

**Exploring Economic Incentives for Effective
Solid Waste Management in Rhode Island**

By

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Thesis

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EXECUTIVE SUMMARY

My thesis analyzes economic incentives that influence the management and disposal of solid waste in Rhode Island. This examination is timely for the following reasons.

First, Central Landfill, the state landfill responsible for accommodating nearly all the state's solid waste, is facing a disposal capacity shortfall of seven to eight years and at present disposal rates is expected to last till November 2017. Land and political constraints will make siting a new landfill in Rhode Island a challenging task, making preserving landfill life at Central Landfill an immediate priority.

The second reason is the opportunity provided by the Rhode Island Comprehensive Waste Management Plan revision process. The Waste Management Plan is a part of the larger State Guide Plan and provides guidance for environmentally sound management and disposal of solid waste in the state. Specifically, the Plan may be used to recommend economic incentives to improve solid waste management so as to extend life at Central Landfill.

I begin by covering definitions and regulations governing solid waste management in Rhode Island. This is followed by a description of the role of the primary actors concerned with solid waste management, and an analysis of the existing incentives these actors face. Recommendations for economic incentives with regard to municipal solid waste (MSW) and commercial solid waste (CSW) management follow. Since the MSW and CSW streams are different in terms of their composition, management, and the entity responsible for their collection, they are addressed separately, although the results are eventually combined to describe the management of the combined solid waste stream. I end with recommendations for changes to the recycling system.

WASTE MANAGEMENT IN RHODE ISLAND

RIGL (Rhode Island General Law) § 23-19 advocates the use of a waste management hierarchy that ranks environmentally sound strategies for MSW management. The waste management hierarchy places source reduction as the most preferred option followed by recycling and composting; and as least preferred ranks disposal by landfills.

In spite of this mandate, landfilling is by far the dominant method of waste disposal in Rhode Island. For example, in 2002, 76 percent of MSW and 70 percent of CSW generated was landfilled.

Responsibility for solid waste management in Rhode Island is shared by several agencies, principally the Rhode Island Resource Recovery Corporation (the Corporation) and the Rhode Island Department of Environmental Management (DEM). Municipalities also play a role, as do several other state actors.

An analysis of the existing economic incentives facing the primary actors responsible for solid waste management in the state, reveals that the incentives are inconsistent with the legislated goal to reduce and recycle solid waste in preference to landfilling, and none of these actors face effective financial incentives to increase recycling rates or to reduce waste generation.

ECONOMIC INCENTIVES FOR SOLID WASTE DISPOSAL

I argue that the scarcity value of a depletable resource – landfill space at Central Landfill – has not been a consideration in waste management decision-making. As a result, landfill disposal is artificially cheap, which has discouraged waste diversion initiatives. Until the true costs and benefits of disposal by landfilling are accounted for, waste reduction programs will always appear more expensive than disposal.

The current value of landfill space is estimated using the cost of waste disposal in neighboring states as a surrogate of the value of landfill space in Rhode Island. It is assumed that the price charged to dispose of waste at a landfill (the tipping fee) is based on the actual current value of landfill space. The estimate used here is from a landfill in Connecticut with tipping fees priced at \$61/T. This tipping fee, reduced by the Corporation's operating cost of \$20/T puts the value of landfill space at about \$40/T.

Ideally, the current value of landfill space should be calculated based on the cost of acquiring a site, and developing and constructing a new, sanitary landfill to be brought on-line when Central Landfill closes. It appears that the only study undertaken to site an alternative to Central Landfill in Rhode Island was conducted in 1990. The study estimated that the additional tipping fee required to support a new landfill was \$37/T (in 2003 figures). This would raise the tipping fee from the present \$32/T to $(32 + 37) = \$69/T$ at this new facility. It was not been possible to assess the accuracy of the 1990 cost estimate or of its continuing relevance in 2003. It should be noted that the two methods of calculation give remarkably similar answers.

The \$40/T value represents what it is worth to prevent a ton of waste from being buried. A policy implication of the analysis is that an economic incentive that costs up to this \$40/T value may be justified as economical and should be implemented.

Municipal Incentives

User fees or pay-as-you-throw (PAYT) strategies create a direct link between waste disposal and cost by requiring residents to pay for waste disposal based on the amount of waste disposed. As a result PAYT strategies support the waste management hierarchy and are recommended for implementation. Based on experience elsewhere, it appears that no other strategy offers similarly effective incentives.

To provide additional incentives to municipalities to implement PAYT, I recommend that the Corporation provide grants to defray start-up costs, and also reduce municipal cap amounts to account for the increased recycling that would result from full implementation

of PAYT. If municipalities are still resistant, it is recommended that the State mandate the use of PAYT programs by setting a cut-off date by which time every municipality would need to have PAYT (or its equivalent) in place or be required to pay the commercial tipping rate for all of its waste.

I also recommend that L&Y waste be banned from disposal at Central Landfill in order to preserve disposal capacity, reduce disposal costs, and generate a useful soil amendment through composting.

Commercial Incentives

I recommend that landfill bans on commercial recyclables be adopted and the existing commercial recycling regulations be enforced as a priority.

I also recommend that Resource Management (RM) contracting be encouraged by assistance from the Corporation. RM is an alternative to disposal contracting that helps generators craft cooperative hauling contracts with waste haulers that support waste reduction.

In case these combined incentives do not prove effective, I recommend that CSW be diverted out-of-state. Estimates of costs to dispose of waste out-of-state are essentially equivalent to the current commercial tipping fee. One strategy to encourage out-of-state CSW disposal is to increase the average commercial tipping fee (currently \$50) to a rate comparable to that in adjoining states, approximately \$65/T.

The combined effect of implementing these MSW and CSW management strategies will divert about 750 KT of waste and extend landfill life by about 9 months per year.

Incentives for the RIRRC

The Corporation faces a direct economic disincentive in the short term to increase source reduction or recycling, because success in either area would decrease revenues from landfilling. One option to counteract this disincentive is to set a goal for the amount of waste the landfill may accept annually and require the Corporation to put aside a certain sum of money in an escrow account if this waste goal is exceeded. This would provide an incentive to the Corporation to conserve landfill space and would also make available funding for the purchase of future landfill space if necessary. Other suggestions include rewarding the Corporation for reduced 'sales,' permitting the Corporation to keep some portion of its appropriations to use towards reduction and recycling programs, and developing an accounting mechanism that includes resource rent so as to account for the value of the landfill resource over time.

Other overarching recommendations I make are for the use of incentive schedules to effectively coordinate and implement the incentives, development of sources of funding for recommendations made, and measures to increase accountability by the Corporation.

RECYCLING

Benefits of Reduced Greenhouse Gases from Recycling

Besides preserving virgin materials, diverting waste, and extending landfill life, an added advantage of increased recycling is the reduction of greenhouse gas (GHG) emissions, and the conservation of energy from conserving raw materials and energy expended on retrieval, processing, and manufacture of products.

Using the Northeast Recycling Council's Environmental Benefits Calculator estimates of the environmental benefits of recycling from GHG mitigation are calculated. In 2002, Rhode Island recycling programs supplied industry with about 83,880 tons of scrap commodities like paper, glass, metals, plastics, and other materials. These recycling efforts reduced GHG emissions by about 58,000 metric tons of carbon equivalent per year, equal to approximately 6.7 percent of all industrial carbon dioxide emissions from fossil fuel combustion in the state and 2.2 percent of GHG emissions. This saved a total of 1.48 trillion BTUs of energy, equal to 2.2 percent of all energy used by industry in the state, which has a value of \$9 million dollars.

Alternative collection and sorting strategies for recycling

An alternative to the existing dual-stream system of collecting and sorting recyclables is single-stream recycling without glass. Single-stream recycling has been found to lower collection costs dramatically, and also to give rise to other cost savings by optimizing truck payload capacity, and allowing overall fleet deployment flexibility. Removing glass from the recyclables stream reduces paper contamination, allows compaction of recyclables, reduces collection and hauling costs for municipalities, and lowers maintenance costs at the Materials Recycling Facility (MRF). It should be noted that container glass has little or no re-sale value and is no longer marketed by the MRF. At present this glass is being used as a part of landfill cover for Central Landfill at considerable maintenance costs to the MRF.

Another collection strategy to consider is automated waste collection. Evidence shows that automated methods of collecting recyclables give rise to increased collection efficiencies and long-run cost savings for labor and time. If combined it may be expected that single-stream recycling using automated collection will generate even higher cost savings in the long-run.

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LIST OF ABBREVIATIONS

BAU	Business as Usual
BTU	British Thermal Unit
C&D	Construction & Demolition debris
CSW	Commercial Solid Waste
DEM	Rhode Island Department of Environmental Management
DEP	Massachusetts Department of Environmental Protection
EPA	United States Environmental Protection Agency
FY	Fiscal Year
GHGs	Greenhouse gases
HDPE	High Density Polyethylene
KT	Kilotons
L&Y	Leaf & yard waste
LDPE	Low Density Polyethylene
LTCS	Landfill Tax Credit Scheme
MRF	Materials Recycling Facility
MSW	Municipal Solid Waste
MTCE	Metric Tons of Carbon Equivalent
NERC	Northeast Recycling Council
NIMBY	“Not in my backyard”
NIMTO	“Not in my term of office”
PAYT	Pay-as-you-throw
PET	Polyethylene Terephthalate
RCRA	Resource Conservation and Recovery Act, 1976
RIGL	Rhode Island General Law
RIRRC	Rhode Island Resource Recovery Corporation
RM	Resource Management
TPD	Tons per Day

INTRODUCTION

My thesis examines economic incentives that influence waste management and disposal in Rhode Island. This examination is timely for the following reasons.

First, Rhode Island Statewide Planning requirements call for planning for solid waste disposal capacity adequate for a 20-year time frame (Disposal and Disposal Capacity Sub-Committee, 2003). At present, the Rhode Island Resource Recovery Corporation (the Corporation), the agency responsible for solid waste management in the state, is landfilling in Phase IV of Central Landfill. Central Landfill is the only significant landfill in Rhode Island and must accommodate nearly all the state's solid waste. Phase IV went into operation in 2000 with a capacity of 3,720 KT (kilotons) and is scheduled to be full in June 2004.

Licensing and permitting for the next phase of the landfill, Phase V, is under review by the Rhode Island Department of Environmental Management (DEM). The phase will have a capacity of 7,500 KT and will be ready for use in May 2004. At present filling rates of 1,050 KT per year, Phase V is expected to last seven years, till 2012. Pre-planning for Phase VI is underway and once licensed is expected to have a 6,500 KT life expectancy and last till November 2017 when Central Landfill will reach full capacity. This leaves the state with less than 15 years of landfill life and a disposal capacity shortfall of seven to eight years at present rates of disposal. (See Appendix I for a timeline detailing the capacity remaining at Central Landfill).

If no further expansion is possible at Central Landfill, this means that the state needs to consider beginning the siting process for a new landfill in the next five years. Land and political constraints in the state are expected to make this a very challenging task which makes preserving landfill life at Central Landfill an immediate priority.

Second, the Rhode Island Comprehensive Waste Management Plan, last published in November 1996 (the 1996 Plan), is being revised. The Comprehensive Waste Management Plan is a part of the larger State Guide Plan and is intended to provide guidance for environmentally sound management and disposal of solid waste in Rhode Island. The 1996 Plan defined rates for waste disposal, recycling, and source reduction to be achieved by the Corporation and the DEM. These projections were viewed by the 1996 Plan as critical to the planning of facilities and programs necessary to effectively manage solid waste in Rhode Island and to meet the goals established by the Plan. An examination of the Corporation's performance reveals that in the last five years, the actual amounts disposed of at the landfill have totaled 1,900 KT *more* than the Plan allowed for. The actual amounts disposed of at the landfill have been relatively constant for the past six years, averaging 1,090 KT per year. Comparing this average with that projected in the 1996 Plan, by 2015 the Corporation will have disposed of over 7,000 KT more than the amount allowed for by the Plan. This is more than 90 percent of the capacity to be added in Phase V.

The Corporation has had little success bringing the amounts of waste disposed into consistency with the amounts projected by the 1996 Plan – for example, if the 1996 Plan

targets for waste diversion had actually been followed, Phase V would have provided sufficient capacity through 2015.

As a result, the revision process becomes important in that it provides a platform to facilitate change. The revision process is being conducted by a group of stakeholders made up of representatives from the state government, from the solid waste collection, hauling and recycling industries, from municipalities, academia, and environmental non-profit organizations, and from the business community. The revision process started in December 2002 and the final revised plan is expected to be ready for review by Statewide Planning in May 2004.

The revision process provides an opportunity to implement change and require the Corporation to improve their efforts at increasing recycling and reducing the amount of solid waste disposed of at Central Landfill, and thereby extending landfill life. This will need to be carried out by including requirements in the Plan that can mandatorily be enforced. Specifically, for the purpose at hand – devising economic incentives to influence responsible solid waste management in the state – the Plan may be used to recommend ways to improve solid waste management in Rhode Island, to stipulate that of landfill capacity be utilized efficiently,¹ and to devise ways to extend landfill life. It is

¹ Tietenberg (2000) defines efficiency (or static efficiency) as the economic criterion for choosing among various allocations occurring at the *same point* in time. An allocation of resources is said to satisfy the static efficiency criterion if the net benefit from the use of those resources is maximized by that allocation. However, when time is an important consideration, a generalization of the static efficiency criterion, dynamic efficiency, is used to make choices between resource allocations at different points in time. In this generalization, the present-value criterion provides a way for comparing the net benefits received in one period with the net benefits received in another. The objective therefore is to balance present and future uses of the resource in question (in this case landfill space) by maximizing the present value of net benefits derived from the use of that resource.

hoped that by incorporating economic incentives into the Revised Plan this will take place.

My thesis begins with definitions and covers regulations governing waste management in the state. This is followed by a description of the role of the primary actors concerned with solid waste management in the state, and an analysis of the existing incentives these actors face. Recommendations for economic incentives with regard to municipal solid waste and commercial solid waste management follow. I end with recommendations for changes to the recycling system.

It should be noted that except where mentioned otherwise all data have been provided by the Rhode Island Resource Recovery Corporation and are 2002 figures.

WASTE MANAGEMENT IN RHODE ISLAND

Solid Wastes defined

Solid wastes are classified under the non-hazardous waste category by the US Environmental Protection Agency (EPA) and comprise household, municipal, food, and some industrial or commercial wastes. The 1996 Plan defines solid wastes as garbage, refuse, and other discarded solid materials generated by residential, institutional, commercial, industrial and agricultural sources. The definition does not include solids or dissolved material in domestic sewage or sewage sludge, or hazardous waste (as defined in the Rhode Island Hazardous Waste Management Act, § 23-19.1).

Municipal solid waste (MSW) is one subset of solid waste; in Rhode Island it is all waste that municipalities have a responsibility to collect. This is primarily waste generated at residences, although certain institutional wastes, such as that generated by public schools, are often also included. The 1996 Plan defines MSW as solid waste generated by the residents of a municipality in the course of their daily living, the disposal of which is undertaken by the governing body of that municipality.

Commercial solid waste (CSW) is another subset of solid waste and for the most part comprises the remainder of the solid waste stream. Since it is not the responsibility of municipalities to collect this waste, businesses and other commercial waste generators contract with private collection agencies for this service. CSW also includes non-

municipal residential solid waste generated in multi-unit housing. Non-municipal residential solid waste is solid waste generated by the residents of a municipality in the course of their daily living for which the governing body of that municipality does not accept responsibility for disposal. Multi-unit housing includes any housing that the governing body of that municipality has designated as a multi-unit dwelling. The 1996 Plan defines CSW as solid waste generated by stores, offices, institutions, restaurants, warehouses, and activities at industrial facilities.

