a well-defined location. Considerable detail would therefore be required to accurately analyze recoverable waste products at the state level. In many instances, data was missing or inaccurate and had to be estimated. In order to retain a manageable level of detail, I have limited the scope of the analysis to Anchorage and have confined the range of materials to tin cans, aluminum, glass, and several grades of waste paper. The analysis is therefore not intended to address the question of statewide recycling potential. Nevertheless, Anchorage constitutes a substantial proportion of statewide economic activity and offers a reasonable study area for an analysis of urban recycling potential.

Part III examines the organization of recycling activity in Anchorage and compares the present extent of Anchorage-based recycling with feasible levels (for various materials) calculated in part II. The objective in Part III is to estimate the average rate of recycling in Anchorage and to establish a setting within which policy may apply.

We combine the information compiled in Parts II and III with relevant data from specific ongoing recycling operations on the Pacific West Coast to construct a set of expanded recycling scenarios in Part IV and to evaluate the costs and benefits of each. We paid particular attention to the "hidden" costs and benefits not captured in market relations, but nevertheless, relevant to a comprehensive evaluation of recycling potential. Additionally, the sensitivity of recycling potential is examined in connection with user buyback policies and changes in product mix.

In Part V, we review factors that limit recycling potential in Anchorage and discuss the impact of a specific set of policy proposals designed to stimulate the rate of recycling.

PART I. RECYCLING: CONCEPTS AND ISSUES

What is Recycling?

The basic principle of recycling is reuse. However, in contrast to reuse, recycled materials are typically transformed into products that do not necessarily retain their original identity.

Recycling may be divided into two phases. The first phase, designated "material recovery," diverts solid waste materials from permanent disposal or dispersion. In the recovery phase, solid waste materials (such as used newspapers, beverage containers, and tin cans) are collected and separated into homogeneous categories or grades. In many cases, separation occurs prior to collection. For example, household waste products may be separated into specific categories directly after final consumption in preparation for collection or delivery to the recycle center. This technique, known as "source separation," aids the efficiency of material recovery by preventing used materials from being mixed at the source of waste creation and represents the principle method of household participation in recycling.

Once recovered, secondary materials of a given grade and composition are allowed to accumulate in a storage facility or recycle center warehouse until sufficient mass is generated to raise total value to make further processing and transportation economically feasible. Collectors then sell recovered waste products to brokers or directly to secondary materials users.

Most recovered materials undergo some form of second-phase "reprocessing" depending on the degree of contamination and the nature of secondary use.

In the second phase of recycling solid waste materials are reconditioned to eliminate additional contaminants and to isolate desirable physical properties needed for a particular reuse application. Reprocessing usually occurs at the location of reuse, where secondary materials are manufactured into recycled commodities.

For example, waste paper fibers are separated from the original product by mechanical agitation in a water slurry. Waste paper may undergo additional treatment to remove ink (deinking) and other chemical contaminants. Generally, waste paper is broken down into fiber which is then remilled into a lower grade of paper. Each "iteration" of recycling reduces fiber size, and therefore, the quality of subsequent paper output.

In Alaska, pulp mills produce woodpulp, the first product category in the sequence of paper making operations using virgin resources. Wood pulp is then marketed to West Coast and Japanese paper mills where various basic paper grades are manufactured. Thus, "final" paper products are not produced in Alaska. Because the pulping segment, which comprises Alaska's paper industry, technically precedes paper milling operations, there is no effective local market for waste paper fiber.

In contrast to paper, glass manufacture is a fully integrated, one-step process which begins with basic raw materials and ends with the finished product at the same location. Cullet (broken glass) that is color separated and contaminant free (especially of metal components) may be used in place of raw material inputs (including sand, limestone and soda ash). Because it melts at lower temperatures than raw materials, cullet reduces furnace fuel consumption and air pollution emissions, and increases the life of furnace linings. The utilization of cullet varies widely from 8 to 100 percent, by weight. Northwest Glass Co. in Seattle currently uses about 30 percent cullet. Increases beyond 30 percent reduce the manufacturer's control over final product viscosity and coloration.

The Benefits of Recycling

By recognizing value in materials previously considered valueless, the recycling industry increases the stock of resources and introduces three types of benefits into an economy:

1. Recycling waste materials conserves energy and natural resources.
2. Recycling decreases the potential for environmental damage connected with extraction of primary materials and with landfill disposal.
3. Recycling reduces the volume of waste material that is thrown away and thereby extends landfill life and reduces solid waste management costs in processing and disposal.

Because waste materials retain a portion of the industrial energy used in the original stage of manufacturing, the amount of energy needed to process a unit of virgin ore exceeds the energy required to reprocess an equivalent amount of recycled product from scrap material. Energy is required to ship secondary materials from Alaska to west coast markets. However, containers are backhauled whether or not they are loaded. The extra energy cost of shipping a loaded over an empty container is negligible. Thus, backhauling used materials requires essentially no additional energy and instead makes better use of energy already encumbered in the transport network. Consequently, I ignore the cost of energy consumed for backhauling containers of secondary materials. A comparison of energy requirements is presented in Table 1-1 for selected commodities.

Table 1-1 Energy Used in Processing Virgin and Recycled Materials

Material	Energy Needed to Process: Virgin Ore (Btu/pound)	Energy Needed to Process: Recycled Material (Btu/pound)	Amount of Energy Saved by Recycling (percent)
Steel	8300	7500 (40% scrap)	10
		4400 (100% scrap)	47
Aluminum	134700	5000	96
Copper	25900	1400-2900	88-95
Glass Containers	7800	7200	8
Plastics (polyethylene)	49500	1350	97
Newsprint	11400	8800	23

Source: Hayes, 1978, p. 17.

In general, the benefits of recycling follow from the reduction in raw material processing and in the quantity of waste for collection, processing, and disposal.

With the exception of energy savings, these benefits are largely unrecognized in the commercial system. The full environmental costs created by pollution and waste generation are not readily measurable by traditional economic accounting methods and therefore do not show up as a cost of production using primary raw materials. Similarly, environmental savings created by substituting recyclable materials for primary raw materials and thereby foregoing additional pollution and waste generation are not captured in market prices. As a result, secondary materials used to produce recycled commodities are undervalued and underutilized relative to virgin resources. The extent of under utilization is not clear although Hayes (1978) claims that the average rate of recycling[1] is far below what is attainable without disrupting modern standards of living. The data in Table 1-2 suggest that despite signiicant environmental and economic benefits from recycling, the percentage of materials recycled nationwide is small.

Table 1-2 Recycling Rates for Selected Commodities
(Percent)

	1967-68[a]	1973-74[b]	1979
Paper	18.6	18.4	24 (newsprint only)[c]
Glass	4.2	3.0	
Aluminum	18.3	17.0	25-30[d]

[a] Durnay and Franklin, 1972.
[b] EPA, 1975
[c] Sid Shapiro, President, Paper Fibers, Inc., Seattle, Washington
[d] Peter Whited, District Manager, Recycling, Reynolds Aluminum

1 The average recycle rate is equal to: $\frac{\text{tonnage recycled annually}}{\text{average tonnage available for recycling}}$.

Institutional Constraints

In part, the structure of the national economy is itself responsible for modest recycling activity. The technology of industrial and consumer goods production, and the composition of commodity demand, is geared toward the use of virgin resources rather than secondary materials. The secondary materials industry, in comparison with the more established and often highly concentrated extraction and primary goods manufacturing sector, is characterized by many small, specialized firms which compete vigorously for stable, higher quality secondary materials supplies as well as sources of regular industry demand. In addition to concentration of ownership, primary extraction industries exhibit a high incidence of vertical integration[2] through various levels of product fabrication. Consequently, the extractive sector realizes a competitive advantage over the recycling sector in terms of economies of scale (concentration) and greater control over raw material inputs to production (vertical integration).

The extraction sector is also supported by a tax structure which encourages the production of virgin resources at the expense of recycling available secondary materials. Tax deductions available exclusively to the extractive sector include depletion allowances, the expensing of intangible outlays for exploration and development, and capital gains treatment on profits from appreciation of standing timber land.

---

[2] For example, nearly all wood pulping operations are integrated backward to include harvest and forward to include paper grade production. Alaska pulp mills are not integrated forward and represent an exception to the above statement.

Several technical features particular to secondary materials limit the extent to which they may be recovered, reprocessed and reused commercially. They are:

1. Contamination
2. Mass
3. Accessibility

As components of mixed solid waste, secondary materials are rarely free of contaminants. The degree of contamination determines the amount of handling effort required to collect and sort recyclables. For example, the advent of bi-metal cans requires special magnetic separation devices to remove ferrous materials from aluminum recovery.

Carbonless reproductive paper contains a non-soluble chemical coating that cannot be removed by filters in the initial "hydropulping" stage of waste paper reduction. Left unchecked, these contaminants severely reduce the quality of recycled paper forcing costly mill shut-downs to clean equipment. Thus, considerable sorting is required by the collector to remove undesirable chemical contaminants from higher grades of waste paper.

The unit value of secondary materials increases with their mass. As a result, baling and compacting are important functions to the overall economies of recycling. Economies of scale (i.e. savings in money outlays due to efficiencies inherent in larger scale operations) linked to second-stage reprocessing of dense, homogeneous quantities of secondary materials are sometimes passed back to the collector in the form of higher unit prices that secondary material users are willing to pay for higher mass volumes traded. Moreover, increasing the density of recovered waste products tends to lower the unit cost (cost per ton) of handling and transportation. Thus, greater compaction reduces collection and transportation costs, thereby raising the "netback" value the recycler receives when he sells secondary materials.

Accessibility of secondary materials is largely a function of the degree of dispersion or the spacial distribution of consumption and waste generation as well as the location of manufacturing operations which use secondary materials.[3] In contrast to relatively concentrated natural resources, secondary materials are generated in dispersed patterns. Greater dispersion reduces the collector's control over the quantity and regularity of material recovery. The recycle center which relies heavily on the residential sector is unable to directly control resident participation in material recovery. The recycler can only influence material recovery through educational programs, collection strategies and buy-back policies.

On the other hand, commercial users generate higher, more regular concentrations of secondary materials.

Once established, community involvement in waste separation and delivery is difficult to arrest. This was the experience of the Alaska Center for the Environment's (ACE) earlier newspaper collection program. In this case,

---

[3] This is particularly relevant to Alaska. For example, aluminum cans dispersed throughout Anchorage must first be consolidated into feasible supply and then distributed to markets outside of Alaska.

collected newsprint was recycled locally into cellulose insulation (see discussion of Thermo Kool below). When local demand for used newsprint dissipated following seasonal demand contraction, ACE was forced to terminate its collection effort. However, residents continued to deliver supplies to dispensed drop-off locations for a substantial period thereafter. In this example, the absence of an adequate feedback mechanism to communicate market information to the consumer is partly responsible for persistent newsprint deliveries.

The uniform nature of established community involvement in recovery, a seemingly stabilizing force, can also reduce the responsiveness of supply, to changes in demand and prevent the collector from effectively exploiting sudden and unexpected shifts in demand. In some cases, dealers actively resist attempts to satisfy what they perceive to be irregular or transient demand swings in order not to disrupt established patterns of trade.

Irregular demand tends to exacerbate unstable price behavior caused by the more general lack of supply control. As a consequence of limited accessibility and dependence on community participation, the recycler faces uncertainties in both supply and demand. It is this feature which sets recycling apart from other forms of commercial enterprise which have greater control over supply.

In summary, limited demand for secondary materials has traditionally been identified as the principle deterent in the expansion of the recycling industry. It is becoming increasingly evident that, although certain benefits inherent in secondary materials are not reflected in market prices, the demand for secondary materials is rising. Despite the availability of substantial reserves of untapped scrap, a myriad of institutional and technical factors limit both the recycler's control over and ability to expand supply in response to rising demand.

PART II. MATERIAL THROUGHPUT

The purpose of Part II is to establish a data base for subsequent analysis. In general, the term "throughput" refers to the amount of material put through a process or system. In our example, material throughput refers not only to volume and composition of commodity movement, but to patterns of consumption and disposal, as well. Commodity categories of particular interest to this analysis include tin cans, aluminum cans, glass containers and several grades of waste paper. I revise inbound quantity estimates of specific commodities to reflect the portion that is feasibly recoverable for recycling. The potential for recovery depends on factors related to accessibility and contamination discussed above. I then compare feasible recovery (supply) to potential demand in west coast secondary materials markets.

In addition to a discussion of commodity movement, recovery potential and market demand, I briefly review the structure of maritime transportation between Anchorage and Seattle, paying close attention to factors that limit flexibility in the determination of commodity tariffs.

Finally, an overview of solid waste management in Anchorage is presented to identify the elements of waste management most likely to be affected by recycling, and to provide a framework to evaluate the impact of recycling on solid waste management costs.

Commodity Movement

In Anchorage, the cycle of material throughput begins with imported commodities rather than endogenous production and is completed with disposal at the landfill or roadside. As shown in Table 2-1, a total Anchorage population (including Eagle River, Chugiak, Turnagain Arm and military bases) of 202,101 was supported by about 991,000 tons of imported goods or 4.9 tons per person during 1978. Mixed cargo alone amounts to almost 3,000 pounds per capita. About 17 percent of total inbound tonnage entered landfill and 1 percent was exported primarily as scrap metal (see Part III). The remaining 813,000 tons are durable commodities and commodities that generate negligible waste material (e.g., petroleum).

Table 2-1 Commodity Imports to Anchorage (1978 and 1992)

Commodity Group	Inbound Tonnage	
	1978[a]	1992[b]
	(thousands of tons per year)	
Crude Petroleum, Chemicals, Petroleum Products	171	300
Ores and Minerals, Coal, Cement	125	186
Primary and Fabricous Materials, Machinery and Vehicles	101	173
Wood and Paper	142	218
Food, Fish, and Farm Products	166	274
Mixed Cargo (Metal Products and Household Goods)	286	430
TOTAL	991	1681

Assumptions:

[a]Estimates
[b]Projections
Source: Gray, 1979.

Paper

The total quantity of paper products imported into the railbelt region is divided into newsprint, paperboard and paper products not elsewhere classified (NEC) for selected years in Table 2-2. Paperboard includes a variety of grades ranging from corrugated containers used for packaging to hard pressed board for construction. Paper and paper products not elsewhere classified (NEC) include printing, publishing, and computer paper.

Table 2-2 Railbelt[a] Paper and Newsprint Imports (tons)

	Newsprint	Paperboard	Paper & Paper Products NEC	Total
1973	4048	4425	6310	14,783
1974	5503	7165	5346	18,014
1976	11564	11292	4514	27,370
1977	10488	4334	6916	21,738

Assumptions:

[a] 16-18 percent is for Fairbanks.

In general, the west coast market for assorted secondary paper fiber is steady, strong and large. Recent expansion in U.S. trade relations with China and India implies an extra stimulant to west coast export markets in secondary paper. The supply and price of pulp as well as general economic conditions are principal determinants in cyclical variation in wastepaper prices. Brokers (dealers) attempt to maintain supply continuity in both grade and tonnage while responding to price variation.

The price received by Alaska paperstock collectors depends, in part, on the homogenity and density of shipments. Generally, it is best to ship single item, high density loads although homogeneous, low density shipments may still receive a high price. Mixed loads (e.g. half newsprint and half computer print out (CPO) in a single container) require extra handling to either broker or buyer which will be reflected in the selling price.

Newsprint. Newsprint is the most abundant waste paper product in Anchorage. Two major Anchorage-based newspapers have a combined daily circulation of about 65,000, or 8,900 tons annually. However, local competing uses for newsprint reduce the quantity available for collection and marketing to West Coast paperstock brokers. For example, newsprint is consumed as fuel and is used as a principal ingredient in the fabrication of locally produced cellulose insulation (see discussion of Thermo Kool below).[1] According to Sid Shapiro of Paper Fibers, Inc. in Seattle, local demand for newsprint lowers the "market" recycling rate in Alaska substantially below the current U.S. average of 24 percent. Abstracting from seasonal patterns in local newsprint demand, I assume that the quantity of newsprint readily available for export to west coast recyclers is equal to 50 percent of inbound quantity.[2]

---

[1] Burning newsprint represents energy recovery and is therefore technically different from material recovery for recycling. Combustion uses the biological energy in paper fiber whereas recycling reuses the industrial energy embedded in paper from the first round of production.

[2] This is consistent with the observation in GAAB (1973) that newsprint comprises about 10 percent of waste paper quantities disposed in "municipal landfill" from residential sources.

Approximately 18 percent of newsprint fiber recovered nationwide is recycled back into "new" newspaper. The remainder is recycled into lower grade paper products, including box board and construction paper. The price of "catchweight" newsprint bundles (packed in grocery bags or bundle with twine, not baled) delivered in Seattle is currently (March 1980) $70 per ton. It is up from $60 in late November, 1979. In June, 1973, newsprint sold for $20 per ton in west coast markets. Newsprint is generally more seasonal than other waste products, experiencing shorter supply in winter months. A major Seattle recycler expects the newsprint market to remain strong through August, 1980.[3]

Corrugated Containers (CC). A large quantity of corrugated containers enter the Anchorage economy as packaging for food products, household goods, and general cargo. In some cases, retail outlets that ship regularly backhaul used CC in empty southbound trailers. One Anchorage-based grocery chain bales CC before it is hauled away by municipal refuse collectors.[4]

On average, corrugated containers comprise between 40 and 70 percent (PRT, 1975, p. 28) of retail wastes. In Anchorage, 25 percent of waste paper entering municipal landfill is CC. However, CC is a high bulk commodity and requires considerable compacting for cost-effective transportation. Thus, precrushing is necessary before baling and adds to overall

---

[3] Don Knease, President of Seattle Recyclers Association.

[4] Baled CC must then be broken down before entering the shredder at the municipal resource recovery facility (see discussion of solid waste management below).

handling costs. Also, in mid-1979, the Japanese developed a process to manufacture CC from newspaper. Consequently, a major segment of export demand disappeared resulting in downward pressure on CC prices. Nevertheless, the Seattle price of baled CC rose from $80 to $100 between November 1979 and March 1980.

High-Grade Paper Stock. High-grade waste paper consists of white and colored ledger, computer print out (CPO), and IBM tabulating cards (tab cards). Ledger is generated primarily from professional technical and business offices. In 1978, there were approximately 29,000 non-military employees in federal, state and local government, transportation-communication-public utilities, and finance-insurance-real estate jobs. Under the assumption that 3.4 percent of total wastepaper disposal is office paper (GAAB, 1973, p. VIII-17), the total quantity consumed in 1979 from Anchorage users is about 3,070 tons or .75 pounds per day per office employee.

An unknown percentage of office waste paper includes "mixed file" paper which is contaminated with insoluble chemicals, glue, carbon paper, and plastic. The high grade component is most conveniently recovered through office source separation techniques, accompanied by modifications in janitorial services to handle recyclable and non-recyclable paper wastes.

For example, a prototype program in office paper source-separation was conducted at the State Office Building in Juneau, in Spring 1979. Office employees were encouraged to physically separate white ledger, CPO, and tab cards from other components of office waste. Routine janitorial services were modified (without increasing total labor time) to handle recoverable component separately from other waste and deliver it to a convenient storage location for daily collection by the recycler. Although several logistics problems regarding office participation and the structure of janitorial services were encountered, program results indicate that modifying janitorial procedures was relatively simple. In this particular case, prior to the introduction of the office paper separation program, the janitor contracted to transfer office wastes from the building to the landfill site. The reduction in waste volume from recycling reduced the number of required trips to the landfill and resulted in potential net economic gains to the janitor.

Compared with other grades, the volume of high-grade office ledger traded is less although the market value of high-grade is stable and not expected to decline. Table 2-3 displays west coast prices for assorted high-grade waste paper products and for less valuable mixed file paper.

Table 2-3 West Coast Paper Prices

Type[a]	West Coast Price	
	November 1979	March 1980
White ledger	100-140	180
Colored ledger	100-110	NA
CPO	210	235
Tab cards	250	270
Mixed file paper	20	50

Assumptions:

[a]High-grade products are 95 percent contaminant-free, baled or bundled.

Source: Sid Shapiro, President, Paper Fibers, Inc., Seattle, Washington.

CPO and tab cards are consumed in commercial institutions, in all levels of government, and in military offices as shown in Table 2-4. However, only a modest portion of CPO is feasibly recoverable due to an increasing incidence of non-soluble chemical coatings and of carbon paper. In-house record keeping and restrictions due to classified information (especially in military CPO) further limit potential CPO recovery. On the otherhand, the information on tab cards is typically transferred to computer tape so that, although not an abundant source of recyclable paper, inbound tab cards are 95 percent recoverable. Returning to Table 2-3, we note that tab cards and CPO represent the highest grades of waste paper fiber commercially available.

Glass

The amount of container glass consumed and generated as waste material is tied closely to food and beverage consumption. For example, in 1979, more than 10 million[5] gallons of beer alone entered the Alaska economy. Of this, I estimate that 4.5 million gallons[6] entered Anchorage packaged in 48 million 12-ounce aluminum cans and glass bottles. The distribution of glass and aluminum containers is approximately 41 and 59 percent, respectively.[7] Thus, about 20 million bottles of beer packaged in more than 6 million pounds (3,000 tons) of glass were consumed in 1979. However, according

---

[5] Bob Stevenson, Alaska Department of Revenue.

[6] I assume that 50 percent of beer inbound to Alaska is consumed in Anchorage, and deduct 10 percent of that amount to account for bulk containers.

[7] According to Peter Whited, District Manager for Reynolds Aluminum Co. in Seattle, 3 million pounds of aluminum cans (about 66 million cans) entered the Anchorage beverage market, of which 43 percent contains beer.

Table 2-4 Inbound Computer Print Out and IBM TAB cards for 1979. (The Percent of Feasible Recovery of Inbound Tonnage is in Parenthesis) (Tons)

	IBM TAB CARDS	CPO
Commercial Institutions and State Agencies	25 (95)[a]	118 (38)[c]
Municipal Offices	20 (95)[a]	1400 (38)[c]
Military	228[b] (95)[a]	1050 (2)[d]
Federal Offices	-	1480 (11)[e]
Total Inbound Tonnage	273	4048
Recoverable Portion of Inbound Tonnage	259	950

Assumptions:

[a]Information on cards is eventually transferred to tape such that few cards are retained for record keeping.

