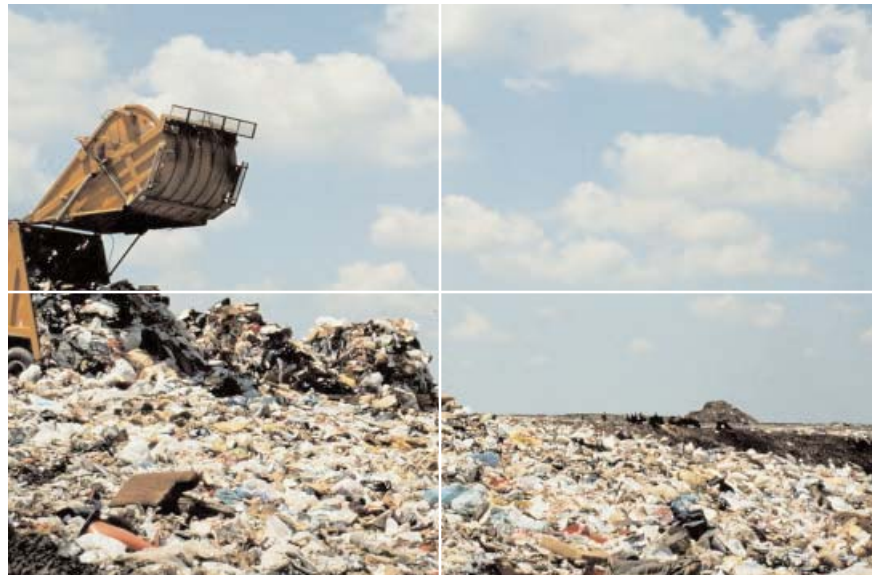


Life After Fresh Kills:

Moving Beyond New York City's Current Waste Management Plan

Policy, Technical and Environmental Considerations

December 1, 2001



A joint research project of Columbia University's Earth Institute, Earth Engineering Center, and the Urban Habitat Project at the Center for Urban Research and Policy of Columbia's School of International and Public Affairs.

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Executive Summary

This report is the result of a unique interdisciplinary collaboration between faculty and students of Columbia University and academic, governmental and environmental experts from the New York region. A research project of Columbia University's Earth Institute, Earth Engineering Center, and the Urban Habitat Project at the Center for Urban Research and Policy of Columbia's School of International and Public Affairs, the report examines New York City's current waste disposal plan and the impact of the Fresh Kills landfill closing. The report concludes that New York City faces a critical period over the next few years during which it must come to grips with its long-term waste disposal needs both from a public policy and a technical perspective.

While the report takes no position as to the appropriateness of the city's current waste export plan in the short-term, it does conclude that long-term this plan leaves the city vulnerable to a wide range of problems including dramatic cost increases and environmental degradation. Specifically, after the closing of Fresh Kills, the City now faces:

Increasing costs:

Contracts negotiated for disposal after Fresh Kills will impose significant cost increases on City taxpayers as waste disposal charges rise from the \$42 per ton cost of disposal at Fresh Kills to prices ranging from \$70-\$100 per ton. In addition, the City will be far more vulnerable to changes in market control, such as the increasing consolidation of the waste industry among a relatively small group of suppliers, and increasing transportation costs.

Political vulnerabilities:

With the closing of Fresh Kills, New York City is more vulnerable to the legislation that seeks to restrict the flow of garbage across interstate lines. Thus far, legislation to permit such restrictions has failed to pass Congress but should it pass, the City could face an emergency situation. Too, reliance on its existing interim contracts, paired with the political reality of siting new facilities in the City, places the City in a particularly vulnerable position when it is time to renegotiate its contracts with the private carting companies that currently have the necessary transfer infrastructure in place. The events of September 11, 2001 raise the specter of future disruptions to New York City's transportation infrastructure. Aside from instant and dramatic increases in municipal waste, if future events disrupt truck and rail transportation for extended periods of time, the City could face a waste disposal crisis.

Environmental concerns:

The lack of a long-term solution to waste disposal raises the potential for significant environmental problems. For example, continued reliance on long distance trucking will increase both increase fuel consumption and air pollutant emissions. Long distance exportation of garbage raises the potential for an environmental calamity should a train or barge fail to transport its cargo to its destination safely. Furthermore, continued focus on landfilling outside the City's borders can result in an "out of sight, out of mind" overlooking of the need for waste diversion and recycling.

Fundamentally, the report concludes that these vulnerabilities make it imperative for the City to look beyond its 20-year interim plan to begin a long-term planning process to put the City's waste disposal operations on a solid footing. The City planners should "think big," as they did 100 years ago when faced with a similar need to address the City's water infrastructure needs. "Thinking big" would include consideration of a wide range of technologies (detailed in this report) which could transform the City's approach to waste disposal. The City must strive for an integrated approach and consider a variety of technical approaches to waste management in areas such as increased recovery of materials (by recycling) and increased recovery of energy (by combustion). As discussed in this report, there are a wide range of advances in waste management technology that, under appropriate

circumstances, could offer both economic and environmental advantages to New York City's current waste exportation approach.

While the City's activities of the last few years have managed to soften the impact of the Fresh Kills closing for the present time, the need remains for a long-term plan to solve the City's waste disposal problems. Given the significant challenges of political consensus building, the process of devising a creative solution for New York City's residential waste disposal challenges must begin immediately.

Part A:

Policy Considerations

**The Urban Habitat Project at the Center for Urban Research and Policy,
Columbia University School of International and Public Affairs
December 1, 2001**

Part A : Summary

In 1947, Fresh Kills landfill opened its scales in Staten Island, amid protests at City Hall and back room negotiations between Cornelius Hall, Staten Island's Borough President, and Robert Moses, City Planning Commissioner. For Hall, the landfill was the answer to his vision of an oceanfront highway; for Moses the landfill helped solve a solid waste problem brought on by an inadequate waste infrastructure. To placate the public, Robert Moses promised that Fresh Kills would be a temporary "clean fill," receiving no municipal solid waste and open for only three years. The fill would serve as the foundation for Hall's highway, and the city was to build one new incinerator in each of the five boroughs. Over fifty years later, Fresh Kills was still open, receiving nearly 13,000 tons of residential municipal solid waste a day from the five boroughs of New York City.

Pressure on City and State officials to close Fresh Kills grew steadily until Mayor Giuliani and Governor Pataki announced the closure of the largest landfill in the world in May of 1996. Over the next five years, the City entered into agreements with private waste management companies for the management of designated portions of the residential waste. The waste is collected in the five boroughs and transported out of the State predominately by truck, but by rail and barge as well. The last barge carrying municipal solid waste to Fresh Kills left the marine transfer station on March 22, 2001.

As an alternative to a locally controlled waste management facility, the City and its Department of Sanitation have released a twenty-year plan for New York City that promotes waste exportation as the sole means for disposal of the City's non-recyclable waste, both commercial and residential. Specifically, New York City plans to contract with a handful of private waste companies for the containerization, transport and disposal of designated portions of the City's residential waste in landfills and incinerators located outside of the State. While such a plan may make sense in the short-term, it suffers from numerous weaknesses as a long-term solution.

The City's waste export plan is not viable economically, politically or environmentally over the long term. Among the reasons are the following:

- Consolidation in the waste management industry will limit the City's options and bargaining power over the long-term
- Rising tipping fees and transportation costs will significantly increase the City's waste disposal costs
- Government regulation and regulatory enforcement could disrupt the movement of waste outside of the city and increase the overall cost of disposal
- Reliance on private waste handling facilities will make it more difficult for the City to develop new approaches in the future
- Unforeseen disasters could instantly increase the amount of waste in New York City and could disrupt the movement of waste out of the state by rail and truck
- Long distance transport of waste could result in increased air pollution, fuel consumption, greenhouse gasses, as well as additional risks from accidents
- Disincentives to recycling

Given these potential problems, now is the time for New York City and its leaders to "think" big with creativity and vision. Efficient disposal of the City's solid waste is vital to the growth and success of New York. City leaders must not leave the residents dependent on out-of-state elected officials, a handful of waste management conglomerates, and unanticipated catastrophes. Proper planning takes time. With the influx of money and attention to

redevelopment following the September 11th tragedy, there is no time better to begin the process than now. Fresh Kills was a poorly planned emergency response to a waste management crisis. The City should learn from its past mistake and begin to plan for the future now.

Table of Contents : Part A

A-1	Introduction	A-1
A-2	The Fresh Kills Landfill	A-1
A-2.1	The birth of Fresh Kills	A-1
A-2.2	The closure of Fresh Kills	A-2
A-3	The City's Plan for Waste Export	A-3
A-3.1	The long distance solution	A-4
A-4	Ramifications of the 20-Year Plan	A-5
A-4.1	Political Considerations	A-6
A-4.2	Economic Considerations	A-8
A-4.3	Environmental Considerations	A-11
A-5	No Time to Waste—Beginning the Process	A-13
A-5.1	Different Approaches	A-13
A-5.2	Examples of Political Successes	A-14
A-5.3	Alternatives to Landfilling	A-15
A-6	Conclusions	A-16
A-7	References	A-17
Appendix A:	Interim Export Vendor Profiles	A-19
Appendix B:	DOS Long-term Export Plan Details	A-22
Appendix C:	Political Successes in Waste Management (Visy Paper, Staten Island, NY; OCRRA, Onondaga, NY; SEMASS RRF, Rochester, MA; SWA, West Palm Beach, FL)	A-26

List of Tables

Table A-1	Interim Export Vendor Profile	A-20
Table A-2	Proposed Long-Term Plan	A-23
Table A-3	Proposed Long-Term Plan: Estimated Annual Costs for Waste Transfer, Transportation and Disposal by Watershed & Facility Type	A-24
Table A-4	New Plan Milestones	A-25

List of Figures

Figure A-1	Annual Phase-Down of Fresh Kills Landfill	A-3
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A-1 Introduction

New York City's 8 million residents and countless number of businesses and construction projects in the five boroughs of Manhattan, Brooklyn, Bronx, Queens and Staten Island generate as much as 36,200 tons of municipal solid waste per day (tpd)¹. The city's Department of Sanitation (DOS) is responsible for nearly 13,000 tpd of waste generated by residents, public agencies and non-profit corporations, while the remainder of the waste is handled by private carting companies². For the last fifty-three years, DOS has relied on the Fresh Kills Landfill for waste disposal, but by April 2001, the city's only landfill closed its scales for good³. In response, the City Council has adopted a twenty-year plan for the exportation of DOS-managed waste as the exclusive waste disposal option which has since been approved by the New York State Department of Environmental Conservation. This report shows that this plan leaves the city vulnerable to a wide range of political and market developments which could lead to drastic cost increases, environmental problems, and other challenges. While the city's current approach successfully dealt with the immediate problem of closing Fresh Kills, it does not adequately address the broader, long-term implications of that closure. In 1946 Fresh Kills was identified as a temporary response to a New York City waste crisis. Fifty-five years later, that "temporary" solution is a nuisance to residents and waterways. In order to avoid a similar waste crisis in the future, the city must begin the long process of developing an efficient, environmentally-sound, locally-controlled waste infrastructure.

A-2 The Fresh Kills Landfill

A-2.1 The Birth of Fresh Kills

New York City disposed of its waste in the Atlantic Ocean until 1935 when a federal lawsuit brought by a coalition of New Jersey coastal cities forced the city to end ocean dumping. With plans for new incinerators slowed by the Great Depression and World War II, the city struggled to secure an adequate waste disposal option. What resulted was a piecemeal plan for doing away with the city's waste. Fresh Kills was proposed as early as 1938, but due to public outrage the plan was retracted. Many alternative dumping sites were used sporadically during the next years with no real planning for a permanent solution.