Waste Management hierarchy

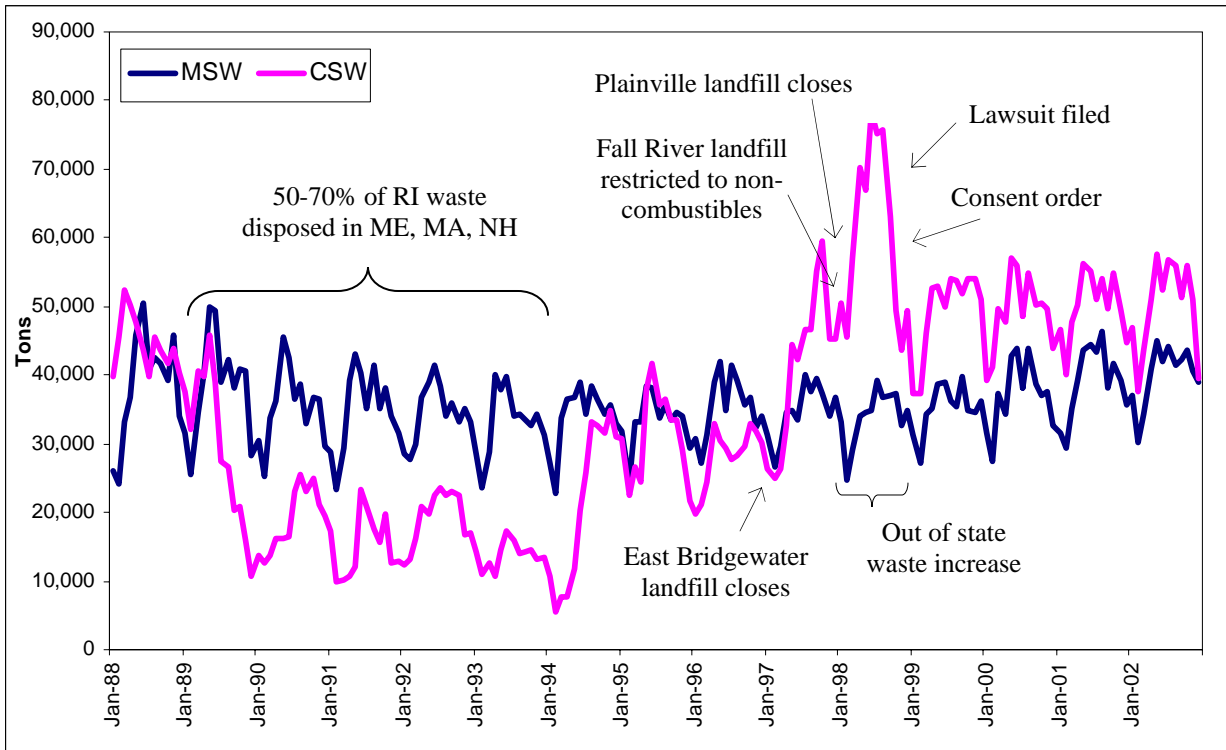
The goal for the management of solid waste in Rhode Island purports to be ‘environmentally sound, cost effective, practical solid waste management with the ultimate objective of maximizing source reduction, recycling, and reuse of solid waste’ (Rhode Island Comprehensive Solid Waste Management Plan, November 1996). RIGL § 23-19 advocates the use of a waste management hierarchy that ranks environmentally sound strategies for MSW management. The waste management hierarchy places source reduction or waste prevention; implying any practice that reduces the amount or toxicity of waste generated; as the most preferred option followed by recycling and composting; which conserve disposal capacity and preserve natural resources by preventing potentially useful materials from being thrown away; and as least preferred ranks disposal in combustion facilities and landfills.

In spite of the waste hierarchy mandate, in 2002, the total amount of MSW generated was 588,206 tons of which 449,570 tons were landfilled and 83,716 tons were recycled. The rest of the MSW stream comprised composting, white goods, and tires. CSW was managed similarly and in 2002, 909,034 tons were generated of which 633,686 tons were landfilled and 22,999 tons recycled (16,999 tons at the MRF and 6,000 tons elsewhere). The rest of the CSW stream was composted or put to beneficial reuse (24,190 tons and 228,159 tons respectively).

(See **Box 1** for the amounts of municipal and commercial solid waste disposed of at Central Landfill).

Box 1: Amounts of Municipal and Commercial Solid Waste disposed at Central Landfill

While MSW disposal at Central Landfill has been more or less constant, accounting for seasonal variations, CSW has seen a lot of variation.



Between 1989 and 1994, 50 to 70 percent of Rhode Island's CSW was disposed of at facilities in Maine, Massachusetts and New Hampshire, drawn by low tipping fees as a result of surplus disposal capacity. Beginning 1994, however, the regional waste disposal markets tightened, driving out-of-state tipping fees up while tipping fees at Central Landfill remained stable. The increase in regional tipping fees, accompanied by the closure of the 1,500 tons per day (TPD) landfill in East Bridgewater in February 1997, the imposition of restrictions on the BFI landfill in Fall River in January 1998, and the closure of the 2,000 TPD Plainville landfill in March 1998, drove Rhode Island generated waste from disposal sites in Massachusetts to Central Landfill. As a result, all of

the State's CSW was once again disposed of at Central Landfill. Further, the low commercial tipping fees in Rhode Island compared to the elevated regional tipping fees in Massachusetts caused a flight of Massachusetts solid waste to Central Landfill in the Spring and Summer of 1998. This flood was staunch by September 1998 as a result of law suits by DEM and the Corporation against the principal transporters of the waste. The litigation concluded with consent orders according to which the largest haulers who signed them stipulated that they would no longer deliver out-of-state waste to Central Landfill. Since then waste disposal has been more or less constant, impacted by seasonal considerations where waste generation drops off in December, January, February and March and picks up again with spring clean-up, and then stays fairly high.

Regulation

The federal government through the EPA regulates solid waste management under the Resource Conservation and Recovery Act, 1976 (RCRA). These regulations require that states adopt solid waste management regulations and state solid waste management plans that cover solid, hazardous, and other wastes. The EPA has delegated its RCRA responsibilities in Rhode Island to the DEM and provides funds for RCRA activities. A state's waste management program must conform to federal guidelines although it may widen the scope of coverage or require more stringent regulation.

In contrast to most other states, in Rhode Island, state government agencies not only regulate solid and hazardous waste management, but also provide recycling and disposal facilities for municipal and commercial solid wastes. In many other states, regulation is dispersed throughout state, county, and municipal government agencies and waste management facilities are provided by local, county or regional agencies or by the private sector. In Rhode Island, current arrangements for solid waste management are a result of the small size of the state, the dominance of the central metropolitan area, and changes over the past 30 years that have expanded the role of government and centralized functions at the state level (See Appendix II for a timeline detailing the evolution of solid waste management in Rhode Island).

AGENCIES RESPONSIBLE FOR WASTE MANAGEMENT IN RHODE ISLAND

Responsibility for solid waste management in Rhode Island is shared by several agencies, principally the Rhode Island Resource Recovery Corporation (RIRRC) and the DEM. Municipalities also play a role, as do several other state actors. The role of these actors as it applies to solid waste management is given below.

Rhode Island Resource Recovery Corporation

The RIRRC (the Corporation) is the principal state agency responsible for solid waste management. Created by the Rhode Island General Assembly in 1974, the Corporation owns and operates the Central Landfill and funds and manages the state's recycling program and the Materials Recycling Facility (MRF) in Johnston, Rhode Island.

The Central Landfill receives approximately 3,500 tons per day of waste and is responsible for accepting more than 98 percent of the state's MSW and an estimated 100 percent of the CSW streams. The landfill covers 199 acres and peaks at an altitude above sea level of about 564 feet, with an actual height of 264 feet. Current legislation (RIGL § 23-19-13.1) prohibits disposal of out-of state waste at Central Landfill.

The MRF in turn serves the recycling needs of all of Rhode Island's municipalities. In 1996, the production capacity of the MRF was doubled and its processing footprint was expanded from about 40,000 square feet to about 72,000 square feet. As a result of this

increase in processing capacity and the introduction of the statewide Maximum Recycling Plan, the quantity of recyclables handled by the MRF increased from about 53,000 tons in 1996 to more than 80,000 tons in 2002.

Tipping fees

Tipping fees are the prices charged for accepting solid waste at a landfill, in dollars per ton. In Rhode Island municipal tipping fees for solid waste are \$32/T, determined at a rate set by statute (RIGL § 23-19-13(g)) and state-subsidized for disposal at Corporation facilities. This is in spite of a legislative mandate that the tipping fees increase by 7.5 percent annually. The \$32/T rate is held constant by a provision included in every state budget overruling this mandate.² It should also be emphasized that while the term ‘state-subsidized’ used here may imply that the state is transferring funds to the Corporation, in actual fact the cash flows the other way in the form of transfers from the Corporation to the State’s General Fund. The only way the state is really ‘subsidizing’ municipal tipping fees is by not charging the true value of landfill space for waste disposal.

Commercial contract tipping fees average around \$50/T. Commercial generators with no contract with the Corporation are charged \$65/T to dispose of their wastes. (Table 1 shows how tipping fees have changed over the past six years).

² RIGL § 23-19-13(2)(g)) states ‘The municipal tipping fee shall be equal to one hundred seven and one-half percent (107.5%) of the prior fiscal year’s municipal tipping fee through the end of the 2009 fiscal year.’

In May 1995, the Corporation began offering waste disposal contracts to municipalities which set terms and conditions under which the municipalities could dispose of their solid waste with, and deliver their recyclables to, the Corporation. At present, 35 municipalities have recycling and disposal contracts.

Table 1: Municipal and Commercial Tipping Fees for the past six years in Rhode Island						
	FY					
	1999	2000	2001	2002	2003	2004
CSW						
Contract	44.00	44.00	46.00	49.00	52.00	53.00
Non-contract	52.00	58.00	58.00	58.00	60.00	65.00
MSW	32.00	32.00	32.00	32.00	32.00	32.00
Municipal over cap, contract	40.30	42.00	44.00	47.00	47.00	50.00
Municipal over cap, non-contract	52.00	58.00	58.00	58.00	60.00	65.00

Rhode Island Department of Environmental Management

DEM's role includes regulation of solid waste facilities and recycling activities, providing technical assistance to municipalities and businesses, public education, and coordination of recycling and litter activities (RIGL § 42-17 and 37-15). Facility regulation is largely the function of DEM's Office of Waste Management which was established under Executive Order 80-8.

(The 1996 Plan elaborates further on waste management responsibilities for the Corporation, DEM and other state agencies and is available at

<http://www.rirrc.org/site/central/CompPlan.pdf>).

Legislature

Historically the state has commandeered funds from the Corporation to bolster the General Fund. (See Table 2). The relevance of this will become apparent in the section on Existing Incentives.

Table 2: Transfers to the General Fund from the Corporation						
(in \$)	FY					
	1998	1999	2000	2001	2002	2003
Transfer to State	2,000,000	4,000,000	-	3,115,000	3,000,000	6,000,000
Net income (loss)	16,312,529	17,704,743	13,596,242	5,099,729	119,308	(3,963,334)

Municipalities

Refuse services

There are 39 municipalities in Rhode Island, of which 38 (the exception is Tiverton³) send their waste to Central Landfill. The large majority of Rhode Island municipalities (33) provide unlimited solid waste service to their residents, financed through property taxes or a flat rate fee. Six communities (Westerly, Hopkinton, Richmond, New

³ The municipal landfill of Tiverton is the only solid waste disposal facility now operating in Rhode Island, other than Central Landfill, and is dedicated solely to receiving MSW from the host community. Sanitary landfills at Charlestown and Bristol, and a privately operated construction & demolition debris landfill in North Kingstown, have closed since the 1996 Plan was published.

Shoreham, North Kingstown and South Kingstown), have implemented user fee programs to pay for the cost of MSW disposal.⁴

Municipal recycling services

A mandatory Municipal Recycling Program (RIGL § 23-18 and 23-19) with a target of diverting 15 percent of the MSW stream from landfilling was initiated in 1987 and was phased in so that by 1995 all Rhode Island municipalities were involved with mandatory recycling programs, with 36 municipalities representing 96 percent of the State's population participating fully in the recycling program and delivering all their recyclables to the MRF.⁵ This basic municipal recycling program succeeded in diverting about 11 percent of the MSW stream from landfilling. This was followed by a Maximum Recycling Program initiated statewide, under which the types of materials included in the recycling program were expanded. Initial operations of the Maximum Recycling Program were launched in 1995 with a target of diverting 40 percent of the MSW stream from disposal. Full statewide implementation was completed in 2002. The current rate of municipal recycling is 14.5 percent (not including composting). In contrast, the 1996 Plan had projected a 35 percent municipal recycling rate by 2002.

⁴ It should be mentioned that all five communities have drop-off programs that require residents to bring their wastes to transfer stations. Drop-off programs are easier to implement than curbside collection programs and do not face the same political constraints as curbside programs. However, drop-off programs typically serve only a fraction of the community. For example, in the case of Westerly and Richmond about a quarter of the community makes use of the drop-off system. In the case of North Kingstown this figure is nearly half. Curbside collection programs, while resulting in higher collection rates, require investment in waste disposal infrastructure and as a result are generally more costly.

⁵ South Kingstown and Narragansett cooperate in a joint program in which their residents source separate recyclables, some of which are delivered to the MRF. New Shoreham, because of its unique circumstances, conducts a source separation program under which recovered recyclables are processed and marketed directly by the town.

Commercial waste generators

Some 1270 businesses, 390 schools, over 100 state agencies, and an unknown number of multi-unit housing facilities fall under the commercial waste generator definition in Rhode Island as established by The Rules and Regulations for Reduction and Recycling of Commercial and Non-Municipal Residential Solid Waste. These regulations were promulgated in September 1996 under the authorities of Chapters 23-18.8-2, 23-18.9-1, 23-18.9-7, 23-19-3, 23-19-5, 37-15, 42-17.1-2, 42-17.6, 42-20.16, and 42-35 of the Rhode Island General Laws of 1956, as amended.

Any person or business who generates CSW and employs 50 or more employees, as listed in Department of Employment and Training records, is required to submit a source reduction and recycling plan that must include a waste audit, a description of the process by which recyclable materials are to be segregated, and a plan for the reduction of solid waste and recyclables generated. Once this plan is approved by DEM, the business must implement the plan and report on the results annually. These requirements also apply to all government agencies and to owners of multi-unit housing who generate non-municipal residential solid waste.

These regulations also prohibit solid waste management facilities from accepting for disposal any CSW containing more than 20 percent recyclables, by weight.

It should be emphasized that these requirements are not being enforced at all and the reasons for this will be discussed in detail in the section on Existing Incentives.

EXISTING INCENTIVES

The economic incentives facing these actors for each sector of solid waste management are identified and elaborated upon in order to evaluate whether these incentives are likely to motivate the actors to work toward the legislative goal of increased source reduction and recycling.

Rhode Island Resource Recovery Corporation

The enabling legislation for the Corporation stipulates in RIGL § 23-19-3 that the Corporation is to follow the waste management hierarchy stipulated by the EPA which puts source reduction and recycling as preferable to land disposal. In spite of this, as seen from figures cited above, landfilling is by far the dominant method of waste disposal in Rhode Island.

This should not be surprising, because the Corporation's management has a direct economic *disincentive* in the short term to increase source reduction or recycling, because success in either area would decrease revenues from landfilling.⁶ The net revenue for MRF operations in FY2001 was \$10.50/T, but net MRF revenues for FY2002 were \$0.67/T – essentially break-even. Every ton recycled and therefore not landfilled reduces

⁶ It may be argued that the Corporation faces an objective function different to that of a private organization that has profit maximization as its key objective. "Rational" behavior on the part of organizations often precludes the goal of profit maximization (Poblador, 1995). Nellis and Parker (1992) note that the traditional theory of the firm does not provide a particularly useful framework for analyzing the behavior of state firms and it is much more difficult to adapt corporate finance principles to not-for-profit organizations, since their objective is often to deliver a service in the most efficient way possible, rather than to make profits.

revenue by \$32 (for municipal waste) or \$50 (for commercial and over-cap municipal waste). In addition, a significant percentage of operating costs are fixed, and would not be reduced by a reduction in the amount of waste landfilled.

Contrary to this short-term view, if a longer-term approach were taken by the Corporation, there would be an incentive to extend the life of in-state landfill disposal capacity by diverting waste from the landfill, when economically feasible. When the disposal capacity at Central Landfill is fully depleted, Rhode Island will have to rely on out-of-state disposal options or site a new landfill in a different in-state location – a politically difficult task. It should be mentioned that legislation (RIGL § 23-19-2) is very clear in directing the Corporation to take a longer term view.