[b]Includes some federal agencies.

[c]25 percent of CPO contains carbon or carbonless chemicals for copying. Thus, 75 percent of inbound CPO is high grade recyclable. 50 percent of all CPO is assumed to be retained for office records. Therefore, .75 x .50 = .38 is available for recycling under ideal conditions.

[d]90 percent CPO contains carbon or carbonless chemicals for copying. Thus, only 10 percent of CPO is recyclable. 85 percent of all CPO is assumed to be retained for office records. Therefore, .10 x .15 = .015 is available for recycling from military offices.

[e]25 percent of CPO contains carbon or carbonless chemicals for copying, 85 percent retained for office records. Thus, .75 x .15 = .11 is available for recycling from federal agencies.

Sources:

1. Chuck Parkam, GSA Customer Services Representative.
2. Bill Miernyk, Account Representative, Moore Business Forms, Inc.
3. Mr. Ferguson, Data Processing Supplies of Alaska.
4. Municipal Data Processing Office.

to national statistics on the breakdown of glass containers (Darnay and Franklin, 1972, p. 71-2), beer comprises only one-fifth of total glass container uses, the remaining four-fifths is used for food, soft drinks and other products. Table 2-5 presents an end-use distribution of glass containers as applied to Anchorage data.

The data in Table 2-5 indicate that a substantial quantity of used container glass exists. The amount that is feasibly recoverable depends in part on resident participation in source separation, since roughly three-fourths of used container glass is generated from household consumption. In contrast to other secondary materials, the potential for glass recovery is also limited by special problems in both handling and freight.

Used glass must be separated by color and crushed into cullet for compaction. Also, metal components such as twist off cap rings and decorative foil must be removed. This creates special handling and storage requirements, which add to the cost of recovery. Glass is also comparatively expensive to ship. Freight costs alone consume from 50 to 80 percent of revenue, depending on market conditions. Because glass companies refuse to off-load containers with stacked bottles or 55 gallon drums of color separated cullet, the collector must hire or provide off-loading services at the glass manufacturing facility. An alternative to this economically unacceptable option is to use open top, gravel type trailers with hydraulic lifts for convenient dumping of cullet. This too, presents logistics and storage problems in addition to the high cost of specialized containers. The steady recovery of

Table 2-5 Glass Containers by End-Use in Anchorage

End-Use Category		Percent[a]		Annual Quantity (tons)	Number of Containers
Food		31.5		5040	NA
Beverages		48.9		7824	
Liquor	4.8		768		
Wine	2.6		416		
Beer	19.3		3088[c]		
Softdrink	22.2		3552		19.7 million
Other[b]		19.6		3136	
	TOTAL	100.0		16000[d]	

Assumptions:

[a]Based on percentage of total U.S. glass container shipments in 1970. (Percentage Distribution, Durnay and Franklin, 1972, p. 71-2.)

[b]Includes medical, cosmetic and chemical containers

[c]Based on assumption that each container weights 5 ounces on average (Alaska Cold Storage Distributors).

10

[d]Note, the discrepancy between total weight of glass beverage containers in Tables 2-5 and 2-11 reflects presence of Eagle River, Chugiak, Turnagain Arm and military base populations in Table 2-5 and not in Table 2-11. The figures in Table 2-5 may contain a large error component depending on the validity of Table Note c.

10

cullet must be stockpiled (in, say, 55 gallon drums or preferably in storage bins) until the container returns from its Seattle destination. Also, the cost of returning a container must be included unless arrangements to ship a commodity bound for Alaska (e.g. cement) could be negotiated with a West Coast producer. These and other problems with glass are examined in the context of specific examples below.

The demand for cullet is growing less rapidly than other secondary materials. A large multinational glass manufacturer in Portland, Owens Illinois, offers $30 per ton for metal free, color sorted glass or cullet. Northwest Glass Co. of Seattle is smaller than Owens, consumes 250-300 tons of cullet per week, and receives all the glass it needs at $20 per ton. A $10 freight premium is offered to collectors at distances greater than 100 miles from the Northwest plant.

As a raw material substitute, glass cullet does not require major process changes by industry, uses less energy, and creates less equipment wear. However, sand and soda ash, limestone, and feldspar, the principal raw material ingredients in glass production, are not expected to be in short supply, in the near future, although location-specific reductions in resource grade may increase the cost of production using raw materials and improve the competitive position of cullet.

Aluminum Cans[8]

The annual quantity of aluminum cans in Anchorage is approximately 3 million pounds (1,500 tons) distributed between soft drinks (57 percent) and beer (43 percent).

Scrap aluminum is an extremely high grade secondary material. Its value stems largely from substantial energy savings over production from bauxite ore (Table 1-1). West coast aluminum producers accept all the scrap aluminum they can get and actively pursue recycling campaigns designed to increase the nation-wide aluminum recycling rate beyond the current 30 percent. In some cases, aluminum can producers are willing to lease shredding, baling and magnetic separating equipment to collectors and recyclers.

Although aluminum prices are comparatively less sensitive to seasonal factors, the export segment tends to reduce stability in prices. In Japan, the demand for recycled aluminum exceeds the level of feasible domestic (Japanese) recovery. Consequently, Japan cannot generate sufficient recovery from internal sources.

The affect of rising energy prices and strong international demand creates upward pressure on scrap aluminum prices as well as positive incentives for aggressive programs in aluminum recovery.

---

8 In addition to aluminum cans, scrap aluminum is generated from aircraft components, furniture, construction materials, foil and other packaging materials. See discussion of Stano Steel below.

Buyers are currently paying upwards of 45 cents per pound ($900 per ton). This price has increased from about 35¢ in summer, 1979.

Tin Cans

The common "tin" can[9] actually consists of a steel can coated with tinplate. As premium metal products, both the tin and steel components of recovered tin cans are separated by a chemical process known as detinning. Tin producers are currently paying $7 per pound of recovered tinplate.

Until recently, detinning of used steel cans was considered uneconomic, because the detinning industry accepted only clean tinplate scrap from industrial sources. However, household waste separation techniques which remove organic, aluminum (bimetals) and paper contaminants can produce a marketable scrap tin product that lends itself to economic recovery and detinning.

In Seattle, detinning capacity can absorb more than 30,000 tons per year of additional quantity.[10] Tin cans delivered in Seattle receive a current price of $78 per ton, up from $71 in November 1979.

---

[9] The "tin" can is distinguished from the "bi-metal" steel cans with aluminum tops. Bi-metal cans must be shredded and the ferrous (steel) portion removed magnetically.

[10] Jack Force, President of M & T Chemicals, Inc., Seattle Washington.

The maximum quantity of tin cans available for recovery from residential source separation in Anchorage is estimated at 4,300[11] tons. This represents about half of scrap ferrous metal generated from Anchorage residential sources in 1979.

Plastics, textiles, organics and other miscellaneious waste materials are excluded from this discussion of recycling. Although technically possible, and energy-conserving, recycled plastic has negligible demand, reflecting limited reuse applications and underdeveloped markets. However, should current trends in fossil fuel prices persist, the economics of plastics recycling may become increasingly attractive. Plastics alone constitute about 2 to 9 percent of the Anchorage waste stream. Textile, rubber and tire wastes comprise an additional 3 to 4 percent. In 1979, wood plastics, textiles, rubber, and leather amounted to 24,339 tons of mixed solid waste.

The impact of recycling and household source separation and on consumer awareness may eventually induce a change in patterns of consumption and product selection that encourage techniques in waste reduction, such as standardized packaging.[12] Waste reduction, an alternative encouraged by the

---

[11]About 9 percent of total residential mixed solid waste in Anchorage is ferrous metal (Metcalf and Eddy, 1979). The pure tin content of all ferrous metal in municipal solid waste is estimated at 2 percent (Darnay and Franklin, 1972). Thus, pure tin disposal from residential sources in 1979 is equal to 179 tons. The typical "tin" can is 4 parts tin and 96 parts steel, thus about 4,300 tons of "tin" cans entered the Anchorage landfill from residential sources.

[12] Evidence of waste production fostered by the establishment of a neighborhood recycling program in Berkeley, California is available in PRT (1975, p. 43).

recycling concept, is perhaps the most efficient solution to the high volume of plastics, textile, rubber and other miscellaneous constituents in the mixed waste stream.

Note that for the food, fish and farm products commodity category in Table 2-1, packaging materials constitute approximately 41,500 tons (25 percent). This is equivalent to more than 400 pounds per person annually in packaging waste alone. Packaging material, of which plastics are a major component, therefore, comprises 40-50 percent of household-generated mixed solid waste.

Table 2-6 summarizes the information regarding recycling potential for selected secondary materials. Glass is the largest source of technically recyclable material. However, comparison of market price and freight costs indicate that glass is least favored of the materials listed. From a preliminary economic standpoint, aluminum cans occur in reasonable quantity (5 percent of total weight of potentially recyclable materials) and offer the highest after-freight return. The annual total quantity of all secondary paper products listed is 14,372 tons or 40 percent of potential recyclables. Wastepaper prices range from $50 to $270 per ton and are not expected to behave as cyclically as they have in the recent past. With the exception of glass, markets for various recyclables in Table 2-6 are strong and are experiencing a phase of steady growth in response to heightened foreign demand and to chronic woodpulp shortages in the pacific northwest region.

In Figure 2-1, the inbound quantities of selected materials are compared to estimates of recoverable tonnage in Table 2-6. Note that the

Table 2-6 Recovery Potential, Market Price and Freight Factor For Selected Secondary Materials

Material[a]	Recovery Potential (tons)	Market Price (Seattle) ($/ton)	Freight Factor[b] ($/ton)
High Grade Ledger			
CPO	950	235	
Tab cards	259	270	
White ledger		180	
Colored ledger	3070	NA	26.95[c]
Mixed file paper		50	
Newsprint	4450	70	
Corrugated Containers	5643	100	56.60[d]
Aluminum cans	1500	900	16.00
Tin cans	4300	73	16.00
Glass	10,085	30	16.00
TOTAL	30,257		
	19 % 1979 Solid Waste	159247	

~~152095~~

Assumptions:

[a]All products should be free of contaminants especially high grade white and colored ledger. White and colored ledger, mixed file paper, and CC are all baled; CPO tab cards bundled; and newsprint neatly stacked. Aluminum cans are shredded, flattened or baled. Organic and paper contaminants removed from tin cans; bottoms removed and cans flattened. Glass is crushed and color separated.

[b]Freights assume a 40- by 8- by 8.5-foot standard size trailer for all secondary materials.

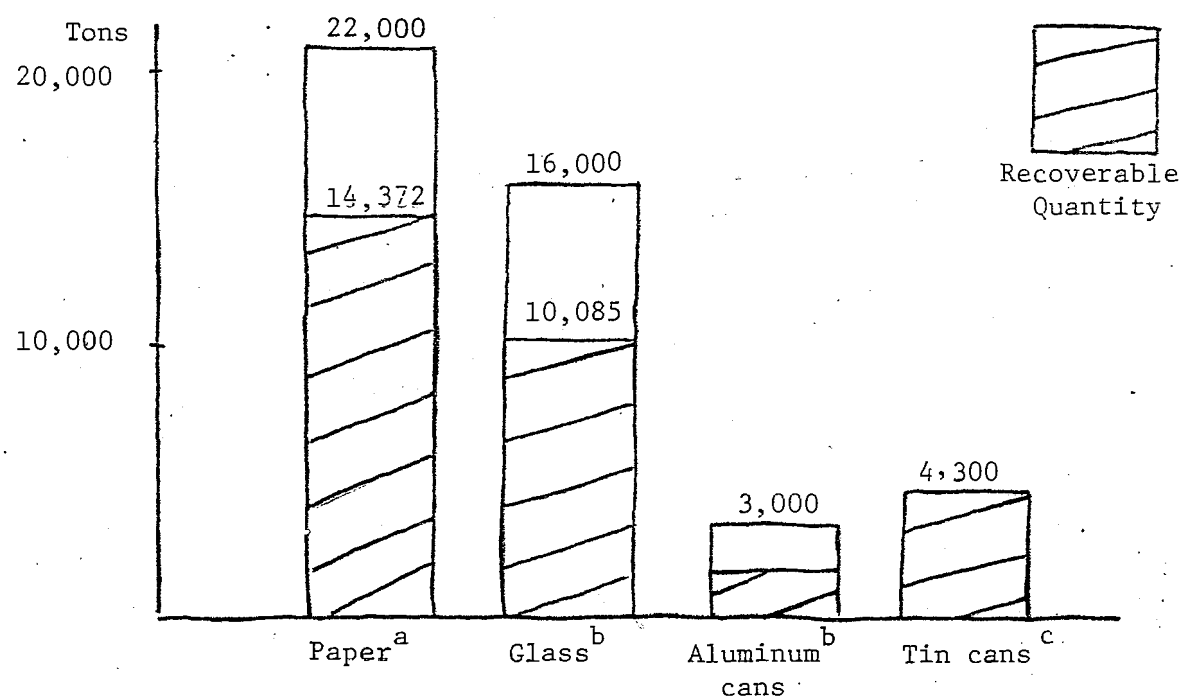
[c]Variation in weight per volume considered negligible. In all cases, paper density is such that container reaches Interstate Commerce Commission (ICC) weight limits before reaching volume capacity of container.

[d]Density of baled CC is low. Here a 40 foot container can hold 10 tons maximum. Note, a 27 foot container holds 6.75 tons. However, higher tariff per ton is charged for smaller load size. Tariff for 27 foot container is equal to $75.89 per ton.

inbound quantity of tin cans is estimated indirectly from municipal solid waste data. In contrast to tin cans, the recoverable component of paper, glass and aluminium cans falls short of respective inbound quantities. For paper, glass and aluminum, the gap between inbound and recoverable reflects the affect of contamination and of local reuse demand. Bimetal cans which contain steel and aluminum components reduce the recoverable portion of aluminum cans to half of pure plus bimetal aluminum cans.

Used tin cans are extremely pure and have few if any local uses that compete with demand in secondary materials markets and are assumed to fully recoverable.

Figure 2-1 Comparison of Anchorage Bowl Annual Inbound and Recoverable Quantities for Selected Commodities. (Tons)



[a]Includes military, CPO and tab cards.

[b]Includes military, Eagle River-Chugiak and Turnagain Arm.

[c]Excludes military.

The Structure of Transportation

The potential for recycling in Alaska is strongly influenced by the cost of transporting secondary materials to destination markets. In general, transportation absorbs about 25 percent of gross revenue from the sale of secondary materials. In some cases, freight costs alone are sufficient deterents to commercial applications in secondary material recovery.

A key feature of commodity movement to and from Alaska is that 90 percent of southbound container capacity is unused. As a result, backhaul revenues are not sufficient to cover the operating cost of southbound movement.

For example, total backhaul from Anchorage to Seattle is equal to 90-100 thousand tons per year, or about 9 to 10 percent of forward and backward tonnage. (See Table 2-7.)

Table 2-7 Breakdown of Backhaul Materials and Revenue Potential

Material	Percent of Total Backhaul (%)	Approximate Quantity (tons)	Average Backhaul Rate per 100 lb.	Backhaul Revenues
Household	43	43,000	$5.20/100 lbs.	$4,472,000
Auto and Machinery	17	17,000	$1.50/100 lbs.	1,710,000
Fish	20	20,000		
Scrap and other metal	20	20,000		
		100,000		$6,282,000

Source: John Gray, Assistant Professor in Transportation, Institute of Social and Economic Research, University of Alaska, Anchorage.

The revenues generated from southbound commodity movement approximate $6.3 million or about 6 percent of $100 million in total (forward and backward) operating costs for both carriers combined. The amount of used container capacity has a minor impact on overall freight costs. Thus, the cost of southbound movement is roughly equal to that of northbound. Backhaul revenues from current tariffs therefore absorb about 12 percent of southbound transport operating expenses.

Carrier's structure northbound tariffs to cover this southbound deficit and, by doing so, effectively integrate the forward and backward rate structure. Although the extra freight cost of shipping an otherwise empty container is negligible, carriers are unlikely to lower backhaul tariffs below current levels and further shift the burden of backhaul deficit on northbound commodity shippers.[13]

One could argue that since a given container would be returned to west coast ports empty and costs roughly the same to ship empty or full (excluding the cost of spotting), why not fill the container (with used materials) and charge the shipper a tariff that he can afford? By not doing so, the carrier foregoes an opportunity to earn extra income without increasing costs. From the perspective of a single extra shipper

---

[13] Note that carriers do give special consideration to organizations shipping non-standard commodities that apply for tariff reductions. Note also that tariffs are established by the carrier and approved by the Interstate Commerce Commission (ICC). The ICC does not regulate or monitor carriers. The ICC will respond to complaints to see that carriers do not depart from tariffs. A uniform rate structure exists as a result of competitive relations between carriers.

this arguement is infallible. However, from the standpoint of aggregate commodity movement, the same policy applied indiscriminantly to all secondary material shippers would lower total backhaul revenues below current levels and deepen the carrier's aggregate backhaul deficit. If the ICC permitted carriers to charge lower backhaul rates (say, one half of original levels) to only secondary material collectors, then annual backhaul revenues would decline 50 percent from $600,000 to $300,000, under constant outbound secondary material recovery. Outbound tonnage of scrap would have to increase 33 percent (10,000 tons) for carriers to breakeven under lower scrap material backhaul rates without disturbing northbound tariffs.

Some latitude in freight rates is available to shippers (i.e. a recycle center) because of flexibility in rate implementation. The tariffs vary depending on the weight of the shipment; a larger load receives a lower tariff. To a certain degree, tariff reductions are matched with the capacity of the container and the density of the particular material in order to encourage shippers to fill containers. Typical container sizes are 27 and 40 feet in length.

The carrier charges the shipper either by container size or by the net weight of goods shipped. Thus, it may be advantageous to the shipper to use a partially filled 40 foot container and incur the 40 foot container tariff, rather than filling a 27 foot container and incurring a higher freight rate per unit of weight.

For example, we note from Table 2-8 that a 27 foot container has a minimum weight of 30,000 pounds (15 tons) of wastepaper. A 35,000 pound load is not sufficient to receive the lower tariff that applies to 42,000 pounds or more. Nevertheless, by shipping 35,000 tons in a 40 foot container and receiving the 40 foot container tariff, the shipper pays less per ton than shipping 30,000 of the original 35,000 pounds at the higher tariff of $34.15 per ton.

Table 2-8 Southbound Shipping Specifications for Waste Paper

Minimum Weight to Receive Tariff	Corresponding Container Size	Tariff (per ton)	Tariff (per container)
30,000 lbs.	27	$34.15	$512
42,000 lbs.	40	$26.93	$566

Source: Tariff Publishing Offices, Sea Land Service, Inc.

In general, carrier services covered in the southbound tariff included spotting at the point of departure and destination. Thus, in addition to shipping the container from departure to destination ports, the carrier will pick up the loaded container at the shipper's location and deliver it to its destination provided these respective locations are within a specified commercial zone. Thus, to some extent, the logistics of mobilizing recyclables to destination markets are subsumed in the rate structure and managed by the carrier.

Solid Waste Management

In this section, I review the principal phases of municipal solid waste management in Anchorage, including collection, processing and disposal. I then identify the probable impact of recycling on each phase.

The quantity of waste disposal in Anchorage is closely linked to population and the level of economic activity. Between 1972 and 1978, the quantity of waste disposal nearly doubled from 94,380 to 168,330 tons. Over that interval, the rate of per capita waste generation increases at an average annual rate of 2 percent, reaching 5.45 pounds per capita per day for non-military,[14] Anchorage bowl residents (as shown in Table 2-9).

Table 2-9 Anchorage Bowl Waste Disposal[a]

	1972	1977	1978	1979
Waste disposal (tons)	94380	158214	168330	160084
Population (bowl)	105320	160035	169269	170281
Mixed Solid Waste per Capita per Day	4.91	5.42	5.45	5.15

Assumptions:

[a]Waste quantity and population figures do not include Eagle River, Chugiak, Turnagain Arm, and military residents.

Source: Planning Department and Division of Solid Waste, Municipality of Anchorage.

[14]The generation rate for military personnel is about 50 percent higher than civilian.

From 1978 to 1979, the quantity of waste disposal decreased 5 percent while population increased 1 percent. During this period, the rate of daily per capita waste generation fell 6 percent to 5.15 pounds.

The composition of residential and commercial waste is broken down into combustible and non-combustible material classifications in Table 2-10. The material percentage distribution is based on recent Anchorage-based surveys conducted by Metcalf and Eddy (1979). The composition of Anchorage refuse is generally consistent with that of other municipalities. Paper and glass are slightly below the national average, whereas metals and assorted debris exceed the average. (Quimby, 1975, p. 18).

Paper products constitute the largest component of mixed solid waste in both residential and commercial classifications. Paper also comprises almost 60 percent of total combustible materials.

Collection

Collection in the Anchorage bowl is carried out by the Municipal Department of Public Works (DPW) and by Anchorage Refuse Incorporated (ARI), a private hauler. The military bases are responsible for their own collection and disposal operations. The state Division of Parks and Recreation and the Environmental Protection agency (EPA) provide collection services for special waste materials. Together DPW and ARI collect about

Table 2-10 Residential and Commercial Composition[a] of 1979 Mixed Solid Wastes

Material	Classification: Residential (62%) %	Residential (62%) quantity (tons)	Commercial (38%) %	Commercial (38%) quantity (tons)	Total %	Total quantity (tons)
Combustible						
Paper	49.9	49527	67.0	40757	56.4	90284
Wood Plastics, Textiles Rubber, and Leather	9.2	9391	25.0	15208	15.2	24339
Garden Wastes	6.5	6451	NA		4.0	6451
Total Combustible	65.6	65109	92.0	55965	75.6	121074
Non-Combustible						
Glass	7.0	6948	2.0	1217	5.1	8165
Metal	10.5	10421	6.0	3650	8.8	14071
Garbage, Ash, Dirt, Rock	16.9	16674	NA		10.5	16774
Total Non-Combustible	34.4	34143	8.0	4867	24.4	160084
Total	100	99252	100	60832	100	160084[b]

Assumptions:

[a]Data do not include Eagle River, Chugiak, Turnagain Arm, and military bases.