Fresh Kills was born out of political maneuvering as a "temporary" solution to the waste management question. Cornelius Hall, Staten Island's Borough President, wanted an ocean front highway through the Fresh Kills meadow. Hall believed that garbage could be an inexpensive method for filling in the meadow making the highway possible. He proposed the idea to Robert Moses, City Planning Commissioner, and a series of back room negotiations began between the two starting in 1943. When word of the proposed site leaked to the public early in 1946, Staten Islanders staged the biggest protest ever at City Hall.

In 1947, Fresh Kills first opened. To placate the public, Robert Moses promised that Fresh Kills was to only be a "clean fill" and was to remain open for only three years. During this time the city was to build one new incinerator in each of the five boroughs. The time of closure was extended an additional four years, but it wasn't until 1961 that the five incinerators were finally finished. Meanwhile, six other incinerators throughout the city had closed, and the total increase in incinerator capacity was only 3,000 tpd. The talk of Fresh Kills as a "temporary" landfill ceased, and by the 1960's, only one-third of the city's trash was burned in over 17,000 apartment

¹ Department of Sanitation, City of New York. *Comprehensive Solid Waste Management Plan, Draft Modification* (May 2000), Table 2.1-1 & Appendix 1.2-2 "RFEI".

² Department of Sanitation, City of New York. *Comprehensive Solid Waste Management Plan, Draft Modification* (May 2000), Figure 2.1-1.

³ Fresh Kills later began receiving debris from the World Trade Center Site following September 11, 2001.

building incinerators and 22 municipal incinerators⁴, while more than half of the rest of the city's refuse went to Fresh Kills⁵.

As environmental awareness grew, public pressure began to mount against incineration and landfilling. Old landfills and incinerators were gradually shut down, with the last municipal incinerator closed in 1992. Only Fresh Kills remained, and in conjunction with the DOS-managed waste transfer stations, has since served as the only waste disposal option for the residential and public waste managed by DOS. [Insert Figure 1.2-1 "Location of MTSs and Freshkills Landfill", source DOS Draft EIS, May 2000.]

A-2.2 The Closure of Fresh Kills

In May of 1996 Mayor Giuliani and Governor Pataki announced the closure of Fresh Kills landfill. In an effort to determine how best the city should go about disposing of the nearly 13,000 tons of waste sent to Fresh Kills daily, the Fresh Kills Closure Task Force was established. The principal goal of the task force was to develop a short-term plan for incrementally diverting the waste from Fresh Kills up to its full closure by the end of 2001, while the next goal was to develop a longer-term solution.

The Task Force's solution to the city's short-term needs called for a four-phased waste exportation approach with the goal of reducing the amount of waste going to Fresh Kills to no more than 4,000 tpd by 2000. In each phase, the city issued a Bid Document for the interim export of certain portions of the DOS-managed waste, and a subsequent contract-procurement with a private company. All interim export contracts are limited to three years with two one-year renewal options.

In July 1997, DOS entered into a contract with Waste Management of New York to dispose of 1,750 tpd of Bronx waste as phase one of the interim plans. The contract has twice been reassigned, most recently to Waste Services of New York, and the first of two one-year renewal options has been exercised. Pursuant to phase two of the interim export plans, DOS entered into a contract with Waste Management of New York in October 1998 to deliver 2,500 tpd of DOS-managed Brooklyn waste to two Brooklyn transfer facilities. This contract is still valid under the original agreement, and the waste is currently exported to landfills in Virginia and Ohio. Phase three of the plan resulted in three contracts between DOS and private haulers. The first contract was awarded to TransRiver Marketing in October 1999, for the interim export of 1700 tpd of Manhattan waste to a facility in Newark, New Jersey. Most of it is combusted at a Waste-to-Energy facility in Essex, New Jersey. A second contract was awarded to Solid Waste Transfer & Recycling in November of the same year for the disposal of 200 tpd of Manhattan and Staten Island waste in Pennsylvania and New Jersey. The last contract was awarded to Waste Management of New Jersey in November 1999 for the disposal of 1,260 tpd of Manhattan and Staten Island waste in Pennsylvania. For the fourth and final phase, although the city may enter into further contracts as needed, DOS entered into three contracts in September 2000 for the disposal of 1,600 tpd of Brooklyn waste and the procurement of an additional 750 tpd of redundant capacity. IESI NY Corp. will dispose of the 1,600 tpd of waste through two transfer stations in Brooklyn. The waste will eventually end up in Pennsylvania landfills. The redundant capacity has been procured in equal proportions with Solid Waste Transfer and Recycling and Waste Management of New Jersey through transfer facilities located in New Jersey⁶. Appendix A includes a "Vendor Profile" of the interim contracts with private carting vendors, entered into by New York City pursuant to the "phased" approach.

In 1996, 12,668 tpd of DOS-managed waste was sent to Fresh Kills, with a city-wide DOS-managed waste diversion rate of 12.6 percent. By the end of 1999, the city exceeded its expectations by limiting the amount of waste going

⁴ McCrory, John. "New York City The First Regional Government Still Cries for Planning The Case of Waste Management." *Planners Network Online*, No. 128 (March/April 1998).

⁵ Miller, Benjamin. *Fat of the Land* (2000). Four Walls Eight Windows, New York, New York.

⁶ Department of Sanitation, City of New York, Bureau of Planning and Budget. *Export Vendor Profile & Export Contract Management Unit Registered Contracts* (see Appendix A).

to Fresh Kills to 5,000 tpd, instead of the projected 6,500 tpd, and the waste diversion rate was 18 percent.^{7,8} By February 5, 2001, New York City entered into seven contracts to dispose of the remaining waste being sent to Fresh Kills. The last barge to Fresh Kills carrying municipal solid waste left the marine transfer station shortly after March 19, 2001.

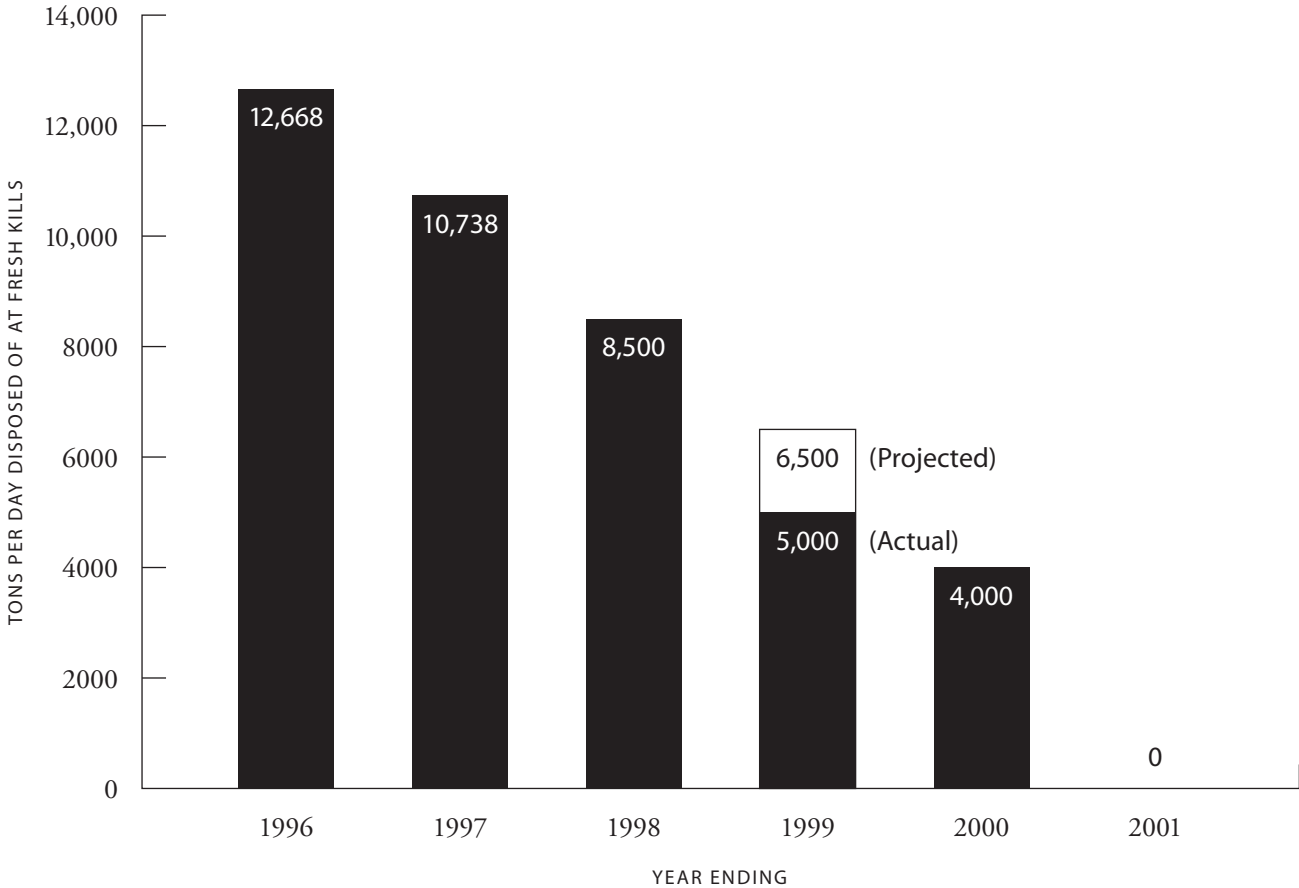


Fig. A-1 “Annual Phase-Down of Fresh Kills Landfill”, source DOS SWMP May 2000

A-3 The City’s Plan for Waste Export

The city’s current plan to deal with a post Fresh Kills world is described in detail the DOS 2000 Comprehensive Solid Waste Management Plan Draft Modification (2000 SWMP). This amended a previously published 1992 Solid Waste Management Plan which called for an extension of the city’s curbside recycling program, gradually

⁷ Department of Sanitation, City of New York. *The DOS Report Closing the Fresh Kills Landfill* (February 2000), Figure 3, p. 2.
⁸ Department of Sanitation, City of New York. *2001 and Beyond: A Proposed Plan for Replacing the Fresh Kills Landfill* (December 1998), p. 1.

reducing the city's reliance on two-outdated municipal incinerators, the construction of a state-of-the-art incinerator in the Brooklyn Navy Yard, and a rehabilitation and upgrade of the Southwest Brooklyn incinerator. A 1996 amendment to this plan called for even further expansion of the city's recycling program and a more extensive environmental review of the Brooklyn Navy Yard and Southwest Brooklyn incinerators. Along with the closure of Fresh Kills, Mayor Giuliani also announced a ban on new landfills and incinerators within New York City. As a result of this dramatic shift in policy, DOS published the 2000 SWMP. A large portion of the plan focuses on waste exportation as a permanent solution for disposing of New York City's DOS-managed municipal solid waste.

A-3.1 The Long Distance Solution

The overall strategy of the "long-term" plan is to develop an environmentally and socially sound solution. DOS believes that waste exportation by rail and barge offers the solution that will limit the amount of environmental impacts caused by new waste management facilities and air pollution, while providing the city with a cost-effective and politically-just disposal alternative.