Rhode Island Department of Environmental Management

The DEM is understaffed, and faces budget constraints that prevent it from carrying out enforcement and monitoring of recycling regulations. For example, DEM staff dedicated to recycling and source reduction have been reassigned to other activities because of a reallocation of DEM priorities. This reallocation was the result of budget limitations and the fact that the fee and surcharge revenues, generated by the DEM restricted receipt accounts that funded many of the commercial recycling programs, have been diverted by the General Assembly, into the State's General Fund (Minutes of Working Group Meeting 7, August 6, 2003).⁷ Without staff to enforce planning and reporting

⁷ The policy conflict between State budget cuts and the professed preference for the waste hierarchy should be acknowledged here. When the State budget is cut, DEM is forced to focus on issues that safeguard the

requirements, compliance with regulations has been strictly voluntary, especially on the part of commercial generators, and is assumed to be very limited.

Legislature

At \$32/T, Rhode Island tipping fees for MSW are far lower than in adjoining states (See Table 3). For example, for nearest neighbors Massachusetts and Connecticut, tipping fees average \$71/T and are in the \$51-61/T range respectively. An obvious incentive therefore, for increased municipal support for recycling would be an increase in the municipal tipping fee.

Table 3: Comparison of Regional tipping fees (Northeast)			
State	Number of MSW landfills	Average landfill tipping fee (\$/ton)	Total landfill capacity remaining (tons)
Connecticut	2	51-61	n/a
Delaware	3	58.50	20,000,000
Maine	8	55	3,030,303
Massachusetts	19	72.60	n/a
New Hampshire	10	68	15,000,000
New Jersey	12	60	40,000,000
New York	26	50	90,000,000
Pennsylvania	49	48	298,585,524
Vermont	5	80	1,453,778
n/a: Not Available			
Source: Kaufman, Goldstein, Millrath, & Themelis (2004).			

However, in Rhode Island the municipal tipping fee has remained at \$32/T for nearly ten years, in spite of a legislative mandate that the tipping fees increase by 7.5 percent

public. This essentially comprises directing limited resources towards making certain that disposal is carried out properly, in lieu of the “higher” preferences of source reduction and recycling, giving rise to policy conflict.

annually. The reason for this is that every year the General Assembly adopts an article to the State Budget that overrides this statutory formula and continues with the \$32 tipping fee for another year. This low tipping fee set and maintained by the General Assembly for MSW does not provide sufficient incentive to municipalities to reduce disposal tonnages or increase recycling.

Further, the General Assembly has for five of the last six fiscal years been appropriating varying amounts of the Corporation's revenues (as noted in the earlier section) in order to bolster the General Fund. The upshot is that the Corporation is unable to invest in waste management programs that either increase recycling or reduce the amount of waste disposed.⁸ The concern also is that the expectation that these funds will be available every year will allow short-term expediencies to overshadow the need to provide cost-effective, sustained waste disposal options in the long-term.

Municipalities

Refuse services

Paying for municipal waste disposal by either property taxes or a flat rate fee sends no clear signal to residents regarding the economic and environmental costs of disposing of

⁸ It may be argued that the Corporation's financial constraints may be somewhat self-inflicted. The State does not pre-program contributions from the Corporation but only appropriates funds *after* the Corporation runs or projects a surplus. Therefore, if the Corporation invested in programs for source reduction, recycling or landfill operations before declaring a budgetary surplus, arguably there would be no transfer of funds.

the solid waste they produce.⁹ Residents have no economic incentive to manage wastes responsibly because of the disconnect between paying for waste related services through property taxes and the amount of waste disposed. Further, this situation imposes a disequity, with residents who produce a small amount of waste subsidizing others who generate larger amounts.

Municipal Recycling services

Under the existing structure, households have no direct economic incentive to increase recycling either. Ample evidence exists that when individuals are charged a fee based on the amount of waste they discard, the percentage of waste recycled is dramatically increased. This type of user fee is popularly designated as Pay-As-You-Throw (PAYT) and is discussed in detail in the section on Economic Incentives for MSW disposal.

Another factor that has hampered the success of municipal recycling programs in Rhode Island is the cost of recycling programs relative to other waste management options. The cost of recycling to municipalities in Rhode Island can be substantial and poses a disincentive for developing successful recycling programs.

A survey conducted by the Corporation is summarized in Table 4 (for 19 municipalities for which there are valid data) giving collection costs for municipal refuse and recyclables for FY2002. Unit costs vary widely between municipalities. This may be for

⁹ Page (1981) describes this as 'free' solid waste disposal ... encouraged and sanctioned by the state (that) constitutes the failure of the price system to internalize costs. According to Page a cost is internal when the cost is borne by its generator.

any number of reasons including sloppy cost allocation between refuse and recycling accounts, differing population densities, different distances from Central Landfill, and different bargains struck with haulers.

Table 4: Collection costs for municipal waste and recyclables for 19 Rhode Island municipalities		
Towns	Refuse/T in \$	Recycle/T in \$
Barrington*	34	72
Burrillville	65	214
Central Falls	47	188
Coventry*	29	51
Cranston	52	101
Cumberland	37	78
East Providence	45	143
Foster	62	143
Lincoln*	31	55
Newport	83	154
North Providence	46	128
North Smithfield	58	125
Pawtucket*	33	92
Providence	41	130
Scituate	59	83
Smithfield	68	153
Warren	32	104
<i>Warwick*</i>	<i>87</i>	<i>67</i>
<i>West Warwick*</i>	<i>56</i>	<i>55</i>
<i>Italicized municipalities are believed to have allocated recycling costs to refuse.</i>		

The towns marked with an asterisk (*) manage their own collection (the other towns hire private companies) and it seems that these towns have been able to keep recycling costs considerably lower. What this suggests is that either these municipalities are not accounting for all the costs associated with recycling (note the overlap for Warwick and West Warwick) or it is possible that when towns operate their own collection service they are able to do this at a lower cost than private operators.

Commercial Waste Generators

Staff cuts and budget constraints faced by the DEM are a significant barrier to implementation of commercial waste regulations. Even with staff to implement the program, enforcement remains a problem. Commercial recycling regulations prohibit solid waste management facilities from accepting for disposal any CSW containing more than 20 percent by weight of recyclables. If a load is suspected to be non-compliant, the effort necessary to separate recyclables from a mixed load ‘was immense and required up to five people for several hours work’ (Commercial Recycling in Rhode Island Draft Report, 2003). Even if more than 20 percent recyclables are found, enforcement resources are limited and the maximum fine of a thousand dollars has limited deterrent value.

Commercial recycling

Rhode Island’s commercial recycling statutes and regulations are meant to provide governmental requirements for Rhode Island businesses to recycle, in part to preserve landfill disposal capacity. This is an expensive undertaking for many businesses, particularly small businesses, and the return on investment is often low when compared with other capital investments. Additionally, the tipping fee for commercial entities delivering recyclables to the MRF is \$25/T.¹⁰ These stumbling blocks have been

¹⁰ The argument made by the Corporation however is that the MRF was not set up to provide for commercial recycling. The MRF is configured to handle materials collected in the Maximum Recycling Program. Commercial recyclables constitute a different waste stream; for example, the commercial waste

compounded by the lack of attention and enforcement with regard to this sector. This has had the unfortunate result of sending a message to businesses that compliance may no longer be a State priority. As a result, the decision to recycle is an economic one that is rarely advantageous for those who recycle.

Waste Haulers

There are no incentives in place for waste haulers to encourage waste prevention. This is because most of Rhode Island's waste is managed through solid waste contracts where waste disposal volumes or service levels determine the compensation for solid waste contractors and haulers, who have a profit incentive to maximize the volume of waste disposed. Contractor responsibilities begin at the dumpster, extend to container rental and maintenance, hauling, and disposal or processing, and end at the landfill or processing site. As a result, the solid waste hauling industry has no economic incentive to support waste reduction or encourage recycling.

In summary, it is very clear that the existing economic incentives are inconsistent with the legislated goal to reduce and recycle solid waste in preference to landfilling, and that none of the primary actors involved with solid waste management in the state has an effective financial incentive to increase recycling rates or to reduce waste generation. As a result it comes as no surprise to discover that the amount of waste landfilled in 2002 was 59 percent higher than was projected in the 1996 Plan (1,047,697 tons actual,

stream contains significantly more corrugated cardboard and office paper which require a different sort configuration from that at the MRF.

compared to 659,840 projected) and that the current rate of municipal recycling is 14.5 percent (not including composting) while the 1996 Plan projected that by 2002 the municipal recycling rate would be 35 percent.

The following sections contain my recommendations for additions and changes to the existing economic incentives in order to bring about responsible solid waste management and disposal in Rhode Island. The first step is an explanation of how the value of landfill space was calculated for the purposes of analysis. This is followed by the section on recommendations for economic incentives that apply for the MSW and CSW streams and for the Corporation.

VALUE OF LANDFILL SPACE

Depletable or nonrenewable resources

Sustainable development is usually defined as growth that allows maximum current economic welfare without reducing the welfare of future generations. Although sustainability is often defined in physical terms such as sustained harvests, landfill capacity may be thought of as a nonrenewable resource... (Goddard, 1995). For nonrenewable resources sustainability can be defined meaningfully as the optimal or correct rate of depletion of the resource. In the case of landfilling in Rhode Island, the argument may be made that because landfill resource scarcity¹¹ has not been a consideration, the rate of depletion of this resource has been unsustainably high.

The idea behind depletable resources is that these are endowments of a finite size. Given this characteristic then, the current use of a depletable resource precludes its future use. Therefore, production decisions made today must take foregone net benefits into account. Hence, the issue of how these resources should be shared among generations is raised. The idea, therefore, of allocation over time or over generations becomes a crucial one. The core concept used to model this in economics is dynamic efficiency. The concept of dynamic efficiency is premised on the notion that the present-value criterion provides a

¹¹ Tietenberg (2000) explains that intertemporal scarcity imposes an opportunity cost, referred to as marginal user cost, such that when resources are scarce, greater current use diminishes future opportunities. Failure to take the scarcity value of the resource into account in the present will lead to an inefficiency or an additional cost imposed on society due to the additional scarcity imposed on the future. This additional marginal value that scarcity creates is what Tietenberg refers to as the marginal user cost.

way for comparing the net benefits received in one period with the net benefits received in another. The assumption is that society's objective is to maximize the present value of net benefits coming from the resource. For a depletable resource like Central Landfill, this requires balancing the current and subsequent uses of the resource. Difficulties arise when this 'efficient allocation' does not come about and the remedy sought is usually some form of intervention to correct the inefficiencies.

The attempt therefore is to estimate longer-term financial incentives that will result in prolonging the useful life of current and projected landfill space at Central Landfill, and thus delay expenditures and the political costs of creating new landfill space. Landfill space, as has been shown above, is a depletable asset and any economic analysis of solid waste management needs to take this into account.

Current value of landfill space

The current value of landfill space has been estimated in two ways.

I.

Ideally, the current value of landfill space should be calculated based on the cost of acquiring a site, and developing and constructing a new, sanitary landfill to be brought on-line when Central Landfill closes. The argument being made here is that the true value of extending landfill capacity is the replacement cost of the landfill, not the present cost.

Valuing a landfill only by past expenditure does not give the present value of the capacity of the landfill and as a result does not allow for increases in the value of that capacity over time. Costs to consider while examining replacement cost include capital investment costs, operation and maintenance costs, depletion costs, closure and post-closure costs, transaction costs to site the new landfill, and liability costs.

It appears that the only study undertaken to site an alternative to Central Landfill in Rhode Island was conducted in 1990 and put the cost of total annual payments for a 630 KT per year capacity landfill at \$23 million (Wessells, Opaluch, Swallow, Weaver and Wichelns, 1990). The study estimated that the *additional* tipping fee required to support a new landfill was \$37/T (in 2003 figures). This would raise the tipping fee to $$(32 + 37) = \69 at this new facility.

It has not been possible to assess the accuracy of the 1990 cost estimate or of its continuing relevance in 2003 but it should be noted that the cost of land has increased much more rapidly than the rate of inflation.

II.

The cost of waste disposal in neighboring states may also be used as a surrogate of the value of landfill space in Rhode Island. At a nearby landfill, the cost of land, and of licensing, and the political and local opposition to siting (NIMTOism – ‘not in my term of office’ and NIMBYism – ‘not in my backyard’) arguably are similar to those in Rhode

Island. For this calculation, it is assumed that privately-run landfills operate at least as efficiently as publicly operated landfills, and that disposal fees are based on the actual current value of landfill space.

An analysis conducted by Gottinger (1991) supports this argument for use of privately operated landfill costs as a surrogate. According to Gottinger, where the state is involved in operating and subsidizing MSW collection and disposal costs, demand estimation is more difficult than private sector demand estimation. In the latter case, demand theory is based on an optimization process involving indifference curves and budget constraints and is revealed through the price system. In the public sector, preferences are only directly revealed to the extent that user charges are imposed. In cases where refuse collection is financed solely through property taxes, as in the case of Rhode Island, the short-run marginal cost to the users is 0 and, hence, the true demand for the service is not revealed even through various observations of price and quantity.

The estimate used here is from a landfill in Connecticut with tipping fees priced at \$61/T. This tipping fee, reduced by operating costs of \$20/T (using the Corporation's operating cost/T) puts the value of landfill space at about \$40/T, representing what it is worth to prevent a ton of waste from being buried.

Ideally net landfill revenue per ton should be calculated as the difference between tipping fees per ton and the marginal operating cost (the marginal cost of disposal). The marginal cost of disposal is the cost of disposing one additional ton of waste. It was not possible to

calculate marginal costs because the cost of operations could not be disaggregated to identify which costs applied to landfill operations in particular.

In the absence of marginal costs, the average total cost of operations per ton was used. This yields a unit cost for waste disposal. As figures with regard to the total cost of operations were used it is likely that the \$20/T average cost of operations figure is inflated. It should be emphasized that generally using average costs is not accurate. Generally, average costs will overestimate cost increases and underestimate cost decreases. Nevertheless it should be noted that the two methods of calculation give remarkably similar answers which would probably be even more similar if marginal cost had been used.

ECONOMIC INCENTIVES FOR SOLID WASTE DISPOSAL

A policy implication of the analysis conducted above is that an economic incentive that costs up to this \$40/T value may be justified as economical and should be implemented.¹² The calculation of the value of landfill assets has been inadequate, making landfill disposal appear artificially cheap which has discouraged waste reduction. Until the true costs and benefits of disposal to landfill are part of the equation, waste reduction programs will always appear more expensive than disposal.

In the analyses below, the impact of an incentive on landfill economics is calculated by estimating the amount of waste diverted by the incentive, the consequent loss in net landfill revenue, and the amount of time landfill life is extended as a result of the incentive.

Since the MSW and CSW streams are different in terms of their composition, management, and the entity responsible for their collection, they are addressed separately, although the results are eventually combined to describe the management of the combined solid waste stream.

¹² Any policy decision however will need to be made subject to revenue constraints available for investing in waste management programs. With limited funds, the return on various investments will need to be compared as part of the decision-making process.

Municipal Incentives

Pay-as-you-throw strategies

Economic theory suggests that to attain the optimal level of demand for waste services, individuals must directly bear the full cost of waste services. Absent this internalization of full costs, traditional systems (taxes) for financing waste collection lead to inefficiently high levels of waste production because of the disjoint between the cost of services and how these are paid for.

The key to understanding why these costs are not internalized lies in the incentives facing households. Existing approaches do not directly relate the amount paid for waste disposal to the amount of waste generated. The marginal cost to the household of throwing out one extra unit of trash is negligible, even when the cost to society is not, and as a result the marginal private disposal cost and the cost to society as a whole diverge (Tietenberg, 2000).

User fees or PAYT strategies impose disposal charges reflecting the true social cost of disposal and tie costs to the amount of waste disposed. As a result PAYT strategies create a direct link between waste disposal and cost, support the waste management hierarchy defined by RIGL § 23-19, and are recommended for implementation here.

Municipalities nationwide have implemented PAYT systems that provide incentives to maximize reduction and recycling. PAYT – also known as variable-rate pricing and pay-by-the bag – requires residents to pay for municipal waste based on the amount of trash they place at the curb or drop-off at disposal facilities. PAYT provides a more equitable waste management fee structure since residents are charged for waste services that they use and as a result have greater control over the amount that they have to pay. The EPA estimates that PAYT programs are in place in more than 4,000 communities nationwide (Draft Report of the Source Reduction Sub-Committee, 2003).

Common concerns regarding PAYT include political resistance, incentives for increased illegal dumping, and hardship for residents with low or fixed incomes. A number of communities that have implemented PAYT indicate that increased illegal dumping has been either a temporary problem that the community was able to handle, or was not a problem at all. If increased illegal dumping does occur, it can be reduced through a public education campaign and an enforcement strategy with significant penalties.