[b]Anchorage bowl population in 1979 was 170,427.

Source: Metcalf and Eddy, 1979, Joel Grundwaldt, Director, Division of Solid Waste Management, GAAB

63 percent of total mixed solid waste. For 1979, this was equal to 100,853 tons. The remainder of Anchorage waste is delivered to the disposal site by citizens in private vehicles. In 1979, ARI collected 60,000 tons, mainly from residential subdistricts in the surrounding bowl area, including Eagle River and Chugiak. ARI currently retains about $2 million in collection equipment. Operating expenses[15] are estimated at $3.4 million, or about $57 per ton in 1979.

DPW is responsible for the remaining 40,853 tons of collected (as opposed to delivered) mixed solid waste. Making 5,700 weekly pick-ups, with eight, 3-cubic-yard dumpster trucks averaging 125 stops daily, DPW services a total of 1850 dumpster containers in addition to primarily single resident dwellings located somewhat more centrally than those of ARI. DPW incurs operating expenses equal to $2.6 million, or about $64 per ton collected.

In 1979, about 120,000 private vehicles delivered the remaining 59,231 tons, averaging 987 pounds per vehicle. Assuming an average roundtrip distance of 7 miles per vehicle, an average fuel economy of 10 miles per gallon at $1 each plus one hour of labor time at $7[16] each, gives a total private delivery cost of $924,000. Table 2-11 summarizes the quantity and cost of collection for each alternative collection mode. Together, private citizens, ARI, and DPW collected 160,084 tons at $6.9 million, averaging $43.25 per ton.

---

[15] Cost estimates are taken from Alaska PUC tariff revision, TA7-217.

[16] Second quarter 1979 wage rate in Anchorage.

Table 2-11 Annual Total Cost of Refuse Collection in 1979

Collector	Quantity (tons)	Annual Total Cost ($)	Cost per Ton ($/ton)
Anchorage Refuse, Inc.	60,000	$3.4 million	$57/ton
Municipal Dept. of Public Works	40,835	$2.6 million	$64/ton
Private Citizen	59,281	$924,000[a]	$16/ton
Total	160,084	$6.924 million	$43.25/ton

Assumptions:

[a]Assuming round trip distance equal to 7 mile at 10 miles per gallon, plus ½ hour labor time per trip: Thus:

84,000 ga. @ $1.00 ea	=	$ 84,000
120,000 hours @ $7.00 ea	=	840,000
		$924,000

Note, vehicle maintenance and depreciation not included. Also, $7 implicit wage is based on average wage rate in Anchorage, second quarter, 1979. (Alaska Department of Labor, Statistical Quarterly, Second Quarter, 1972.)

Processing and Disposal

Once collected, mixed solid waste undergoes processing and disposal. Until recently, processing consisted of the compaction that occurred in the course of spreading waste material over areas in municipal landfill where refuse was previously deposited. On average, the volume of waste material compacted in this fashion is equal to about 800 pounds per square foot.

Beginning in 1980, the Municipality of Anchorage modified waste processing by introducing "front-end" resource recovery. Rather than entering landfill directly, mixed solid waste is first shredded, sifted, magnetically separated, and air classified in order to increase the density of refuse and to convert the combustible fraction of mixed solid waste into a fuel supplement for burning in coal fired furnaces.

The 1000 horsepower shredding plant, costing $4.5 million, can mill up to 50 tons of refuse per hour, but does not burn refuse or generate steam. Planned output for 1980 is 157,800 tons, with a projected $1.9 million annual total operating cost. This reduces to $12.29 per ton and includes the cost of transfer to the landfill site.

Under ideal conditions, resource recovery produces energy from refuse. The energy byproduct, designated Refuse-Derived-Fuel (RDF), is generated from air classification of lighter, more combustible components of mixed solid waste (primarily paper, plastic, and wood scrap, although metal and glass particles are notoriously difficult to exclude from RDF.) Recall from

Table 2-10 that about 75 percent of mixed solid waste generated in Anchorage is combustible.

RDF may be "co-fired" with coal to generate steam for electric power. Prospective local markets are limited by technical considerations involving equipment and facility conversion to accommodate restrictive RDF characteristics. RDF has high moisture content and contains substantial non-combustible elements which reduce efficiency, accelerate corrosion and contribute to substantial pollution emissions (Lipshutz, 1979). In fact, numerous technical difficulties have delayed progress in national development of resource recovery.

Between 1974 and 1978, nationwide capital investment in resource recovery has exceeded $474 million with facility design capacity ranging from 50 to 3000 tons per day. Of 23 resource recovery projects on line or under development over this interval, 6 were able to realize marginal success in marketing or burning internally generated RDF. Until markets for RDF are established in Anchorage, all milled refuse is disposed in the municipal landfill.

In contrast to recycling, which emphasizes <u>material</u> recovery, resource recovery captures only the heat content of the waste material, but in doing so, fails to take advantage of energy savings which could have been realized by not having to process virgin materials displaced by recycled waste materials. Besides conserving for uses other than disposal, resource recovery implies conservation only to the extent that

RDF displaces fossil fuels directly, whereas recycling not only conserves materials, it conserves energy by reusing the energy content of recovered materials.

However, it is unlikely that recycling will recover all mixed solid waste, even under conditions of maximum participation. For waste products not recycled, resource recovery is capable of reducing refuse volume and thereby reducing the volume of waste disposed of in the landfill.

The density of refuse milled in the shredding plant is increased 50 percent from 800 to 1200 pounds per cubic yard. As a result, an acre of landfill space having an average depth of 10 feet (GAAB, 1973) can absorb 9700 tons of milled refuse compared with 6500 tons of loose, semi-compacted mixed solid waste. Under conditions of a constant stream of future waste equal to 1979 levels, the shredder can increase the longevity of remaining landfill capacity by 50 percent.

Whereas resource recovery (shredding) increases the density of mixed solid waste, and thereby adds to the quantity of refuse a given volume of landfill may absorb, recycling reduces the actual quantity of mixed solid waste intended for disposal. Despite important qualitative differences, an ultimate effect of each process is to extend the life of the landfill.

The present landfill site encompasses 211 acres, of which 80 are already filled, and services the entire Anchorage bowl, excluding military bases. The remaining 131 acres are projected to reach capacity in 1986. The landfill site is situated adjacent to Merrill Field Municipal Airport and is planned to accommodate airport expansion after it is filled.

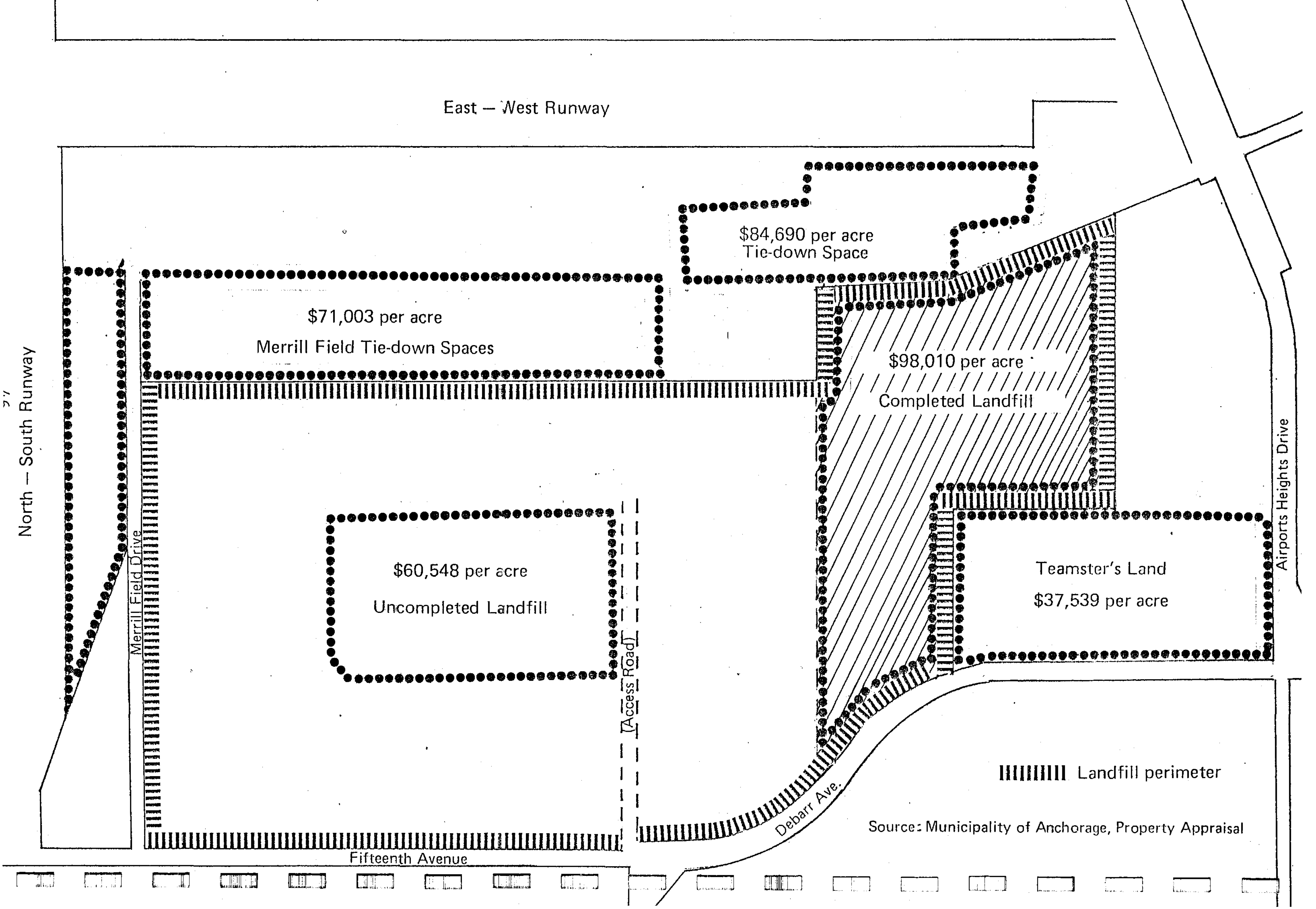
The impact recycling has on landfill costs depends on several factors, including current waste disposal practices, land use alternatives, and replacement costs associated with new landfill site development.

Figure 2-2 depicts the filled and unfilled portion of the municipal landfill site and compares the 1980 assessed value of selected land parcels in and adjacent to the landfill site (excluding buildings and other improvements). The figures suggest that mixed solid waste enhances property value in the landfill site. In fact, the assessed value of completed landfill exceeds the value of both filled landfill property as well as adjacent non-landfill property.

These results may reflect the combined effects of physical improvements caused by dumping mixed refuse and raising the surface level above the water table and of landfill space becoming available for alternative uses sooner. Thus, from the standpoint of municipal airport expansion, refuse disposal in landfill does not induce permanent damage, but enhances property value, in part, by providing space for airport expansion.

Under these circumstances, recycling delays opportunities for alternate land-use applications by extending landfill longevity. To some extent, we may discount the costs associated with delayed implementation

Figure 2-2. 1980 Assessed Value for Select Land Parcels in or Near the Municipal Landfill Site



of land-use alternatives (e.g. foregone airport tie down earings) to reflect the 5 to 10 year interval required for settling. Also, the landfill is not indivisible. Completed segments can be used for alternative purposes prior to completion and settling of the entire landfill site.

The impact of recycling is probably most strongly felt in connection with the long-run costs of developing new sanitary landfill locations. Landfill sites in Anchorage (near the international airport), Eagle River-Chugiak, and Girdwood have all terminated since 1978. With the exception of military bases, which operate their own landfill sites, all mixed solid waste collected in the greater Anchorage area is now deposited in the landfill site near Merrill Field. According to Joel Grunwaldt, director of the municipality's Division of Solid Waste, the only remaining "environmentally acceptable" landfill site is located in a gravel pit near Sand Lake.

The cost of developing alternate locations for waste disposal depends primarily on phyisical characteristics at alternative landfill sites. The level of ground water in the vicinity of the site is a particularly important consideration. In order to meet federal drainage and ground water pollution requirements, the Sand Lake site will require impervious liners to prevent downward subsurface migration of contaminants[17] into the relatively low ground water table that characterizes the area. At a current

---

[17] Note that leachate solutions generated from landfills have 200 times the toxicity of raw sewage.

cost of $1 per square foot, it is likely that preparation of liners for the Sand Lake location would exceed $1 million (Grunwaldt).

Landfill grading, access, fencing and equipment maintenance facilities must also be considered in the determination of overall landfill development costs. In general, the combination of increasingly restrictive pollution controls, greater landfill distances from urban centers, and escalating land values contribute to rapidly rising landfill operation and relocation costs.

However, in the Sand Lake example, landfill replacement costs are reduced to the extent that equipment and facilities may be transferred from the old to the new site. Also, in its present condition, the Sand Lake site has few competing uses, which lowers the potential for displacing other land-use alternatives. Consequently, the land-use savings implied by recycling pertain largely to the earnings that may be generated from funds earmarked for landfill replacement over the interval that landfill replacement is delayed.

If, for example, the cummulative effect of a recycling program over a 5 year interval extends landfill life for six months (this implies recycling program diverts about 16,000 tons per year from landfill disposal) and $3 million in funds earmarked for leachate liners, fencing, road construction, and facility set-up are invested in 9.5 percent securities over that extra half-year interval, then the savings of recycling, discounted to reflect present value (at 9.5 percent), are equal to about $88,500 or $1.10 per ton recycled. These savings would increase with an increase in the projected replacement cost of the alternate landfill site.

In the discussions that follow, I assume that the cost of developing an alternate landfill site at Sand Lake is $3 million in 1986, so that, on average, each recycled ton of waste material would save the municipality $1.10.[18] in 1980 dollars. I also assume that recycling has no affect on property damage or improvement created by mixed solid waste disposal, nor does recycling affect the opportunities for land-use alternatives at the existing landfill. Thus, the net affect of recycling on landfill operations is confined to savings realized through reduced pressure on new site development.

The impact of recycling on the solid waste management system as a whole are defined in terms of savings in processing and disposal, and in landfill operations. I assume the impact of recycling on refuse collection by ARI and DPW is negligible.

Further, there is no indication that RDF markets exist at this time. Thus, the potential costs recycling imposes on the quantity or quality of RDF is not considered.

---

[18] Note that this result does not depend on the assumed rate of recycling. A lower rate of recycling would extend the landfill life less, reduce the delay time for new landfill development, and therefore, reduce the interest earning potential of landfill development funds over the extension period. However, by assumption, the quantity recycled is less. Consequently, savings per ton recycled do not change.

Processing and dispoals costs are based on budget estimates for 1980. In Table 2-12, the cost of disposal is divided into fixed and variable components reflecting that category's sensitivity to changes in the quantity disposed. These costs are based on planned disposal of 173,200 tons, of which 157,800 tons would be shredded. Annual total cost per ton is equal to $16.65; $10.73[19] is variable and $5.92 is fixed (operating and capital recovery cost). The variable component is 77 80 percent of annual total operating cost. Thus, a ton of mixed solid waste diverted from processing and landfill disposal saves $10.73 in direct processing disposal expenses. Fixed expenses, by definition are not affected by tonnage reductions.[20]

Table 2-12 Annual Total Operating and Capital Costs for Processing and Disposal

Operating Cost		Cost/ton[a]
Variable	1,858,410	10.73
Fixed	552,980	3.19
Total Operating Cost:	$2,411,390	
Capital Recovery Cost	472,880	2.7
Annual Total Cost:	$2,883,870	16,65

Assumptions:

[a]Based on 173,000 tons disposal.

Source: Processing and Disposal Fund, Financial Detail for the Division of Solid Wastes, Department of Public Works, Municipality of Anchorage. Joel Grunwaldt, Director, provided interpretive assistance.

---

19 Note that the total cost of shredding one ton of mixed solid waste is equal to $12.29. The difference between $12.29 and $10.73 reflects two factors: (1) $12.29 includes fixed costs, and (2) not all waste entering landfill is shredded.

20 Recycling may, in fact, delay or preclude future capital outlay in both collection and disposal. We ignore this effect. Under the assumption that in the near future, recycling will not grow to substantial levels; or that collection and disposal are operating at or near capacity such that tonnage reduction will not "free" an appreciable amount of equipment.

The combination of processing and disposal, and landfill savings from recycling are equal to $11.38 (10.73 + 1.10) for each ton diverted from solid waste management.

Summary

I conservatively estimate the potential for secondary material recovery in Anchorage to be 30,000 tons per year, or about one-fifth of total commercial and residential Anchorage bowl refuse deposited in sanitory landfill.

West coast secondary materials demand is strong and growing, and appears capable of absorbing quantities of accessible waste materials in Anchorage. Rising secondary materials prices in pacific northwest markets reflects shortages in competing virgin materials (notably woodpulp) and the commercial importance of energy conservation in the production of recycled commodities.

Under the existing tariff structure for commodity movement between Anchorage and Seattle, an individual southbound shipper would contribute more to backhaul revenues than to costs since most southbound containers are shipped empty. From the standpoint of the individual shipper, a tariff reduction that permits commercial operation without lowering backhaul revenue below carrier cost is reasonable and implies extra revenues to the carrier that would otherwise not be realized under the existing, commercially-prohibitive rate structure. However, the backhaul deficit is unlikely to increase unless backhaul tariff reductions for secondary materials are accompanied by increases in southbound commodity movement.

In 1979, 160,084 tons of mixed solid waste was disposed in municipal landfill at a total budgeted cost of $9.8 million, or $61 per ton. As an alternative to disposal, recycling directly affects several elements of the solid waste management system. Each ton of mixed solid waste diverted from the waste stream saves $10.73 in processing and disposal and $1.10 in earnings from delayed expenditures on new landfill site development. Until recycling is established on a broader scale, it is unlikely to initially affect the frequency or spacial distribution of collection. Nevertheless, collection costs comprise 71 percent of the solid waste management budget and offer an opportunity for significant savings from recycling.

PART III. CURRENT RECYCLING STATUS

Anchorage recycling effort may be described as "collection for external recycling." Viewed as a two stage process, recycling effort is confined largely to first-stage material recovery in Anchorage. To date, there are few examples of instate manufacturing that utilize materials from the solid waste stream. Consequently, second-stage reprocessing of solid waste products into raw material substitutes occurs after secondary materials have been recovered and shipped to outside users.

Modest internal recycling potential reflects a fundamental characteristic of Alaska's economy: most commodities are imported. To date, high cost of capital and wages continue to discourage the development of local endogenous commodity producing capacity. More importantly, with a total statewide population of only 400,000 persons, the risk of insufficient local market demand and the difficulty of achieving adequate economies of scale continue to hinder industrial development at the expenses of added dependence on commodity imports. The manufacturing sector in Anchorage generates two percent of total Anchorage employment and total payroll, and comprises about 17 percent of statewide manufacturing. The principal segments of this industry are printing and publishing, stone, glass and clay products, and food and kindred products. It is likely that until the Anchorage industrial profile, composed largely of services industries, develops a broader commodity producing sector the potential for commodity production from secondary materials will similarly remain dormant.

Material recovery for external reprocessing and reuse is confined largely to scrap metal with some paper and textile products. Table 3-1 identifies outbound quantities of general secondary materials categories for selected years. Scrap metal attracts a significant portion of recovery effort reflecting relatively high demand in west coast and international secondary materials markets.

Table 3-1 Waste and Scrap Materials Outbound from Anchorage, Whittier and Seward Ports in 1973, 1977 and 1978

Material	Quantity (tons)		
	1973	1977	1978
Iron and Steel[a]	9,263	30,169[c]	37,969[c]
Non-Ferrous Metal[b]	5,208	552	NA
Paper		92[d]	NA
Textile	77		NA

Assumptions:

[a]Includes automobile wreckages
[b]Copper, brass, lead, aluminum
[c]Includes pipeline clean-up
[d]Scrap paper and rags

Source:

1. Department of the Army Corps of Engineers, "Waterborne Commerce of the United States," Part 4, 1976.
2. Alaska Railroad, "Monthly Commodity Statistics."

Scrap Metal Collection

Six organizations are currently involved in scrap metal collection in Anchorage. With the exception of Stano Steel and Metal Co., Inc. most collectors are small and deal in specialized scrap metal products.

Stano Steel, the largest, independent private scrap metal operation, collects, separates and decontaminates about half, by weight, of total Anchorage-based metal recovery shown in Table 3-2. With warehouse and equipment valued at $1 million and a full time crew of eight, Stano Steel collects a wide range of scrap metal products (including pipeline clean-up) and in some cases operates strictly as a broker without physically handling materials.

Table 3-2 identifies an approximate level of scrap metal recovery based on informal interviews with various collectors. Although total outbound scrap metal in Table 3-1 is not indicated for 1979, one may infer from Table 3-2 that the general decline in metal recovery reflects a reduction in pipeline clean-up. Total metal recovery in Table 3-2 is likely to more accurately reflect scrap metal generated locally in Anchorage (and the Matanuska Valley).

All metals are marketed outside of Alaska, including battery and aluminum exports to Korea, Taiwan, and Japan. In 1979, the total market value of recovered scrap metal was about $2.2 million, excluding automobile scrap.[1]

In addition to scrap aluminum from aircraft parts, furniture, sidings, and transformers, about 46 tons of aluminum cans are recovered annually through a cooperative agreement between the Anchorage Chamber of Commerce

---

[1] Note the price and quantity figures in Table 3-2 are tentative. They are not composed from accurate records, but instead reflect estimates specified by individual collectors.

Table 3-2 Metal Salvage by Commodity in 1979

Material	Price[a] ($)	Quantity (tons per year)	Value ($)
Ferrous			
Steel	$.03/lb.	1500	$ 90,000
Cast Iron	.03/lb.	150	9,000
Automobile	NA	3600	NA
TOTAL FERROUS		5250	99,000
Non-Ferrous			
White:			
Stainless Steel	.03/lb.	40	24,000
Lead (soft)	3.00/lb.	16	96,000
Battery	.08/lb.	1872	312,000
Aluminum:			
Cans	.42/lb.	71	59,640
Other	.45/lb.	372	334,800
Zinc	-	-	-
Red:			
Copper	.70/lb.	672	940,800
Brass	.50/lb.	291	291,000
Radiators	.46/lb.	93	85,560
TOTAL NON-FERROUS		3427	$ 2,143,800
TOTAL FERROUS & NON-FERROUS		8677	$ 2,242,800

[a]In some cases, prices are approximate because of variation in the grade of specific metal products.