One key to the DOS strategy has been the development of a "borough-based approach", by which each borough will export only residential waste generated within its borders. Community groups have worked hard to equally distribute the city's waste burden, and DOS has sought to allay their concerns. Critics, however, feel that the Plan's failure to consider commercially-generated waste will do little to counteract the environmental injustice caused by the high concentration of privately managed facilities in Brooklyn and Queens.

Furthermore, DOS believes the reuse of existing DOS waste transfer facilities and the construction of new containerization facilities for waste exportation via rail and barge will limit environmental damage. Earlier proposals considered retrofitting existing DOS waste transfer stations, but studies found that such an action would decrease the efficiency and existing capacity. By locating new and in some cases retrofitting existing, facilities for barge and rail waste exportation, DOS hopes to limit the amount of air pollution caused by diesel trucks and fairly distribute the waste burden of each community. Again, opponents to the plan argue that private carting companies still account for the majority of truck traffic, and the best alternative is to promote cleaner fuel technologies.⁹ Even with this criticism, DOS determined that waste exportation is the superior alternative. As demonstrated in the following section, however, a number of political challenges, market changes, and environmental impacts could place New York City in an extremely vulnerable position if reliant solely on waste exportation.

Although at the time this report was written none of the long-term contracts had been entered into, under the proposed long-term export plan, the city would undertake the following actions:

- For the 950 tpd of DOS-managed waste formerly delivered to the Southwest Brooklyn Marine Transfer Facility (MTS), the Department will develop a truck to container to barge transfer facility. This facility will replace the Southwest Brooklyn MTS, and will result in the demolition of the old incinerator. The facility will be owned by DOS, but most likely will be managed by the private carting company exporting the waste.
- For 990 tpd of DOS-managed Brooklyn waste formerly delivered to the Greenpoint Brooklyn MTS, the city will contract with a private carting company to convert the MTS into a truck to container to barge transfer facility, or develop a truck to container to barge or railroad transfer facility on a site proximate to the Greenpoint MTS, adjacent to the Brooklyn Shoreline of Newtown Creek. If the Greenpoint retrofit

⁹ See the comments in Chapter 26 of the Final Environmental Impact Statement for the Comprehensive Solid Waste Management Plan, prepared for the DOS.

proceeds, DOS will act as a long-term lessor to the respective private carting company.

- For the 1,080 tpd of DOS-managed waste from Queens formerly delivered to the Greenpoint MTS, the city will contract with a private company for waste exportation via a truck to container to barge or railroad transfer facility developed on a site adjacent to the Queens shoreline of Newtown Creek. The waste sheds were designated in the approval process of the Solid Waste Management plan put forth to the City Council, however, further approval may be needed.
- For the 1,900 tpd of DOS-managed waste from Bronx, the city will enter into a waste export contract with a private carting company. DOS will most likely favor proposals from companies with an existing truck to container to barge or railroad transfer facility in Bronx, however, a new facility may also be developed.
- For the 1,150 tpd of DOS-managed waste from Staten Island, DOS will develop a truck to container to railroad transfer facility at the Fresh Kills landfill. The facility will be managed and operated by a private company.
- For the 2,390 tpd of DOS-managed Manhattan waste formerly delivered to three MTSs, the remaining 1,860 tpd of DOS-managed waste from Brooklyn formerly delivered to the Hamilton Avenue MTS, and the remaining 2,180 tpd of DOS-managed Queens waste formerly delivered to the North Shore MTS, the city will enter into a contract with Browning Ferris Industries for the development and operation of an Enclosed Barge Unloading Facility (EBUF), capable of handling up to 10,000 tpd, to be located in Linden, NJ. Waste will most likely be exported to Georgia and South Carolina.

The terms of all contracts will be 20 years, with 2-5 year extensions at DOS' option. DOS plans to pay the private haulers a monthly fee to cover fixed cost, and per ton of municipal solid waste delivered. Since all of the fixed costs will be covered regardless of how much waste is delivered, there will be no minimum tonnage requirements. The average annual cost to the city was estimated at \$323 million¹⁰; but a recent article reported that the city's annual bill for collecting and disposing residential trash has jumped to about \$658 million¹¹.

For the truck to container to barge or railroad facilities in Brooklyn, Queens and the Bronx, the city anticipates waste exportation to begin no sooner than Fiscal Year 2002, and no later than Fiscal Year 2004. The city anticipates that the Brooklyn (Southwest) truck to container to barge facility will begin receiving waste in Fiscal year 2003, and the Staten Island truck to container to barge or railroad facility by Fiscal Year 2002. The Linden EBUF will probably not begin receiving waste before Fiscal Year 2004. Except for on-going negotiations with Browning Ferris Industries, DOS had just begun the process of requesting contract proposals by the end of 2000. Given the events of September 11, 2001, however, these schedules may be pushed back considerably. Appendix B includes detailed information on the estimated costs, facility locations, and estimated time-line for the DOS long-term plan.

A-4 Ramifications of the 20-Year Plan

Many cities around the nation are confronted with similar waste disposal constraints, ultimately leading to waste exportation regionally, statewide, and in many cases, out-of-state. This report does not address the reasonableness

¹⁰ Department of Sanitation, City of New York. *Comprehensive Solid Waste Management Plan Draft Modification* (November 2000), p. 131.

¹¹ Eric Lipton. "City Begins Its Last Phase In Closing Out Fresh Kills Site." *The New York Times*, Metro Section, B1 (February 5, 2001).

of New York City's exportation of waste over the short-term. It focuses instead on the potential issues that could arise in the future and that require government attention now. For example, rising landfill and transportation costs, restrictions on the interstate movement of waste, and further consolidation of the waste industry, to name a few, are all potential problems that over the next twenty years make an indefinite commitment to waste exportation an unsound policy for the city of New York.

A-4.1 Political Considerations

With less local control over the city's waste, New York will be increasingly vulnerable to political decisions from within and outside the State, to the demands of private carting companies exerting the greatest dominance over the industry, and to unforeseen events such as those that took place on September 11, 2001 which could lead to sharp increases in disposal demand and disruptions in transportation links. Three political challenges, in particular, could lead to higher disposal costs and a limit on the city's growth: federal regulation of interstate waste trade and new landfills, further consolidation of the private carting industry, and local resistance to the siting of future waste facilities.

Government Regulation

As landfill space continues to diminish and political pressure from communities opposed to waste importation builds, it is possible (though not likely) that Congress could allow states to impose restrictions on the interstate flow of municipal waste. Similarly, stricter regulations on new landfills by federal and state Environmental Protection Agencies could increase the cost of new landfills and limit future landfill capacity.

Gauging future contracts by those already entered into, nearly all, if not all, of the city's waste will be exported out of the state. With only 28 landfills operating in the state of New York, down from 300 in 1986¹² and less than 10 years of remaining landfill capacity¹³ it seems unlikely that reliance on out-of-state facilities will diminish twenty years into the future. Restrictions on the interstate flow of waste and construction of new landfills could drastically alter the price of landfill disposal and waste exportation for the city of New York, and may even leave the city without adequate space to deposit its municipal waste. Without a locally controlled waste management infrastructure, New York City could face a substantial limit on the city's economic growth, and may even face a major crisis.

There are currently two bills in the U.S. Senate that would amend the Solid Waste Disposal Act to authorize local governments, state governments, and governors to restrict or prohibit the receipt of out-of-state municipal solid waste. One bill was introduced by Senator Robb from Virginia and the other was introduced by Senator Voinovich from Ohio who sits on the Committee on Environment and Public Works. Both are from states that currently receive New York City waste. Furthermore, Congressman Paul E. Kanjorski of Pennsylvania, one of New York's largest waste importers, just recently reintroduced his Solid Waste Compact Act, H.R. 667 limiting out of state trash imports. While the passage of these bills is far from certain, over the next twenty years and beyond it is at least possible that similar bills may be enacted. While the likelihood of enactment appears low, were such legislation to pass it could lead to a real crisis for New York City.

Even without authority from the Federal government, indirect actions can be taken by States to disrupt the flow of waste through their borders. A recent New York Times article entitled, "Crackdown on Trucks Leaves Piles of Trash in New York," described how repeated truck inspections by Pennsylvania authorities, and in some cases

¹² Aquino, John. "A Down-to-Earth Look at Landfill Markets." *Waste Age* (June 2000), 57.

¹³ Repa, Edward. "Landfill Capacity: How Much is Left in the United States." *NSWMA Research Bulletin 00-4* (October 2000), Table 1.

the side lining of garbage trucks for safety violations, caused serious disruptions in New York City¹⁴. With nearly 34 percent of the trucks inspected ordered off the road, waste transfer stations in New York City filled to capacity and garbage stacked up in the street in front of commercial establishments. No one questions Pennsylvania's interest in ensuring the safety of trucks on its highways, but the actions undertaken by the state highlights New York City's potential vulnerability to the actions of out-of-state authorities.

Private Waste Industry Consolidation

The private waste carting industry has just recently emerged from a period of mergers and acquisitions leaving only a handful of companies with the national reach needed to handle the exportation of New York City waste. Furthermore, these companies are beginning to lobby with the same voice. During the month of January, three companies controlling a quarter of the total New York City commercial waste market, Waste Management Inc. of Houston, Allied Waste Industries of Scottsdale, Ariz, and IESI Corporation of Hamilton City Texas, threatened to pull out of the market if the city does not raise the price cap imposed by the City Waste Trade Commission. According to company representatives, they would have to increase the price per ton by nearly 150 percent just to break even¹⁵.

The same three companies that exert pressure in the commercial sector also account for over 50 percent of the interim, non-redundant residential contracts measured by tons per day.¹⁶ Waste Management Inc. and its subsidiaries, alone, account for over 35 percent. Whether provisions in the long-term contracts allow price adjustments under certain circumstances such as legislative and technological changes, or simply renegotiating contracts in twenty years, if New York City has no options other than waste exportation, the city will be at a competitive disadvantage when bargaining against a consolidated private waste carting industry. A more flexible local waste infrastructure would help equalize the city's bargaining power.

Reliance on Private Waste Handling Facilities

Meanwhile, dependence on a few private carting companies for the exportation and disposal of the city's DOS-managed waste could lead to a series of political difficulties resulting from the city's shift of management and facilities to these companies and the local communities' discomfort with an impermanent waste management environment. According to the SWMP Draft Modification long-term plan, three of the six local waste facilities will be owned and operated by private companies instead of DOS, handling over 60 percent of the residential waste¹⁷. Assuming that the siting of these facilities is successful in the face of strong local opposition, New York City residents will become accustomed to those new facilities over the twenty-year life of the contracts, as will DOS. Rather than facing political opposition to the siting of new facilities, the city will be more inclined to enter into contracts with the same companies. When the time comes to renegotiate the city's contracts with the private carting companies, the city will be at an economic and political disadvantage.

So long as there is no finality, the five boroughs and numerous community groups will continue to use political pressure to oppose new facilities. Meanwhile, the private companies will have an upper hand in negotiations because they have the added value of controlling the infrastructure already in place. This is most evident in the case of the BFI's Linden, New Jersey EBUF.

Unforeseen Catastrophes

Authorities estimate that as much as 1 million tons of debris will be removed from the World Trade Center site

¹⁴ Eric Lipton. *The New York Times*, Metro Section, B1 (June 16, 2001).

¹⁵ Eric Lipton. "With Mob Gone, Trash Haulers Flex Muscle in City". *The New York Times*, Metro Section, B8 (January 29, 2001).