Also, PAYT strategies may be structured to provide assistance so as to avoid economic hardship for residents with low or fixed incomes. Communities can reduce the charges by a set amount, offer a percentage discount, or offer a certain number of free bags or stickers to low-income residents. Assistance also can be offered through existing low-income programs. In fact, the fairness argument – that those who impose the greatest cost on the community by discarding large amounts of trash should pay a higher cost than

those who manage their waste more responsibly – may be particularly persuasive at such times.

The analysis conducted here is based on estimates made by the Tellus Institute (1999) that *on average* project a 5 percent source reduction and 20 percent reduction in waste disposed by increased recycling, based on the average experience with PAYT in over 100 Massachusetts communities.¹³ While it is expected that some Rhode Island communities will not achieve this level of reduction and that others will exceed it, it is believed that the average should be similar to that achieved in Massachusetts.

Table 5 estimates the changes that would have resulted if PAYT strategies had been implemented in 2002, assuming the 25 percent reduction in waste disposed.

It is important to note that while *total* waste generation is expected to increase at approximately two percent per year because of population and per capita waste generation increases, *comparable* results from implementation of PAYT strategies may be assumed for the future as the *relative* differences will be approximately the same between Business As Usual (BAU) and various PAYT projections.

¹³ Miranda, Bauer, and Aldy (1996) conducted a study for the EPA which supports these findings. The study found in general that communities that adopt PAYT programs reported an average reduction in waste landfilled of 28 percent, with a range of 25 percent to 50 percent. Ribeiro, Schlegelmilch, and Gee (1999) report similar results for municipalities in the Netherlands with PAYT systems in place. The study found that municipalities operating PAYT strategies produced 10 to 20 percent less waste per capita than comparable municipalities with traditional systems. Also illegal dumping or dumping of waste in adjacent towns was reported to be of no major problem, provided the price of the waste bag did not exceed 2 NLG (Dutch guilder).

Table 5: Effect of PAYT strategies on 2002 figures				
(tons)	BAU	% of waste stream	25% Diversion rate	% of waste stream
Recycling	83,716	16	173,630	34
Refuse	449,570	84	337,178	66
Source Reduction	0		22,479	
Total waste	533,287		510,808	

The results of full PAYT implementation are projected to be a diversion of 112 KT from the landfill and reduced Corporation net revenues of \$1.35 million (at the \$32/T municipal tipping fee, offset by \$20/T operating costs). Since the present value of landfill space is estimated at \$40/T and reductions are achieved by PAYT at a net loss of revenue of only \$12/T, in the long run, it should be economically prudent for the Corporation to encourage the implementation of PAYT programs by municipalities, as long as the additional cost of implementation does not exceed \$28/T.

For the past five years, recycling has been a close to break-even operation for the Corporation, independent of the volumes recycled (income has exceeded costs per ton recycled for the years 1998 to 2003 on average by \$6/T). However, it is very likely that the MRF would need to be expanded to handle an increase in volume of over 100 percent (~ 90 KT).¹⁴ Since current recycling revenues cover the cost of the existing facility, it

¹⁴ According to Patrick Fingliss, Business Manager for the MRF, the existing MRF is not equipped to handle an increase of this magnitude and in order to handle ~90 KT of additional material, there would have to be a major retrofit of the MRF's processing systems, buildings and grounds. The existing MRF was designed only to handle the materials collected in the Maximum Recycling Program.

The MRF has two processing systems – one for bottles and cans and one for paper. The MRF's bottle and can processing system is at capacity and presently operates 16 processing hours a day, five days a week, and the paper processing system is at approximately 55 percent of capacity, assuming eight processing hours a days, five days a week. The yearly capacity of the present MRF, operating 16 hours a day, five days a week, is approximately 34 KT yearly for bottles and cans and approximately 93.6 KT yearly for paper. The composition of the material and the products to be sorted and marketed are extremely important in any discussion of capacity at the MRF.

might be reasonable to assume that this also will be the case for the expanded facility, but lacking estimates of the cost of expansion, that assumption cannot be confirmed.

As the annual amount of waste disposed at the landfill ranges from 1,050 to 1,100 KT a year, the PAYT measure, if fully implemented, is predicted to extend landfill life by over one and a half months each year – that is, in eight years, landfill life would be increased by an additional year.

An analysis similar to that conducted above has been carried out to assess the effect of PAYT programs on costs in four Rhode Island municipalities in Table 6.

Table 6: Effect of PAYT Strategies on Four Rhode Island Municipalities				
	Coventry*	Cranston**	East Providence	North Smithfield
BAU (in tons)				
Recycling	3,400	7,470	4,550	1,300
Refuse	14,900	33,990	19,800	4,475
PAYT (in tons)				
Recycling	6,390	14,045	8,510	2,190
Refuse	11,185	25,045	14,850	3,355
<u>Tons diverted by PAYT</u>	<u>3,730</u>	<u>8,945</u>	<u>4,950</u>	<u>1,120</u>
%age increase or (decrease) in overall costs	(4%)	(5%)	11%	1%
* Cost savings result because under BAU, Coventry was over the municipal cap limit by ~170 T.				
** At \$29/T, the differential in collection and hauling costs between recyclables and refuse gives rise to cost savings for Cranston.				

The collection and hauling costs are average costs reported in the survey conducted by the Corporation (mentioned earlier) of municipalities in Rhode Island. (Note that the use

of average costs does not capture any economies of scale from increased recycling, and may therefore over-predict cost increases and under-predict cost savings).

Grants to defray start-up PAYT costs

The Corporation budgeted \$480K in FY2004 to fund start-up costs for any municipality that initiates PAYT, but as yet no municipality has requested this assistance. The Corporation should provide adequate financial, technical, and in-kind support in the form of grants for municipalities seeking to implement PAYT programs much like the grants in the '80s and early '90s that promoted recycling statewide. At a minimum, grants will need to fully cover the start-up costs incurred by municipalities electing to implement PAYT. Covering start-up costs will likely be the starting point for a discussion on implementing a new and somewhat politically challenging program but on their own are unlikely to be sufficiently enticing for municipalities.

Municipal Caps

All existing evidence illustrates that breaking even or projecting a small cost reduction through PAYT will be insufficient to persuade many municipalities to implement PAYT programs (Economics Sub-Committee Final Report, 2003). It is recommended therefore that the municipal cap be adjusted to account for the increased recycling that would result from full implementation of PAYT. Under RIGL § 23-19-13 (g)(3), the Corporation has the discretion to set a cap on the amount of waste a municipality can dispose of at the

municipal tipping fee. Any amount of waste disposed of at Central Landfill in excess of these allotted caps is charged the commercial tipping fee.

The current caps are set by population and statewide waste generation rates, and then adjusted by a factor to account for reduction by recycling – this was a reduction of 15 percent in 2002 and was recently changed to 20 percent for FY2004 municipal contracts. It is recommended that this cap be further reduced by 15 percent in keeping with results expected under PAYT programs, bringing the total reduction to 35 percent. This reduction will need to be phased in over time, so municipalities have the time to implement PAYT programs or other waste reduction measures.

It is recommended that the municipal caps be reduced from the current 20 percent to 35 percent in 2008, in increments of five percent over four years, according to the schedule illustrated in Table 7.

Table 7: Municipal Cap Reduction Schedule					
Year	2002	2004	2006	2007	2008
Cap	15%	20%	25%	30%	35%

The cap reduction should serve as an incentive to municipalities to institute PAYT programs and when implemented in this staggered manner will create incentives for the various municipalities to act at different time periods (which would distribute the cost to the Corporation over several years). An analysis was conducted of the effect of the cap reduction schedule outlined above on the costs of recycling and waste disposal for the 18 municipalities for which accurate information was available from the 2003 Corporation

survey. It is assumed that a municipality will institute PAYT when the total costs of recycling and waste disposal increase relative to 2002 baseline costs (Business As Usual or BAU). (It is noted that this assumption of economic rationality is almost certainly unrealistic, since willingness and ability to institute a new and potentially controversial program may play a dominant role.) This phase-in schedule shows when a community starts to face a positive financial incentive. This order of implementation is desirable from a waste-reduction perspective, but would require communities that have shown little progress in waste reduction to take the lead – again, perhaps an unrealistic expectation.

Table 8 combines the decreasing municipal cap and the *minimum* start-up funding recommendations. The table shows when municipalities would face overall collection and disposal cost increases as a result of the progressive municipal cap reductions and gives the minimum amount for a start-up grant necessary to cover the cost of bags for the first year of the program. These approximate costs are calculated by dividing the total household waste generated by the volume per bag (assumed to be 20 lbs) and then multiplying this figure by the cost per bag (assumed to be \$0.17) (Bayard, 2004). If bags are priced to cover the full cost of recycling and waste disposal (including the cost of the bags) these start-up grants will serve as a revolving fund, to decrease the need for upfront investment by the municipality.¹⁵

¹⁵ The basic implementation costs of a curbside PAYT program include (Bayard, 2004):
Staff time - Some municipalities hire a program coordinator, while some may assign the task of coordination to the Department of Public Works, which means that extra staff time may be needed. Coordination of implementation includes logistical planning, monitoring, and educational outreach campaigns to inform residents of the pending changes in the trash service.
Bags, Tags, etc. - Municipalities must provide the initial layout of revenues to cover bags and/or tags (and sometimes toters), depending on the type of program.

Table 8: Minimum start-up funding expected to be necessary to implement PAYT			
Cap	Year	Municipality	Cost of start-up grant from RIRRC*
20	2005	<ul style="list-style-type: none"> • Coventry • Cumberland • East Providence • Foster • North Providence • Pawtucket • Providence • Scituate • Warren • West Warwick 	<ul style="list-style-type: none"> • \$ 190K • \$ 201K • \$ 252K • \$ 24K • \$ 201K • \$ 414K • \$ 1,010K • \$ 60K • \$ 70K • \$ 159K
25	2006	<ul style="list-style-type: none"> • Burrillville • Cranston • North Smithfield 	<ul style="list-style-type: none"> • \$ 87K • \$ 426K • \$ 57K
30	2007	<ul style="list-style-type: none"> • Barrington • Central Falls 	<ul style="list-style-type: none"> • \$ 85K • \$ 98K
35	2008	<ul style="list-style-type: none"> • Lincoln • Smithfield • Warwick 	<ul style="list-style-type: none"> • \$ 101K • \$ 91K • \$ 394K
*The cost of the grant is calculated using 2002 figures and is based on assumptions that weight per bag = 20 lbs and cost per bag = \$0.17 (Bayard, 2004)			

Costs incurred from the combined effect of implementing PAYT and the 35 percent municipal cap reduction are shown in Table 9 for 18 municipalities for 2002.

A convincing argument may be made for adopting these incentives when the costs under implementation of PAYT and the 35 percent cap reduction are compared with and found to be much lower than the *real* costs for municipalities. (Real costs are calculated by internalizing the \$40/T value of landfill space). It should be noted that while the direct costs to municipalities of PAYT with a 35 percent cap increase a modest three percent,

Educational materials - Successful PAYT programs are preceded by an educational outreach campaign of a few weeks. Mailings are generally the preferred mechanism of information distribution. Town meetings (usually only in small towns) can serve as effective forums in which to address the concerns of residents.

after including \$40/T value of landfill space, the real cost is a dramatic saving of 46 percent.

Table 9: Effect on Costs of the combined implementation of PAYT programs and a 35 percent waste cap reduction

	Municipality	Overall Costs in 2002 figures					
		BAU costs			Real Cost (internalizing value of landfill space)		
		Baseline	35% cap rate and PAYT	%age increase or decrease	Baseline	35% cap rate and PAYT	%age increase or decrease
1.	Coventry	\$ 1,039,848	\$ 993,623	(4)	\$ 2,369,048	\$ 2,143,879	(10)
2.	Cumberland	\$ 1,359,821	\$ 1,363,824	0	\$ 2,759,501	\$ 2,563,636	(7)
3.	North Providence	\$ 1,540,368	\$ 1,672,868	9	\$ 2,912,248	\$ 2,855,508	(2)
4.	Pawtucket	\$ 2,242,948	\$ 2,467,722	10	\$ 5,005,148	\$ 4,840,642	(3)
5.	Providence	\$ 6,064,168	\$ 7,127,703	18	\$ 12,719,328	\$ 12,832,355	1
6.	Scituate	\$ 461,500	\$ 461,153	0	\$ 881,500	\$ 824,981	(6)
7.	Warren	\$ 439,200	\$ 440,576	0	\$ 919,560	\$ 854,912	(7)
8.	West Warwick	\$ 1,120,184	\$ 1,118,927	0	\$ 2,210,424	\$ 2,059,167	(7)
9.	Burrillville	\$ 950,689	\$ 1,077,406	13	\$ 1,555,009	\$ 1,600,066	3
10.	East Providence	\$ 2,100,000	\$ 2,327,917	11	\$ 3,866,160	\$ 3,856,477	0
11.	Foster	\$ 237,444	\$ 247,018	4	\$ 405,404	\$ 392,262	(3)
12.	North Smithfield	\$ 571,000	\$ 578,622	1	\$ 980,880	\$ 934,802	(5)
13.	Barrington	\$ 610,000	\$ 599,406	(2)	\$ 1,239,160	\$ 1,148,742	(7)
14.	Central Falls	\$ 746,400	\$ 883,500	18	\$ 1,391,840	\$ 1,436,600	3
15.	Cranston	\$ 4,233,152	\$ 4,033,515	(5)	\$ 7,199,112	\$ 6,598,783	(8)
16.	Lincoln	\$ 625,000	\$ 580,353	(7)	\$ 1,343,200	\$ 1,203,345	(10)
17.	Smithfield	\$ 1,024,520	\$ 1,063,035	4	\$ 1,675,280	\$ 1,628,367	(3)
18.	Warwick	\$ 3,963,504	\$ 3,207,761	(19)	\$ 6,844,184	\$ 5,717,365	(16)
	TOTAL	~ \$ 29.3 M	~ \$ 30.2 M	3	~\$ 56.3 M	~\$ 53.5M	(5)

Compulsory PAYT or Equivalent programs

Interviews with local officials have revealed considerable apprehension and resistance from residents that is so strong that for some municipalities even the combined incentives of start-up grants and a reduced municipal cap may be insufficient to prompt those communities to adopt PAYT (Bayard, 2004). Municipal officials fear that their residents will see PAYT as a new tax – as being asked to pay for a service for which they already pay through property taxes.¹⁶

In this case, the State may need to mandate a user fee program. Minnesota took this step in January of 1994, with a statute requiring pricing by weight or volume as a condition for waste disposal. Although exemptions were allowed, over 1800 communities in Minnesota have now implemented some form of PAYT (Skumatz, 2003). A cut-off date should be set – probably the year the municipal cap reaches its minimum – by which time every municipality would need to have PAYT (or its equivalent) in place or be required to pay the tipping fee for commercial waste for all of its waste. This variable or sliding scale for tipping fees will reflect the commitment of the town and create a disincentive for not implementing PAYT.

In the example above, PAYT would become mandatory in 2008. In order to encourage earlier participation, the Corporation could offer start-up financial assistance only up to this date, after which municipalities will be expected to fund start-up costs from their

¹⁶ According to Butlin (1981), however there is no reason why the charge for PAYT should not replace the municipal property tax contribution to MSW disposal, thereby avoiding the double transfer of funds from the taxpayer.

own resources. The Corporation also could offer more generous start-up funding for the pioneer communities. In evaluating this recommendation it should be recalled that the existing municipal recycling system is based on a legislated mandate.

However, it should be emphasized that municipalities be free to select and combine alternative programs, as long as these programs attain the necessary diversion from the landfill. Experiences of some communities make it necessary to acknowledge that municipalities may be able to achieve comparable diversion rates by use of alternatives to PAYT. (See Box 2 for one such example).

Box 2: The UK Landfill Tax

In response to a disposal shortfall expected by the year 2010, the UK Government has begun to promote a landfill tax and the Landfill Tax Credit Scheme (LTCS), through which environmental protection projects may be funded from the revenue raised by the tax to preserve future landfill space.

The landfill tax, introduced in October 1996 is placed on every ton of waste disposed, and is set at £10 for active wastes and at £2 for inert. The standard rate of £10 is set to increase annually by a £1 per ton per annum until 2004. This has raised the cost of landfilling considerably with the hope that this will encourage the adoption of alternative strategies as these become economically competitive against an ever more expensive landfill route. More explicitly the tax was instituted primarily 'to ensure that landfill waste disposal is properly priced so as to reflect its environmental cost' and secondly 'to promote a more sustainable approach to waste management in which less waste is produced and more waste is either reused or has value recovered from it.'