Source: Stano Steel and Metal Co., Inc.
M & M Enterprises
Boyle Metals Recycling
Jerry the Battery Guy
ABC Auto Supply
Hilltop Sales and Service

and Stano Steel. Approximately 60 drop-off dumpsters are dispersed in specific locations throughout the Anchorage bowl. Twice a month aluminum is collected from each dumpster and returned to the Stano Steel warehouse where it is sorted, shredded and marketed to Japanese and west coast refineries. Stano Steel provides equipment (dumpsters and dumpster truck), collection, and marketing services. The Chamber of commerce establishes dumpster locations and pick-up schedules. Stano Steel retains 12 cents per pound of gross receipts to help cover freight and collection expenses. The remaining proceeds from aluminum sales are donated by Stano Steel to the Chamber of Commerce's aluminum collection program (a non-profit organization) to cover administration and to finance the Chamber of Commerce, Anchorage Youth Corps Clean-Up Program. According to one Chamber of Commerce representative, dumpster contamination from bimetal cans and other non-aluminum materials increases the costs of sorting and shredding cans and presents a major deterent to program success.

Between January and September, 1979, Chamber of Commerce aluminum can collection averaged about 7,600 pounds (3.8 tons) per month and totaled 68,481 pounds. On an annual basis, this represents about 6 percent of aluminum can recovery potential identified in Table 2-6.

With the exception of aluminum can collection, which depends on aluminum donations by the general public, scrap metal collectors pay established rates or bid on available secondary metal. Bids are typically made for larger lump sum quantities from petroleum and mineral mining, construction, and railroad operations, but are also contractual for on-going scrap recovery.

Waste Oil and Waste Paper Recovery

A hand-full of additional, small, specialized enterprises are involved in recycling assorted non-metal waste products.

Alaska Pollution Control (APC) collects and reuses waste oil locally. With $250,000 in storage tanks, trucks and assorted equipment, APC collects annually about 200 to 250 thousand gallons of waste oil from service stations, maintenance shops, car lots and military bases. Customers pay 12 cents for each gallon collected by APC. The oil is then stored in settling tanks until water settles to the bottom. APC contracts with the municipality or with private organizations to spray used oil on secondary roads and alleys to reduce dust and add substance to road surfaces. According to Zalob (1979), only a small fraction (1 percent) of waste oil used for recovering road surfaces stays on the road. The remainder, including heavy metal components seeps back into the environment. In general, most waste oil is dumped into sewers, backyards, and landfill sites without regard to environmental hazards. About 10 percent of waste oil generated nationwide is re-refined.

From a technical standpoint, Thermo Kool, Inc. is the only Anchorage based collection operation that actually recycles secondary materials. Thermo Kool manufactures cellulose insulation from a combination of newsprint and fire retardant chemicals. Newsprint is conveyed into a hammer mill where it is shredded and mixed with chemical ingredients. One ton of cellulose insulation uses three parts newsprint and one part chemical. Production is tied to statewide construction activity and is therefore highly cyclical. Thermo Kool consumes about 30 tons per month over a six month production cycle. This represents about four percent of potential newsprint recovery from Table 2-6. They collect and purchase newsprint from private citizens, from the leftover stock of newspaper printers, and from community groups engaged in newsprint collection (e.g. Boy and Girl Scouts).

As a secondary activity to help generate offseason (January to May) revenue, Thermo Kool also collects and markets CPO and tab cards to west coast paper brokers. Although the quantity collected is unknown, Thermo Kool purchases non-contaminated CPO and tap cards for not less than $25 per ton.

The newest entry in waste paper collection for recycling is Green Earth Recycling, a single-person operation that began in January, 1980. In the first two months of operation Green Earth recovered and marketed about 16 tons of CPO and tab cards netting $2,800 in income after deducting materials purchased and freight expenses from gross receipts of $4,000. Green Earth pays CPO and tab card users $40 per ton and is expected to offer $50 sometime soon. Scott Walyer, president of Green Earth, describes the strategy of his operation as "low key" recycling. Green Earth contacts staff level office personnel in state and local government and commercial institutions that take it upon themselves to become involved in recycling in lieu of authorization from top management. The money paid by Green Earth is typically used to cover office coffee machine expenses. Walyer claims this technique is effective and is used by other local, independent private collectors. However, because of legal and policy considerations concerning the disbursement of government property (which was previously thrown away) the Anchorage Municipality is in the process of organizing a bidding system which will properly internalize funds and stimulate paper recovery simultaneously.

Full Line Recycling: The Alaska Center for the Environment Recycle Center

In April 1979, the Alaska Center for the Environment (ACE) received an appropriation from the state legislature to provide start-up funds for a non-profit, independently operated, full-line recycle center. The Alaska Center for the Environment Recycle Center (ACERC) was established in part to actively participate in material recovery. ACERC also functions as a demonstration project to explore the difficulties of collecting and marketing a broad range of secondary materials. The intent of Bob Morrison, manager of ACERC, is to achieve a breakeven level of material recovery within the first year of operation.

The ACERC began operations in October, 1979 and performs two basic functions. First, it operates as a citizen drop-off station for newsprint, CPO, tab cards, tin and aluminum cans, used motor oil, and worn out car batteries. Table 3-3 shows monthly frequency of citizen participation broken down by material type. The frequency of newspaper drop-offs was highest, followed by aluminum cans and then tin cans. Average participation grew from a low of 12 deliveries per day in November, to a high of 17 per day in February. Under the interpretation that each delivery represents a single household, and that the average household is expected to recycle once a month, the level of participation given in the first 5 months of operation represents less than 1 percent of Anchorage bowl households.

Table 3-3 Recycling Participation at the Alaska Center for the Environmental Recycle Center

Month	Number of Days Opened	Frequency of Citizen Drop-Off by Material					TOTAL
		Newsprint	Tin	Oil	Aluminum	Batteries	
November, 1979	25	280	32	20	54	16	301
December, 1979	25	303	37	10	110	9	313
January, 1980	27	325	62	9	117	8	339
Monthly Average		303	44	13	104	11	318

Source: Bob Morrison, Manager, ACERC.

The second function of the recycle center is to collect (i.e. pick up) CPO and tab cards from organizations that accumulate at least 300 pounds of combined CPO and tab cards. Table 3-4 identifies the number of pick-ups and total weight of collected computer paper from December, 1979 through February, 1980. About 25 organizations including military (5), state (4), federal (2), municipal (2), commercial banks (4) and private businesses (8) provided CPO or tab cards for collection over the indicated 3 months period.

Table 3-4 Alaska Center for the Environment Recycle Center Computer Paper Pick-up Frequency

Month	Pick-Ups					
	IBM (tab) Cards		CPO		Combined	
	number	weight (lbs.)	number	weight (lbs.)	number	weight (lbs.)
December, 1979	6	1490	13	2920	19	4410
January, 1980	10	2435	17	6975	27	9410
February, 1980	8	3320	15	5575	23	8895

Source: Bob Morrison, Manager, ACERC

To service deliveries and make pick-ups, the ACERC employs one full-time manager and two part-time assistants. Whenever possible, volunteer help from a local pretrail training program for juvenile offenders is accepted.

The recycle center operates out of a 2,200 square foot quonset warehouse with 3,000 square feet of additional yard space. In addition to miscellaneous materials such as pallets, barrels, boxes and binders, a forklift, a single axle truck with a 12- by 8- by 8.5-foot enclosed bed, and a baler were purchased with start-up funds. Thus far, the baler, used normally to compact and compress mixed paper and light metal, has not been used.

Citizen drop-off is structured to minimize handling. Used newspaper is loaded directly into a 40 foot TOTEM trailer which sits in the recycle center yard. The container is made available to the recycler for a maximum interval of 10 days. It is then shipped and replaced with an empty container. Satisfying this time interval is a principal constraint in newsprint collection for ACERC. If this requirement cannot be met, then ACERC must pay a penalty fee or stockpile newprint in the warehouse until sufficient quantity is generated to fill a container. Warehousing absorbs considerable manpower and storage space which would otherwise be available for sorting and compacting other materials.

To get around these problems, ACERC sometimes combines shipments of CPO, tab cards and newsprint into one container. (Recall a single southbound tariff applies to most grades of paper stock.) Thus, when a container partially filled with newsprint approaches the end of its on-location loading interval, CPO and tab cards that have been sorted from contaminants and bundled on pallets are used to fill available container space, and therefore, to reduce the unit transportation cost (cost per ton). However, combined shipments increase the dealers handling costs and may detract from the market value of total shipment.

Collection of CPO and tab cards absorbs about 2 hours of trucking for daily pick-ups. Materials are returned, sorted and stockpiled for eventual bundling. CPO stacks must be sprayed and chemically tested to check that undesirable carbonless copying chemicals have not evaded sorting procedures. The value of contaminated CPO declines 80 percent to $50 per ton and is equivalent to low grade mixed file paper.

For the first five months of operation, ACERC recovered, sorted, bundled and marketed 184,525 pounds or 92 tons of newsprint, CPO and tab cards. Gross receipts from secondary material sales were $7,540 ($82/ton). Shipping costs[2] were $2,689 (5 shipments averaging $538 each) or almost 30 percent of gross receipts.

Table 3-5 presents a quarterly statement of ACERC operating income and expenses. The start-up month of October was not included in order to more accurately identify on-going expenses. Total variable operating costs (VOC) have been allocated to individual wastepaper products in order to isolate and compare cost factors that are pertinent to specific secondary materials. ACERC purchases newsprint, CPO and tab cards from users. All material purchases in Table 3-5 apply to

---

[2] The freight cost incurred by ACERC is a special reduced rate granted by TOTEM. The modified rate is about 87 percent of the original southbound tariff for waste paper.

Table 3-5 Quarterly Report, Alaska Center for the Environment
(November and December, 1979; January, 1980)

	NEWS		CPO		TAB		Combined	
Quantity Sold (tons)	36.9		10.7		6.4		54	
Price per ton	$ 70		$ 215		$ 265			
Revenue	$ 2578		$ 2272		$1671		$ 6521	
Variable Operating Cost (VOC)		% VOC		% VOC		% VOC		% VOC
Materials Purchased[a]	360	15	--	0	--	0	360	6
Freight	1078	44	314	17	185	14	1577	28
Labor[b]	989	41	1385	73	989	77	3363	60
Trucking[c]	--	0	198	10	116	9	314	6
TOTAL VOC	2427	100	1897	100	1290	100	5614	100
Gross Operating Profit (Loss)	151		375		381		907	(14% Rev)
Fixed Operating Cost (FOC)								
Rent							2250	
Advertising							296	
Overhead[d]							1947	
TOTAL FOC							4493	
TOTAL VOC and FOC							10,107	
NET SURPLUS (Deficit)							(3,586)	

Assumptions:

[a]ACERC purchased 18 tons of used newspapers from non-profit organizations.

[b]Manpower is distributed among newsprint CPO, tab cards, and overhead as follows:

	News	CPO	Tab	Overhead	Total
Percent:	25%	35	25	15	100%
Wage bill:	$989	1385	989	595	$3958

Newsprint requires little sorting, but must be neatly stacked in the container. CPO requires more extensive sorting, stacking, bundling and to control for other materials that are collected (but not yet marketed) and general administration.

[c]Trucking includes operating and maintenance for CPO and tab card collection. CPO is allocated 63 percent and tab is allocated 37 percent.

[d]Overhead includes administration, labor cost, utilities, general maintenance, supplies, travel and miscellaneous expenses.

newsprint only. Of the total quantity shipped, 18 tons or about half of newspapers delivered were actually purchased by ACERC at $20 per ton or 1 cent per pound. Freight absorbs 44 percent of newsprint variable operating costs. The relatively high freight cost on newsprint reflects larger quantities recovered. The combined cost of freight and materials purchased absorbs 59 percent of newsprint VOC and 56 percent of newsprint revenues.

In contrast to newsprint, CPO and tab cards did not incur materials purchasing costs. The freight factor is also lower. Manpower for CPO and tab card collection and handling is notably greater than for newsprint, since newsprint requires only modest restacking in the container. Gross operating profits (defined as revenue minus variable operating costs) are positive for all three materials for the specified product mix. Yet the excess of total revenues over variable operating costs for all materials combined is not sufficient to cover fixed operating costs, which alone, equal 69 percent of total revenues. (We also ignore equipment costs equal to $12,700 covered by the state grant.)

In order to break even (i.e. to attain a level of recovery such that annual total revenues equal annual total costs, collection and marketing must expand to a quarterly total of 267 tons (1068 annual tonnage), using the same product mix proportions specified in Table 3-5. By focusing recovery efforts on tab cards and CPO, which exhibit higher unit, gross profitability than newspapers, the break even level of total recovery is reduced somewhat depending on the specific product mix. Nevertheless, an approximate fivefold increase in marketable tonnage is required to cover all expenses. All else equal, participation by residents and commercial organizations must jump from .6 to 3 percent in order to generate break even tonnage.

The above break even analysis is based only on private costs and benefits recognized in the market and internalized by market prices. Recall that a number of hidden costs and benefits are not captured in the market for secondary materials. These include savings of extended landfill life, reduced processing and disposal costs, and from a broader standpoint, reduced pollution and environmental damage.

From these benefits, however, we "net out" the non-market cost of time and effort to separate secondary materials from household waste and deliver it to the recycle center. Recycling operates in a social framework that routinely and permanently discards used materials as valueless waste. In order to integrate recycling into this "throw-away" structure, citizens must spend extra time and energy to sort and deliver recyclables to ACERC. To approximate these costs we estimate the amount of time required to source-separate the specified quantity. We assume that the opportunity cost of manpower in source separation is equal to the average second quarter, 1979 wage rate in Anchorage ($7.09) times the total amount of time allocated to waste separation.

Over the 3 month period, a total of 953 households (318 per month) delivered about 25 pounds of recyclables per trip. Each participating household is assumed to spend 14.2 minutes per month (PRT, 1975, p.24) sorting newsprint. On average, each delivery is assumed to cover a roundtrip distance of 7 miles. 50 percent of citizen deliveries are assumed to occur in conjunction with other errands and are ignored. In Table 3-6, the total "external" cost of source separating and delivering 54 tons of assorted waste paper is $2,417.

The effect of recycling 54 tons of waste paper on landfill site longevity saves $60 in delayed replacement expenditures. Processing and disposal savings amount to $579 or 91 percent of total external benefits. Although not an explicit component of external benefits,[3] energy conservation corresponding to forgone paper production from raw materials is equal to 280 million Btus and converts to 50 barrels of crude petroleum equivalence. External benefits in Table 3-6 are likely to be understated, since the benefits of reduced environmental damage are not quantified.

Under the assumptions given in this particular example, external costs exceed benefits by $1,778 or $34 per ton collected. However, it may be argued that the cost of household source separation as calculated in

---

[3] I assume that the value of energy savings is captured in rising market prices.

Table 3-6 External Benefits and Costs Estimates for 54 Tons of Paper Recovery

External Costs	
Source Separation 953 households at 14.2 minutes each, at an implicit wage of $7.09 per hour.	$ 1,599
Delivery 50 percent of deliveries occur in conjunction with other errands and are ignored. Thus, 477 deliveries at 7 miles each, 10 m.p.g. times $1.25/gallon ($418) plus 12 cents per mile for maintenance ($400).	818
TOTAL EXTERNAL COSTS	$ 2,417
External Benefits	
Processing and Disposal $10.73/ton diverted	$ 579
Landfill Longevity $1.10/ton	60
Total External Savings	$ 639
Net Benefits (Costs)	($ 1,778)
Energy Conservation 5.6 x 10^6 Btu/ton are sav~~ing~~ed by recycling and foregoing paper production from raw material. 280 million Btu is equal to 50 barrels of crude petroleum using 5.6 million Btu/barrel. Assume $24 per barrel.	1,200

Table 3-6 overstates the actual burden implied by recycling. Home separation of recyclables easily integrates into routine household chores without disturbing normal patterns of lifestyle (Hayes, 1978).

The implicit wage used in Table 3-6 more realistically represents an upper limit that corresponds to the cost of hiring private labor to substitute for ongoing resident participation in household source separation.

Thus, the social cost of household source separation is, at best, tentative. If we ignore the cost of household source separation as calculated in Table 3-6 net non-market costs reduce to $179. To the extent that savings in energy and in environmental integrity are not captured in market prices, net costs are further reduced.

Summary

In summary, we note that 9,000 tons of scrap metal are recovered annually by six Anchorage-based scrap metal collectors. Two thirds of this is generated locally in Anchorage and represents about 41 percent of total ferrous and non-ferrous metal waste entering mixed and solid waste. A single waste oil collector recovers and reuses 250,000 gallons annually. At least three organizations are involved in limited paper recovery and together are responsible for total monthly recovery of over 56 tons assorted paper. This represents less than 5 percent of waste paper that is available for recovery.

With the exception of Chamber of Commerce aluminum can collection and the Alaska Center for the Environment's full-time recycle center, all collection operations are profit-motivated. Generally, collection is specialized and small scale. Payment is usually made to users that deliver or make available waste materials to collectors. Exceptions are the Chamber of Commerce which depends on citizen donations of aluminum cans, and Alaska Pollution Control which charges users to collect their waste oil. The Alaska Center for the Environment Recycle Center purchases assorted waste paper strictly from non-profit organizations.

Two observations are relevant at this point. First, the potential secondary material for recovery is largely untapped in Anchorage, although an active, somewhat low key, assembly of collectors exist. The recycling rate in Anchorage is substantially less than the national average of 25 to 30 percent for general materials. This reflects a more fundamental problem: resident participation in recycling is, for all intents and purposes, negligible.

To a large extent, negligible participation reflects a general lack of awareness about recycling and its potential impact. Additionally, there are few, if any, economic incentives currently operating that stimulate consumer involvement. This, in part, reflects the problem of hidden benefits not captured in market exchange. In Part V, we explore policy proposals aimed at exposing benefits and stimulating citizen participation. Before doing so, we explore the affects of expanding resident and commercial participation in Part IV.

PART IV. RECYCLING SCENARIOS

In this section, we examine three alternate recycling scenarios. Each scenario may be thought of as an experiment. The basic recycling scenario depicts a nonprofit, full-line recycling center that depends on secondary material donations by household residents and commercial institutions. The basic scenario also establishes a frame of reference to evaluate the effects of changing the commercial status and collection policy.

The buy-back scenario simulates recycling under the assumption that the recycle center is profit-oriented and offers to pay customers for specific secondary materials. The basic and buy-back scenarios are distinguished mainly by the profile of materials they recover (i.e., product mix) reflecting more fundamental differences in commercial status.

The office-collection scenario modifies the buy-back scenario conditions by introducing a comprehensive program in which state offices separate high-grade office ledger paper from other materials and sell it to the recycle center.

We assume for all scenarios a constant level of resident and commercial participation in recycling. Specifically, 25 percent of households separate tin, aluminum, glass, and wastepaper. Commercial institutions contribute approximately 25 percent of recoverable computer printouts (CPO), tab cards, and corrugated containers (CC) estimated in Part II.

Household and institutional participation, therefore, functions as a control variable in the recycling experiments and creates an opportunity to examine more closely the effects of operational and structural changes. However, by holding the level of participation constant, we do not mean to imply that it is less important to the analysis. Citizen participation in recycling is difficult to predict or model and from a scientific point of view is best left unchanged.[1]

The assumption of 25 percent participation reflects average participation in the United States as a whole. For example, a recent Seattle program in collection of household recyclables experienced overall participation of 23 percent (SRI, 1979). Lee Barrett, General Manager of the Portland Recycling Team, conservatively estimates recycling participation there at 35 percent.

The analysis of each scenario considers two levels of benefit and cost as criteria for an evaluation of economic feasibility. In the first level, designated "commercial feasibility," only private sector revenue and cost factors are used; other non-market value considerations are ignored. If commercial feasibility is satisfied,

---

[1]Note that the total quantity of material recovery changes between scenarios, reflecting changes in product mix, but not in participation.

private benefits exceed costs and the scenario would be profitable without government financial assistance.

The second level of benefits and costs is designated "social feasibility." Here, non-market costs and benefits similar to those identified in the earlier example concerning ACERC are incorporated to adjust private factors and create a more comprehensive benefit/cost profile. If social feasibility is satisfied, then the combination of private and public benefits (i.e., social benefits) exceed social costs. Satisfaction of social, but not commercial, feasibility is a necessary condition for government financial assistance. However, if social benefits do not cover social costs, the criteria for social feasibility is not satisfied and government subsidies would not be economically justified.

Basic Scenario

The basic recycle center scenario is a nonprofit, full-line operation with a primary goal of handling the maximum quantity of materials generated by community participation. It does not incorporate a policy of buying recovered secondary materials from consumers but depends instead on resident and institutional donations. The recycle center in the basic scenario is similar in design to that of the Alaska Center for the Environment Recycle Center (ACERC), except that ACERC purchases a limited range of materials from nonprofit organizations.

Recovery and Revenue

The quantity and composition of recyclable household material shown in Table 4-1 were taken from estimates by the Council on Environmental Quality and modified to reflect current trends in Anchorage.[2]

Table 4-1. The Quantity and Composition of Residential Waste Per Household (HH) for Selected Materials

Material	Lbs./HH/Month	Lbs./HH/Yr.
Newspaper	22	265
Other Paper	16.42	197
Glass	24.17	290
Ferrous (tin cans)	4	48
Aluminum (cans)	1	12

Source: Council on Environmental Quality

In this analysis, the total number of households are limited to residential districts in the Anchorage bowl, Eagle River, and Chugiak. Turnagain Arm and military populations are excluded. The Municipal Planning Office estimate for 1979 housing units in the Anchorage bowl is 57,463, of which 9.1 percent are vacant. Approximately 4,500 additional homes are located in Eagle River and Chugiak. At 25 percent, the participating portion of total-occupied housing for the specified area is about 14,000.

[2] Generally, higher aluminum and paper consumption and lower glass consumption than national average.