¹⁶ See Appendix A.

¹⁷ See pages 2-4.

over the next year. State and city officials have reopened Fresh Kills landfill for the sole purpose of receiving this debris. Had the events of September 11 taken place some years into the future, it is quite possible that the landfill would not have been available. The availability of Fresh Kills has dramatically reduced the burden, both logistically and financially, of the clean up effort. In addition, the events of September 11 raise new concerns about the vulnerability of the city's transportation infrastructure to terrorist attacks. An export plan that is heavily reliant on truck and rail transportation would make the impact of any sustained closing of key city tunnels and bridges immediate and dire. These events further underscore the city's need for additional options. While everyone hopes that the act of terrorism was an isolated event, further catastrophes could occur, and the city must have flexibility in coping with their implications.

Conclusion

Fresh Kills has been a source of political contention ever since its creation. Its closure appeased the city's Staten Island constituency, and environmental voices alike. In the short-term, waste exportation is a politically favorable alternative. The borough-based approach ensures that each community will shoulder its own waste burden, and the city will not have to embark on the arduous process of locating a new facility. On the other hand, waste must still be collected and transferred, and the problems associated with its disposal do not simply disappear on a magical barge or train. Some community ultimately becomes the end point, and growing political pressure over the next twenty years may lead to restrictions. The easier political choice today may leave the city unprepared and ill-equipped tomorrow.

A-4.2 Economic Considerations

There are three primary economic concerns regarding the long-term cost of municipal solid waste management costs: consolidation in the private waste management industry, consolidation of available landfill space in the hands of a few large companies, and a national trend of increasing tipping fees. Individually each of these forces and their upward pressure on costs is a concern for any city, however for New York the size of the costs and commensurate risk of cost increases are spectacular and merit careful study and planning.

Consolidation in the Waste Management Industry

Over the past several years the waste management industry has undergone tremendous changes and consolidation. One company, Waste Management Industries, has emerged as the market leader, with over 31 percent of the national municipal solid waste management market. While the industry has not made headlines the way it did in 1998 and 1999, Waste Age's 8th Annual Survey of the top 100 firms in the industry again shows growth rates for the industry leaders that are well above the growth rate for the industry as a whole¹⁸. In order to outpace the overall industry growth rate, the largest firms are either buying smaller companies or simply winning work away from them. Given shareholders' pressure to achieve consistently better numbers, we may yet see more dramatic mergers.

The consolidation of recent years has seen the number of publicly traded companies in the industry dwindle to seven, and significant consolidation of services to those companies. In fact, seven companies were responsible for tipping 58 percent of all average daily tonnage in the United States in 2000, up from around 52 percent in 1998¹⁹. Indeed, the municipal solid waste management business is increasingly likely to suffer from regulatory capture, as the large waste management firms exercise their growing market and financial power to influence pub-

¹⁸ Wolpin, Bill; "The 8th Annual Waste Age 100", Waste Age, September 1, 2001.

¹⁹ Young, Lenore T.; "Solid Waste ABCs—Part 2"; Pollution Control Monthly, Salomon Smith Barney Equity Research, May 29, 2001

lic policy toward their favor. Not only are a handful of companies responsible for more waste overall, there are also fewer companies. Waste Management, which acquired USA waste services and Eastern Environmental in 1998, controls 31.1 percent of the national average daily tonnage; Allied Waste, which acquired American Disposal Services in 1998 and Browning-Ferris Industries (BFI) in 1999, now controls 19 percent of the national market; Republic Services controls 4.7 percent of the national market; and Superior controls 1.3 percent.²⁰ These four companies are all active participants in New York City waste management, and together they account for over half (56.1 percent) of all waste management nationally. IESI should also be mentioned, because it has been growing at a rate of over 150 percent annually for the last five years (largely through acquisition), and it is a large vendor in New York City.

Consolidation in Landfill Ownership

Statistics on industry consolidation are disconcerting when viewed through market share, but they are even more alarming when viewed in-terms of landfill ownership. Roughly three-quarters of all non-recycled municipal waste is disposed of in landfills, and while landfills account for only 35 percent of the aggregate spending on municipal waste, they are the most profitable part of the business, with gross margins sometimes reaching 40 percent²¹

The EPA's Subtitle D regulations for landfill operation and construction have been a large part of changing the economics of landfills. With specific requirements for liners, financial assurance and monitoring and maintenance post-closure, Subtitle D raised the minimum efficient scale for landfills and made ownership and operation difficult for smaller firms and municipalities. Those forces combined with the general trends of consolidation of the industry place an undue amount of market power within a few public traded firms.

In 1996, publicly held firms controlled about 37 percent of the landfill market share and by 2000, the number of public firms had dropped and the percentage of average daily tonnage controlled by them had grown to 58 percent. Control of remaining landfill capacity has also consolidated. While seven publicly held firms now control approximately 61 percent (3.22 billion tons) of available landfill capacity, compared with 31 percent (1.63 billion tons) owned by municipalities, and 8 percent (0.43 billion tons) owned by privately held firms, they have an even larger share of control over the larger, more efficient landfills. Publicly-held companies control 61 percent of the landfills that handle more than 500 tons per day, and have even more control over newer and more cost effective "mega-landfills" which can handle more than 3,500 tons per day. In 1996, there were only 21 mega landfills in the country and today there are 40. Of the 40 mega-landfills, publicly held firms control 31, and over 77 percent of the market²² For New York City the implications are clear. Generating 13,000 tons per day of waste, New York will rely heavily on larger landfills to dispose of the city's waste, and those landfills are run by a handful of companies.

Legislation in Pennsylvania and Virginia could also adversely affect the landfill market. Pennsylvania and Virginia import a significant amount of garbage from throughout the Northeast, including substantial amounts from New York. Pennsylvania is the country's largest importer of waste, bringing in 9.8 millions tons of waste, while Virginia was second with 3.9 million tons²³ To date, attempts at flow control and legislation to prevent interstate movement of MSW have been unsuccessful, but both Virginia and Pennsylvania are contemplating local legislation that would make it harder to build and expand landfills. This kind of regulation could certainly raise the cost of building and operating landfills, likely reducing the amount of capacity available, and forcing prices up. While there is no clear plan or even immediate threat, New York City's exposure to this kind of regulation warrants consideration of long-term alternatives.

²⁰ Ibid.

²¹ Young, Lenore T.; "Solid Waste ABCs—Part 1"; Pollution Control Monthly, Salomon Smith Barney Equity Research, March 30, 2001

²² Ibid.

²³ Duff, Susanna; "Interstate Waste Keeps Crossing the Lines", Waste News, August 6, 2001

Tipping Fees

Over the past several decades tipping fees at landfills have been rising steadily. Tightening environmental standards and new requirements for monitoring and maintenance post closure have substantially raised the cost per ton of managing a landfill. Between 1985 and 1998 the average tipping fee in the United States rose \$23.61 a ton, an average of 7 percent annually and nearly a 300 percent total increase.²⁴ Nationally that trend has largely stabilized prices today are roughly equivalent to what they were in 1995 but in the Northeast the problem of increasing tipping fees is becoming especially acute.

According to the National Solid Waste Management Association, the average national tipping fee in 2000 was \$32.19 per ton, roughly equivalent to the costs in 1995. But over the past two years, tipping fees in the Northeast rose by almost 5 percent (\$3.14) to a national high of \$69.84. This can be directly related to a shortage of capacity. Nationally, the United States has nearly 18 years of landfill capacity available, up from 10 a few years ago, but in the Northeast several states (New York, Vermont, and Massachusetts) have less than ten years of landfill capacity. Furthermore, New York and New Jersey together exported nearly 6.2 million tons of garbage²⁵ The closure of Fresh Kills will add another 4.7 million tons to this total. All this combines to create a market where tipping fees are over twice the national average and rising.

Planned Annual Expenditures and Available Capital

A quick examination of the expenses New York City has budgeted for the next twenty years shows that using very conservative numbers, New York City could finance a substantial amount of capital investment, and may be able to better control its own costs over the long term. In order to provide some guidance on the city's capacity to finance its own infrastructure, we have developed some rudimentary calculations based on common assumptions and national trends.

If we assume constant MSW generation rate of 13,000 tons per day, and constant cost disposal fees of \$95.00 per ton, (per the Department of Sanitation's estimate) New York City plans to spend roughly 450 million dollars a year on waste removal and disposal. Approximately 55 percent of the money spent nationally on waste removal is spent in the collection of waste²⁶; so we have assumed that only 45 percent of New York City's planned expenditures of roughly 200 million dollars is available for capital investment. Using an interest rate of 4.5 percent (current yield-to-maturities of New York City's long-term debt are around 4.2 percent) the present value of 20 years of planned capital expenditure is around 2.7 billion dollars.

2.7 billion dollars translates to roughly 28 dollars a ton today for the estimated 95 million tons of municipal solid waste that will be generated over the next 20 years. Current estimates of construction costs for smaller (500 tpd) and generally less efficient landfills are around \$25-\$30 a ton of capacity, while the cost of building a million ton-per year waste-to-energy facility is roughly 400 million dollars. The comparison is important because it implies that exporting waste is not necessarily the lowest cost option for New York. In fact, the city has the financial wherewithal to build sufficient landfill capacity to meet its need over the next twenty years, or to easily build the five million tons per year of waste to energy capacity required to dispose of all of New York City's municipal solid waste. This can be done without raising projected costs and may eliminate a substantial portion of the risk associated with contracting to third-party providers such as unplanned increases in export fees, provider default, inadequate service, and national legislation hampering the free movement of municipal solid waste.

These back-of-the-envelope calculations are by no means complete, and should not be construed as advocating substantial capital investment by the city. Instead, these calculations merely highlight the need to more carefully examine all of the options available to the city, and to more closely analyze the true cost of long-term contracts.

²⁴ Repa, Edward, W.; "The Tip Off", *Waste Age*, May 1, 2001

²⁵ *Ibid.*

²⁶ Young, Lenore, T.; "Solid Waste ABCs—art 1"; *Pollution Control Monthly*, Salomon Smith Barney Equity Research, March 30, 2001

Conclusion

New York City is becoming a large customer in a market with very high and rising costs. The increasing consolidation of market power in a handful of publicly held companies is bound to drive up costs throughout the waste management system. Given the amount of money that New York City has budgeted to spend on waste collection and disposal over the next twenty years, it is imperative that New York take a comprehensive look at all of the waste management options available.

A-4.3 Environmental Considerations

While any solid waste management proposal would present serious environmental considerations, there are certain considerations that arise which are either inherent to waste exportation practices or are exacerbated by them. They include environmental consequences due to longer distances traveled, an increased risk of environmental calamity, and increased tension with recycling efforts.

Consequences of Longer Distances Traveled

Transporting solid waste long distances will require extensive use of truck, rail or barge or some combination thereof. All of these forms of transportation contribute to air pollution, although to varying degrees. The more miles traveled, the more fuel consumed. Fuel consumption is directly related to both air quality and greenhouse gas (GHG) emissions. In fact, fuel combustion is currently the largest contributor to air-pollution²⁷. Trucks, trains, and barges emit a wide variety of air pollutants when they are operated, including criteria and related pollutants, toxic pollutants, and chlorofluorocarbons (CFCs), among others. These contribute to ill health, acid deposition, smog, stratospheric ozone depletion, and climate change²⁸. Inland water transport, considered to be the most fuel efficient of the options, requires 3.15 gallons of fuel per 1,000 ton-miles of freight; rail freight requires 4.21 gallons or 33 percent more than barges²⁹; and truck freight requires 8.33 gallons, or 164 percent more than barges. Whereas inland water transport used to make up the majority of transportation during the years of Fresh Kills, the vast majority of waste will now be delivered via railroad.