According to Hogg (1999) the Landfill Tax has been successful in pushing some 30 percent of firms towards more responsible approaches to waste matters. A survey conducted by him found that some firms are taking significant steps not just at reducing their disposal costs, but reducing the wastes they generate in the first place. A number of firms indicated that they were moving in this direction, so presumably, the tax simply made these efforts worthwhile.

Source: Hogg, 1999.

Leaf & Yard Waste Ban

Since 1997 municipalities have moved away from the development of their own composting facilities to the development of curbside leaf & yard (L&Y) waste collection programs using paper bags. Further, effective FY2004, the Corporation eliminated the \$17/T municipal L&Y tipping fee for L&Y waste delivered to the Corporation by municipalities with recycling and disposal contracts.

A waste composition study conducted in 1990 estimates that L&Y waste constitutes 13.5 percent of the municipal waste stream and 12.2 percent of the combined municipal and commercial waste streams (RIRRC, 1990). It is believed that even this estimate is low (the real figure is perhaps closer to 17 percent of the waste stream) as many municipalities manage their leaves locally and were not accounted for in the waste composition study. The removal (by banning) of L&Y waste from the waste stream is believed will preserve disposal capacity, reduce disposal costs, and generate a useful soil amendment through composting. This is supported by a study conducted by Jenkins, Martinez, Palmer, and Podolsky (2000) that showed results which indicate that curbside collection of L&Y waste could lead to substantial diversion from the landfill of this significant component of MSW.

In order to tie the ban on L&Y waste to the proposal to implement PAYT strategies, municipalities should offer paper bags to residents at a rate considerably cheaper than the refuse bags. In this way residents will have an incentive to separate L&Y waste from the

rest of the waste stream and also even consider the option of backyard composting of their L&Y waste.

A ban on L&Y waste may be enforced by a combination of DEM monitoring and inspection of transfer station facilities and contract management procedures instituted by the Corporation whereby the Corporation could add to its commercial and municipal waste disposal contracts a clause that prohibits the delivery of L&Y waste to the Central Landfill for disposal.

Given the estimates of L&Y waste cited above this would succeed in diverting 55 to 65 KT of L&Y waste from Central Landfill at little or no cost, and would extend landfill life by up to two weeks per year.

Commercial Incentives

Strictly Enforce Commercial Recycling Regulations

As noted earlier, Rhode Island's commercial recycling statutes and regulations require Rhode Island businesses to recycle, 'in part to preserve landfill disposal capacity, an important State resource' (Commercial Recycling Sub-Committee Draft Report, 2003). These regulations prohibit solid waste management facilities from accepting for disposal any CSW containing more than 20 percent by weight of recyclables. Unfortunately, lack of enforcement has sent a message to businesses that compliance is not a priority

(Commercial Recycling Sub-Committee Draft Report, 2003). It is recommended that the existing commercial recycling regulations be enforced as a priority, thereby providing commercial generators and haulers with an immediate economic incentive to divert recyclables from the commercial waste stream.¹⁷

Improvements to landfill operations made in 2002 saw the Central Landfill Tipping Facility being brought on line. Trash trucks now dump their loads on the floor of the 57,500 square foot facility rather than at the operating face of the landfill. Therefore the argument made in the past that it was too dangerous for inspectors to work on the tip face no longer applies as all waste to be landfilled is dumped and sorted before being taken to the landfill. As a result, enforcement of these regulations on recycling of commercial waste is expected to be easier.

Ban commercial recyclables from being landfilled

Difficulties however arise with proving that a particular waste load exceeded 20 percent by weight of recyclables. Therefore it is recommended that landfill bans on commercial recyclables be adopted instead. A ban is expected to be easier to verify and enforce when compared with the percentage limit and should not be problematic for several wastes that are currently required to be recycled including automobiles, white goods, vehicle batteries, used oil, and aluminum. The Commercial Recycling Sub-Committee to the Working Group (2003) further recommended bans for the following: leaf and yard waste,

¹⁷ It is acknowledged that the cost of enforcement of these regulations is expected to be considerable and a detailed cost-benefit analysis will need to be conducted to assess the cost savings from implementing the regulations against the costs of enforcement.

wood wastes, office paper, cathode ray tubes, and corrugated cardboard. Presumably enforcement would be applied with discretion – only for flagrant violations.

It is also noted that while this measure will shift the responsibility for monitoring and compliance to the Corporation, the DEM can help by enforcing the ban through inspections at transfer stations (Minutes of the Working Group Meeting 7, August 6, 2003).

Resource Management

It is recommended that Resource Management (RM) contracting be encouraged for commercial generators. A RM approach provides incentives for haulers and helps generators craft cooperative hauling contracts that support waste reduction.

RM provides an alternative to disposal contracting and is premised on the idea that contractors will pursue resource efficiency (or reduce the quantities of waste they collect) when provided with financial incentives to do so. For example, RM contracts could align waste generator and contractor incentives by placing a ‘cap’ on garbage hauling and disposal compensation or include a profit-sharing arrangement for waste minimization innovations initiated by the contractor. In this way, the contract shifts focus from increasing disposal volumes to improving waste management efficiency (in other words, resource management) at the customer’s facility.

Rewards may be in the form of performance bonuses (or liquidated damages) based on the value of resource efficiency savings achieved.

Studies show that RM contracting typically reduces CSW generation by up to 20 percent, and increases the recycling rate by up to 14 percent (Source Reduction Sub-Committee, 2003) (See Table 10).

Table 10: Effect of Resource Management contracting on 2002 figures		
For 2002 (in tons)	BAU	Diversion rate (20%)
Refuse	633,686	506,949
Total waste	656,685	618,664
Source Reduction	0	38,021
The figures used in this table are based on Commercial waste and recycling numbers for 2002 expected to appear in Part 5 of the new Comprehensive Solid Waste Management Plan.		

This strategy would lead to a diversion of ~127 KT from the landfill and reduced net revenues of nearly \$3.8M (at the \$50.25/T average commercial tipping fee, offset by \$20/T operating costs). This measure alone will increase landfill life by a little over two months per year – so that in six years, landfill life is increased by a year. Effective enforcement of a ban on disposal of commercial recyclables would provide a strong incentive for adoption of RM by commercial generators, as would a significant increase in commercial tipping fees.

It has not been possible to assess the amount of commercial recyclables in the waste stream but it is generally accepted that these are a substantially higher percentage than in municipal waste, so that when measures for enforcing commercial recycling regulations

and banning commercial recyclables are *combined* with RM contracting, the combination will serve to extend landfill life significantly. In the case that this does not prove effective it is recommended that the following additional approach be adopted.

Divert commercial waste out-of-state

This idea appears to be a viable alternative given that estimates of costs to dispose waste out-of-state are essentially equivalent to the current commercial tipping fee. The benefits of undertaking this measure soon cannot be overemphasized. Assuming it takes ten years to build a new landfill, 2008 is the last year waste can begin being diverted out-of-state in order to preserve capacity sufficient to dispose of MSW to 2025 without creating landfill sites beyond those currently available.

Increase Commercial Tipping fees

One strategy for the Corporation to encourage out-of-state CSW disposal is to increase the average commercial tipping fee (currently \$50) to a rate comparable to that in adjoining states, approximately \$65/T. The level of tipping fees should be set with regard to costs of out-of-state disposal of CSW and also with respect to tipping fees in adjacent states so as to mitigate the problem of out-of-state waste disposal in Rhode Island. The tipping fee may be priced above or below the out-of-state rate depending on whether the goal is taking care of 100 percent of Rhode Island's CSW in-state, or if a decision is made to export some portion of the CSW.

The anticipated result of a pricing strategy that raises commercial tipping fees as high as the market will bear will induce price responsiveness expected from major haulers who will begin to ship to less expensive landfills, in Ohio or Georgia. (See Appendix III for the cost structure to ship to a landfill in Charing, Georgia). It is expected that smaller commercial haulers who lack the volume to afford rail-loading facilities will still be able to retain an in-state option at Central Landfill.¹⁸

It should be noted that banning commercial recyclables from the landfill, coupled with attentive enforcement of the ban would provide a further incentive for CSW to go out of state.

This is illustrated using estimates based on the amount of CSW brought to the Central Landfill over the 12 months ending September 30, 2003. For the purposes of illustration, it is assumed that all haulers bringing in 10 or more KT per year will find it fiscally advantageous to ship their waste out-of-state at a \$65/T tipping fee. This amounts to nearly 75 percent of the waste brought in and will divert approximately 460 KT per year. Diversion of 460 KT from the landfill leads to reduced net revenues of \$6.6M (at the \$50.25/T average commercial tipping fee, offset by \$20/T operating costs and net of incoming revenue from commercial generators that stay in-state). This measure alone will increase landfill life by a little over five and a half months a year.

¹⁸ According to Peterson (1996) however, rail has the capability to transport waste at a lower cost than by truck, particularly at distances in excess of about 240 km (150 miles).

Combining the municipal PAYT and shipping commercial waste out-of-state strategies, the cumulative effect is a diversion of approximately 570 KT per year. These strategies will save a little over seven months of landfill space each year. Said a different way, these combined strategies will more than double the remaining useful lifetime of the landfill, whenever they could be implemented.

It is important to emphasize that any incentives to encourage commercial recycling will reduce income from commercial tipping fees although this reduction would be partially offset by increasing the per ton tipping fee. It should be mentioned that at the November 5, 2003 Solid Waste Management Plan Working Group Meeting, the Executive Director of the Corporation, said that the Corporation is prepared to accept reduced revenues if accompanied by substantial reductions in the amount of waste to be landfilled.

Appropriateness of the out-of-state option

On a cautionary note however, the option to ship waste out-of-state may be questioned for two reasons.

First, the issue of the long-term reliability of out-of-state disposal especially with regard to changed circumstances of private operators (for example, financial insolvency) or changes in state-level regulation could make this option less available. According to Rabe (2003), growing interstate conflicts, which often become protracted battles in the federal courts, have emerged in recent decades as states allege that they are recipients of

unwanted imports ... and nowhere is the problem of interstate transfer more evident than in the disposal of solid, hazardous and nuclear wastes. Rabe says that out-of-state (and region) waste export has been an increasingly common pattern, with wastes often shipped to facilities opened before concern over waste and facility siting became widespread. At its worst, the system resembles a shell game in which waste is ultimately deposited in the least resistant state or facility at a given moment. Rabe lists deterrents to out-of-state waste disposal. He suggests, for example, federal per-mile fees be levied on waste shipments to provide a disincentive for long-distance transfer, and instead encouraging states, regions, and waste generators to either develop their own capacity or pursue waste reduction options more aggressively. If incentives such as this are implemented it will make the out-of-state waste option less viable for Rhode Island. It should be noted that capacity at Central Landfill will remain available on short notice and as a result businesses will not be dependent only on out-of-state options.

Second, the question to consider is whether as a matter of environmental responsibility, Rhode Island should manage its own waste when the resources exist in-state to deal with the problem. Both these considerations may lead us to conclude that Rhode Island should continue to have available in-state landfill capacity.

Incentives for small businesses

With regard to the lack of incentives faced by small commercial generators it is suggested that the use be made of waste cooperatives,¹⁹ as it does not appear profitable for these small generators to separate recyclables themselves. While almost all businesses generate recyclable materials, because of the small quantity of material they generate, many small businesses have difficulty finding a recycler willing to serve them at a reasonable cost. Business recycling cooperatives help small and medium sized businesses gain access to cost-effective, convenient recycling. While small businesses generate small amounts of materials individually, cumulatively their generation of recyclables is both significant and under collected. For example, nationally, offices with 100 or more employees generate about 45 percent of the total quantity of discarded printing and writing paper (office paper), and about 95 percent of these offices recycle their paper, while offices with less than 50 employees generate nearly 40 percent of the supply, but only 30 percent have on-site recycling programs (Northeast Recycling Council [NERC], 1998).

In Rhode Island, the town of North Smithfield, is facilitating cooperation among neighboring companies to fund single containers and share pick-up schedules. The town is also planning on seeking request for proposals for hauling, and take advantage of economies of scale if enough participants come forward (Commercial Recycling in Rhode Island Draft Report, 2003).

¹⁹ A business recycling cooperative is a group of businesses, located in a single geographic area, that separate the same recyclable material for prearranged collection by a shared hauler. Cooperatives can be set up to accommodate single industry sectors, such as retail stores, offices, manufacturers, or restaurants, or different sectors which generate similar materials, such as cardboard, plastics, office paper, bottles or cans (NERC, 1998).

It is recommended that the institutional barriers that prevent the use of such cooperatives be overcome by use of grants to promote cooperatives.

Incentives for the Rhode Island Resource Recovery Corporation

As mentioned earlier, the Corporation faces strong short-term financial disincentives to reduce the amount of waste that is landfilled, since tipping fees are the major source of Corporation revenues. The non-profit status of the Corporation makes it challenging to craft economic incentives that would offset the existing short-term disincentives. Recommendations made above that provide economic incentives for the other sectors, rely in some part on Corporation funding.

One option to counteract the negative incentive faced by the Corporation is to set a goal for the amount of waste the landfill may accept annually and require the Corporation to put aside a certain sum of money in an escrow account if this waste goal is exceeded. This would provide an incentive to the Corporation to conserve landfill space and would also make available funding for the purchase of future landfill space if necessary. This incentive would also ensure that excess profits from landfilling are reserved to fund waste diversion initiatives. The escrow fee should be set equal to the value of preventing a ton of waste from being landfilled. From the explanation above this is \$40/T.

An example of a similar concept of designated waste allowances is applied in Massachusetts where provisions exist which enable Massachusetts to regulate sanitary

landfills on the basis of a state-imposed absolute limit on solid waste tonnage that may be accepted at a facility.²⁰

It should be mentioned that representatives of the sub-committees to the Waste Management Plan Working Group charged with preparing updates to the 1996 Plan have petitioned the DEM, as part of the licensing process for Phase V of Central Landfill, to attach specific conditions to any license granted for Phase V of Central Landfill that would *require* the Corporation to take the steps necessary to maximize source reduction and recycling. Specifically the representatives are asking that the requirements of RIGL § 21-19-4(b),²¹ that public solid waste facilities may not be constructed unless need is established by the solid waste plan, and that source reduction and recycling be maximized when evaluating the need for disposal capacity, be built into the licensing requirements of Phase V.

If this happens this will provide an additional incentive to the Corporation to reduce the amount of waste landfilled in order to stay in business and not violate their licensing requirements.

²⁰ 310 CMR 19.043 (2) Condition(s) on Amount of Solid Waste Accepted: Every permit or authorization to operate shall contain one or more limits on the amount of solid waste which the facility can accept during a fixed period of time, not to exceed one year.

²¹ RIGL 21-19-4(b): The corporation will prepare and implement a plan for an integrated statewide system of solid waste management facilities which plan shall define the state's disposal needs and define the manner to meet the needs in accordance with the requirements of this chapter. *Capacity, maximizing the use of source reduction, reuse, and recycling at public and private facilities shall be considered when assessing state need. No public facility shall be constructed unless need is established pursuant to the plan.* The plan shall be reviewed and adopted as an element of the State Guide Plan by the State Planning Council. *(emphasis added)*

Other suggestions include rewarding the Corporation for reduced ‘sales,’ permitting the Corporation to keep some portion of its appropriations and use this towards reduction and recycling programs, and developing an accounting mechanism that includes resource rent so as to account for the value of the resource over time and in this manner estimate what the potential value of the resource is and how much of the resource is saved year-on-year through measures undertaken to divert wastes.

The real problem, however, lies in the fact that the Corporation as noted earlier is viewed as an easy source of revenue by the Legislature to bolster the General Fund and it is difficult to imagine the Legislature supporting any initiatives that will decrease this flow of funds.

OTHER RECOMMENDATIONS

In addition to the recommendations made above for economic incentives the following suggestions are also made.

Establishing Incentive Schedules

It is essential that the incentives being recommended are coordinated and are implemented in the manner that they will be most effective. In this regard the following incentive implementation schedules are suggested.