Participation in the commercial sector is also assumed to be 25 percent of potential recovery. The commercial sector includes federal, state, and municipal offices; private companies; and public institutions. Waste materials generated in this sector are computer printouts (CPO), IBM tablulating cards (tab cards), and corrugated containers (CC).

Monthly and annual quantity estimates are given in Table 4-2 for 14,000 participating households, based on the information in Table 4-1. Note that if each household delivers recyclables once a month, then the monthly quantity delivered per household is about 68 pounds.

Revenue potential for the specified product mix is presented in Table 4-3. Comparing the mass of a given material to its market value provides a partial indicator of the material's relative value. Under current market conditions, mixed scrap, CC, and glass containers are worth less per unit of recovered mass than all other materials listed. On the other end of the spectrum, the market value of aluminum relative to its mass is exceptionally high.

Total revenue from the recyled materials in the basic scenario would be equal to $436,423 in 1980 dollars, of which waste paper materials would contribute 65 percent. Overall revenue potential is approximately $70 per ton.

Table 4-2. Total Residential and Commercial Quantity and Composition of Recyclable Materials (tons)

Residential (86% of total quantity)

Material			Total Amount per month	per year	Percent Residential
Newsprint			155	1855	33
Other Paper			115	1379	24
Kraft[a]	10%	11.5	138		
Scrap	90%	103	1241		
Glass			169	2030	36
Ferrous			28	336	6
Aluminum			7[b]	84	1
TOTAL RESIDENTIAL			474	5684	100

Commercial (14% of total quantity)

Material	Total Amount per month	per year	Percent Commercial
CPO[c]	20	238	25
Tab cards[c]	5.4	65	7
CC	53	637	68
TOTAL COMMERCIAL	78.4	940	100
GRAND TOTAL	552	6624	

Assumptions:

[a] Brown paper bags.

[b] Assumes 4 lbs. per household per month. Based on Metropolitan Service District, City of Portland estimate.

[c] Includes military quantites.

Table 4-3. Basic Scenario Revenue Potential

Material	Annual Amount (tons)	Percent of Total Weight	Price/ton ($)	Annual Revenue ($)	Percent of Total Revenue
Paper					
Newsprint	1855	28	70	148,400	32
Kraft[a]	138	2	150	20,700	4
Mixed Scrap	1241	19	20	24,820	5
CPO	238	3	215	51,170	11
Tab cards	65	1	265	17,225	4
CC	637[b]	10	55-75	38,220	8
Glass (mixed)	2030	31	30[c]	60,900	13
Ferrous (tin cans)	336	5	78	26,208	5
Aluminum cans	84	1	900	75,600	16
TOTAL	6624	100		463,423	100

[a] Brown paper bags.

[b] 75 percent of total OCC is prebaled in non-commercial sizes (3-1/2-4'), receiving $55 per ton; 25 percent is baled in the recycle center receiving $75 per ton.

[c] Northwest Glass Co., Seattle, Washington.

Recovery Technology

The cost of recovering waste materials may be divided into three general classifications: collection, processing, and freight. A broad range of collection and processing techniques exist. Applicability or suitability of a given technique depends on a host of conditions, including:

1. The commercial status (profit or nonprofit) and pay-back policy.

2. The product mix and the weight, mass, degree of homogeneity, and level of contamination of each material.

3. The physical characteristics of a community, its density and dispersion, and its proximity to secondary materials markets.

Operating costs are categorized as fixed or variable depending on whether or not a given cost element is affected by the quantity of recovery.

Collection. Waste materials would be collected at two levels in order to control for moderate dispersion which characterizes the location of residential and commercial sub-districts in the Anchorage bowl for newsprint and glass. Drop-boxes with an avarage 30-cubic-yards capacity would be located throughout the Anchorage bowl to maximize user convenience and area-wide material recovery. These boxes would be segmented to allow separating newsprint and glass, as well as different colors of glass. We assume that 75 percent of total glass and newsprint would be recovered via the drop-boxes. The remaining 25 percent plus other residential waste materials, including mixed scrap paper, kraft (brown paper bags), and tin and aluminum cans, would be delivered directly to the recycle center drop-off station. Drop-boxes are permissable because the basic scenario does not incorporate a buy-back policy. The drop-box collection would be restricted to newsprint and glass to prevent extensive contamination of recyclables from carelessly deposited materials.[3]

A single "roll-off" container truck would be used to service drop-boxes. Assuming an average density of 500 pounds per cubic yard for

---

[3]This was the experience of the Stano Steel/Chamber of Commerce aluminum collection program which distributes drop-boxes or dumpster bins for aluminum only.

materials delivered in drop-boxes (Quimby, 1975), four drop-boxes would be picked up and replaced daily.

The annual trucking cost of servicing a residential drop-box collection route covering 17,280 miles is estimated at $8,160.[4]

The second level of collection pertains to commercially generated CPO, tab cards, and CC. A minimum of 300 pounds of combined paper products would have to be accumulated prior to pick up. At 300 pounds per pickup, the monthly quantity of commercially-generated waste paper would equal about 25 pick-ups per day.

Two single-axle, 12-14 foot-long enclosed trucks, operating continuously, would be required to satisfy the frequency of commercial collection. The annual total non-payroll commercial trucking expense is estimated at $9,225.[5]

Processing. In general, processing waste materials refers to sorting, decontaminating, and compacting. The more carefully these

---

[4]We assume the average round-trip distance from drop-box to recycle center would equal 15 miles. Fuel cost is estimated at $1.25 per gallon, assuming an average 10 mpg fuel economy. Maintenance ($2,000) and insurance ($4,000) are added to fuel cost to derive total residential drop-box collection costs.

[5]Based on actual ACERC experience, each pick-up averages seven miles round trip. Total annual mileage equals 63,000 miles. Fuel economy is 10 mpg at $1.25 per gallon. Annual maintenance and insurance are estimated at $450 and $900, respectively.

tasks are achieved, the greater the market value of recyclables. For example, shredded aluminum usually receives a higher price than crushed aluminum, which requires comparatively more handling and reprocessing by the ultimate user. Mixed cullet (broken glass) not separated by color is rejected by glass manufacturers.

Processing, manpower, and equipment requirements depend on specific characteristics of the materials recovered. Table 4-4 outlines specific processing requirements for the basic scenario recovery configuration. Except for newsprint, all wastepaper products require some sorting and compacting (either by baling or bundling). CC must first undergo pre-crushing before it is baled, in order to achieve cost-effective density. (Even then, CC density is only about 25 percent that of newsprint.)

In general, processing glass containers requires more elaborate handling and equipment. In the basic scenario, bottles from drop-box collections would have to be checked for proper color separation and metal components removed. Bottles of a certain color would be fed into a crusher and then conveyed into 25-foot, open-top, hydraulic lift containers[6] (similar in design to a gravel trailer) for shipment.

---

[6]This hydraulic lift feature is the only practical design for unloading cullet at the glass manufacturing plant. Cullet is unmanageable and difficult to remove vertically or horizontally. It must, therefore, be dumped. The open-top container is non-standard and is not available from carriers. Northwest Glass Company in Seattle is unwilling to provide container equipment. In the basic scenario, I assume that the recycle center invests in four such containers to handle the quantity of recovered cullet. Note that it may be possible to leave the container to another shipper for its northbound return trip to Seattle.

Table 4-4. Basic Scenario Processing Requirements

Material	Daily Quantity (lbs.)	Processing Technique	Processing Crew (all full-time)
Paper			
Kraft	958 lbs/day	sort, bale, stockpile, precrush OCC prior to baling	1 baler, 2 sorters
Mixed Scrap	8583		
OCC	1104		
CPO	2117	sort, test, bundle on pallet	1 sorter-bundler
Tab cards			
Newsprint	12917	no processing, load container	1 sorter
Glass	14083	remove metal parts, color separate, crush stockpile in drums or bins	1 sorter, 1 crusher
Aluminum	2333	remove bimetal, flatten, blow stockpile	1 sorter-equipment operator
Tin	583		

Aluminum- and tin-can processing is similar to that of glass. Aluminum and tin cans are hand-collected separately. Each type is checked for bimetal components and then fed into a hopper where they are crushed and blown into a storage bin. Processed secondary materials are either stockpiled or loaded directly into standby containers (supplied by the carrier).

In addition to that required for collecting and processing, equipment is needed for general operations. This includes a forklift, scales, tables, tools, supplies, and office furniture. An equipment cost breakdown is specified in Table 4-5. Total equipment cost is equal to \$182,107. This converts to \$54,630 in annual capital recovery cost for debt amortized over 5 years at 15-percent interest.

Recycle center employment for the basic scenario is divided into administrative, collecting, and processing categories in Table 4-6. The structure of administrative personnel reflects staff organization at Portland Recycle Team (PRT). Pay-scale ranking is also derived from PRT with adjustments suited to the higher cost of living in Alaska. (Salaries include 15 percent for fringe benefits.) The production crew in processing is derived from the workload specified in Table 4-4. Annual total wages and salaries would be \$189,500.

Freight. Transporting costs are an important element in the overall cost of Anchorage-based recycling. Backhaul tariffs differ by commodity. All paper categories receive the same tariff. In general,

Table 4-5. Basic Recycling Scenario - Equipment Costs[a] for Collection, Processing, and General Operation

Collection		$138,415
Trucks (1) Roll-off container	40,000[b]	
(2) Single axle, 14', enclosed	9,000[c]	
Drop boxes (23) @ $2,200 each, plus freight	53,415[d]	
Trailer (4) Open top, hydraulic lift (25 x 8 x 8 @ $9,000 each)	36,000	
Processing		18,724
Baler - vertical stroke	5,324	
Glass Crusher - conveyor	8,292[d]	
Metal Flatlever - blower	5,108[c]	
General Operation		24,962
Forklift	5,498[e]	
Scales	3,146[d]	
Tables	500	
Storage bins - 12 @ $600 each, plus freight	7,718[b]	
Barrels - 24 @ $25 each	600	
Miscellaneous equipment	7,500	
TOTAL EQUIPMENT		$182,101

---

[a] Includes freight from Seattle

[b] Lee Barrettt, General Manager, Portland Recycle Team, Portland, Oregon

[c] Used

[d] Don Knease, General Manager, Seattle Recycling, Inc., Seattle, Washington

[e] Bob Morrison, Manager, Alaska Center for the Environment Recycle Center

Table 4-6. Basic Recycling Scenario
Personnel and Payroll

Administration		$ 79,925
General Manager	25,875	
Bookkeeper	16,675	
Marketing Manager	20,125	
Public Relations Manager	17,250	
Collection		62,100
Drivers (3) @ $20,700 each	62,100	
Processing		91,800
Warehouse Manager	15,000	
Production Crew ($5/hr.)		
Baler (1)	9,600	
Sorter (4)	38,400	
Bundler (1)	9,600	
Crusher (2)	19,200	
TOTAL EMPLOYMENT		$233,825

larger shipments receive lower rates per unit weight. Table 4-7 calculates the annual total freight charge for each material in the basic scenario. Densities are based on the form in which the materials are shipped: baled, bundled, crushed, flat, or loose-stacking specific materials. I assume that a 40- by 8- by 8.5-foot container of 100 cubic yards capacity would be used for all materials except glass. The ICC has established a maximum limit of 42,000 pounds (21 tons) for a 40-foot container. Materials not having sufficient density will fill the volume capacity of a container before reaching ICC weight limitations. (This is the case for CC, tin, and aluminum.) The annual transportation cost of exporting 6,624 tons of recyclables is equal to $158,778, or $24 per ton.

Commercial Feasibility

Cost and revenue relationships identified in Tables 4-3 through 4-7 are brought together by Table 4-8 in a comprehensive statement of estimated private sector revenues and expenses. Allocation of costs for collecting, processing, and shipping material are based on quantity, volume, and manpower requirements identified above. Table 4-8 compares the effects on costs of collecting, processing, and shipping on each material and provides for convenient manipulation in subsequent scenario adjustments.

Costs of collecting, processing, and shipping are components of annual cost which, by definition, vary directly with the volume of secondary material recovered. Fixed costs not directly affected by

Table 4-7. Basic Scenario Freight Specifications and Costs

Material	Monthly Quantity Recovered (tons)	Compacted Density (lbs/ft)	Quantity per 40' Container (tons)	Number of Containers Per month	Number of Containers Per year	Tariff per Container[a] ($)	Total Annual Freight ($)
Newsprint	155	20		7	84		$ 47,544
Mix Scrap	103	21		5	60		33,960
Kraft	11.5	21	21	.5	6	$566	3,396
CPO	20	25		1	12		6,792
Tab Cards	5.4	30		.25	3		1,698
CC	53	8	10.5	5	60	359	21,540
Glass	169	28	21	8	96	336	32,256
Tin	28	9	12.5	2.25	27	336	9,072
Aluminum	7	5.5	7	1	12	210	2,520
TOTAL	552				360		$158,778

[a]The tariff per container is based on published (Sea Land) tariffs associated with a full container load (whether or not this load is met) or on published tariffs for the actual weight of the shipment, independent of container size, whichever is less. See above discussion of transportation structure in part II.

Table 4-8. Basic Scenario Distribution of Revenues and Costs by Material

	Product Mix: Residential Recovery							Product Mix: Commercial Recovery					
	Newsprint	Kraft	Mixed Scrap	Glass	Tin	Aluminum	Total Residential	CPO	TAB	CC	Total Commercial	Total Residential and Commercial	Per Ton
Quantity Received (tons)	1,855	138	1,241	2,030	336	84	5,684	238	65	637	940	6,624	
Revenue	148,400	20,700	24,820	60,900	26,208	75,600	356,628	51,170	17,225	38,220	106,615	463,243	69.93
Variable Operating Cost (VOC)													
Collection[a]	18,990			18,990			37,980	12,150	2,531	35,944	50,625	88,605	
Processing[b]	11,550	5,700	17,250	22,950	5,700	5,700	68,850	5,700	5,700	11,550	22,950	91,800	
Freight[c]	47,544	3,396	33,960	32,256	9,072	2,520	128,748	6,792	1,698	21,540	30,030	158,778	
Total VOC	78,084	9,096	51,210	74,196	14,772	8,220	235,578	24,642	9,929	69,034	100,365	339,183	51.21
Gross Operating Profit (Loss)	70,316	11,604	(26,390)	(13,296)	11,436	67,380	121,050	26,528	7,296	(30,814)	3,010	124,060	

Fixed Operating Cost (FOC)	
Warehouse (rental)[d]	36,000
General Administration Payroll	79,925
Overhead[e]	61,052
Total FOC	176,977
Total Operating Costs (VOC + FOC)	516,160
Operating Surplus (Deficit)	(52,917)
Capital Recovery Cost (CRC)[f]	54,630
ANNUAL TOTAL COSTS (VOC + FOC + CRC)	570,790
ANNUAL NET INCOME (LOSS)	(107,547)

[a] Collection costs are distributed in proportion to volume.

[b] Processing costs include warehouse manager and production crew payroll distributed according to material specific labor requirements in Table 23.

[c] See Table 4-7 for details.

[d] Warehouse floor space is equal to 7,500 square ft. Rental is equal to 40 cents per square foot.

[e] Overhead includes utilities, office supplies, phone, warehouse supplies, maintenance and depreciation. Overhead is not necessarily fixed, and instead varies with the level of activity, although not directly with production. Overhead is estimated as 18 percent of total VOC.

[f] See Table 4-5 for details.

the quantity of material recovered include staff payroll, general overhead, warehouse rental, and capital recovery costs.

We assume for the basic scenario that gross operating profits (i.e. revenues minus variable operating costs) would be negative for mixed scrap, glass, and CC. All remaining secondary materials generate gross profits high enough to compensate for unprofitable material recovery. However, although there would be a gross operating profit for the entire product mix, it would not be enough to cover all fixed operating and capital costs. Consequently, annual net losses in the basic scenario would exceed $108,000. Net losses would equal $7.68 per year for each participating household and reduce to $1.91 per household for total households in the Anchorage bowl.

The results in Table 4-8 indicate that expanding the range and quantity of material recovery to a level twenty-five times greater than actual participation recorded at ACERC would not guarantee a net profit or even enough revenues to cover costs. The aggregate level of secondary material recovery would have to expand by 80 percent to 12,372 tons in order for total revenues to match total costs.[7] If we ignore capital recovery costs, then the breakdown level of

---

[7] It is likely that increases this large would require additional equipment and personnel and, thus, raise annual operating plus capital recovery costs beyond the level indicated in Table 4-8. Thus, the above breakeven calculations may understate the breakeven level of material recovery.

recovery would have to rise 43 percent over the level of original recovery to 9,454 tons.

Basic scenario recovery for recycling is designed to simulate the operation of a nonprofit, full-line recycle center under the principle of maximum secondary material recovery. Mixed scrap, glass, and CC all contribute unfavorably to the financial profile shown in Table 4-8. In order to identify how mixed scrap, glass, and CC affect commercial feasibility, we exclude these materials from the basic scenario product mix.

A number of important equipment, personnel, and organizational changes are implemented to accommodate the modified product mix. Most importantly, the system of city-wide, drop-box delivery depots are eliminated in favor of a single, centrally located recycling drop-off station where all payments for recyclables are issued.

Consequently, roll-off container truck and the drop boxes are eliminated. Plant capacity would be reduced from 7,500 to 5,000 square feet, reflecting most notably the spacial requirements for glass and CC. Elaboration of yard facilities to accommodate heavier traffic would be required.

In addition, the glass crush-conveyor for open-top glass containers, four storage bins, and twenty-four barrels--all related to glass--are no longer required. Because CC is no longer collected, one single-axle commercial collection vehicle is dropped. The total value of foregone equipment is $146,666, about 80 percent of the original cost of capital. Total remaining equipment is equal to $35,435, which reduces to $10,630 in annual capital recovery costs.

Personnel adjustments exclude four production crew and two drivers from the basic scenario employment configuration. Freight is reduced substantially from the basic scenario, corresponding to the elimination of 216 annual container loads of mixed scrap, glass, and CC.

Omitting CC reduces commercial collection to 25 tons of CPO and tab cards per month, or about eight pick-ups per day. Annual trucking expenses, excluding driver, now equal $2,916, for fuel, maintenance, and insurance.

The effect of eliminating these materials from the basic scenario is shown in Table 4-9. Unit variable operating costs corresponding to the modified product mix increase slightly to $53.29, suggesting the onset of diseconomies from the 59 percent decline in aggregate material recovery from 6,624 to 2,716 tons. Nevertheless, by eliminating the secondary materials that have low earning potential, unit revenues increase dramatically. Thus, the commercial losses of $16.24 per ton in the basic scenario are replaced by a commercial gain equal to $39,000, or $14.40 per ton. Thus, commercial feasibility is satisfied in the modified basic scenario.

Table 4-9. Summary Statement of Revenues and Expenses for Basic Scenario and Basic Scenario with Modified Product Mix

	Recycling Scenario		
	Basic	Basic with Modified Product Mix	Dollars per Ton in the Modified Product Mix
Quantity Recovered	6,624 tons	2,716 tons	
Revenue	$463,243	$339,303	124.93
Variable Operating Costs (VOC)			
Collection	88,605	33,671	
Processing	91,800	40,050	
Freight	158,778	71,022	
Total VOC	$339,183	$144,743	53.29
Gross Operating Profit	$124,060	$194,560	
Fixed Operating Costs (FOC)			
Warehouse	36,000	24,000	
Administrative Payroll	79,925	79,925	
Overhead	61,052	40,905[a]	
Total FOC	$176,977	$144,830	
Total Operating Costs (VOC + FOC)	$516,160	$289,573	
Operating Surplus (Deficit)	(52,917)	(49,730)	
Capital Recovery Cost (CRC)	54,630	10,630	
Annual Total Costs	570,790	300,203	
Net Income (Loss) Before Tax	$(107,547)	$ 39,100	14.40

[a]67 percent of basic scenario overhead, based on decline in plant size.

The results of product mix adjustments in the basic scenario suggest that the commercial feasibility of a recycling recovery system depends as much on the level of aggregate material recovery as it does on the type of materials recovered. By eliminating specific unprofitable materials, the basic scenario could become commercially feasible. However, aggregate material recovery would decline by 60 percent or 3,900 tons of used glass and paper. A closer look at specific public (non-market) benefits and costs illustrates the desirability of adjusting the basic scenario product mix from the standpoint of social feasibility.

Social Feasibility

In order to evaluate social feasibility in the basic scenario, we measure external, non-market benefits and costs of material recovery and integrate the result with the gains or losses realized under commercial conditions. Non-market social costs, as defined here, include the opportunity cost of time and effort in home preparation (source separation) of recyclables plus an estimate of fuel consumption costs for resident delivery to the recycle center. Source-separation of newsprint, glass, tin, and aluminum cans would require a total of 72.7 minutes of monthly home preparation (PRT, 1975, p. 24). The breakdown for each material is presented in Table 4-10.

Table 4-10. Home Separation Requirements

Material	Preparation Time Per Month
Newspaper	14.2
Glass	19.8
Tin cans	33.1
Aluminum	5.6
	72.7

Source: PRT, 1975.

"External benefits," as used here, include cost reductions in the municipal waste management system as a result of reduced tonnage of mixed solid waste. These reductions include savings in processing and disposal and in delayed expenditures on new landfill site development. Not included are potential savings in the cost of refuse collection that would be realized by either individual residents or the municipality. We assume that energy savings associated with reduced raw material processing would be reflected in rising secondary materials prices and are not included in the estimate of external benefits.

Table 4-11 summarizes the effects of external benefits and costs on social feasibility for the basic scenario and its modified counterpart. External costs would be substantially larger than external benefits in both scenarios. Consequently, neither scenario would satisfy the conditions for social feasibility; in both cases, combined private and public costs would exceed benefits. Note, however, that net social costs per ton would be lower for the unadjusted basic scenario. This suggests that from the standpoint of social feasibility

Table 4-11. Social Feasibility of Basic Scenario and Basic with Modified Product Mix

	Basic 6,624 Tons	Basic, excluding glass, Mixed Scrap and CC 2,716 Tons
External Costs		
Residential Fuel Consumption	$ 42,078[a]	$ 31,500[b]
Source Separation	1,443,240[c]	1,052,156[d]
Total External Costs	$1,485,388	$1,083,656
External Benefits		
Processing and Disposal	$ 71,076	$ 29,143
Landfill Longevity	7,286	2,988
Total External Benefits	$ 78,362	$ 32,131
Net External Benefits (Costs)	$(1,407,026)	$(1,051,525)
Net Commercial Income (Loss)	$ (107,547)	$ 39,100
Net Social Benefits (Costs)	$(1,514,743)	$(1,012,425)
Net Social Benefits (Cost) Per Ton	$ (229)	$ (373)

[a]50 percent of total recycle center residential delivery plus all drop box deposits are excluded from fuel consumption calculation as conjunctive errands. Effective annual quantity delivered is equal to 1,611 tons. As before, assume participating households recycle 67 pounds of assorted paper, glass, and metal per month and 7 miles round trip. Total mileage is 336,627 based on 48,089 trips. Fuel economy is 10 miles per gallon. Fuel cost equals $1.25 per gallon.