New legislation placing greater restrictions and/or costs on fuel consumption is possible especially in light of the reports released in February by the Intergovernmental Panel on Climate Change (IPCC)³⁰; reaffirming in more certain and imminent terms than ever before the effects of global warming. Carbon dioxide is the greatest contributor to global warming, accounting for 76 percent of the predicted increase³¹; and burning one gallon of gasoline generates 22 pounds of carbon dioxide³². Every extra mile traveled means more gallons of fuel burned, which ultimately means more pounds of greenhouse gasses added to our atmosphere. If restrictions on carbon dioxide emissions are enacted over the next twenty years, the cost of long distance transportation could increase dramatically.

There are other negative by-products that are magnified with long-distances travel. The more miles traveled, the greater the congestion on roads, rails and waterways. Increased congestion leads to greater noise pollution, visual blight, as well as human frustrations. Additionally, the more miles traveled, the more maintenance is required on the vehicles, regardless of which means of transport is selected. In addition to the obvious costs that increased maintenance entails, there are environmental consequences as well. Parts need to be exchanged more fre-

²⁷ New York State Dept. of Environmental Conservation, Fact Sheet Motor Vehicle Pollution, <<http://www.dec.state.ny.us/website/dar/beim/factsht3.html>>.

²⁸ Bureau of Transportation Statistics, *Transportation Statistics Annual Report – 1999*.

²⁹ U.S. Department of Transportation, Maritime Administration, *Env'tl Advantages of Inland Barge Transportation*, August 1994.

³⁰ IPCC WG2 Third Assessment Report, Draft (19 Feb. 2001), *Summary for Policy Makers Climate Change 2001: Impacts, Adaptation, and Vulnerability*, approved by IPCC Working Group II in Geneva, 13-16 February 2001.

³¹ Environmental Defense Fund, *Global Warming is Happening, Sources of Greenhouse Gasses (1997)* <<http://www.enviroweb.org/edf/ishappening/sources/index.html>>

³² Id. at <http://www.enviroweb.org/edf/ishappening/sources/sources_co2_facts3.html>

quently, and ultimately vehicles will need to be disposed of more frequently. All this leads to a greater production of waste at a more rapid rate. Longer journeys will require more frequent cleaning of the vehicles as well. The wastewater produced from these activities is itself a pollutant that needs to be treated.

Increased Risk of Calamity

Increasing the number of miles traveled also has the negative consequence of increasing the risk of calamity en route. Trucking the waste would clearly be the most troublesome choice. Not only do trucks have the most inefficient use of fuel as discussed above, but the rates of accidents with large trucks are astounding. According to a Department of Transportation study there were an estimated 453,000 accidents involving large trucks, causing 5,362 deaths and 142,000 injuries in 1999 alone. The report totaled the cost of these accidents at over \$24 billion³³. Accidents involving barge or rail, while less frequent, could be far more catastrophic. The Coast Guard in a study found there were 9,000 oil spills a year on average between 1993 through 1999³⁴. While oil spills present their own unique set of environmental harms, absent for the most part in the context of solid waste, the figure does give an idea as to number of potential accidents. Rail cars are even more susceptible to accidents than barges. Because shipments generally involve a large number of massive units traveling at high speeds and in a single line, if an accident occurs it usually results in multiple collisions causing severe damage³⁵.

Moreover, the cleanup costs involved in such transport accidents can be far higher, in light of the kind of cargo involved. For example, a collision involving a barge could result in solid wastes spilling over potentially ecologically sensitive waters. Household toxic wastes are not regulated any differently from household solid wastes³⁶. Americans generate an average of 1.6 million tons of household hazardous waste a year³⁷. This may include such things as paint, stains, varnish, car batteries, and cleaning solvents. Consequently included in municipal solid waste may be toxic contaminants from such things as cleansing detergents. Additionally, solid waste spills negatively impact global warming as well.

Disincentives to Recycle

It can be argued that in being forced to live with its own trash, the pressure will be greater on New York City to find better and more efficient ways both to recycle as well as to reduce the production of wastes. So long as everything is being shipped far from home the incentives are not present to cut back and to streamline. There is much truth to the old adage "Out of sight, out of mind." If New York City were forced to contend with its own waste on a permanent basis, spatial as well as clean-environment considerations would put pressure on the city as well as its citizens to curb their waste production and to recycle what waste is produced. Currently New York City recycling rates lag far behind most of the other major cities in this country. New York City, according to a recent study of the recycling program of the 30 largest municipalities, recycles at a rate of 18.2 percent, as opposed to 35.2 percent in Philadelphia, 44 percent in Los Angeles, 47.3 percent in Chicago, 42.3 percent in San Diego, and 30 percent in San Antonio, for example³⁸. The over-all national recycling rate in 1998 was 28.2 percent according to the EPA³⁹, and while more recent reports issued by DOS show an increase in the recycling rate to just over 20 percent, the national average is still far above New York City's rate.

³³ Sandy Smith, "Taking a Toll on Trucking Accidents," Feb. 13, 2001 <<http://www.solidwaste.com/content/news/article>>

³⁴ U.S. Coast Guards, Pollution Incidents in and Around U.S. Waters A Spill Release Compendium: 1969-1999.

³⁵ See, *supra* n. 3.

³⁶ See Solid Waste Disposal Act, 42 U.S.C. § 6921(i) for the household waste exclusion from identification of hazardous wastes.

³⁷ EPA Office of Solid Waste, Household Hazardous Waste Steps to Safe Management, <<http://www.epa.gov/epaoswer/non-hw/household/hhw.htm>> (last updated Oct. 12, 1999).

³⁸ Waste News, Municipal Recycling Survey, Feb 19, 2000 <<http://www.wastenews.com/rankings/mrs.html>>.

³⁹ EPA, Environmental Fact Sheet, Municipal Solid Waste Generation, Recycling and Disposal in the United States: Facts and Figures for 1998.

Conclusion

Any waste disposal option has environmental consequences. All facilities require local approval for siting, and rarely are people easily convinced that a waste facility is in their best interest. Even long distance transport, however, requires the siting of facilities, and increased distances traveled create a unique set of environmental issues above and beyond the siting of a facility. Long distance travel leads to increased disposal costs from fossil fuel consumption and calamity insurance, as well as increased external costs such as air pollution and waste spills. With further government regulation, these externalities could some day increase disposal costs as well.

A-5 No Time to Waste—Beginning the Process

While the current plan to export the city's waste out-of-state seems on the surface like a good short-term strategy for handling the enormous amount of DOS-managed waste generated daily, this report shows that there are varied and profound reasons why the city cannot do so indefinitely. For many, thinking twenty years into the future is unreasonable. However, if history has taught New York City anything, it is that planning the type of infrastructure needed requires at least as much time. As described in the section entitled "The Birth of Fresh Kills," the landfill's creation was haphazard and its permanence unintended. Today Fresh Kills accounts for 5.7 percent of all daily U.S. methane emissions (see Part B, Section 14.2), and the City estimates that the cost of closing the landfill will be in excess of \$1.1 billion over thirty years, of which only \$75 million has been earmarked from the State.⁴⁰ In order to avoid a similar situation ten to twenty years from now, New York City must begin developing a locally controlled alternative today.

The creation of large-scale infrastructure can take decades to develop properly. Forty-seven years ago, New York City recognized the need for a third water tunnel to meet the growing demand on the more than 150-year old water supply system. Planning for City Tunnel No. 3 began in the early 1960s, but the project will not be completed until 2020. While the development of an environmentally-sound, cost-effective, and stable waste infrastructure should not take sixty years, experience shows that the process certainly takes time, something New York City may be short of. No one option is clearly desirable, and public reaction is often fierce to siting efforts. While this report does not recommend any particular option, it does argue for thinking creatively and with a long-term perspective whether dealing with creating sites in New York City or elsewhere. The following section describes various approaches to the siting of facilities. No matter which approach the city ultimately chooses or how much resistance there is in the local community at first, political opposition need not stifle innovation.

A-5.1 Different Approaches

Community opposition is the primary obstacle to the siting and development of waste management facilities. Opposition is routinely focused on the argument, "not in my backyard," or NIMBY. These beliefs are often fueled by historical inequity in facility siting tending to place a disproportionate burden on low income communities, and differing risk perceptions and aversions depending on ones proximity to the controversial facility. Regardless of the underlying rationale both the source and solution to NIMBY issues center upon the siting approach undertaken and the political process that ensues. A process that does not provide the community with adequate information in a timely manner, and does not open itself to public involvement, creates suspicion, distrust and opposition.

⁴⁰ NYDOS, Year 2000 Financial Assurance Plan and Cost Estimate Detail (April 2001), p. 3-2.

Recognizing the need to begin the long process of developing a locally-based waste infrastructure, the city's leaders must first choose an appropriate decision-making approach. Three main approaches, regulatory, market and voluntary, are at the center of all political processes requiring community buy-in⁴¹

Any political decision that results from a centralized-decision making process including only government entities and their affiliated independent agencies can be classified as a regulatory approach. In the context of waste management, governing agencies such as DOS and the New York State Department of Environmental Conservation, identify, permit and locate waste facilities, and create waste management strategies. Often this approach involves the use of tactics and legal tools such as preemption and eminent domain, and at times may be facilitated by state legislation waiving local approval. Top-down regulation and decision-making require the least amount of consensus-building and public support, making the process less burdensome at the outset; however, public distrust in government and the decisions may lead to strong opposition even if the project is ultimately found to be in the community's best interests. In today's legal climate, well-organized community opposition can easily lead to political failure.

In contrast to the regulatory approach, decisions under a market approach are resolved through private contracts between companies, individuals and communities. The government's role is typically confined to oversight, and market participants often attempt to garner community support for their actions through economic compensation (from NIMBY to YIMBY/FAP- Yes in My Backyard for a Price). Compensation can be direct, i.e. profit-sharing, employment, electrical energy provision or free garbage services, or it can be indirect, i.e., support for community initiatives like swimming pools, roads and schools. This approach runs into problems, however, when individuals in the community have competing interests. The more diverse the interests, and the higher the costs of mediating between the parties, the less seamless a purely market-driven approach will be.

Instead of using the market or a regulatory agency to locate a site and identify the appropriate technology, a request for proposals can be extended to communities throughout the region. This type of voluntary approach presents community stakeholders with an opportunity to tailor a solution that is most compatible with the host's interests. While this approach may lead to greater acceptance by the community, it does not ensure that the technology or site will be an economically or technically viable solution. Instead of inviting proposals from various communities, cities may choose to lead and tailor public debate among particular groups to help devise the appropriate plan. This type of voluntary approach fosters community input and trust in the regulatory state, however, competing interests can often lead to wrangling and stagnation.

The three approaches laid out above, are merely the primary components of a diverse palate of possible courses of action the city could take in developing a solution to the city's waste management needs. Often it is a combination of approaches that works best. The strength of the market lies in its ability to identify the most economically efficient solution, while tying the economic and employment benefits of the project into the community. The state, however, must ensure that market failures common to waste management facilities, namely externalities and misinformation, are addressed through regulation and permitting. Even with economic incentives and regulatory safeguards, projects ultimately need community support. This community support can only be achieved by fostering public participation.