Municipal Solid Waste

Immediate notice should be given to municipalities about impending waste cap reductions; beginning in 2005 with the first of the four five percent reductions and a leaf and yard waste ban, also effective in 2005. Legislation should be proposed to make PAYT mandatory statewide, beginning in 2008, enforced by setting the tipping fee at the commercial rate for non-compliant municipalities after that date. If the Corporation cannot devise a way to fund start-up costs for all communities in the same year, the availability of funding for a limited number of communities could be announced in each of the four years in which the waste reductions caps are being implemented – to be distributed on a first-come, first-served basis. An alternative would be for the Corporation

to plan to fund all PAYT start-up costs, and let the legislature assume the responsibility of meeting the costs.

Commercial Solid Waste

The rule-making necessary to ban the landfilling of commercial recyclables should be begun by DEM as soon as possible.²² Enforcement of commercial recycling regulations should start at the time that the landfilling ban regulations have become effective. This will send a signal that the State is serious about preserving landfill space.

The proposed increase in contract commercial tipping fees should also be announced now, to become effective after a period of time adequate to allow haulers to make arrangements for out-of-state disposal. Corporation assistance to develop Resource Management programs should be announced at the same time.

Funding

Several of the recommendations made here will require funds not currently budgeted for by the Corporation. It is possible that revenues will increase, perhaps temporarily, if commercial rates are increased. However, there appears to be a ready source of these funds in the operating surplus the Corporation has run in the recent past. For fiscal years 1998, 1999, 2001 and 2002, the amount turned back to the state General Fund has

²² It should be noted that a petition under the Administrative Procedures Act has been filed to this effect as mentioned above in the section on Incentives for the Rhode Island Resource Recovery Corporation.

averaged approximately \$3M. Funds at this level are more than adequate to cover the additional expenditures proposed here. However, as has been illustrated in the analysis above, if PAYT and enforcement of commercial recycling regulations are successful in achieving significant reductions in the amount of waste landfilled, the Corporation's operating surplus also is likely to be reduced. In this case it may be recommended that the state consider beginning raising municipal tipping fees marginally now as opposed to implementing a much higher raise later when financial constraints at the Corporation create the need to do so.

Accountability

It is suggested that in order to ensure accountability, specified public reporting (perhaps through their web site) be undertaken by the Corporation. To encourage continuous progress in reducing waste generation and disposal, this reporting could require comparison with projections made in the Revised Plan.

RECYCLING

Benefits of Reduced Greenhouse Gases from Recycling

Besides preserving virgin materials, diverting waste, and extending landfill life, an added advantage of increased recycling is the reduction of greenhouse gas (GHG) emissions, and the conservation of energy from conserving raw materials and energy expended on retrieval, processing, and manufacture of products.

The management of MSW presents many opportunities for GHG emission reductions. Source reduction and recycling can reduce GHG emissions at the raw material acquisition, manufacture, transport, and product use stage, increase forest carbon sequestration, and avoid landfill methane emissions. Landfill emissions can be reduced by using gas recovery systems and by diverting organic material from landfills. Landfill methane can be flared or utilized for its energy potential. When used for its energy potential, landfill methane displaces fossil fuels, as with MSW combustion. (See Appendix IV for a discussion of how GHG sources and sinks are affected by various MSW management strategies.) In the case of Rhode Island, nearly all the landfill gas recovered at Central Landfill is used to generate electricity.²³

²³ The entire landfill gas well field at Central Landfill consists of more than 120 active gas wells and six horizontal trenches. Flaring systems are utilized and primarily serve as a back-up for the removal of excess landfill gas. Recovering methane for power generation involves drawing gas out of the landfill cells through a system of pipes, pumps, trenches and methane wells using an extraction blower. The gas is cleaned and dried, and the methane component is separated from the other gasses (Landfill gas is typically comprised of methane (50-55 percent), carbon dioxide (45-50 percent), and trace amounts of other gases such as oxygen, nitrogen, and hydrogen sulfide.) The purified methane gas then flows through eight 12-cylinder engines. Outside air is filtered in and combined with the methane to produce an energy-rich mix. The power generators in the methane facility's engines have the capability to generate 13.6 megawatts of

Recycling, in particular, results in the second lowest GHG emissions (after source reduction). Recycling lowers the demand for new products and reduces GHGs by saving energy and reducing emissions in the manufacturing process (specifically, combustion of fossil fuels), reducing non-energy-related manufacturing emissions (such as the carbon dioxide released when limestone is converted to lime needed for use in aluminum and steel manufacturing), increasing forest carbon sequestration, and reducing the GHG emissions associated with landfills (in particular methane emissions). Different wastes and waste management options have different implications for energy consumption, methane emissions, and carbon sequestration. (See Box 3.)

Box 3: Materials with the greatest potential to reduce GHGs when recycled

Recycling the following materials has the greatest climate benefit (from greatest to least)

- Aluminum cans
- Paper materials (office paper, phonebooks, textbooks, magazines)
- Mixed recyclables
- Dimensional lumber
- Steel cans
- Plastic containers (HDPE, LDPE, PET)

Source: EPA (2002)

Specific to Rhode Island

The analysis below is the summary of results of the environmental benefits of recycling as a result of GHG mitigation. All these figures were arrived at using the Northeast

electricity and a portion of this power (1.3 megawatts) is used for internal plant needs. The remaining 12.3 megawatts of electricity travels off-site and is sold to New England Power Company. For the sake of comparison, 12.3 megawatts of electricity can power about 17,000 homes annually.

Recycling Council (NERC) Environmental Benefits from Recycling Calculator. For a detailed explanation of how the estimates were calculated see Appendix V.

In 2002, Rhode Island recycling programs supplied industry with about 83,880 tons of scrap commodities like paper, glass, metals, plastics and other materials. These recycling efforts reduced GHG emissions by about 58,000 metric tons of carbon equivalent per year, equal to approximately 6.7 percent of all industrial carbon dioxide emissions from fossil fuel combustion in the state and 2.2 percent of GHG emissions. This saved a total of 1.48 trillion BTUs of energy, equal to 2.2 percent of all energy used by industry in the state, which has a value of \$9 million dollars. It also resulted in reductions of as much as 355 metric tons of water pollutants and 6,044 metric tons of air pollutants (net of carbon dioxide emissions). Lastly, recycling reduced overall emissions of sulfur oxides, an important ingredient in acid rain formation, by about 350 metric tons. Nitrogen oxides were reduced by about 330 metric tons.

Alternative collection and sorting strategies for recycling

Single-stream recycling

Rhode Island uses a dual-stream system of collecting and sorting recyclables. This requires the use of separate recycling containers, green and blue in the case of Rhode Island, for paper and mixed containers respectively.

An alternative to the existing system is single-stream recycling, where recyclables are collected in a single container and separated at the MRF. The reasoning behind single-stream recycling is that collection costs are lowered and also as source separation is sharply reduced on the part of residents there is the possibility that participation and recycling rates will increase.

The other advantage with single-stream recycling is that by using trucks with a single compartment for recyclables, truck payload capacity can be optimized. This is significant especially when compared with the present system that uses split-compartment trucks with separate compartments for paper and mixed recyclables, which limit the amount of recycling that can be accomplished by being unable to maximize payload capacity, leading to an increased number of trips to the MRF and higher costs.²⁴ Single-stream recycling allows for compaction, optimized collection routes, and a minimum number of trips to the MRF with partially filled compartments. A municipality can standardize its waste disposal fleet by settling on one truck design, with advantages in maintenance, training and overall deployment flexibility.

For the present, municipalities could adopt single-stream recycling by using their existing refuse fleet – single-compartment garbage packers – and run these on different days for refuse and recycling pick-ups.

²⁴ According to a study conducted by Louis and Shih (2002) it is suggested that municipalities interested in reducing recycling program costs and increasing recycling rates should consider policies to reduce materials transportation costs before considering price supports for recyclables as this was found to be more effective.

A stumbling block to implementing single-stream recycling in Rhode Island is the significant capital expenditure that will be required to retrofit the MRF. This may be alleviated somewhat given that at the Working Group meeting on August 6, 2003 it was revealed that the MRF was due for a retrofit sometime in the near future and as a result this retrofit could be adjusted to accommodate single-stream recycling. An example of the use of this strategy is seen in the case of the city of Ann Arbor, Michigan, where the recycling coordinator for the city suggested considering the shift to single-stream recycling when the city's MRF was due for an upgrade in order to justify the costs (Snow, 2003).

Another disadvantage cited in the literature on single-stream recycling is the increased level of contamination and the potential of reducing the market value of commodities from commingling of recyclables. This contamination is especially significant in the case of paper contamination from glass that reduces the value of the paper in secondary markets. Glass usually breaks during the collection and sorting processes and ends up fairly useless, and significantly reduces the lifetime of MRF equipment by requiring greater maintenance. The presence of glass in the municipal recycling stream prevents compaction of recyclables and therefore substantially raises collection and hauling costs for municipalities. Further, container glass has little or no value. At a Working Group meeting it was stated that glass is no longer marketed by the MRF because positive markets no longer exist for glass (Minutes of Working Group Meeting 7, August 6, 2003). This glass is presently being used as a part of the landfill cover for Central Landfill at considerable maintenance costs to the MRF. It seems then that the largest cost

savings from single-stream recycling would come from removing glass from the recyclables stream and as a result it is recommended that glass no longer be recycled at the MRF if and when single-stream recycling is adopted.

If recycling of municipal glass is no longer required, single-stream recycling appears to be feasible. It is expected that single-stream recycling will reduce collection and hauling costs for recyclables, which currently are from 50 to 100 percent higher than collection and hauling costs for refuse (See Table 4). Municipalities will be able to compact recyclables on collection which is expected to reduce collection costs by increasing truck payload capacity and reducing the number of trips to the MRF. Glass is benign in the landfill, and takes up relatively little space after compaction, as is demonstrated by the use of glass as landfill cover at present.

In practice single-stream recycling without glass would work by having residents leave glass in the refuse stream and not separating it out as a recyclable. This will require that municipalities reeducate residents. Municipalities may question a proposal to leave glass in the refuse stream at first because of the anticipated increase in tipping fees from the additional weight of the glass. However, this strategy should reduce costs both for the municipalities (additional tipping fee costs should be more than offset by the reduced cost of collecting recyclables) and the MRF (in the form of reduced maintenance and workers' compensation costs).²⁵ **Table 11** shows the effect on disposal costs for 16 municipalities, after implementing single-stream recycling and moving glass over to the refuse stream

²⁵ An American Forest & Paper Association (AF&PA) study conducted in 2004 evaluated the system-wide cost of single-stream versus dual-stream recycling while also assessing recovered fiber quality. The study showed that curbside collection costs tended to be about \$15/T *lower* for single-stream programs.

while keeping municipal caps at 20 percent. It is assumed that the percentage of glass in the recyclables stream is five percent.²⁶

Table 11: Increase or (decrease) in disposal costs from implementing single-stream recycling without glass	
Municipalities	%
Barrington	0.12
Burrillville	(2.50)
Central Falls	(5.11)
Coventry	5.81
Cranston	0.90
Cumberland	3.74
East Providence	(1.03)
Foster	(0.06)
Jamestown	(9.26)
Lincoln	1.57
North Kingstown	2.22
North Providence	(0.09)
North Smithfield	(0.29)
Pawtucket	6.17
Providence	4.18
Smithfield	(1.16)

The municipal caps will also need to be lowered percentagewise (or raised in absolute amounts) to account for the increase in tonnage from moving glass to the refuse stream and this will add to the cost savings shown in Table 11. While it is expected that the earlier target of 35 percent will need to be revised, because of the low recovery rates for glass (reflected in national figures) it is believed that a significant portion of the glass stream is already being included and is accounted for as part of the waste stream.

²⁶ According to the EPA in 2001, 10.9 MT glass was generated out of a total of 229 MT. This comes to approximately 4.7 percent by weight (which approximates the 5 percent used in Table 11). It should also be added however, that of this 10.9 MT only about 22 percent is recovered. As a result it may be assumed that it is very unlikely that all the glass in the waste stream is being recovered in Rhode Island. It should also be noted that the percentage of glass has been decreasing and is expected to continue to do so. (See, <http://www.epa.gov/epaoswer/non-hw/muncpl/glass.htm>).

Automated Collection

Another collection strategy to consider is automated waste collection. Evidence points to higher collection efficiencies and long-run cost savings with regard to labor and time when collection is automated using the more efficient, automated, single-operator packer (Bader, 2004).

An automated system has been adopted by the town of Warwick. In the first phase of a four-stage process,²⁷ the automated recycling program has seen an increase in recycling by 42 percent overall (45 percent paper, 36 percent mixed containers).²⁸ The recycling coordinator for Warwick attributes much of the increase in recycling to the increase in size of the new bins provided to each household. Each household was given three \$38 bins for free – one 95 gallon trash bin, and two 65 gallon recycling bins (one for paper and cardboard, one for mixed containers).

Further, the single-operator staffing of the automated side-loaders reduces staffing requirements and increases operator safety. Among the largest cost savings seen by Warwick have been reductions in workers' compensation costs. Since the drivers no longer have to get out of the truck and bend and lift heavy cans and bins, there are likely to be less on-the-job injuries and the cost of workers' compensation insurance is greatly

²⁷ The automated system has only taken effect on one route consisting of 4,000 households. There are 28,000 total households in Warwick, making up 8 separate routes. April 1st 2004 marks the next phase of this system, when 4,000 more households will be served. In October 2004, Warwick plans to add an additional 8,000 households to the plan, and eventually, over a three to four year period, the entire city.

²⁸ The recycling increase is year-on-year for the period August 4 to October 10, 2003.

reduced. Also, it is believed that if a municipality was to convert to automated collection, they would do the collection themselves rather than contract it out, resulting in more control, and better cost savings to the community (Bayard, 2004).

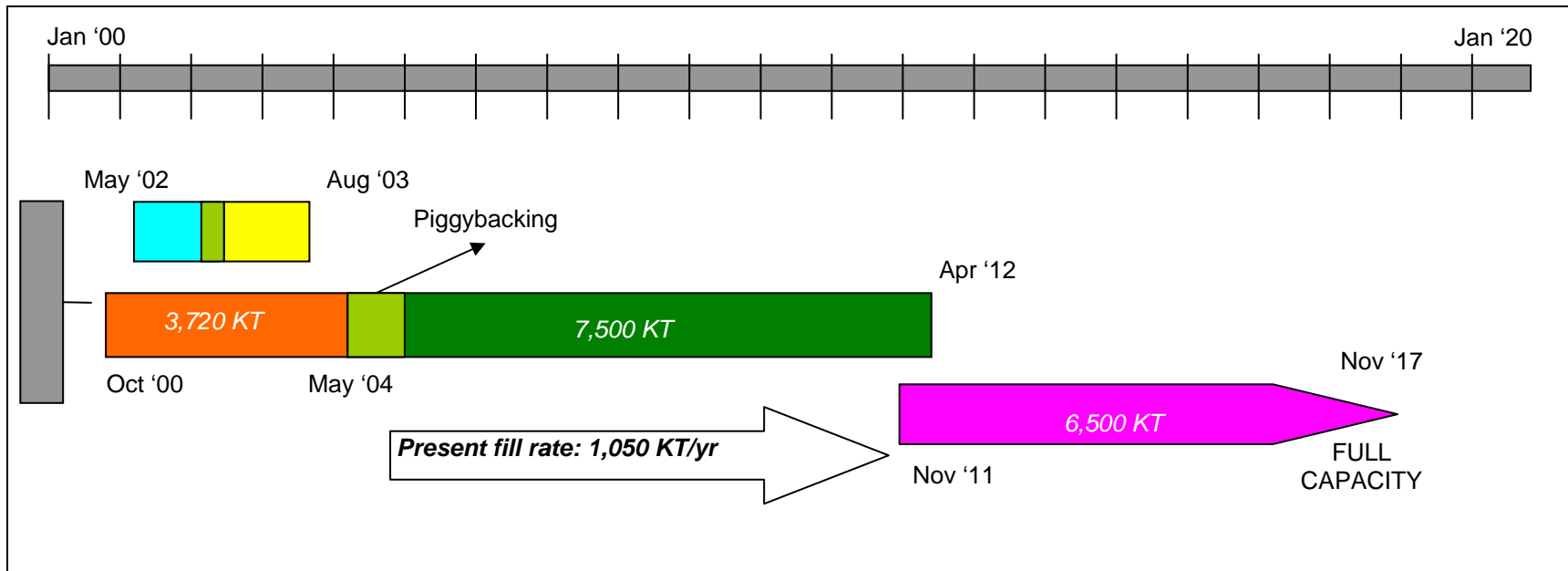
Besides the cost of reeducating households, municipalities may be unable to justify the high initial capital costs of automated equipment – retrofitting or buying new trucks and the cost of bins. It is believed that it will be difficult to retrofit existing trucks and that the cost of an automated collection truck runs to about \$160,000.²⁹ A collection study of St. Paul, Minnesota, found that the key factor that prevented the shift to single-stream was the cost of new bins. The same study also found that an increase in recycling was significantly impacted by container capacity (Eureka Recycling, 2002). Other expected costs are those for advertising the new program and delivering the new bins to every household, developing maintenance infrastructure (garages, fleet service mechanics), and hiring a coordinator to manage the operation.