[b]The effective annual quantity delivered by residents is 1,206 tons and implies 36,000 deliveries at 67 pounds per delivery, per month. Total mileage is 252,000, assuming an average of 7 round trip miles per delivery. Fuel economy is 10 miles per gallon.

[c]A total of 72.7 minutes is required for monthly home preparation of newsprint, glass, tin cans, and aluminum (PRT, 1975, p. 24). This is equivalent to 203,560 annual hours for 14,000 participating households. The implicit wage equals $7.09 per hour.

[d]Deduct 19.7 minutes per month from 72.7 minutes of total monthly household source separation. Thus, 14,000 participating households at 53 minutes per month gives 148,400 annual total hours in home preparation of recyclables. The implicit wage equals $7.09 per hour.

the community would be better off by expanding the product mix and enlarging the aggregate level of material recovery despite evidence of substantial commercial losses. In other words, commercial gains realized under conditions of restricted product mix do not compensate for the extra social costs of reducing aggregate recovery from original basic scenario levels.

The configuration of costs and benefits outlined in Table 4-11 reflects fairly restrictive assumptions about the impact of recycling. For example, the non-market benefits that I have quantified do not include the amenity value of reducing litter and pollution from recycling, nor does the table consider the resulting potential reductions in refuse collection.

On the other hand, the non-market costs of separating and delivering household waste may conceivably be incorporated into everyday household chores and overlapping errands. Thus, the figures in Table 4-11 tend to understate net social benefits. The extent to which this occurs depends partly on the relative importance one places on competing benefits and costs.

A more favorable evaluation of social feasibility would be reflected under the following assumptions:

1. Home separation and delivery impose negligible costs on the average resident who participates in recycling.

2. The volume of recycling assumed in the basic scenario is sufficient to reduce the frequency of municipal refuse collection and, therefore, to lower refuse collection costs.

Returning to Table 2-11, we note that of the \$2.6 million in annual total municipal refuse collection costs approximately \$1.4 million is needed to cover costs of labor, supplies, equipment rental, and repairs and maintenance. By definition, these costs vary with the frequency of collection. If we assume that the frequency of collection and the variable components of collection cost fall in proportion to the decline in the quantity of mixed solid waste collected by the municipality, then material recovery in the basic scenario reduces the variable components of annual collection cost by 4 percent, or \$56,000. The restricted product mix in the basic scenario reduces variable collection costs by 2 percent, or \$28,000.

The effects on external benefits and costs of more favorable assumptions on recycling are presented in Table 4-12. This results in positive net social benefits in both recycling scenarios. Note the trend in net social benefits and costs and external benefits and costs pertaining to respective levels of recovery in both basic and modified basic scenarios.

In the basic scenario, net external benefits exceed commercial losses and generate social benefits of \$4.05 per ton. Under conditions of restricted product mix, the combination of private income and public benefits yield net social benefits equivalent to \$36.54 per ton.

Two general results emerge from the analysis of social feasibility under changing assumptions. First, the elimination of residents'

Table 4-12. Social Feasibility Under Assumptions More Favorable to Recycling

	Basic 6,624 Tons	Basic, Excluding Glass, Mixed Scrap and CC 2,716 Tons
External Costs		
Residential Fuel Consumption	$ 0	$ 0
Source Separation	0	0
Total External Costs	$ 0	$ 0
External Benefits		
Processing and Disposal	$ 71,076	$29,143
Landfill Longevity	7,286	2,988
Collection	56,000	28,000
Total External Benefits	$134,362	$60,131
Net External Benefits (Costs)	$134,362	$60,131
Net Commercial Income (Loss)	(107,547)	39,100
Net Social Benefits (Costs)	$ 26,815	$99,231
Net Social Benefits (Cost) Per Ton	$ 4.05	$ 36.54

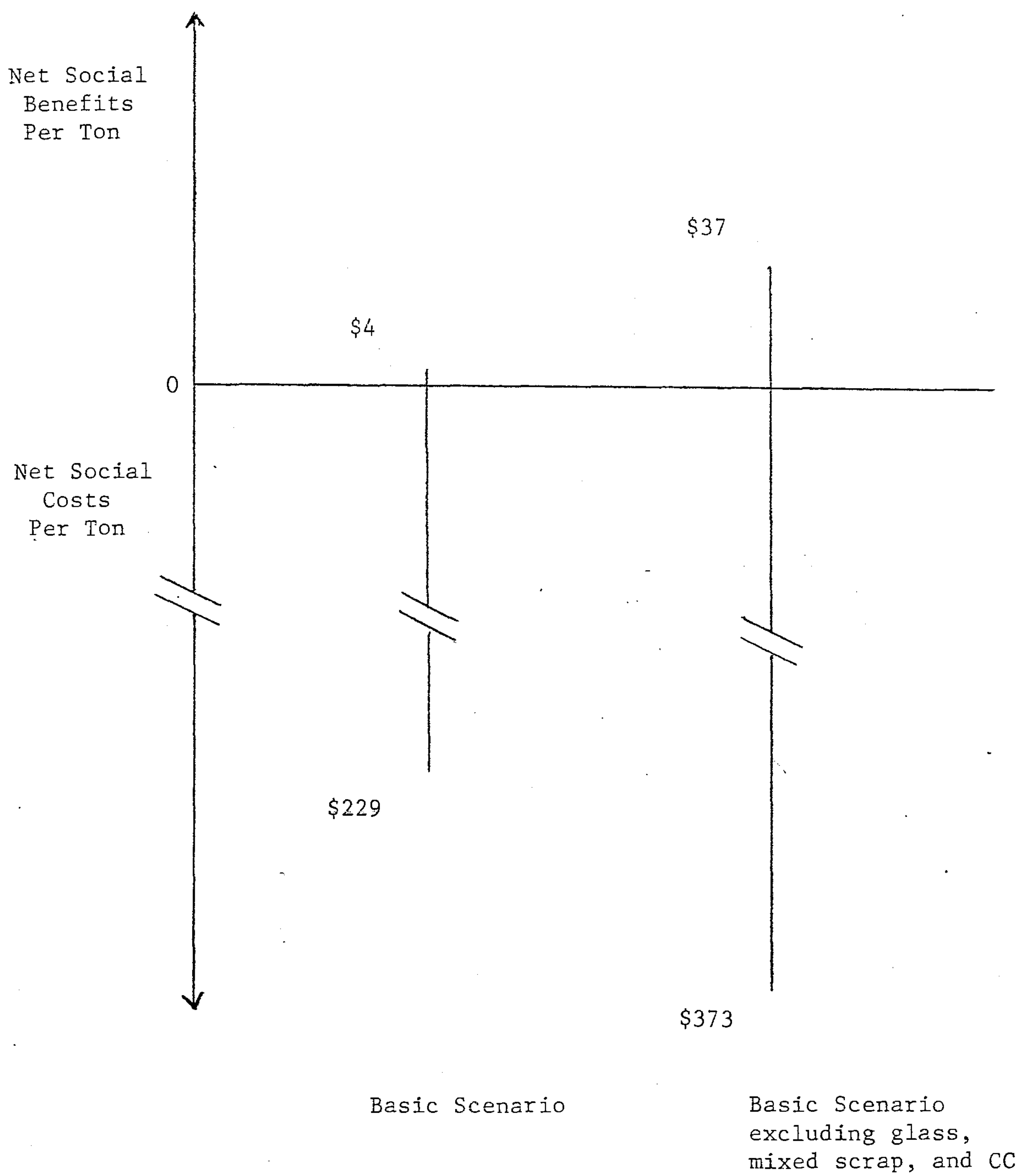
waste separation costs is the major reason that the external and social benefits are positive in both scenarios. Thus, household waste separation that is carried out effectively at minimum inconvenience to the household improves the feasibility of recycling by reducing the level of external costs and by increasing the quantity of recovery per unit of time and effort.

Second, as shown in Figure 4-1, the spread of net social benefits and costs generated by changing the definition of externalities decreases as the quantity of materials recovered increases. Although net social benefits per ton decline under the favorable interpretation of externalities, a greater quantity of aggregate recovery reduces the recycling recovery system's sensitivity to unfavorable circumstances, such as inefficient and costly methods of waste separation in either the residential or commercial sector.

Buy-back Scenario

A principal feature of the basic recycling scenario is the absence of any type of buyback policy to encourage participation and increase material recovery. Material recovery in the basic scenario depended on consumer donations. In the recycling industry, both systems are practiced. Portland Recycling Team (PRT), a large, non-profit, full-line recycling center in Portland, Oregon, recycles over 8,000 tons annually, enjoys $400,000 in revenues from sales, and does not have a buyback policy. In contrast to PRT, Seattle Recycling, Inc. (SRI) is profit-oriented and buys back most recyclables from consumers.

Figure 4-1. A Comparison of the Range of Net Social Benefits Between the Basic Scenario and the Basic Scenario with Modified Product Mix



SRI experiences about the same volume of business and level of sales as PRI. Both outfits retain the status of full-line recycling centers.

To determine the probable effect of a buy-back policy or recycling potential, I assume that the recycling center in the basic scenario is a profit enterprise and does not recover unprofitable materials such as glass, CC, and mixed scrap. Consequently, the buy-back scenario is identical to the basic scenario under the restricted product mix, except for the buy-back policy itself. The materials are purchased from the user, except for kraft paper, which is accepted without payment. Prices are shown in Table 4-13 and reflect prices actually offered by Anchorage-based recycling centers.

Table 4-13. Buy-back Policy

Material	Cash Payment/Pound	Cash Payment/Ton
Newsprint	1¢	$20
Tin Cans	1	20
Aluminum Cans	15	300
CPO	2	40
TAB	4	80
Kraft	Accept no payment	

Note that prices in Table 4-13 are essentially the same as the average buy-back prices in Seattle.

Commercial Feasibility. The introduction of a buy-back policy increases variable operating costs in the modified basic scenario by the value of disbursements to customers for materials purchased. The cost of material purchases would be $83,740, raising total annual costs 28 percent from $300,203 to $383,673. If the buy-back policy does not increase citizen participation beyond a level of 2,715 annual tons of recovered material, then the conditions for commercial feasibility would no longer be satisfied. In order to generate sufficient earnings to cover the additional costs of materials purchased, the quantity of annual recovery would have to increase 34 percent to 3,638 tons. This implies that citizen participation in newsprint, kraft paper, tin, aluminum, CPO, and tab card recovery would have to increase from 25 to 34 percent (18,690 households), which, from the standpoint of national participation in home separation, represents an upper limit of achievement and is probably unlikely to immediately occur in Anchorage where household waste separation and commercial recycling are just underway.

Thus, the responsiveness of consumers to buy-back incentives is an important determinant of commercial feasibility in the buy-back scenario. Returning to the Portland and Seattle examples, we note that with nine years of recycling experience depending entirely on consumer donations of recyclables, Portland Recycle Team incurred consecutive annual losses of approximately $20,000 in both fiscal 1978 and 1979, in spite of receiving well over $100,000 in annual grants and non-revenue, supplementary income (e.g., CETA and work study) over the same period. Under similar conditions, Seattle Recycling, Inc., was able to generate sufficient community involvement through its buy-back program to break even or realize commercial profits.

Social Feasibility. Assuming a constant participation (25 percent), a buy-back policy has no effect on the level of social feasibility in the basic scenario under assumptions of restricted product mix. "Buy-back" represents a transfer from the private to the public sector without introducing an economic gain or loss to the community as a whole. By distributing funds to the public sector, a buy-back program does compensate for non-market, household waste separation and delivery costs under a more pessimistic interpretation of external benefits and costs.

As shown in Table 4-14, raising the rate of participation to reach a break-even level of material recovery in the buy-back scenario would not substantially affect net social benefits or costs per ton.

Office Paper Collection Scenario

In this case, the buy-back recycling scenario is modified to include office waste paper recovery. We assume that the State of Alaska and Municipality of Anchorage mandate that all office employees separate high-grade white and colored ledger paper for recycling. In 1978, 17,195 professional and technical employees[8] generated approximately 3,070 tons[9] of mixed office paper. This averages out to about 1 pound a day per employee.

[8] Ender, 1978.

[9] Office paper constitutes 3.4 percent of total waste paper entering landfill disposal (GAAB, 1975).

Table 4-14. Net Social[a] Benefits and Costs in the Buy-back Scenario Under Alternate Assumptions on Participation and on Interpretation of Non-market Benefits and Costs

Interpretation of Non-market Benefits and Costs	Participation	
	25 % (2,716 Tons)	34%[b] (3,638 Tons)
Restrictive	($1.01 Million),[d] ($373/ton)	($1.33 million), ($364/ton)
Favorable[c]	$99,000,[e] $37/ton	$158,000, $43/ton

---

[a] Combined private and public sector returns.

[b] Breakeven commercial recovery.

[c] Exclude home separation and delivery costs. Include refuse collection cost reductions due to 2 percent decline in total municipal refuse collection.

[d] Table 4-11.

[e] Table 4-12.

Currently, there are approximately 10,000 state and local government employees in Anchorage. I assume that each employee generates 1 pound each of recoverable white and colored ledger paper per week. This amounts to a total of 500 total tons per year from state and local public offices.

The implementation of office wastepaper separation introduces two basic logistics requirements in addition to a general commitment by all employees. First, source separation trays would be required for most office desks. Larger, centrally located containers would also be required for office workers to deposit their daily accumulation of separated wastepaper. Second, the daily accumulation of office paper would have to be collected from each centrally located office container and deposited at the loading areas for pickup by a recycle center collection truck. The second task could be accomplished by employees until janitorial contracts were modified (Dick Stokes, DEC).

In this analysis, I ignore the cost of separation wastepaper trays and containers, which could be financed through receipts from wastepaper sales to the recycler. Also, I note no attempt to calculate the value of time and effort of employee participation in source separation. For all intents and purposes, the impact of wastepaper separation on office employment would be negligible.

In order to accommodate office wastepaper collection and processing, the recycle center would have to modify plant capacity, equipment, and personnel, as well as make adjustments in operating costs and revenues. These adjustments are outlined in Table 4-15 and are derived from specifications used consistently throughout this report.

The recycle center would be responsible for daily collection from office buildings. Separated office wastepaper would be returned to the warehouse, checked for contaminants, baled, and loaded directly on a standby container. Two containerloads would be shipped each month.

I assume that high-grade office ledger paper would be purchased from respective offices. The recycle center would pay 2 cents per pound for white ledger paper ($40/ton) and 1 cent per pound for colored ledger paper.

Implementation of office source separation and collection may be carried out informally as it is currently exercised, in connection with computer paper, or under contractual agreement in which case public agencies solicit bids for collection and payback from recyclers.

Commercial Feasibility

In this example, high-grade office paper recovery is integrated into the previous buy-back scenario. The effect of office waste paper recovery on commercial feasibility is compared to the original buy-back scenario in a summary statement of revenues and expenses in Table 4-16.

Table 4-15. Operation and Equipment Requirements for 500 Tons of Annual Office Paper Recovery

Annual Operation

Revenue		$ 76,250
White Ledger 250 Tons @ $180/ton	45,000	
Color Ledger 250 tons @ $125/ton	31,250	
Materials Purchase		15,000
White Ledger @ $40/ton	10,000	
Colored Ledger @ $20/ton	5,000	
Personnel		30,300
Driver (1)	20,700	
Sorter (1)	9,600	
Freight		13,584
2 containers/month @ $566 each		
Collection		3,840
Trucking (fuel, maintenance, and insurance)		

Plant and Equipment

Plant		2,400
500 square feet additional @ .40/ft^2		
Equipment		5,359
Truck (1) 12' bed, enclosed, used	4,500	
Bins (6) 3 yd^3	859	

Table 4-16. Summary Statement of Revenues and Expenses for Buy-back and Buy-back Plus Office Paper Scenarios

	Buy-back	Buy-back Plus Office Source Separation	Dollars Per Ton in Office Source Separation
Quantity Recovered	2,716 tons	3,216 tons	
Revenue	$339,303	$415,553	129.21
VOC			
Materials Purchased	83,740	98,740	
Collection	33,671	58,211	
Processing	40,050	49,650	
Freight	71,022	84,606	
Total VOC	$229,253	$291,207	90.55
Gross Operating Profit	$110,820	$124,346	
FOC			
Warehouse	24,000	26,400	
Administration	79,925	79,925	
Overhead	40,905	44,995	
Total FOC	$144,830	$151,320	
Total Operating Costs	$373,313	$442,527	
Operating Surplus (Deficit)	$(34,010)	$(26,974)	
Capital Recovery Cost	10,630	12,237	
Annual Total Costs	383,943	454,764	
Annual Net Income (Loss)	$(44,640)	$(39,211)	(12.19)

Social Feasibility. Under a restrictive interpretation of non-market benefits and costs, the addition of 500 tons of high-grade office ledger would reduce net social costs in the buy-back scenario from $1.01 million to $986 thousand. As shown in Table 4-17, net social costs per ton would decline 18 percent from $373 to $307. Thus, although the office paper collection scenario is not cost effective, from the standpoint of social feasibility the community would realize significant reductions in net social costs with each additional ton of office paper recovered. These savings would result from several factors which distinguish the buy-back and office paper collection scenarios. Most notably, office wastepaper separation would be confined to the commercial or institutional sector and would not raise external costs of home separation and delivery. Also, the office paper collection scenario would result in less commercial losses (Table 4-16) and greater disbursements to the public sector for material purchased.

Under a more optimistic interpretation of external benefits and costs, office paper separation and collection would raise net social benefits from the original level in the buy-back scenario without office paper collection. However, the increase in net social benefits is less per ton ($2) than the decrease in net social costs under the pessimistic interpretation of public sector benefits and costs ($66 per ton). The discrepancy occurs because the pessimistic interpretation of externalities incorporates household waste separation costs while the optimistic interpretation does not. Consequently, even though office paper collection does not affect the residential sector, and therefore

Table 4-17. Comparison of Net Social[a] Benefits and Costs in the Buy-back and Office Source Separation Scenarios

Interpretation of Non-market Benefits and Costs	Scenario	
	Buy-back[b] (2,716 tons)	Office Source Separation (3,216 tons)
Restricted	(\$1.01 million), (\$373/ton)	(\$986,000), (\$307/ton)
Favorable[c]	\$99,000, \$37/ton	\$126,000, \$39/ton

[a]Combined private and public sector returns.

[b]Table 4-14.

[c]Exclude home separation and delivery costs. Include refuse collection cost reductions due to a 2 percent decline in total municipal refuse collection.

the external cost of household collection, the constant level of total external costs from the buy-back scenario is spread over a larger total quantity of material recovery (buy-back plus office paper collection) which reduces the average unit cost (cost per ton) of household waste separation. Whereas office paper collection increases public benefits under both interpretations of externalities, external costs are absent from the optimistic interpretation and, therefore, cannot undergo unit reductions with increases in aggregate recovery.

Summary

We have examined three scenarios, each with a 25 percent participation in both commercial and residential sectors. All examples represent full-line recycling (i.e., at least three different materials), although some were more specialized than others. None of the three scenarios demonstrated a waste-materials recovery plan that was able to break even.

In the alternative buy-back scenario, the latitude of material recovery is restricted to include only those materials exhibiting a positive return after deducting material-specific variable operating expenses from revenue in the basic scenario. Nevertheless, a break-even total revenue-total cost profile was not attained; instead, this plan would require a 10 percent increase in residential and commercial participation in order to generate enough secondary materials to financially break even.

This example illustrates the importance of citizen participation in recycling. Even under conditions in which participation in material recovery is 25 times greater than estimates of current Anchorage participation (less than 1 percent), first-level, commercial feasibility would not be attained. To some extent, the product mix configuration would contribute to unprofitable recovery. When the product mix is subsequently narrowed to eliminate all unprofitable secondary materials (i.e., mixed scrap, glass, and CC), commercial prospects improve modestly but remain unprofitable. Recycling, under the modified-product mix in the buy-back scenario, would be profitable only under conditions in which recyclables are donated by residents and commercial groups. Citizen participation is therefore critical to the commercial viability of full-line waste material recovery.

A buy-back policy can be expected to encourage participation and increase the rate of material recovery. Yet, the cost of purchasing secondary materials from users would absorb 25 percent of gross reve nues and weigh heavily against commercial implementation, particularly under circumstances in which the effect of buy-back is not a clear factor in developing incentives to recycle.[10]

We also examined the consequences of instituting a program in state and local offices wherein office employees would collect and

[10] Again, I refer to the Portland Recycling Team (PRT) and Seattle Recycling, Inc. (SRI). In contrast to SRI, PRT depends on customer donations of all recyclables. Nevertheless, PRT and SRI share parallel structural features, including capacity and actual volume recovered.

separate high-grade ledger paper for recycling. Under the assumptions made, the program would not have broken even financially, although the economics improved somewhat over the buy-back scenario. In this particular example, more than twice the increase in office paper separation alone (as opposed to an across-the-board proportionate increase in all materials) would be required to cover the annual cost of collecting and processing, as well as losses incurred in the original buyback scenario, which incorporates office wastepaper separation.

Thus, although the level of participation, and therefore the quantity of recyclables available for recovery, is a necessary condition for cost-effective recycling, the mix of secondary materials selected for recovery is also an important determinant of commercial breakeven potential.

"Hidden" benefits and costs outside of private sector exchange are also considered in the analysis. In order to determine the sensitivity of material recycling to different interpretations of external benefits, both a pessimistic and an optimistic benefit-cost analysis of each recycling scenario are performed. Under the pessimistic interpretation, social costs not reflected in market prices include fuel consumption costs for resident delivery of recyclables to the recycle center and the cost of time and effort in household waste separation.