In the end, there is no cookbook recipe for choosing the appropriate political process and approach. Different approaches work in different locations, and many factors must be weighed including population and population density, land availability, zoning, and the political sophistication of the surrounding communities. Whichever combination of approaches the city chooses, the process of developing a locally-based waste infrastructure will be a long and difficult process that will need strong political leadership and community involvement. To guide the process, the following section summarized four examples of siting successes both in the city of New York and

⁴¹ Rabe, Barry. *Beyond NIMBY: Hazardous Waste Siting in Canada and the United States* (1994). The Brookings Institution, Washington, DC.

around the nation.

A-5.2 Examples of Political Successes

Appendix A-C provides four case studies from both within and outside of the State of New York in which waste management facilities were successfully located. The studies are not meant to present a full universe of political strategies or technical alternatives. Rather, they are meant to show that while the necessary process for the city may be difficult, it is far from impossible.

In 1996, Visy paper mill opened in Staten Island, New York. The mill converts recycled waste paper into forms of cardboard used for packaging liners and boxes. The siting of the mill was unique because rather than viewing the recycling plant as a waste management facility, the city saw the mill as a vessel for economic development and job growth. Indeed, the city's Mayor used the New York City Economic Development Corporation to actively pursue Visy, and its classification as a manufacturing facility rather than a waste handling facility subjected it to a very different regulatory process.

Onondaga County in New York is worth highlighting both for its facilities and approach to siting. Facing stiff opposition from concerned citizens, government officials recognized that the only feasible course of action was to abandon its centralized regulatory approach for a more community-based approach that included financial incentives to host communities. After almost two decades of wrangling with the community, the county created an independent citizen-based agency to deal with its solid waste problem, and in 1989 the Onondaga County Resource Recovery Agency (OCRRA) was approved. Over ten years later, the county manages its municipal solid waste through an integrated approach including recycling, composting, landfilling, and a waste-to-energy facility.

The history behind the SEMASS waste-to-energy plant in Rochester, Massachusetts offers an example of a market-driven approach to facility siting. In the late 1970's Energy Answers Corporation approached the officials in Rochester about located a waste-to-energy facility within the town limits. As an incentive, the company agreed to provide free waste disposal services to the town and one dollar for every ton of waste received by the facility (with annual increases based on the consumer price index). Through a democratic procedure the town agreed, and today SEMASS processes nearly 1 million tons of municipal solid waste annually. Those towns, cities, and counties with the foresight to enter into long-term contracts early on pay roughly \$18 per ton compared to present tipping fees of almost \$75 per ton.

Lastly, Palm Beach County's experience offers an example of how a government-initiated approach can successfully lead to an innovative integrated waste management facility through partnerships with both government and private contractors. After its creation by municipal and county officials in the early 1970's, the Solid Waste Authority of Palm Beach (SWA) slowly began building assets and management experience. Between 1982 and 1989, the SWA generated \$320 million in funds through Resource Recovery Bonds. Today the SWA owns a 1,400 acre site which includes a waste-to-energy facility, two landfills, five transfer stations, a 300 ton per day composting facility, a multi-stream material recovery facility, and a ferrous-metal recovery facility. Daily operations of the waste-to-energy and material recovery facility are contracted out to a private company.

A-5.3 Alternatives to NYC's Present Approach

Part B of this report discusses in detail the technical alternatives to the present plan of New York City to export its municipal solid wastes to other states, principally for landfilling. Environmental and economic aspects of these alternatives are also considered.

A-6 Conclusions

New York City faces perhaps one of its most challenging moments in its history. As the city recovers from the tragic events of September 11, 2001, its leaders must seize the opportunity to shore-up the vital infrastructure upon which the city is built and further strengthen the city's resilience and self-sufficiency. Our capacity to manage the waste created within our city is essential.

As described in this paper, doing nothing would leave the city vulnerable to a wide-variety of economic, political and environmental concerns. The city must not be left at the mercy of political decisions made by governments in other states and members of Congress, or market pressure from the handful of waste management firms equipped to handle a large-scale waste exportation program. Regardless of which type of development process the city wishes to take, the process will take time. Fresh Kills was borne out of crisis, and we must learn from our past mistakes to ensure that the city has an environmentally and economically sound waste infrastructure in place decades into the future. The responsible course of action is to begin a long-term development strategy with the goal of creating a locally-controlled waste management infrastructure that truly works for the 21st Century.

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Va. St. § 10.1-1454.1(E) (2000) "The owner or operator of a ship, barge or other vessel from which there is spillage or loss to state waters of wastes subject to regulations under this article shall immediately report such spillage or loss in accordance with the regulations of the Board and shall immediately take all such actions as may be necessary to contain and remove such wastes from the state waters." See also Va. St. § 10.1-1454.3 (B) for same regulation with trucks.

Waste Management Holdings v. Gilmore, 87 F. Supp 2d 536 (E. D. Va. 2000) (Holding landfill caps and barge use restrictions to be unconstitutional). This case is currently pending on appeal in the Fourth Circuit.

Waste News, *Municipal Recycling Survey*, Feb 19, 2000 <<http://www.wastenews.com/rankings/mrs.html>>.

Appendix A:

Interim Export Vendor Profiles

INTERIM EXPORT VENDOR PROFILE

Phase	Vendor	Contract Number	Expended To Date	Facility Location	Borough Served	Awarded Contract TPD	FY 2001 Cost Per Ton	Term of Contract	Disposal Site/State
I	Republic Services of NY	82799H2456 \$81,252,325	\$43,851,281 7/1/97 – 8/9/00	East 132 nd Street, Bronx	Bronx	1,700	\$54.86 (7/1 – 6/30)	7/1/97 – 6/30/00, plus two one-year renewal options	Atlantic Waste Rail/VA Atlantic Waste/VA Greenridge Reclamation/PA Modern Landfill/PA
II	Waste Management, Inc.	82799G4321 \$133,340,550	\$57,812,275 10/27/98 – 8/9/00	75 Thomas Street, Brooklyn	Brooklyn	1,100	\$58.87 (7/1 – 10/26) \$60.05 (10/27 – 6/30)	10/27/98 – 10/26/01, plus two one-year renewal options	Atlantic Waste/VA Amelia/Maplewood/VA Chambers/Charles City/VA
II	Waste Management, Inc.			215 Varick Avenue, Brooklyn	Brooklyn	1,400	\$58.87 (7/1 – 10/26) \$60.05 (10/27 – 6/30)	10/27/98 – 10/26/01, plus two one-year renewal options	American Waste/OH Atlantic Waste/VA Amelia/Maplewood/VA Chambers/Charles City/VA
III	Solid Waste Transfer & Recycling	82720000012207 \$12,475,620	\$3,189,129 11/8/99 – 8/9/00	442 Frelinghuysen Avenue, Newark, NJ	Manhattan Staten Island	200	\$67.50 (7/1 – 11/7) \$68.85 (11/8 – 6/30)	11/08/99 – 11/07/02, plus two one-year renewal options	American Waste/OH Modern Landfill/PA Southern/PA Warren/NJ Delaware Valley/PA
III	TransRiver Marketing	82720000012148 \$97,229,438	\$16,289,231 10/25/99 – 8/9/00	183 Raymond Boulevard, Newark, NJ	Manhattan	1,700	<301 = \$54.29 301-600 = \$58.62 601-900 = \$62.13 >900 = \$65.88 (7/1 – 10/24) <301 = \$55.38 301-600 = \$59.79 601-900 = \$63.36 >900 = \$67.20 (10/25 – 6/30)	10/25/99 – 10/24/02, plus two one-year renewal options	American Ref-fuel, Essex/NJ
III	Waste Management of NJ	82720000012126 \$72,471,708	\$8771,640 11/8/99 – 8/9/00	864 Julia Street, Elizabeth, NJ	Manhattan Staten Island	625	\$62.24 (7/1 – 11/7) \$63.48 (11/8 – 6/30)	11/08/99 – 11/07/02 plus two one-year renewal options	Grand Central/PA Shade Landfill/PA Southern Alliance/PA Pine Grove/PA
III	Waste Management of NJ			666 Front Street, Elizabeth, NJ	Staten Island	635	\$62.24 (7/1 – 11/7) \$63.48 (11/8 – 6/30)	11/08/99 – 11/07/02 plus two one-year renewal options	Grand Central/PA Shade Landfill/PA Southern Alliance/PA Pine Grove/PA
IV	IESI	82720010005614 \$41,146,443	Contract Registered 9/7/00	577 Court Street, Brooklyn	Brooklyn	650	\$68.50 (9/11 – 6/30)	9/11/00 – 9/10/03 plus two one-year renewal options	Blue Ridge Landfill/PA Bethlehem Landfill/PA
IV	IESI	82720010005609 \$61,015,023	Contract Registered 9/7/00	110 50th Street, Brooklyn	Brooklyn	950	70 (9/11 – 6/30)	9/11/00 – 9/10/03 plus two one-year renewal options	Blue Ridge Landfill/PA Bethlehem Landfill/PA

Phase	Vendor	Contract Number	Expended To Date	Facility Location	Borough Served	Awarded Contract TPD	FY 2001 Cost Per Ton	Term of Contract	Disposal Site/State
IV	Solid Waste Transfer & Recycling	82720010005577 \$22,178,880	Contract Registered 9/7/00	442 Frelinghuysen Avenue, Newark, NJ	Brooklyn	375 (Redundant Capacity)	\$64.00 (9/11 - 6/30)	9/11/00 - 9/10/03 plus two one-year renewal options	Cumberland County Landfill/PA Modern Landfill/PA
IV	Waste Management of NJ	82720010005583 \$22,871,970	Contract Registered 9/8/00	666 Front Street, Elizabeth, NJ	Brooklyn	375 (Redundant Capacity)	\$66.00 (9/11 - 6/30)	9/11/00 - 9/10/03 plus two one-year renewal options	Grand central/PA Shade Landfill/PA Southern Alliance/PA Pine Grove/PA
IV	Tully Environmental, Inc.			127-20 34 th Avenue, Corona, NY	Queens	500	\$83.35 (\$76.41)		
IV	TransRiver Marketing Co., L.P.			American Ref-fuel of Hemstead Resource Recovery Facility Hemstead, NY	Queens	150	\$89.38 (\$79.93)		
IV	ACS Services, Inc.			PenPac Fulton Street Transfer Station Patterson, NJ	Queens	1000	\$93.82 (\$62.72)		
IV	ACS Services, Inc.			PenPac Totowa Transfer Station Totowa, NJ	Queens	480 (Permitted capacity) 558	\$94.27 (\$62.72)		
IV	Waste Management of New York, LLC			Review Avenue Transfer Station Long Island City, NY	Queens		\$95.89 (\$81.00)		
IV	ACS Services, Inc.			Eastern Waste Services Transfer Station Jersey City, NJ	Queens	350	\$110.72 (\$63.19)		
IV	Solid Waste Transfer and Recycling (SWTR)			SWTR Transfer Station Newark, NJ	Queens	1025	(Backup Capacity) (\$64.00)		

NOTE: For the Queens contracts, the figure listed in the "Cost Per Ton" column represents the "Adjusted Bid Price after Transportation Model Adjustment." The Transportation Model utilizes a complex linear/integer program to determine the lowest overall total cost to the City for each ton of Queens-generated MSW. The figure in parenthesis represents the "Original Bid Price."

SOURCE: Department of Sanitation Bureau of Planning and Budget.