It is expected that if the two methods are combined, single-stream recycling using automated collection will generate even higher cost savings in the long-run.

²⁹ Interview with Geoff DiCenso, Recycling Coordinator for the towns of Burrillville, Smithfield, North Smithfield and Cumberland.

APPENDICES

Appendix I: Capacity Remaining at Central Landfill



Landfill Phase	Acres	Disposal Status	Started Filling	Projected Completion
Phase I	121	Not in use	pre-1980	Filling completed July 1993
Phase II	24	Not in use	June 1993	Piggyback completed August 2002
Phase III	10	Not in use	March 1995	Piggyback completed August 2002
Phase IV	45	On-going	Area 1 & 2: Sept 2000; Area 3: Sept 2002; Area 4: March 2003	Phase IV will be filled by June 2004
Phase V	32	In permitting	May 2004	June 2012
Phase VI	28+/-	Future	Expect 4 year capacity	June 2016

Source: Disposal and Disposal Capacity Sub-Committee Draft Recommendations, April 2, 2003

Appendix II: The Evolution of Solid Waste Management in Rhode Island

1968	<ul style="list-style-type: none"> • Environmental regulatory authority transferred to the state Department of Health; local boards of health eliminated. • State regulations for solid waste facilities adopted including the prohibition of open burning.
1974	<ul style="list-style-type: none"> • Rhode Island Solid Waste Corporation established to provide waste management facilities and services. • The Corporation contracted for use of the state's major landfill (previously Silvestri Landfill). • The Corporation initiates efforts to develop resource recovery facilities.
1975	<ul style="list-style-type: none"> • DEM regulations adopted requiring that solid waste management facilities be licensed by the state.
1978	<ul style="list-style-type: none"> • Broad state (DEM) authority for hazardous waste regulation established.
1981	<ul style="list-style-type: none"> • The Corporation purchases the Central Landfill (formerly Silvestri).
1982	<ul style="list-style-type: none"> • Mechanism for negotiating siting for hazardous waste facilities established.
1984	<ul style="list-style-type: none"> • DEM Litter Control and Recycling Act established.
1986	<ul style="list-style-type: none"> • Solid Waste Act amended to include flow control, state-subsidized municipal disposal, and mandatory municipal, commercial, and state agency solid waste recycling.
1987	<ul style="list-style-type: none"> • Establishment of statutory priorities for integrated solid waste management. • Municipal recycling begins.
1989	<ul style="list-style-type: none"> • State office and municipal recycling begins. • Legislation adopted to modify the licensing and permitting process for the development of solid waste facilities and the development of a systematic procedure. • The Corporation granted the power of eminent domain. • DEM Hard-to-Dispose Material Control and Recycling Program begins.
1990	<ul style="list-style-type: none"> • System for the collection, disposal and recycling of telephone directories established in state law. • Legislation adopted requiring DEM to regulate conditions for use of the labels "degradable," "environmentally safe," and similar terms. • DEM regulations adopted setting standards to identify materials that are packaged in a source reduced manner utilizing recycled and recyclable materials.
1991	<ul style="list-style-type: none"> • Legislation adopted to set requirements for the use of recycled content for newsprint.
1992	<ul style="list-style-type: none"> • Legislative goal of 70 percent recycling for new processing facilities enacted. • Statutory ban on incineration adopted by General Assembly.
1993	<ul style="list-style-type: none"> • Legislation enacted prohibiting use of certain portions of the buffer zone

	<p>for Landfill expansion.</p> <ul style="list-style-type: none"> • Commencement of operations of an 11-acre section of the Landfill with a double geo-membrane and clay liner. All disposal from this point on to use double liners. • Closure of Central Landfill – the original 121-acre unlined section of the State Landfill. • The State Planning Council certifies a new landfill site for development by the Corporation on its property in Johnston.
1994	<ul style="list-style-type: none"> • The Corporation implements the Foster Maximum Recycling Pilot Project designed to test the extent to which residents will participate in a more intensive recycling effort, the economic feasibility of recycling a much larger percent of the waste stream, and methods of reducing the cost of collecting recyclables. • The Corporation applies for licensure of the Southwest Landfill, an approximately 45-acre cell abutting the existing Landfill and providing six to ten years of disposal, depending on quantities disposed. • EPA determines that the Central Landfill has not and will not threaten the Scituate Reservoir. • Legislative approval required for all new bond debt. • The Towns of Westerly, South Kingstown and Narragansett introduce volume-based solid waste user fee systems incorporating the use of bags and/or tags. • Legislation enacted requiring DEM licensure of construction & demolition debris (C&D) processing facilities and establishing siting, construction and operating standards for these. • DEM establishes newspaper recycled content regulations. • DEM implements project to increase the use of post-consumer materials in manufacturing processes to develop waste-based industries in Rhode Island. • DEM and Department of Administration develop specifications for purchasing recycled products – conduct workshop for municipal officials to “piggyback” state bids for recycled products. • Several municipalities begin leaf and yard waste composting programs.
1995	<ul style="list-style-type: none"> • Expansion of the MRF undertaken by the Corporation. • DEM opens Household Hazardous Waste Facility on Narragansett Bay Commission property at Fields Point, Providence. • The Corporation officially launches the Maximum Recycling Program in Foster and Scituate after successful completion of the pilot program in Foster meant to be a precursor to Maximum Recycling statewide. • EPA and the Corporation agree to the terms of a Consent Order to be issued by EPA concerning remediation of the Central Landfill Superfund site. • The Corporation initiates the alternative cover material program designed to recycle a material that would otherwise be disposed, reduce the use of gravel (a virgin natural resource) for landfill cover, reduce the costs of

	<p>mining or buying virgin cover materials, and generate revenue by charging a disposal fee.</p> <ul style="list-style-type: none"> • The transfer station owned by Allied Waste Industries on Plainfield Pike in Cranston is purchased by the Corporation, enabling the Corporation to grind C&D waste for re-use as a landfill cover material, thus backing out an equivalent amount of virgin material that would otherwise have to be used.
1996	<ul style="list-style-type: none"> • Expansion of the MRF by about 35,000 sq. ft., (to accommodate the Municipal Maximum Recycling Program) and the installation of new process trains in the MRF are completed, more than doubling processing capacity (about 150,000 tons of recyclables annually) and nearly doubling the facility's footprint (75,000 sq ft floor space). The expansion involves the addition of new paper processing capability enabling the MRF to process up to seven different paper or paper-related products and an optical glass sorting system. • The new education center at the MRF is completed. • Completed dredging of Upper Simmons Reservoir to remove silt washed into the reservoir from the Landfill by erosion. • The Host Community Agreement between the Corporation and the Town of Johnston is ratified to remain in effect for as long as the Corporation operates a solid waste management facility in Johnston.
1997	<ul style="list-style-type: none"> • Statewide implementation of the Maximum Recycling Program inaugurated, thereby increasing the categories of materials extracted from the waste stream and moving from one blue bin to two bins – one blue and one green. As a result the processing of materials by the MRF increases from about 65,000 tons to more than 90,000 tons annually.
1998	<ul style="list-style-type: none"> • The closure of a number of nearby landfills in Massachusetts and new policies by the Commonwealth placing restrictions on the operation of landfills in Massachusetts impacts regional disposal capacity and results in a substantial increase in the amount of out-of-state solid waste disposed of at Central Landfill. Rhode Island generated waste that had been going to Massachusetts is forced to divert to Central Landfill for disposal. • The Corporation joins with the Attorney General in suing several major haulers for bringing out-of-state waste to Central Landfill; three haulers sign court orders agreeing not to deliver out-of-state waste to Central Landfill. • Phase I relocation of Cedar Swamp Brook is completed thereby permitting construction of Phase IV of Central Landfill.
1999	<ul style="list-style-type: none"> • Phase IV of the Central Landfill is licensed. • The leachate pre-treatment facility becomes operational, receiving all leachate captured from the landfill and removing manganese and iron from the leachate as stipulated by the City of Cranston before discharging it to the Cranston wastewater system.
2000	<ul style="list-style-type: none"> • Construction of the baseliner and leachate collection system of Areas 1

	<p>and 2 (22 acres) of Phase IV of the Central Landfill is completed.</p> <ul style="list-style-type: none"> • Closure and installation of the final cap over 37 acres of Phase I of Central Landfill are completed under a consent decree between the Corporation and EPA concerning the remediation of the Central Landfill superfund site, with the 54 remaining uncapped acres of Phase I of the landfill to be completed by 2005.
2001	<ul style="list-style-type: none"> • The Eco-Depot, a household hazardous waste receiving and transfer station begins operation at the Central Landfill complex after the Corporation assumes responsibility from DEM for household hazardous waste disposal. In its first two years of operation, Eco-Depot receives and transfers to licensed disposal nearly 450,000 pounds of household hazardous waste. • Construction of the baseliner and leachate collection system of Area 3 (11 acres) of Phase IV of Central Landfill is completed.
2002	<ul style="list-style-type: none"> • The Central Landfill Tipping Facility begins operation. Trash collection vehicles now tip there rather than at the landfill working face, improving management of landfill capacity, improving safety at the landfill face and dramatically lowering the operating costs of haulers while at the landfill complex. • Construction of the baseliner and leachate collection system of Area 4 (11 acres) of Phase IV of Central Landfill is completed. • Commencement of closure and capping of 14 acres of Phases II and III of Central Landfill. • Construction of ramps at Route I-295 and Scituate Avenue in Johnston begins, fully-funded by the Corporation. The new ramps will provide a direct route from the interstate system into Central Landfill, diverting about 75 percent of the trash truck traffic from Plainfield Pike and lowering the approach to Central Landfill by several miles.
2003	<ul style="list-style-type: none"> • Phase II of the relocation of Cedar Swamp Brook is completed, restoring the riparian integrity of Cedar Swamp Brook as a free-flowing stream for the first time in about 12 years. • Construction begins, fully funded by the Corporation, to widen Scituate Avenue/Shun Pike for the one-mile distance from the new ramps at Route I-295 to the Central Landfill complex main gate from a two-lane road to a four-lane highway to provide a safe heavy-duty access route directly to the Landfill from I-295. • The Corporation begins grinding leaf and yard debris and clean wood as the amount of these materials diverted from landfilling to composting increases from about 3,500 tons annually to more than 10,000 tons annually – this has been the case for the past two to three years. • Application for licensure of Phase V of Central Landfill is submitted to DEM. • The Corporation initiates a consumer electronics collection program (this went from being a pilot to a full-fledged program). • The planning process begins to improve and expand the system of

	<p>collecting landfill gas generated by the Central Landfill and to expand the utilization of the gas by developing a second electric generating plant at the Landfill to complement the existing one.</p> <ul style="list-style-type: none">• Planning is underway to move the C&D debris grinding operation on Plainfield Pike to the Central Landfill complex, consolidating all of the Corporation's solid waste management operations onto one site.• Planning begins to develop an extensive commercial waste recycling operation at the Corporation's new tipping facility.
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Appendix III: Price Structure for Rail Hauling Solid Waste from Rhode Island to a landfill in Charing, Georgia

Base Assumptions	Estimates
Working Days per Year, Assuming a 5-Day Work Week	260 Days
Total Tons Shipped Annually	150,000 Tons
Tons Shipped Daily	577 Tons
Landfill Disposal Cost at Charing, GA	\$7.50/Ton
CSX Transport Cost/Rail Car/Trip, Worcester -- Charing, GA	\$3,169.00/Car
P&W Transport Cost/Rail Car/Trip, Providence -- Worcester	\$400.00/Car
Tons per Rail Car per Trip, Assuming 4 Containers/Car	92 Tons/Car
Rail Transportation/Ton	
	\$38.79
Purchase Cost per Rail Car, High Estimate	
Purchase Cost per Rail Car, High Estimate	\$60,000
Useful Life of Rail Car	12 years
Monthly Cost	\$416.67
Rail Car Cycle Time	22 days
Rail Car Trips Annually	16.59 Trips/Year
Containers per Rail Car	4 Containers
Tons per Rail Car per Trip	92 Tons
Total Rail Cars Needed to Ship ~577 Tons per Day	99 Rail Cars
Total Rail Car Capital Outlay	\$5,940,000
Rail Car Fixed Cost/Ton	
	\$3.30/Ton
Land, Rail Head & Related Improvements -- Cost	
Land, Rail Head & Related Improvements -- Cost	\$300,000
Land, Rail Head & Related Improvements -- Life	20 years
Equipment (includes container handler & flat bed truck--Cost	
Equipment (includes container handler & flat bed truck--Cost	\$1,000,000
Equipment Life	7 Years
Fixed Rail Head & Equipment Costs	
	\$1.05/Ton
Loading Cost/Year	
Loading Cost/Year	\$250,000/Year
Loading Cost	
	\$1.67/Ton
Cost per Container	
Cost per Container	\$5,000/Container

Container Cycle Time	22 Days
Working Days per Cycle	16 Days
Container Life	5 Years
Tons per Container	23 Tons
Containers Needed per Working Day	25 Containers
Total Containers Needed	394 Containers
Total Container Capital Cost	\$1,970,855
Container Cost per Ton Shipped	\$2.63/Ton
TOTAL COST PER TON SHIPPED	\$54.94/TON
March, 28, 2003	
Source: Dante Ionata, Consultant to Rhode Island Resource Recovery Corporation	

Appendix IV: Components of Net Emissions for Various Municipal Solid Waste Management Strategies

MSW Management strategy	GHG Sources and Sinks		
	Raw Materials Acquisition and Manufacturing	Changes in Forest or Soil Carbon Storage	Waste Management
Source Reduction	Decrease in GHG emissions, relative to the baseline of manufacturing	Increase in forest carbon sequestration (for organic materials)	No emissions/sinks
Recycling	Decrease in GHG emissions due to lower energy requirements (compared to manufacture from virgin inputs) and avoided process non-energy GHGs	Increase in forest carbon sequestration (for organic materials)	Process and transportation emissions associated with recycling are counted in the manufacturing stage
Composting (food discards, yard trimmings)	No emissions/sinks	Increase in soil carbon storage	Compost machinery emissions and transportation emissions
Combustion	Baseline process and transportation emissions due to manufacture from the current mix of virgin and recycled inputs	No change	Non-biogenic CO ₂ , N ₂ O emissions, avoided utility emissions, and transportation emissions
Landfilling	Baseline process and transportation emissions due to manufacture from the current mix of virgin and recycled inputs	No change	CH ₄ emissions, long-term carbon storage, avoided utility emissions, and transportation emissions
Source: Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks, EPA			

Appendix V: Calculation of GHG reduction estimates

The Northeast Recycling Council (NERC) have developed an Environmental Benefits Calculator (the calculator) found at <http://www.nerc.org/documents/aboutcalc1003.html> which is used here to estimate the environmental benefits derived from recycling based on tonnages of materials recycled and landfilled in Rhode Island.

The calculator was developed primarily for use by US state and local governments, and in large part data inputs for GHG inventory, carbon dioxide emissions, acid rain emissions, and energy statistics are based on specific states. The calculator is based on per ton figures of the estimated energy use and emissions from several life-cycle analysis studies. The estimates are average figures based on “typical” facilities and operating characteristics existing in the US. The calculator tailors the results to the amount of materials recycled and the current mix of landfilling and other waste disposal options in the study area. (Factors that are not included are benefits from landfill gas recovery and generation of electricity.)