If labor invested in home separation of recyclables represents labor time that would otherwise be used in leisure or in work, then waste separation has an opportunity cost and must be priced accordingly. The average second quarter Anchorage wage rate ($7.09) is used for this purpose and results in substantial implicit labor costs.

On the other hand, the nature of household waste separation allows it to be easily integrated into routine household functions and helps alert consumers to the inefficiencies of excessive producer packaging and the more general waste flow problem. To some extent, waste separation can actually reduce the frequency of garbage chores and ultimately the cost of garbage collection. Thus, applying a market wage rate to time spent separating recyclables may unfavorably overstate hidden (non-market) costs of recycling.

The cost of fuel used in residential delivery of recyclables to district drop-off depots or to the recycle center represents a relevant social cost. However, it is likely that these deliveries will be combined with other errands and the costs spread accordingly.

Thus, the optimistic interpretation of external costs ignores estimates of residential delivery and household waste separation. The community realizes direct social benefits through reduced costs related to garbage processing and disposal, as well as landfill site development. I estimate that on the average each recycled ton of waste saves $11.83 in waste management costs, excluding the cost of refuse collection. Both the pessimistic and optimistic interpretations of external benefits include these cost reductions in solid waste management. Under the assumption that recycling can also reduce refuse collection costs, the relaxed benefit/cost profile includes a measure of refuse collection savings based on reductions in collection frequency.

Several qualitative benefits are absent from the interpretation of external, non-market factors. They include aesthetic and other benefits resulting from reduced pollution, litter, and waste; such benefits are subjective and therefore difficult to measure. By omitting these benefits, I do not intend to undervalue their importance, but rather leave their relative significance to individual interpretation. Also, I assume that the benefits of energy conservation are fully reflected in rising market prices.

The social (i.e., public and private) benefits calculated above are understated to the extent that physical amenities related to the environment are positive and energy savings are ignored in market prices.

Table 4-18 summarizes the effect of competing definitions of external benefits and costs in connection with the basic, buy-back, and office paper separation scenarios. In each of these scenarios, net external benefits are realized only under the optimistic interpretation of non-market benefits and costs for all scenarios. In the pessimistic interpretation, the cost of separating recyclables in the home contributes importantly to the resulting unfavorable benefit/cost profiles. Note that under either benefit/cost interpretation, the office paper

Table 4-18. Comparative Benefit/Cost Summary of Recycling Scenarios Under Alternate Interpretations of External Benefits and Costs

	Basic (6,624 tons)		Buyback (2,716 tons)		Office Paper Separation (3,216 tons)	
	Dollars	$ Per Ton	Dollars	$ Per Ton	Dollars	$ Per Ton
Commercial Income (loss)	(107,547)	(16)	(44,640)	(16)	(39,211)	(12)
PESSIMISTIC INTERPRETATION						
Net External Benefits (costs)	(1,407,026)	(212)	(967,694)	(356)	(946,780)	(294)
Net Social Benefits (costs)	(1,514,743)	(229)	(1,012,334)	(373)	(985,991)	(307)
OPTIMISTIC INTERPRETATION						
Net External Benefits (costs)	134,362	20	143,871	53	164,785	51
Net Social Benefits (costs)	26,815	4	99,231	37	125,574	39

collection scenario, in contrast to the basic scenario, demonstrates the highest social benefits and the lowest social costs, even though its total material recovery is 50 percent less.

The tradeoff between commercial and social feasibility is illustrated in the context of glass recycling in the basic and buy-back scenarios. In the basic scenario, requirements for extra capital investment, handling, and shipping for glass (and to a lesser extent, mixed scrap and CC) would absorb positive income-generating potential from other recyclables and severely disrupt the commercial viability of the overall recovery program. Thus, glass was subsequently withdrawn from consideration in the profit-making, buy-back scenario. Returning to Table 4-8, we note that unit variable operating costs (i.e., variable operating costs per ton) in glass recovery exceed unit revenue potential by $6.55 per ton. That is, the recycler loses $6.55 for every ton of cullet that is recovered and marketed. In addition to operating costs, costs allocated to glass recovery equipment in the basic scenario would be about $58,000, or one-third of total basic scenario equipment costs. The annual capital recovery cost for glass collection and processing equipment would reduce to $8.60 per ton and increase the operating deficit from $6.55 to $15.15 for each ton recycled. From the standpoint of commercial feasibility, the high cost of equipment, processing, and shipping would contribute to unfavorable conditions in glass recovery.

However, under the relaxed interpretation of external benefits and costs, 2,030 tons of glass recovery would generate $41,320, or $20.35 per ton in net external benefits. Thus, by eliminating glass recovery, the reduction in commercial losses ($15.15 per ton) would not compensate for the total value of foregone benefits--$20.35. From the standpoint of more comprehensive social feasibility, glass recycling in the basic scenario is socially desirable.

In contrast to glass recovery, mixed scrap paper and CC incur commercial losses (even ignoring equipment costs) that exceed public sector gains. Thus, recycling these two materials does not satisfy the formal condition for social feasibility. Net social costs equal $.92 and $28.02 per ton for mixed scrap and CC, respectively.

PART V. PUBLIC POLICY

In the preceding sections, we examined the nature of material throughput in Anchorage, the cost of solid waste management, the current extent of recycling, and a few carefully constructed, expanded recycling scenarios to determine whether or not sufficient conditions exist in Anchorage to warrant greater private or public sector involvement in recycling.

There are currently at least a dozen profit and nonprofit, Anchorage-based organizations engaged in secondary material recovery. The annual quantity of material recovery includes 250,000 gallons of waste oil, 250 tons of waste paper, and 9,000 tons of scrap metal. By weight, material recovery is equivalent to 4 percent of total mixed, solid waste entering landfill disposal (160,084 tons in 1979). Until the reservoir of recoverable secondary materials is exploited further, the disposal of secondary materials will absorb landfill space at a rate of 16 acres per year.[1]

The quantity of material throughput and the modest extent of current recycling activity in Anchorage suggests that substantial untapped reserves of recyclable material are available for immediate recovery. I conservatively estimate that out of 30,000 tons waste paper, glass, and

---

[1] Assuming the Municipal refuse shredder is operating (see discussion of solid waste management in Part II).

tin and aluminum cans that are readily available for recovery (excluding the segment involved in heavy metals recovery), only about 2 percent are actually recycled. The remaining tonnage is destined for landfill disposal.

In constructing our recycling scenarios, we have borrowed from the experience of active recyclers in Anchorage (notably the Alaska Center for the Environment Recycle Center) and from ongoing recycling recovery systems in the Pacific Northwest. However, even under circumstances in which community participation in source-separation of recyclables would be substantially greater than current participation in Anchorage, none of the recycling scenarios was able to achieve net positive income based upon strict commercial cost accounting without government assistance.

In order to break even financially, commercial recyclers would have to either increase the quantity of wastes recovered to match the upper limits of what a well-developed program of community participation could achieve or restrict the range of material recovery to more valuable, high-grade materials that are capable of generating positive commercial returns at the expense of an overall reduction in material recovery. In general, the scenario results suggest that a broad-based, full-time recycling recovery system in Anchorage cannot occur without state involvement.

Whether or not the state should become involved in policies to stimulate recycling depends partially upon how we define external benefits and costs used to evaluate effects of recycling on the public sector. The recycling scenario results suggest that the economic interpretation of household waste separation is the most significant factor in determining net external benefits and costs. If, for example, the time and effort spent in household waste separation of recyclables is interpreted to be at the expense of leisure or employment (and is priced accordingly), then home separation imposes net external costs on the Anchorage community in all recycling scenarios. Thus, under the "pessimistic" interpretation of costs and benefits, negative returns in the public sector would compound commercial losses and net social costs would prevail.

On the other hand, if waste separation is interpreted as a routine household function that stimulates compensating reductions in other household chores (e.g., reduced garbage accumulation) and, therefore, does not impose extra costs on residents, then recycling could have net social benefits in connection with the same recycling scenarios after accounting for losses in the private sector. Thus, in the optimistic interpretation of external benefits and costs, public sector gains would more than compensate for commercial losses. These conditions would then justify government subsidy.

Yet the relationship between the quantity of material recovered and the level of net social benefits is not clearcut. A comparison of recycling scenario results suggests that the level of net social benefits is affected not only by total quantity of a material recovered but also by the particular combination of materials recovered (i.e. product mix) as well. For example, in Table 4-18, under the optimistic interpretation of externalities, the basic scenario has a wider product mix and a larger quantity of materials recovered but has less net social benefits than either of the alternate recycling scenarios. As shown in Figure 5-1, the discrepancy occurs because recycling certain materials is socially beneficial but commercially unprofitable; recycling of other materials would be unprofitable from both a commercial and social standpoint.

Public policy must, therefore, accommodate tradeoffs in private and public sector benefits for materials that do not economically satisfy both commercial and social criteria. Policy proposals that stimulate private sector recovery without regard to product mix considerations may omit materials that are socially beneficial. Glass recovery is a case in point. Basic scenario results indicate that the cost of equipment, handling, and freight would exceed private benefits. Cost reductions in solid-waste management and landfill site development, however, would generate positive returns in the public sector that outweigh public sector losses from glass recovery.[2]

Conversely, public policy that is confined to a commercially unprofitable product mix but satisfies the conditions for social feasibility may relinquish the opportunity to produce additional net social benefits. Recall, for example, that the Alaska Center for the Environment Recycle

---

[2] Glass is a major component of roadside litter and is considerably less biodegradable than either aluminum or tin cans. Thus, public benefits from glass recovery are understated by the value of litter reduction amenities from recycling.

Figure 5-1. Product Mix Matrix[a]

		Commercial Feasibility	
		Positive	Negative
Social Feasibility	Positive	newsprint, kraft, CPO, tab cards, tin cans, aluminum cans	glass
	Negative		CC, mixed scrap

[a]From basic scenario, using favorable interpretation of externalities.

Center has incurred commercial losses in CPO, tab cards, and newsprint. Those losses, according to basic scenario results, would become commercial gains when the scale of recovery is increased.

Also, if the calculation of external benefits does not include the benefits realized from reducing litter and pollution, as well as other benefits not recognized explicitly (e.g. energy conservation and reduced rates of nonrenewable resource depletion), then net social benefits will be understated. Consequently, materials not satisfying quantitative conditions may still be socially beneficial from a broader interpretation of external benefits from recycling.

In addition to the total quantity of material recovery, the level of net social benefits implied by a specific product mix, and the definition of externalities, some important non-economic factors enter into policy design. The existing recycling recovery system in Anchorage consists of several independent, specialized, small-scale, profit and nonprofit recyclers that compete vigorously for supplies of available secondary materials that are limited in part by a relatively low rate of citizen participation. The potential economic gain from public intervention that leads to direct competition with private recyclers would decline by an amount equivalent to the value of foregone private material recovery displaced by direct public intervention.

The objective of public policy is to increase material recovery in order that the community may realize economic and non-economic benefits from recycling. Ultimately, the primary source of material recovery is derived from citizen participation. Citizen participation is an important determinant of scale economies to the recycler and, therefore, represents a key goal of public policy. Policies to stimulate citizen participation would indirectly affect the recycling recovery sector without the potentially harmful effects of direct government interference in the market.

Policy Proposals

Several policy proposals are examined in this section. The selection of policies is designed to represent a broad range of policy options but is not intended to exhaust all the possibilities. The policies presented illustrate several economic and non-economic tradeoffs and provide guidelines for policy design. Two general policy classifications are explored: those that affect the recycling recovery system directly and those that are directed toward stimulating citizen participation and therefore affect the recovery sector indirectly.

Once the policy maker determines a target quantity and composition of material recovery, the corresponding level of net social benefits provides guidelines for the socially desirable level of public investment in recycling.

The following policy options are reviewed and evaluated from the standpoint of private sector response, impact on material recovery, and cost to the State of Alaska. They are:

Recycling Recovery Sector

Subsidy

Central recovery wholesaler

Depletion deduction

Tax credit

Community Participation

Compulsory office paper separation

Returnable beverage container legislation

Recycling Recovery Sector

Subsidy. Subsidization can be implemented on two general levels. The State may either appropriate start-up funds for a large-scale, non-profit, full-line recycler or establish a grant program designed to distribute smaller amounts of funds to numerous private organizations involved in material recovery.

The purpose behind concentrating state support on a single recycler is to establish an overall scale of material recovery that captures important economies not otherwise attainable. Economies of scale would then permit a product mix that includes less profitable materials that would typically not be handled by private, profit-motivated recyclers.

This is an important consideration since Anchorage-based organizations involved in material recovery generally specialized in one or two commercially favorable materials and, under the present circumstances, are unlikely to contribute significantly to the objective of comprehensive material recovery.

The small, independent, private collectors whom I interviewed in the course of collecting information on local recycling effort all expressed concern over direct State intervention of this type. In their view, public start-up assistance unconditionally discriminates against their effort to compete effectively, particularly if a nonprofit, publicly-funded recycler purchases materials from users and, in so doing, captures some of their business.

To minimize the adverse effect of public intervention in the private sector, the State could prohibit the subsidized recycle center from purchasing materials that are openly purchased by other private collectors. Yet, without buy-back incentives, a State-assisted, "full-line" recycle center may experience limited success in attracting source-separated materials--especially more centralized commercial sources of high-grade CPO, tab cards, and ledger paper. The State could compromise moderately and allow the subsidized recycle center to purchase recyclables from nonprofit organizations only. This is, in fact, the present policy followed by the Alaska Center for the Environment Recycle Center. Although it is met with considerable dissatisfaction by private recyclers, it does represent a more equitable arrangement from the standpoint of direct, private-sector interference. As an additional condition, the subsidy could be contingent on the recycler accepting a carefully specified, broad range of materials. The financial latitude provided from public support creates an opportunity to introduce socially beneficial, yet commercially unprofitable, materials into the product mix and to innovate techniques in collection, separation, compaction, and transportation. Under conditions of prohibited buyback, financial assistance can be used to fund educational programs designed to stimulate participation.

To reduce the potentially harmful effects of direct public intervention, the State could decentralize its involvement by issuing a limited number of moderate-size grants to recyclers. This, however, does not eliminate the problem of unfair competition and of animosity developing between subsidized and nonsubsidized recyclers. To protect the interests of those not receiving grants, and to increase the potential for broader range of secondary material recovery, the State could require that subsidized recyclers accept (without payment) certain less profitable materials. The recycler would stockpile these materials until sufficient mass is accumulated to raise a commercial profit, or until the cost of storage exceeds freight costs, whichever occurs first. The grant would absorb commercial losses related to unprofitable materials. In addition to increasing the overall quantity of materials recovered, public funds would increase the individual recycler's scale of recovery and potentially reduce certain unit operating costs (e.g. the cost of collection, of bundling, or of freight per ton).

I would expect a qualitative difference in range of materials recovered under the decentralized program of public support in comparison to the case of a large, lump-sum appropriation to a nonprofit, full-line recycler. For example, moderate-scale glass recovery (2,030 tons per year or 13 percent of feasible recovery) requires $58,000 in equipment alone and would, therefore, be implemented only under the large, lump-sum appropriation.

In either case, the level of subsidization would be a function of projected participation, the composition of material recovery, the cost of attaining that level of recovery, and the level of direct net social benefits (i.e. solid waste management savings less resident delivery costs).

Results from the basic and buy-back scenarios may be used as preliminary guidelines to determine the level of subsidization for respective subsidy programs.

Several economic parameters are presented in Table 5-1 as subsidy guidelines. Annual commercial operating losses reflect the ongoing economic burden of material recovery in the private sector; the actual losses that would be reported in financial statements. Total capital investment is an estimate of required startup expenditures. Note that commercial operating losses subsume annual capital recovery costs to reflect the cost of debt incurred in commercial money markets to finance equipment. Net social benefits reflect the combination of ongoing private and public sector benefits and costs and indicate the implicit cost to the community of not expanding material recovery for recycling. By construction, net social benefits reflect only direct net benefits of material recovery to the Anchorage community and not the broader consequences of recycling itself.

Table 5-1. Subsidy Guidelines[a]

Subsidy Program	Annual Commercial Operating Losses[d]	Total Capital Investment	Net Social Benefits
Full-line[b]	$108,000	$147,000	$29,000
Decentralized[c]	$45,000	$35,000	$99,000

[a]Assuming 25 percent participation.

[b]Basic Scenario. [c]Buy Back.

[d]Commercial operating losses include annual capital recovery costs (i.e., debt service, depreciation).

Circumstances in the basic scenario reflect those of a nonprofit, full-line recycler under a policy of prohibited buyback. Therefore, as shown in Table 5-1, I apply basic scenario results as guidelines for lump-sum subsidization of a single, full-line recycler. Alternatively, the buy-back scenario reflects a narrower range of more specialized, high-grade material recovery. Buy-back scenario results are used to determine the aggregate level of decentralized public assistance for several smaller-scale reyclers. I implicitly assume that 25 percent citizen participation is achieved in each recycling program.

Central recovery wholesaler. As an alternative to direct subsidization of independent, profit or nonprofit recyclers, the state could subsidize a central wholesaler/processor that would be impowered to accept secondary materials without payment to individuals or to pay existing small collectors for unprocessed shipments. The recovery wholesaler would operate as an intermediary between collectors that comprise the Anchorage-based recycling recovery system and "stateside" dealers and secondary materials users that otherwise trade directly with Anchorage collectors.

Several trade arrangements between the recovery wholesaler and local collectors are possible. For example, the subsidy could, in part, be used to raise payments for secondary materials from levels representing private sector values to levels that include net social benefits of recycling. Under this arrangement, local collectors share in at least some of the net social benefits. Even without price supports, however, local collectors would no longer incur the cost of shipping materials to stateside markets and, in some cases, the cost of handling and processing certain materials. For example, the total unit cost of collecting, handling, and shipping processed glass to Seattle is about $45 per ton, including glass-related capital costs, properly allocated. A market price of $30 per ton produces a commercial loss equal to $15 per ton and is slightly less than the unit cost of freight--$16. Thus, direct trade with an Anchorage-based recovery wholesaler would eliminate the local collector's shipping requirement and thereby establish a feasible program in local glass collection.

As an alternative to explicit price support, the buy-back price offered to the local collector could intentionally be kept more stable than market prices of recovered materials to circumvent the seasonal and cyclical patterns of totally market-responsive recycling operations.

In addition to improving the economic conditions for commercial recovery of secondary materials, the central recovery wholesaler would help preserve competition and avoid grant discrimination among small collectors. Further, the small collector would be free to choose whether or not to trade with the central recycler.

Although a subsidy would most likely be required to cover equipment and a portion of ongoing operating expenses, several economic benefits would be available to the nonprofit, publicly-operated central recovery facility that would not be available to the small, independent collector. Economies of scale in first-stage processing (shredding, baling, compacting) and in transportation constitute the most important economic benefits. Basic scenario results suggest that a ten-fold expansion of newsprint, CPO, and tab card recovery from ACERC quarterly production of 54 tons reduces combined collection, processing, and transportation costs 50 percent, from $104 to $52 per ton. Although handling, processing, and transportation costs depend on the specific physical characteristics of each material, it is likely that these scale economies are representative of general conditions in secondary material recovery.

A central recovery wholesaler that is capable of shipping consistently larger, more homogeneous quantities of secondary materials would reduce the dealer's uncertainty and lower the dealer's handling requirements. Dealers often reward recyclers by sharing with them a portion of the savings realized as a result of improvements in the quality, mass, and consistency of shipments. Also, the large scale of recovery would place the recovery wholesaler in a stronger bargaining position to negotiate more favorable terms of trade with dealers or secondary materials users. Further, the recovery wholesaler would be able to more realistically explore the potential for direct trade in international markets, notably Japan, Taiwan, and Korea.

To illustrate the economic effects of a publicly subsidized recovery wholesaler in Anchorage, the configuration of assumptions in the basic scenario is applied jointly to a hypothetical recovery wholesaler and to the set of independent, small-scale, secondary materials collectors. A comparative statement of annual revenues and expenses for the recovery wholesaler and independent collectors is presented in Table 5-2 and is based on the following general assumptions:

1. The recovery wholesaler purchases materials from Anchorage-based independent collectors at spot prices in Seattle secondary materials markets and is unable to sell recovered materials at a higher price than it pays.

Table 5-2. Comparative Statement of Annual Revenues[a] and Expenses for the Recovery Wholesaler and Independent Collectors

	Recovery Wholesaler	Independent Collectors
Revenue	463,000	463,000
Variable Operating Cost (VOC)		
Materials Purchased	463,000	149,000
Collection	-	89,000
Processing	92,000	-
Freight	159,000	-
Total VOC	714,000	238,000
Fixed Operating Costs (FOC)	133,000[b]	88,000[d]
Capital Recovery Costs (CRC)	55,000[c]	28,000[d]
Annual Total Costs (VOC + FOC + CRC)	902,000	354,000
Net Income (Loss)	(439,000)	109,000

[a]Figures from basic recycling scenario.

[b]Seventy-five percent of total FOC in the basic recycling scenario.

[c]One hundred percent of total CRC in the basic recycling scenario.

[d]Fifty percent of total FOC and of total CRC in the basic recycling scenario.

2. Independent collectors purchase secondary materials from consumers. The aggregate cost of materials purchases from consumers equals $84,000 from the buy-back scenario, covering newsprint, kraft, tin, aluminum, CPO, and tab cards, plus $65,000 for beverage bottle buyback at about one-half cent per bottle.

3. First-stage processing (sorting, shredding, baling, and compacting) and transportation to secondary materials markets are carried out by the recovery wholesaler.

4. Independent collectors are responsible for servicing consumer deliveries and collecting from commercial institutions. They incur the full collection costs from the basic scenario--$89,000.

5. Fixed operating costs (FOC) and capital recovery costs (CRC) are distributed between the recovery wholesaler and independent collectors such that the sum of each exceeds estimated levels in the basic scenario. This assumption insures that overlapping equipment, overhead, and administrative costs are not overlooked.

Several observations emerge from the figures in Table 5-2. Net commercial losses equal those incurred by the recovery wholesaler ($439,000) less the aggregate private gain realized by independent collectors ($109,000). Commercial feasibility is, therefore, not satisfied.