Appendix B:

Details of the City's Long-term Plan

TABLE I-1

PROPOSED LONG-TERM PLAN

Boroughs, Marine Transfer Stations and Wastesheds											
Manhattan			The Bronx			Brooklyn			Queens		Staten Island
W. 135 th SL	E. 91 st St.	W. 59 th SL	South Bronx	Hamilton	Southwest	Greenpoint	North Shore	North Shore		N/A	
M9, M10 & M12	M5, M8 & M11	M1 through M4, M6 & M7	Bx1 through Bx12	B7, B6 through B10, B14 & B16 through B18	B11 through B13 & B15	B1, B3 through B5	Q1 through Q6	Q7 through Q14	S1 through S3		
AVG TPD (PEAK TPD)	AVG TPD (PEAK TPD)	AVG TPD (PEAK TPD)	AVG TPD (PEAK TPD)	AVG TPD (PEAK TPD)	AVG TPD (PEAK TPD)	AVG TPD (PEAK TPD)	AVG TPD (PEAK TPD)	AVG TPD (PEAK TPD)	AVG TPD (PEAK TPD)	AVG TPD (PEAK TPD)	Totals
By truck to a TRUCK TO CONTAINER TO BARGE (TCB) TRANSFER STATION to be developed by the Department on the site of the now closed SOUTHWEST BROOKLYN INCINERATOR					950 (1,060)						950 (1,060)
Via a NEW PROCUREMENT: by truck to a TRUCK TO CONTAINER TO BARGE AND/OR RAIL (TCB/R) TRANSFER STATION in BROOKLYN that is likely to be located on a site adjacent to NEWTOWN CREEK and/or					990 (1,140)						990 (1,140)
by truck to a TRUCK TO CONTAINER TO BARGE (TCB) TRANSFER STATION created by converting the GREENPOINT MTS											
Via a NEW PROCUREMENT: by truck to a TRUCK TO CONTAINER TO BARGE AND/OR RAIL (TCB/R) TRANSFER STATION in QUEENS that is likely to be located on a site adjacent to NEWTOWN CREEK							1,080 (1,200)				1,080 (1,200)
Via a NEW PROCUREMENT: by truck to a TRUCK TO CONTAINER TO BARGE AND/OR RAIL (TCB/R) TRANSFER STATION located in the BRONX			1,900 (2,160)								1,900 (2,160)
By truck to a TRUCK TO CONTAINER TO BARGE AND/OR RAIL (TCB/R) TRANSFER STATION to be developed by the Department on a site at the FRESH KILLS LANDFILL										1,150 (1,250)	1,150 (1,250)
Via an MTS/RFP contract award: by barge to a barge to container to rail EBUF to be developed by BROWNING-FERRIS on a site in LINDEN, NEW JERSEY	930 (1,090)	620 (730)	840 (985)	1,860 (2,135)				2,180 (2,430)			6,430 (7,370)

**Table 4.2-1
Proposed Long-Term Plan
Estimated Annual Costs for Waste Transfer, Transportation and Disposal by Wastehed and Facility Type ⁽¹⁾**

	Design Characteristics				Cost ⁽²⁾					
	Facility Type	Design Capacity (tpd)	Throughput (tpd)	Annual Debt Service	MTS	O&M	Transportation	Disposal	Annual Total	
Brooklyn – Southwest MTS Districts 11,12,13 and 15	TCB (harbor)	1150	814	4,905,700		7,204,400	18,621,100	5,585,850	36,317,100	
Brooklyn – Location to be determined	TCB (coastal)	1150	814	5,064,500		7,005,500	5,992,100	5,585,850	23,647,900	
Queens – Location to be determined	TCB (harbor)	1150	844	4,905,700		7,309,300	19,215,000	5,791,700	37,221,700	
	TCB	1150	967	4,905,700		7,717,200	21,622,200	6,635,800	40,880,900	
	TCR	1150	967	4,549,400		9,298,600	11,219,300	6,635,800	31,703,000	
	TR ⁽³⁾	2160	1626	4,369,900		8,717,000	13,973,200	11,158,000	38,218,100	
	TCR	2160	1626	5,572,000		9,896,400	20,654,600	11,158,000	47,281,000	
	TCB (coastal)	2300	1626	6,547,900		9,377,500	11,296,000	11,158,000	38,379,300	
	TCB (harbor)	2300	1626	6,415,300		9,496,200	33,939,300	11,158,000	61,008,800	
	TCR	1150	867	4,549,400		8,981,000	10,148,400	5,949,500	29,628,300	
	TCTR	1150	867	4,694,200		8,196,600	11,587,900	5,949,500	30,428,300	
	TCTB (coastal)	1150	867	2,889,700		4,781,300	14,120,700	5,949,500	27,741,300	
Staten Island – Fresh Kills Landfill Districts 1,2 and 3										
EBUF – Linden, NJ Manhattan- Hamilton Avenue and North Shore	EBUF-Rail	7370	5723	5,471,600	17,750,600	15,057,200	66,199,600	39,272,500	143,751,500	
Average Annualized Cost for Proposed Plan ⁽⁴⁾			10,840	29,900,000	17,750,000	54,700,000	146,100,000	74,400,000	\$323,000,000	
Average \$/ton ⁽⁵⁾									\$95.50	

- Notes:**
- (1) Costs are not based on proposals actually received. The annual costs are for the year the proposed plan long-term export is fully implemented. Costs are expressed in current year 2000 dollars.
 - (2) Costs may not add due to rounding.
 - (3) Truck-to-rail - direct loading of open-top rail cars.
 - (4) Average costs are calculated by weighting the average cost for a facility type within a given wastehed.
 - (5) Average \$/ton is calculated using 10,840 tpd and first year average costs for the Proposed Plan.

Table A-4: New Plan Milestones

PROGRAM MILESTONE	SCHEDULED FISCAL YEAR	STATUS COMMENT
Southwest Brooklyn		
Truck-to-Container-to-Barge Transfer Facility		
Complete design and permitting	2001	NEW— See Section 1.3
Complete construction and begin facility operation	2003	NEW— See Section 1.3
Greenpoint Brooklyn		
Truck-to-Container-to-Barge or Rail Transfer Facility		
Complete procurement and award contract	2002	NEW— See Section 1.3
Complete design and permitting	2002	NEW— See Section 1.3
Complete construction and begin facility operation	2004	NEW— See Section 1.3
Queens		
Truck-to-Container-to-Barge or Rail Transfer Facility		
Complete procurement and award contract	2002	NEW— See Section 1.3
Complete design and permitting	2002	NEW— See Section 1.3
Complete construction and begin facility operation	2004	NEW— See Section 1.3
Bronx		
Truck-to-Container-to-Barge or Rail Transfer Facility		
Complete procurement and award contract	2002	NEW— See Section 1.3
Complete design and permitting	2002	NEW— See Section 1.3
Complete construction and begin facility operation	2004	NEW— See Section 1.3
Staten Island		
Truck-to-Container-to-Rail Transfer Facility		
Complete design and permitting	2001	NEW— See Section 1.3
Complete construction and begin facility operation	2002	NEW— See Section 1.3
Linden New Jersey		
Enclosed Barge Unloading Facility		
Complete contract negotiations	2001	NEW— See Section 1.3
Complete design and permitting	2002	NEW— See Section 1.3
Complete construction and begin facility operation	2004	NEW— See Section 1.3
Fresh Kills Landfills		
Cease waste disposal operations at Fresh Kills	December 31, 2001	NEW— See Section 1.1 and 1.2(1)

Appendix C:

Political Successes in Waste Management

A-C.1 Visy Paper Mill, Staten Island, NY

The Visy paper mill is a paper recycling facility in northwestern Staten Island which opened in 1996. The mill is located on a 41-acre parcel of privately-owned industrial land at the western end of Victory Boulevard abutting the Arthur Kill, just north of the Fresh Kills landfill. The Visy mill converts mixed post-consumer waste paper into forms of cardboard used in packaging liners and corrugating medium for cardboard boxes. Visy Paper is a division of Pratt Industries, a large, privately owned Australian Company headquartered in Melbourne, Australia. Visy began its North American search in 1992 during the mayoral administration of David Dinkins.

In the early 1990s, Visy Paper was in the process of looking for a site to build a recycled paper mill in the eastern United States, close to urban sources of recycled paper. Visy's geographic site selection area was quite large, reaching west from the east coast to Chicago, and from the Canadian border south to Baltimore. In order to meet Visy's business needs, the site needed to conform to a number of criteria. A suitable site must be at least 20 acres, must have adequate sewer capacity to handle the water waste of the papermaking operation, must eventually have rail access to ship the manufactured product, must have sufficient electricity, and must have easy truck access. Eventually the search narrowed down to two locations in the New York metropolitan region, New York City, and South Amboy, New Jersey. Initially, South Amboy was the preferred site, but New York City provided financial incentives to bring the project to New York, and reportedly would not sell its enormous quantity of waste paper to Visy if the facility were built in New Jersey. Seeking to attract new industry and jobs to New York City, the Mayor's office, the Staten Island Borough President's office, and the New York City Economic Development Corporation (EDC) actively pursued Visy, and included \$120 million in tax-exempt bonds through the Industrial Development Agency.⁴² Also, the New York State Department of Environmental Conservation (DEC) facilitated the project by certifying it under its brownfields program, thus allowing the site to be developed without fear of liability for industrial contamination. The Visy mill was the first brownfield site developed in New York City.

Within New York City there were only three locations that could meet Visy's criteria and were zoned M3 for heavy industry. One was in the Bronx, one was in Brooklyn, and one was in Staten Island. The Bronx location was the Harlem River Rail Yards, which at that time had a recycled newsprint paper mill proposed for that site. The sponsors for this project were the non-profit environmental group Natural Resources Defense Council (NRDC) and a community organization, the Banana Kelly Community Development Corporation. Although the newsprint mill project eventually fell through, the Bronx location had the additional problem of being opposed by railroad advocates because it was located on an underutilized freight rail yard, which could be used for more active freight railroad use.⁴³ The potential Brooklyn site was along the waterfront in Sunset Park. Because this site was in a port location, the fact that the Visy mill was not a maritime use of the land made it less favored. Furthermore, the value of the land at both the Bronx and Brooklyn sites was much higher than in Staten Island.

The Staten Island site was just north of the Fresh Kills landfill, and at the time of the site selection, the closure of Fresh Kills was not imminent, thus depressing nearby land values. Thus, Visy was able to purchase a sizeable industrial lot within New York City for less than the price of similar parcels in other parts of the city. The Staten Island site has access to an unused rail corridor, that accesses the Howland Hook container port in Staten

⁴² The IDA is the City's primary vehicle for providing financing assistance to businesses, including small industrial and manufacturing companies. The IDA is a conduit agency that issues tax-exempt industrial revenue bonds that assist eligible industrial, not-for-profit, and other qualified entities to finance expansion opportunities. The IDA also offers qualified companies abatements on sales, real estate, and mortgage recording taxes.

⁴³ It is noteworthy to contrast the siting of the Visy paper mill with the failed Bronx newsprint plant. The Bronx plant was intended to be a model community-run industrial ecology facility located in New York City, close to a large source of waste newsprint. There are essentially three major differences between the Bronx plant and the Visy plant. First, the Bronx facility was designed as a paper plant and community development project, not a paper making project. In fact, there was no paper company involved in the planning of the facility. The project proponents hoped to lure a paper company in after the facility was designed. Second, the Bronx facility was located on public lands. Finally, the Bronx plant was to be a newsprint facility, as opposed to a cardboard mill. Newsprint recycling requires an expensive de-inking facility, which also generates an additional waste stream. The cost of the Bronx facility was to be far greater than Visy's investment in Staten Island.