The calculator can be used to generate the following information:

1. Materials Management Overview
2. Reductions in Greenhouse Gas Emissions as a Result of Recycling
3. Greenhouse Gas Savings Comparisons
4. Energy Savings as a Result of Recycling
5. Energy Savings Comparisons

6. Life-Cycle Stage Comparisons
7. Air Emission and Waterborne Waste as a Result of Recycling
8. Emissions Savings Comparisons
9. Selected Natural Resource Savings
10. Energy Savings from Computer Recycling
11. Energy Savings from Computer Reuse

Directions for using the Calculator and Fact Sheets are in the worksheet “About the Model” within the Excel spreadsheet containing the calculator. Given below is an extract of the directions for inputting data into the calculator.

Step 1: Go to “Worksheet 1. Data Inputs” to enter materials management data produced. This input data includes tonnage statistics for recycling, landfill and incineration. For state-specific information, the suggested source is the state recycling agency. See notes to the right of the blue cells in the “Worksheet 1. Data Inputs” for additional hints on entering the materials management data.

Step 2: Also in “Worksheet 1. Data Inputs,” enter state-specific data obtained through the Internet.

This input data includes statistics such as energy consumption and GHG emissions, used to put the recycling benefits into context. Sources for the data to be inputted are listed in each Input Section in “Worksheet 1. Data Inputs.” To find data, go to the website listed in the sources and follow the instructions given in each Input Section in “Worksheet 1. Data Inputs.”

Step 3: *Click on “Worksheet 2. Environmental Impacts,” using the tabs at the bottom of the spreadsheet.*

This sheet includes 11 automatically generated tables, each presented on a separate page with descriptive charts.

Step 4: *Read (or Develop) the Fact Sheet in a separate Word document.*

NERC produced a fact sheet for each state in the Northeast region, which corresponds with the figures generated from the calculator. If you are updating NERC’s fact sheet for your study area, refer to the next section for a description on how to retrieve the figures from the calculator.

There are several details involved in deriving environmental benefit estimates, and the calculator uses statistics from different sources, and involves assumptions and caveats. What follows is an explanation of each of the summary tables given here.

Table A.VI.1 is based on the data and methodology developed by the EPA. The EPA based its calculations on data from a number of academic, government, and private sector sources. The reductions in emissions from recycling are equal to the difference between the net emissions of disposed materials and those recycled. Emission estimates are derived from estimated impacts of activities throughout the material life cycle. Recycling net emissions include raw material acquisition and manufacturing, processing, transportation, and forest carbon sequestration. Landfill net emissions include transportation, CH₄ from landfills, avoided CO₂ emissions from energy recovery, and

landfill carbon sequestration. Column three in the table is a weighted average of disposal emissions, based on the input ratio between landfiling and incineration.

EPA data was used in the NERC calculator, because it is fast becoming a standardized source for GHG estimates used by states and other entities throughout the nation, and because it represented recent revisions based on a broad review of sources. However, it should be noted that other sources are independently investigating the life-cycle environmental impacts of various industry processes and waste management practices; most notably the Environmental Defense, ICLEI, EPA's Office of Research and Development, and Ecobilan.

Table A.VI.1: Reductions in Greenhouse Gas Emissions as a Result of Recycling				
	Tons Recycled	GHG Emissions Associated with Recycling (MTCE)*	GHG Emissions if Recyclables Had Been Disposed (MTCE)	Net GHG Emissions from Recycling as Compared to Disposal (MTCE)
2002				
RECYCLABLE COMMODITIES				
Aluminum Cans	753	-3,018	8	-3,026
Steel Cans	1,591	-778	16	-794
Ferrous Scrap Metal	2,009	-983	20	-1,003
Glass	4,270	-325	45	-370
HDPE	335	-128	4	-132
LDPE	6,530	-3,046	71	-3,117
PET	419	-177	5	-182
Corrugated Cardboard	4,939	-3,499	380	-3,879
Magazines/Third-class Mail	1,842	-1,358	-222	-1,137
Newspaper	8,706	-8,264	-1,810	-6,453
Office Paper	2,093	-1,417	1,301	-2,718

Table A.VI.1: Reductions in Greenhouse Gas Emissions as a Result of Recycling				
	Tons Recycled	GHG Emissions Associated with Recycling (MTCE)*	GHG Emissions if Recyclables Had Been Disposed (MTCE)	Net GHG Emissions from Recycling as Compared to Disposal (MTCE)
Phonebooks	7,534	-6,856	-1,567	-5,289
Textbooks	0	0	0	0
Dimensional Lumber	3,014	-2,017	-316	-1,701
Medium-density Fiberboard	0	0	0	0
Mixed Paper, Broad Definition	0	0	0	0
Mixed Metals	167	-290	2	-292
Mixed Plastics	0	0	0	0
Mixed Recyclables	30,701	-23,409	1,584	-24,993
Whole Computers	5,714	-4,213	59	-4,272
TOTAL - COMMODITIES	80,617	-59,780	-422	-59,358
OTHER MATERIALS				
Food Scraps	0	0	0	0
Yard Trimmings	72,568	-3,921	-6,815	2,895
Grass	5,609	-303	58	-361
Leaves	2,428	-131	-708	577
Branches	251	-14	-26	13
Mixed Organics	22,771	-1,230	764	-1,994
Construction & Demolition	118,043	NA	NA	NA
Other Recyclables	3,263	NA	NA	NA
TOTAL - OTHER MATERIALS	224,933	-5,599	-6,729	1,130
TOTAL - ALL MATERIALS	305,550	-65,379	-7,150	~ -58,000

	Tons Recycled	GHG Emissions Associated with Recycling (MTCE)*	GHG Emissions if Recyclables Had Been Disposed (MTCE)	Net GHG Emissions from Recycling as Compared to Disposal (MTCE)
* MTCE (Metric Tons of Carbon Equivalent)				
Sources: RIRRC, EPA. (2003) Revised "WARM" model. Available online at http://yosemite.epa.gov/oar/globalwarming.nsf/WARM , EPA (2002) Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks. 2nd edition. EPA 530-R-02-006. Available at: http://www.epa.gov/epaoswer/non-hw/muncpl/ghg/ghg.htm				

Table A.VI.2 compares the total GHG reduction estimate from Table A.VI.1 to several other sources and sectors.

MAJOR GHG EMISSION SOURCES	Annual Emissions (Million MTCEs)	Percent of Total Emissions	Recycling Emission Reductions as a Percent of Emissions from Source*
Reporting Year	1990		
Industry	0.20	7.7%	29.1%
Utility	0.10	3.8%	58.2%
Landfills	0.10	3.8%	58.2%
Extraction/Mining	0.10	3.8%	58.2%
Transportation	1.10	42.3%	5.3%
Other	1.00	38.5%	5.8%
Total	2.60	100.0%	2.2%
MAJOR CO2 EMISSION SECTORS FROM FOSSIL FUEL COMBUSTION			
Reporting Year	1999		
Commercial	0.30	9.8%	19.4%
Industrial	0.87	28.3%	6.7%
Residential	0.63	20.5%	9.2%
Transportation	1.27	41.4%	4.6%
Utility	0.00	0.0%	-
Total	3.07	100.0%	1.9%

Table A.VI.2: GHG Savings Comparisons			
MAJOR GHG EMISSION SOURCES	Annual Emissions (Million MTCEs)	Percent of Total Emissions	Recycling Emission Reductions as a Percent of Emissions from Source*
* These percentages are not additive			
Sources: Table: Reductions in GHG Emissions as a Result of Recycling, EPA (2003). State GHG Inventory. Available at: http://yosemite.epa.gov/globalwarming/ghg.nsf/emissions/StateAuthoredInventories , EPA (2003). Energy CO ₂ Inventories. Available at: http://yosemite.epa.gov/oar/globalwarming.nsf/content/EmissionsStateEnergyCO2Inventories.html?OpenDocument			

Table A.VI.3 is based on energy use estimates derived from EPA's Waste Management and Energy Savings: Benefits by the Numbers Report. The results in that paper have since been updated to reflect EPA's revised WARM model.

Table A.VI.3: Energy Savings as a Result of Recycling				
	Tons Recycled	Energy Use if All Recycled (Million BTUs)	Energy Use if Recyclables Had Been Disposed (Million BTUs)	Net Energy Consumption from Recycling as Compared to Disposal (Million BTUs)
2002				
RECYCLABLE COMMODITIES				
Aluminum Cans	753	-142,715	397	-143,112
Steel Cans	1,591	-31,766	795	-32,561
Ferrous Scrap Metal	2,009	-40,112	1,003	-41,115
Glass	4,270	-9,075	2,249	-11,325
HDPE	335	-6,363	173	-6,535
LDPE	6,530	-157,366	3,371	-160,737
PET	419	-9,303	218	-9,522
Corrugated Cardboard	4,939	-64,215	1,703	-65,918
Magazines/Third-class Mail	1,842	-1,263	785	-2,048

Table A.VI.3: Energy Savings as a Result of Recycling

	Tons Recycled	Energy Use if All Recycled (Million BTUs)	Energy Use if Recyclables Had Been Disposed (Million BTUs)	Net Energy Consumption from Recycling as Compared to Disposal (Million BTUs)
Newspaper	8,706	-143,527	3,801	-147,328
Office Paper	2,093	-21,100	256	-21,356
Phonebooks	7,534	-89,888	3,290	-93,178
Textbooks	0	0	0	0
Dimensional Lumber	3,014	1,772	1,405	368
Medium-density Fiberboard	0	0	0	0
Mixed Paper, Broad Definition	0	0	0	0
Mixed Metals	167	-13,378	88	-13,466
Mixed Plastics	0	0	0	0
Mixed Recyclables	30,701	-483,401	11,435	-494,836
Whole Computers	5,714	-248,200	3,004	-251,204
TOTAL - COMMODITIES	80,617	-1,459,901	33,973	-1,493,874
OTHER MATERIALS				
Food Scraps	0	0	0	0
Yard Trimmings	72,568	42,380	33,526	8,854
Grass	5,609	3,276	2,548	727
Leaves	2,428	1,418	1,142	276
Branches	251	147	118	29
Mixed Organics	22,771	13,298	9,999	3,299
Construction & Demolition	118,043	NA	NA	NA
Other Recyclables	3,263	NA	NA	NA
TOTAL - OTHER MATERIALS	224,933	60,518	47,333	13,185
TOTAL - ALL MATERIALS	305,550	-1,399,383	81,306	~ <u>-1.48</u>

The negative sign denotes energy savings.

Sources: RIRRC, EPA, Revised "WARM" model. July, 2003. Available online at <http://yosemite.epa.gov/oar/globalwarming.nsf/WARM>, EPA (2002) Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks. 2nd edition. EPA 530-R-02-006. Available at: <http://www.epa.gov/epaoswer/non-hw/muncpl/ghg/ghg.htm>

Table A.VI.4 compares the total energy savings estimate from Table A.VI.3 to statewide energy consumption, statewide energy expenditures, and statewide energy generation.

Table A.VI.4: Energy Savings Comparisons

	Consumption Comparisons		Expenditure Comparisons		Generation Comparisons	
	Statewide Consumption (Million BTUs)	Recycling Energy Savings as a Percentage of Each Sector & Source Consumption*	Statewide Expenditures (Million Nominal Dollars)	Value of Recycling Energy Savings (Million Nominal Dollars)	Statewide Energy Generation by Source (Million BTUs)	Recycling Energy Savings as a Percent of Each Generation Source**
ENERGY SECTOR						
Reporting Year	2000		2000			
Residential	66,000,000	2.2%	\$690	\$15		
Commercial	50,900,000	2.9%	\$480	\$14		
Industrial	68,000,000	2.2%	\$413	\$9		
Transportation	65,500,000	2.3%	\$798	\$18		
Total Consumption	250,400,000	0.6%	\$2,381	\$14		
ENERGY SOURCE						
Reporting Year	2000				1995	
Petroleum	97,200,000	1.5%				
Natural Gas	81,300,000	1.8%				
Coal	100,000	1480.7%			0	-
Hydroelectric	10,300,000	14.4%				
Nuclear	0	-			0	-
Total	188,900,000				2,389,078	62.0%
OTHER COMPARISONS						
Million BTUs Per Household	161.60					
* These percentages are not additive						

Table A.VI.4: Energy Savings Comparisons						
	Consumption Comparisons		Expenditure Comparisons		Generation Comparisons	
	Statewide Consumption (Million BTUs)	Recycling Energy Savings as a Percentage of Each Sector & Source Consumption*	Statewide Expenditures (Million Nominal Dollars)	Value of Recycling Energy Savings (Million Nominal Dollars)	Statewide Energy Generation by Source (Million BTUs)	Recycling Energy Savings as a Percent of Each Generation Source**
<p>** Generation information is only available for coal and nuclear options in the NERC EBC</p> <p>Sources: Table: Energy Savings as a Result of Recycling, US Energy Information Administration, http://www.eia.doe.gov/emeu/states/_states.html, US Department of Commerce. (1997-1998). State and Metropolitan Area Data Book - 5th Edition. Available at: http://www.census.gov/prod/3/98pubs/smadb-97.pdf, US Census Bureau. State and County QuickFacts. Available at: http://quickfacts.census.gov/qfd/</p>						

Table A.VI.5 and Table A.VI.6 present estimates of air and water emissions resulting from recycling (including collection, processing, transportation and substitution for virgin materials in manufacturing) and from the current mix of incineration and landfilling in the study area (including collection, processing, landfill operations and/or incineration electricity generation). The tables are based on a mixture of recyclables, using an average of figures from Franklin Associates.

NERC warns that the data on air emissions and waterborne wastes must be interpreted with considerable caution. While the data do provide an indication of the relative impacts of waste management and manufacturing practices, and indicate a general magnitude of impacts, comparing the impacts to other sources may be problematic. It should be noted especially that the estimate for carbon dioxide makes up a very high percentage of the overall estimate for air emissions, and is probably much less accurate than the carbon equivalent estimates provided in Table A.VI.1.

Air emissions and Waterborne wastes as a result of Recycling

Table A.VI.5: Air Emissions			
	Emissions from Recycling Collection, Processing & Manufacturing (Metric Tons)	Emissions if Recyclables Had Been Disposed (Metric Tons)	Net Emissions from Recycling as Compared to Disposal (Metric Tons)
Aldehydes	-16.3	0.6	-16.9
Ammonia	-0.2	0.0	-0.2
Carbon Dioxide	-79,038.7	10,080.7	-89,119.4
Carbon Monoxide	-798.1	30.9	-829.0
Chlorine	-1.4	0.0	-1.4

	Emissions from Recycling Collection, Processing & Manufacturing (Metric Tons)	Emissions if Recyclables Had Been Disposed (Metric Tons)	Net Emissions from Recycling as Compared to Disposal (Metric Tons)
Hydrogen Fluoride	-5.6	0.0	-5.6
Lead	-0.2	0.0	-0.2
Hydrogen Chloride	0.0	0.0	0.0
Metals	0.0	0.0	0.0
Hydrocarbons	-213.7	12.2	-226.0
Methane	-0.3	3,891.6	-3,891.9
Nitrogen Oxides	-299.1	32.3	~ -330
Other Organics	-8.7	18.9	-27.5
Particulates	-358.1	7.1	-365.2
Sulfur Oxides	-344.6	4.3	~ -350
Totals	-81,085.0	14,078.6	-95,163.6
NET of CO ₂ emissions			~ -6,044

	Emissions from Recycling Collection, Processing & Manufacturing (Metric Tons)	Emissions if Recyclables Had Been Disposed (Metric Tons)	Net Emissions from Recycling as Compared to Disposal (Metric Tons)
Acid	-14.0	0.0	-14.0
Ammonia	-3.0	0.0	-3.0
BOD	-17.0	0.0	-17.0
COD	-47.1	0.1	-47.1
Cyanide	-0.1	0.0	-0.1
Dissolved Solids	-169.4	10.7	-180.1
Fluorides	-3.3	0.0	-3.3
Iron	-2.5	0.0	-2.5
Metal Ion	-6.5	0.0	-6.5
Oil	-1.4	0.1	-1.5
Phenol	-0.1	0.0	-0.1
Sulfuric Acid	0.0	0.0	-0.1
Suspended Solids	-79.2	0.0	-79.2
Totals	-343.5	11.0	~ -355

Sources: RIRRC, Denison, Richard A., Environmental Life-Cycle Comparisons of Recycling, Landfilling and Incineration: A Review of Recent Studies, Annual Review of Energy and the Environment. 1996.21:191-237. Available at <http://www.inceneritori.org/denison.pdf> (Table taken directly from Table 6 on Page 227), Franklin Associates. 1994. The Role of Recycling in Integrated Solid Waste Management to the Year 2000. Stamford, CT: Keep America Beautiful.

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