Net external benefits from the basic scenario equal $134,000 and do not cover net losses in the commercial sector. Thus, net social costs equal $196,000 (439,000 - 109,000 - 134,000); and social feasibility is not satisfied. Net social losses equal $30 for each ton recovered in the basic scenario and convert to less than one cent per bottle for the 30 million twelve-ounce beer and soft-drink bottles "consumed" in Anchorage in 1979.

Since independent collectors no longer process or ship secondary materials, the purchase price offered to them by the recovery wholesaler could be less than stateside secondary materials market prices and still leave collectors better off. Note that the annual aggregate commercial gain to collectors with centralized recovery wholesale services ($109,000) is roughly equal in magnitude to the absolute value of commercial losses in the basic scenario ($107,000). The commercial gain to collectors, however, is less than one cent per pound collected. A lower price than that assumed in Table 5-2 would lower collection incentives and jeopardize recovery potential. Even if the quantity collected remains constant, a lower price level results in a transfer of funds from one group (the collectors) to another (the recovery wholesaler) such that no overall net economic gain would result.

As shown in Table 5-3, in addition to commercial profits and to waste management benefits, $149,000 in economic benefits accrue to consumers and institutions as cash rebates for waste-separated secondary materials.

Table 5-3. Economic Gains to Various Groups as a Result of Recovery Wholesale Services

	Public or Private Gain
Waste Management System	$130,000
Independent Collectors	109,000
Consumer and Institutional Cash Rebate	149,000
Total Economic Gain	$388,000

In general, the relatively large net social costs ($196,000) suggest that subsidization of a recovery wholesaler will strongly depend on the policy makers' interpretation of amenity benefits and other non-economic considerations.

Depletion deduction. To avoid the danger of concentrating public assistance too narrowly and thereby disrupting competitive relations among recyclers, the State can modify existing tax policies to accommodate the ongoing financial needs of all recycling operations. I explore potential impacts of two specific proposals for tax relief based on recent national legislation (see Anderson, 1977).

The first example consists of a deduction against taxable income from recycling. It is analogous to the depletion allowance for primary raw material production. Deductions for secondary materials are comparable in magnitude to the depletion allowance for the corresponding primary commodity and would be made available on some secondary materials having renewable virgin counterparts (notably, waste paper). For example, deduction for waste paper is equal to 18 percent of taxable income.

Alternatively, the allowance could be constructed to reflect a portion of the local or statewide public benefits from material recovery. For example, the net public benefits (recall that public benefits are distinguished from social benefits, which integrate both public and private sector costs and benefits) in the basic scenario equal $20.35 for each ton recovered. Public benefits per ton equal approximately

23 percent of the average waste paper price per ton in the basic scenario. The depletion deduction could be set equal to 23 percent of taxable income from waste paper recovery. The cost to the state would depend on several factors, including the quantity recovery and the level of taxable income as determined by market prices and recovery costs. I illustrate the potential cost of a 23 percent depletion deduction for taxable income in connection with the previous example of aggregate waste paper recovery by independent collectors. In this case, taxable income is equal to $314,000 (463,000 - 149,000), of which about 63 percent (by weight) or $198,000 accrues from waste paper collection. The depletion deduction therefore equals $45,500, which represents about 60 percent of total public benefits from waste paper recovery.

Tax credit. Credits against income tax liabilities could be granted to collectors and recyclers that purchase secondary materials from users. According to national legislative proposals (HR 10612), the tax credit would equal between 7.5 and 11 percent of market price, depending on the secondary material (subject to specified lower and upper bounds) and would apply to production that exceeds 75 percent of a base-year level.

The following assumptions are used to estimate the cost to the State of Alaska of a tax credit on waste paper recovery:

1. The base period level of waste paper recovery equals my estimate of current annual waste paper recovery in Anchorage--672 tons.

2. The tax credit is equal to ten percent of market price, based on HR 10612.

3. The quantity of waste paper recovery to which the tax credit applies is equal to recovery in the basic scenario (4,172 tons) and is consistent with assumed recovery in the previous example of the depletion deduction.

Under these conditions, the tax credit would require $26,400 from the state operating budget.

Tax credits, in contrast to depletion deductions, would apply only to profitable operations that incur income tax liabilities. Nonprofit operators would, therefore, not benefit from a tax credit policy.

Further, while tax relief protects the interests of some recyclers, it does not correct the more complex problem of discriminatory tax regulations and of traditional accounting practices that distort production decisions in favor of primary commodity producing segments. That is, resource misallocation will persist, although a more favorable balance between primary and secondary commodity production might be achieved.

Tax relief measures, as well as direct subsidies, encourage the development of and entry into the recycling recovery sector but do not directly address the more fundamental issue of citizen participation. Their impact on supply creation is, instead, indirect and occurs only to the extent that these policies encourage collectors themselves to develop stimulants for citizen participation in waste separation. For example, Anderson (1977) estimates that the depletion deduction and the tax credit proposals would increase national waste paper recycling between 1.4 and 1.6 percent, respectively.

The impact of tax relief on the quantity of secondary material recovery in Alaska is unclear. On the one hand, tax relief redistributes a moderate portion of public benefits to the recycling recovery sector. Tax relief, however, does not affect public participation directly and may not reduce operating costs enough to permit decentralized recovery by independent, small-scale recyclers to successfully incorporate less profitable secondary materials. Tax relief may best be used as an ancillary proposal in conjunction with other more direct recycling policies.

Community Participation

Two final policy proposals are considered. They are distinguished from previous policies in that they address the problem of participation in residential and institutional sectors directly.

Compulsory office paper separation. The first policy I consider is compulsory separation and collection of high-grade office waste paper. In the earlier discussion of office paper, high-grade separation in the "buyback-plus-office-paper" scenario, I conservatively estimated that upwards of 1,000 tons of high-grade white and colored ledger paper, valued at more than $150,000, is recoverable from federal, state, and local government agencies in Anchorage (excluding military). An additional 1,000 tons of recoverable CPO and tab cards are also available from all levels of government, plus commercial institutions (excluding military). (See Table 2-4.)

The impact of office ledger and computer paper recovery from state offices alone would more than double current waste paper recovery in Anchorage. More importantly, by increasing the level of overall tonnage recycled, compulsory office paper separation would generate positive economies of scale in material recovery. In addition to reducing unit recovery costs, we note that the impact of office collection over the preceding buy-back scenario would raise net social benefits from $37 to $39 per ton (Table 4-18).

The total cost of office paper separation to the state would depend on whether or not office paper is purchased by or donated to recyclers. Under a buy-back program, the state would recoup $15,000 annually which would cover from one-third to one-half of initial start-up equipment, consisting of paper-separation desk trays and bulk containers for offices. Under the assumption that the burden of paper separation on office employees is negligible, the only remaining cost consideration concerns contract modifications with janitorial services to handle office paper separately from other mixed office waste.

Returnable beverage container legislation. Returnable beverage container legislation (RBCL) establishes a refund value on most beverage bottles and cans and requires distributors and grocers to redeem from, customers, beverage containers they normally handle. In some cases (e.g., the Alaska bottle bill initiative, 1978), containers not subject to a mandatory deposit would have to be reusable, recyclable, or biodegradable. Other provisions that are common to RBCL establish standardized containers for interchangeable use by several manufacturers, prohibit detachable "pull tops," and call for creation of redemption centers where customers may return empty beverage containers (e.g., Oregon bottle bill, 1972).

Also known as "mandatory deposit legislation," RBCL is not a direct form of compulsory recycling but does create strong economic incentives that encourage citizen participation in material recovery. RBCL is currently in effect in eight U.S. jurisdictions,[3] three Canadian provinces, Norway, and Sweden. In most cases, it receives strong public support and participation with negligible disruption to economic activity in the beverage and container industry. For example, the Oregon Department of Environmental Quality (1977) claims that implementation of Oregon's bottle bill in 1972 has resulted in higher rates of reuse and recycling, energy savings, higher employment, and a 72-83 percent reduction in roadside litter.

According to Zalob (1979) a recent U.S. Environmental Agency Study estimates that 3 percent of the nation's primary energy ". . . could be saved by switching to a total returnable/refillable bottle system." This is equivalent to 42 million barrels of oil each year (Zalob, 1979).

Despite the direct effect on material recovery, litter reduction, and energy conservation, the Washington State Recycling Association (WSRA)

---

[3]Including: Oregon (1972), Vermont (1973), South Dakota (1973), Michigan (1976), Maine (1976), Delaware (1978), Iowa (1978), and Connecticut (1978).

criticized a recent returnable beverage container act as a partial solution to the overall problem of solid waste management, a solution that would not accommodate the existing recycling recovery system in Washington.

According to the WSRA, about 400 independently owned private profit and nonprofit, full-line recycling centers in Washington State depend mainly on revenues from the collection and sale of bottles and cans. Aluminum cans and refillable bottles are bought back from consumers, sorted, warehoused, and marketed intact to bottlers and aluminum producers. For example, in addition to recycling 220 tons of assorted waste paper, household aluminum (pie pans and foil), tin and aluminum cans, and automobile batteries, Seattle Recycling, Inc. (SRI) handled 128,000 cases (480 tons) of sorted, locally produced, refillable beer bottles.[4] SRI pays customers a cash rebate of 25 and 50 cents for each case of beer bottles delivered to SRI. The cash rebate, unlike a deposit, represents an economic gain to beverage consumers which reduces the total initial purchase price of the beverage and container.

The WSRA is concerned that RBCL would eliminate the economic foundation on which Washington's established recycling system prospers by redirecting revenue-producing bottles and cans through the state's grocery stores. More importantly, for those recyclers that do function

[4] Refillable is distinguished from returnable. The State of Washington has no RBCL in effect. Refillable bottles, therefore, have no deposit. Their value is determined in secondary glass and aluminum markets.

as redemption centers, the deposit disbursements, which (in contrast to cash rebates) would not represent a net economic gain to consumers, would impose severe liquidity constraints on recyclers and would reduce operating margins by more than 50 percent.[5]

Although beverage bottles and cans comprise between 3 and 6 percent of total mixed solid waste, they represent important commodities to the independent, full-line recycler as a result of an established refillable container system in Washington state.

Thus, depending on the initial conditions, RBCL can reduce the commercial gain of established beverage container recovery to both the consumer and the recycler. Further, the potential decline in the overall commercial position of full-line recyclers that depend on revenues from an established network of bottle and can recovery may cause a reduction in recovery of less profitable materials previously supported by high value bottles and cans.

Recent developments in the patterns of recycling in Oregon suggest a trend toward specialization in glass and aluminum recycling recovery

---

[5] Under RBCL, the recycler performs the same handling and shipping functions as under the established refillable, no-deposit system. However, more funds are tied up in the deposit than in the cash rebate, which increases the cost of operation. According to SRI, operating margins would be reduced from 33-to-15 percent per case. Operating margin is defined as gross receipts from sales minus the cost of materials purchased, divided by gross receipts. Under RBCL, gross receipts and the cost of materials purchased would include the refundable deposit.

systems. For example, in 1979, Smith and Hill Systems, Ltd., (S & H) entered greater Portland area markets for secondary glass and aluminum. S & H collects, processes, and ships all types of beverage containers, including those captured under Oregon's RBCL. Returnable bottles and cans redeemed by distributors are then sold to S & H, where they are sorted, crushed, shredded, and shipped to glass and aluminum producers. Equipment and production techniques are geared toward large-scale material recovery and represent the most up-to-date applications of recycling technology. S & H is able to profitably integrate into the network of material recovery through a combination of specialization and large-scale production.

In contrast to S & H, the main objective of Portland Recycle Team (PRT), a nonprofit, full-line recycle center, is to widen the scope of material recovery to include commercially unattractive secondary materials. For example, PRT focuses recovery effort on glass containers that are not subject to mandatory deposit under Oregon's RBCL. Portland Recycle Team collects and washes primary wine and cider bottles and resells them to respective bottlers at substantial losses.[6]

Further, PRT is unable to compete with S & H in the quantity of returnable bottles and cans which it does recover. In November 1979, the managers of S & H and PRT were negotiating the mutually advantageous

---

[6]In 1978, PRT's Bottle Works Division incurred losses equal to $13,000, which increased to $30,000 in 1979.

transfer of an aluminum can collection contract held by PRT. The transfer would increase the scale of S & H's aluminum recovery and reduce losses incurred by PRT.[7]

Although conclusive evidence is not available, the experiences of Portland Recycling Team, Smith and Hill Systems, Ltd., and Seattle Recycling, Inc., suggest that Oregon's RBCL is responsible for a shift in recycling effort toward large-scale, special-recovery techniques. While PRT--the largest full-line recycler in Portland--is unable to successfully compete in markets for secondary materials subsumed in RBCL, SRI--having comparable product mix, quantity, and composition to that of PRT--identifies aluminum cans and refillable bottles as its strongest revenue generating components.

Proximity to secondary materials markets is an important difference between recyclers in the Pacific Northwest and in Alaska. The basic recycling scenario presented above showed that, under conditions of 25 percent participation, commercial standards for glass recovery are not satisfied. According to the revenue and cost data in Table 4-8, a break-even level of glass recovery is unattainable.[8] It is therefore unlikely that commercial recyclers would undertake glass recovery.

---

[7]PRT was unable to collect a sufficient volume of aluminum cans to generate a positive return in that segment of material recovery.

[8]Note that variable operating costs per ton exceed revenue per ton. Thus, losses increase with increases in tonnage unless unit variable operating costs decrease with expanded recovery.

On the other hand, positive net social benefits in glass recovery justify the implementation of a mandatory deposit system under the assumption that basic scenario collection, processing, and freight costs reflect aggregate costs of RBCL to grocers, distributors, and recyclers in the private sector.[9] Returnable beverage container legislation may be the only practical solution to mobilizing glass recovery in Anchorage, and elsewhere in Alaska.

RBCL may encourage the kind of large-scale, specialized recovery exemplified by Smith and Hill Systems, Ltd. At 25 percent participation, the difference between revenue and cost for combined glass bottle and aluminum can recovery is positive in the basic scenario. Although not reflected in basic scenario data, it is possible (and likely) that a scale of glass recovery that exceeds 25 percent would lower unit variable costs of recovery and provide additional incentive for commercial involvement in glass recycling recovery systems.

More importantly, since used glass is presently not recovered for any form of recycling in Anchorage and since the quantity of current aluminum collection represents only six percent of feasible recovery, RBCL should not interfere with present Anchorage-based recycling effort.

---

[9] Basic scenario glass recovery costs do not capture the extra warehousing costs to grocers and distributors in stockpiling and transferring glass bottles to the recycler and may therefore understate commercial losses and overstate net social benefits.

Summary

The public policy response to a large, unexploited reserve of secondary materials and to a recycling recovery system that includes several independent, small-scale recyclers must be taylored to circumstances and problems unique to Alaska and to the domestic and international recycling industry as a whole. The primary constraint to the development of local recycling recovery systems is Alaska's distant proximity to secondary materials markets.

In the preceding discussion, I reviewed several public policies to stimulate material recovery for recycling. The type of policies examined include subsidies, tax relief, and compulsory measures.

Policy measures therefore affect secondary material recovery directly by stimulating community participation in waste separation and indirectly by strengthening the recycling recovery sector (i.e., scrap collectors and recycle centers) which, in turn, develops its own economic or information incentives to encourage community involvement in waste separation.

Policy measures that strengthen recovery sector activity include direct subsidization, depletion deductions on taxable income, and tax credits. Direct subsidization is capable of stimulating the recovery of less profitable secondary materials but constitutes a form of direct public intervention in private markets that discriminates against existing independent profit and nonprofit recyclers. Attempts to spread the impact of public assistance may not fully eliminate this effect and reduce the opportunity for recovery of commercially less favorable materials (e.g., glass, mixed scrap paper, and corrugated containers).

We examined the implications of a publicly funded "central recovery wholesaler" as an alternative to direct subsidization. As an intermediary between independent Anchorage-based collectors and "stateside" dealers, the recovery wholesaler would preserve competition, would avoid the problem of grant discrimination, and would achieve greater economies of scale in first-stage processing and shipping. Although noticeable gains would accrue to commercial collectors, the provision of recovery wholesale services would require plant and equipment outlays and ongoing expenses that exceed combined measures of private and public benefits.

Depletion deductions and tax credits are indirect subsidies that benefit some, but not all, recyclers.

Compulsory office paper separation and returnable beverage container legislation (RBCL) affect community participation directly. RBCL directs glass bottle and aluminum recovery to the grocer and distributor; replaces consumer cash rebates with refundable deposits; and, under certain conditions, reduces the potential return to recyclers. Recent developments in Oregon's recycling industry suggest that, in contrast to full-line recycling, large-scale, specialized recycling recovery systems may best accommodate RBCL. However, in Alaska, used glass is unlikely to enter the product mix of the full-line recycler. Consequently, RBCL may provide the institutional framework to mobilize a form of material recovery that would not otherwise develop in the commercial sector.

Compulsory separation and collection of state office waste paper would provide an immediate source of waste paper supply to recyclers with negligible public intervention in private sector markets. Office paper separation implies a host of management and logistics problems which, like other policy measures, would require attention and commitment on the part of several groups, especially in the initial stages.

In conclusion, I would like to stress four general factors in the development policy to stimulate private and public sector involvement in recycling. First, the recycling industry is unusually sensitive to events which induce even slight changes in market conditions or in technology. Recall that secondary materials are generated from commodities produced in earlier periods and are therefore affected by factors which influence the quantity and physical characteristics of primary commodities. Additionally, secondary materials compete in markets for primary materials from which they are originally produced (e.g., waste paper and wood pulp). Thus, to avoid unintended disruptions in the recycling industry, public policy should minimize the extent of direct intervention in the private sector. That is, policy makers should avoid regulatory policies and institutional impediments that compete with or discriminate against independent recyclers in the private sector.

Second, community participation is the key to effective development of used materials supplies for market exchange. It is likely that in view of rising demand in most used materials markets, the recycling recovery sector will respond in tandum to forthcoming secondary material supplies from residential and commercial sources.

In the absence of economic incentives, however, changes in consumer "throwaway" attitudes would be unlikely. As we have seen, although conservative estimates of direct social benefits to the local community from material recovery are large, they are not reflected in market prices. Market prices, therefore, understate the real value of recycling to society and neither the recycling recovery sector nor the residential and institutional community receive adequate economic incentives to expand material recovery.

Legislative initiative is required to expose "hidden" economic benefits in order to stimulate participation in several sectors of the economy.

Third, better information is needed in all sectors of the economy. The state can facilitate information improvements by establishing an information exchange system which circulates technical and market information and provides a source for feedback from consumers and recyclers. An example is the state-funded "Recycling Hot Line" in Oregon.

Fourth, the importance of non-economic factors as criteria for evaluating policy proposals should not be overlooked. The assumptions used throughout this report tend to be conservative (even under optimistic conditions), so that the net social benefits corresponding to specific recycling scenarios are understated just as net social costs are overstated. The aesthetic benefit in reduced pollution and roadside litter is perhaps the most important unquantified benefit of recycling. Therefore, in addition to economic criteria, policies to stimulate recycling should be ranked according to qualitative public benefits and costs. For example, given two policies that both would achieve net social benefits, the policy having greater total recovery or greater recovery of more environmentally damaging materials would be selected regardless of comparative rankings of net social benefits.

BIBLIOGRAPHY

ACLW and M&E, Inc., Consulting Engineers. Study of On-Site Storage, Collection, and Bulk Transportation of Solid Wastes. Prepared for the Greater Anchorage Area Borough Public Works Department, Solid Waste Management Division, [1973].

Anderson, Robert C. "Public Policies Toward the Use of Scrap Materials." American Economic Review 67 (February 1977): 355-8.

________. "Recycling Policy - Basic Economic Issues," in Resource Conservation: Social and Economic Dimensions of Recycling. ed. David W. Pearce and Ingo Walter. New York: New York University Press, 1977.

Bomhoff and Associates, Inc. Solid Waste Management Processing and Disposal Study. Prepared for the Greater Anchorage Area Borough Public Works Department, Solid Waste Management Division, [1975].

Darnay, Arsen and Franklin, E. William. Salvage Markets for Materials in Solid Waste. Kansas City: Midwest Research Institute, [1972].

Ender, Richard L; Gehler, Jan; Gorski, Susan; and Harper, Susan. Anchorage Socioeconomic and Physical Baseline: Technical Report Number 12. Anchorage: Bureau of Land Management, Alaska Outer Continental Shelf Office, [1978].

Gray, John T. Transportation Systems Planning for Alaska. Anchorage: Institute of Social and Economic Research, University of Alaska, [1979].

Greater Anchorage Area Borough. Preliminary Solid Waste Management Master Plan. Public Works Department, Solid Waste Management Division, [1975].

Hayes, Dennis. Repairs, Reuse, Recycling - First Steps Toward a Sustainable Society. Worldwatch Paper 23, 1978.

Metcalf and Eddy Engineers. Feasibility of Resource Recovery from Solid Waste. Anchorage: Public Works Department, Division of Solid Waste Management, [1979].

Nebesky, William E. "A Simultaneous Equation Model of the Domestic Market for Waste Paper," M.S. Thesis, University of Wisconsin, 1979.

Portland Recycling Team. Resource Conservation Through Citizen Involvement in Waste Management. Portland: Metropolitan Service District, [1975].

Quimby, Thomas H. E. Recycling: The Alternative to Disposal. Baltimore: John Hopkins University Press, 1975.

Resource Conservation Consultants, Inc. An Analysis of the Waste Collection Industry in Portland, Oregon. Portland: Teamsters Local 281, 1979.

Schwegler, Ronald E. Solid Wastes Facts. Washington: Institute for Solid Wastes, [1978].

Seattle Recycling, Inc. Final Report for the Sort Project. Seattle: Solid Waste Utility, [1979].

Tania, Lipshutz. Garbage-to-Energy: The False Panacea. Santa Rosa: Sonoma County Community Recycling Center, [1979].

U.S. Environmental Protection Agency. Resource Recovery and Waste Reduction. Washington, D.C.: U.S. Government Printing Office, [1975].

Zalob, David S. "Current Legislation and Practice of Compulsory Recycling: An International Perspective." Natural Resources Journal 19 (July 1979): 611-28.