Island and crosses the Arthur Kill and connects to New Jersey and the rest of the continent via the Arthur Kill Lift Bridge near the Goethals Bridge. The city acquired the Staten Island Railroad with the help of a Federal grant from the Intermodal Surface Transportation Efficiency Act (ISTEA), and currently is repairing these tracks and the bridge. Although the railroad was slated to be completed by now, work continues and now is estimated to be complete in 2002. Once the rail line is completed, Visy will ship its finished product via rail.

Even after the Staten Island site was the preferred site, two significant hurdles remained. First, the land was privately owned by two corporate landowners and initially was not for sale. Thirty-five acres of the land was owned by the utility Consolidated Edison, and the mill is adjacent to a Con Ed generating plant. A smaller six-acre parcel containing an abandoned industrial facility was owned by the Chicago-based Liquid Carbonic Corp. Both parcels were eventually sold to Visy, although neither parcels were “for sale” at the time. Second, the land was an old industrial “brownfield,” and suffered from some hazardous contamination. The contamination was typical of old industrial sites, but not significant enough to be classified as a hazardous waste superfund site. The Con Edison and Liquid Carbonic sites in Staten Island suffered from mild contamination, including petroleum and lime. Cleanup standards for the site were eventually negotiated with New York’s Department of Environmental Conservation (DEC). Because the site only had low-level contamination and the groundwater under the land was not used for drinking water purposes;⁴⁴ the state decided to certify it as a brownfield project. In order to facilitate selling the land to Visy, Con Ed took on the obligation of studying the contamination and cleaning it up. This project was a priority for the state and city, and thus received a maximum amount of coordination within the DEC.

At the time Visy was attempting to site its plant, the Fresh Kills landfill was not slated to close. In order to renew its state permit to operate Fresh Kills, the city needed to demonstrate that it was recycling the maximum amount it could. State DEC officials realized that the Visy project would not only help New York recycle more paper and reduce waste, but would also serve the purpose of creating jobs in New York state, boosting the local economy, and redeveloping an old industrial site.

Finally, because the Visy mill was essentially a private economic development project located on private land, environmental review was limited. The city conducted an environmental assessment under the New York State environmental review law, but did not prepare a full environmental impact statement. In contrast to many public works projects, only one public presentation was given, to the Staten Island Borough Board. Additionally, one meeting was held open to the public, as a result of a requirement of the IDA. Because the land was privately owned and zoned M3 for heavy industry, Visy could develop as of right, and no City Council land use approvals were necessary.

According to Visy’s siting consultant, Auric Ventures Limited, the combination of Visy’s streamlined decision-making process and the city’s aggressive solicitation of the project were the keys to the project’s completion in New York City. Visy’s investment in the Staten Island mill was the largest manufacturing development project in New York City in 50 years. The plant employs about 90 to 120 people, which includes approximately 80 paper-making employees, and 40 support employees, including administrative and cleaning staff

Interestingly, the siting of the Visy mill was not controversial, and both citywide and local politicians supported and actively solicited the project. Potential community opposition to the plant was limited because of the remote, industrial location, which was not directly adjacent to residential neighborhoods. Additionally, this paper recycling process does not produce unpleasant odors or visible pollution, and there is limited truck traffic to the site. Perhaps most important, this paper mill is considered a manufacturing factory under the law, not a waste handling facility, even though it processes waste paper. This distinction avoids the strict and time consuming regulatory process for siting waste facilities.

⁴⁴ With the exception of limited portions of Queens, none of New York City uses groundwater for drinking water. Additionally, because this land abuts the Arthur Kill, the groundwater beneath the site is saline, and thus would never be used for drinking water.

A-C.2 Waste-to-Energy, Composting, and Recycling Facilities, Onondaga County, NY

The city of Syracuse, in upstate New York's Onondaga County, presents a case study of both the typical centralized regulatory approach and a modified community-based regulatory approach. Syracuse is an excellent example of how a centralized regulatory approach can run into a standstill when faced with the problems of community resistance and mobilization. After almost two decades of wrangling with community groups, the city ultimately decided to change their methodology and involve citizen groups by creating an independent citizen-based agency to deal with the solid waste problem.

In the early 1970s the city's only landfill became filled to capacity, forcing the city to take responsibility and develop a strategy for future waste management. By 1984 the city had developed a plan for a waste-to-energy plant and received a permit for it on a 12-acre site within Onondaga County owned by the New York State Department of Transportation. That same year the city's mayor dropped the plan when he was unable to get enough political support.

After almost twenty years of stalemate, the Onondaga County Legislature decided that the solution lay in creating an independent agency to deal with waste problems. The county had come to understand that a centralized regulatory approach was not going to work when it came to such a charged issue as waste management. The county knew that there was no way that they were going to be able to appease every group interested in the issue, and as long as the power lay in the hands of the elected officials there would be a substantial deadlock. A considerable portion of the Legislature felt that the answer lay in the creation of an independent agency. However, many other legislators strongly opposed the loss of control. The key pressure to pass the measure came from the city of Syracuse; the city had threatened to pull out of the trash project if the measure were not passed. Consequently, in 1989 the Onondaga County Resource Recovery Agency (OCRRA) was approved as an independent, citizen-run regulatory agency.

Since OCRRA's assumption of the waste management burden, 33 of the 35 municipalities within Onondaga County have signed on to have their wastes handled by OCRRA; the remaining municipalities contract privately. OCRRA bases their waste management program on an integrated waste management approach which includes recycling, landfilling, composting, and a waste-to-energy (WTE) plant. The WTE plant was built in 1992 on a site that was previously approved by the 1984 permit plan. OCRRA issued over \$178 million in bonds for construction of the facility, including \$15 million for environmental controls. The plant is comprised of three combustion units capable of burning 990 tons of trash per day. In addition to building the waste-to-energy plant, OCRRA also obtained a permit for a proposed ash landfill, as required by the NY State incinerator permit requirements, in the town of Van Buren, NY. However, OCRRA has not built that landfill since it already has a contract with Seneca Meadows to take the ash waste.

Although OCRRA has been cited several times with prestigious awards regarding its performance in regulating waste management, the path towards its success has been rocky, and its future remains unsure. Throughout OCRRA's campaign to pass the proposal to build the waste-to-energy plant, it was faced with substantial opposition from both environmental and community groups such as Recycle First, S.E. University Neighborhood Association, the Sierra Club, and the Atlantic States Legal Foundation to name a few. On the other hand, OCRRA's efforts were backed by the County Executive Nicholas Pirro, much of the traditional Syracuse political system, the area's trade unions, and the newspaper editors of the two major Syracuse-based papers. In addition to these players, the plant was pushed by the major incinerator company Ogden Martin Systems, which has successfully built several waste-to-energy plants throughout the country.

OCRRA clearly learned a lesson from the earlier debacles experienced by the city in its attempt to force community groups into agreement with their plans, and instead found that a compensatory method was far more successful in getting groups to align with their efforts. The best example of OCRRA's use of economic compensation comes from their experiences with the site's neighbors. At the time that the incinerator was still in the proposal stage, there was a great deal of opposition from the immediate neighbors of the site. The suggested site was on the edge of the town of Onondaga. The town itself has the distinction of having the highest percentage (45 percent)

of the county's elderly living within 3 miles of the incinerator site in a geriatric center and senior housing. Additionally, within 8/10ths of a mile there is a trailer park, and within 4 miles there is a state-run prison. Several of the community groups took action and protested the siting of the incinerator. In reaction, OCRRA designed a compensation package for the town including a minimum of \$200,000 per year in return for waiving any and all rights to oppose the incinerator, while providing energy to the community at the state regulated 6 cents/kilowatt hour price. At the same time, Ogden stepped up its relations with some of the opponents, reassuring them of the environmental and technical soundness of the project. Their efforts were successful, as the Hospice of Central New York, which is located in the town, presented Ogden Martin with an Award in recognition of Ogden's Good Neighbor policy in 1991.

In addition to the waste-to energy plant, OCRRA also has an extensive recycling and composting program. As the program stood in 2000, 65.3 percent of all discarded materials are recycled or composted. The composting program is the only permitted method for yard and brush waste disposal, and ultimately produces mulch which can be sold to various businesses. For example, the local prison system uses the mulch produced by OCRRA as a thickener for their own food composting program. In contrast to the incineration element of the OCRRA's program, recycling and composting programs have enjoyed the strong support of many of the municipal and environmental groups such as Recycle First. These groups have repeatedly argued for developing a complete recycling/compost strategy for treating solid waste.

A-C.3 SEMASS Resource Recovery Facility, Rochester, MA

The SEMASS Resource Recovery Facility employs a shred-and-burn waste-to-energy technology (WTE) to process nearly 1,000,000 tons of municipal solid waste (MSW) annually. SEMASS, which is 90 percent owned by American RE-Fuel Company of SEMASS (a joint venture formed by subsidiaries of Browning-Ferris Industries, Duke Energy Power Services and United American Energy Corp.), opened in 1989 and has since been providing southeastern Massachusetts communities with an alternative to landfilling.

The facility is located in the northeast corner of Rochester, a small town with a population of 4,500 and an area of only 39 square miles. Rochester is approximately 60 miles south of Boston, and about 10 percent of the MSW arriving at SEMASS comes from the Boston metropolitan area. Most of the municipalities within the SEMASS geographic area have contracted with SEMASS, serving up to 1 million people and more than 300,000 households. In addition to handling 2,700 tons per day of MSW, the facility also recovers and recycles approximately 50,000 tons of metal per year and provides enough electricity to meet the needs of more than 75,000 homes.

SEMASS is a privately funded facility that developed the site using a market driven approach. Development began in the late 1970's when Energy Answers Corporation (EAC) approached the Rochester town officials regarding developing the plant on privately-owned land. At the time, Massachusetts encouraged the development of waste management facilities through the provision of low-interest business loans through its finance agencies. Similarly, WTE facilities do not pay real estate tax on their buildings, or income tax. Rather, WTE facilities pay a per ton tax. According to Massachusetts procedure, private companies were responsible for the development of the project, while the state and local authorities provided operating permits and regulatory oversight.

Political decisions in towns similar to Rochester and its neighbors are made through the "Town Hall Meetings" approach. All citizens are encouraged to attend meetings and vote. Energy Answers (the original developer) conducted a number of meetings with town leaders to discuss appropriate financial incentives, while at the same time, the company held town meetings to explain the proposed technology to residents and arranged tours of similar facilities operating in upstate New York. A close working relationship with the town and its residents minimized NIMBY (Not In My Backyard) concerns.

Ultimately, Energy Answers agreed to provide free waste disposal services to Rochester and \$1 per ton of waste received by the facility (with annual increases based on the CPI), in return for approval. The developer also offers free recycling services. For both the recyclable and the MSW, the town pays for collection. All electricity

generated by the facility is transmitted to a local utility company through private contracts. The town of Rochester agreed, and the corporation purchased 100 acres from a private landowner.

Energy Answers had a site for the facility and permission from the host community, but they needed a landfill to dispose of the unburned MSW and the ash from combustion. A sugar-sand landfill, without protective liners or monitoring systems, was located on leased land from a cranberry grower, and was under the authority of the Tri-Town Regional Refuse Disposal District (Marrion, Whareham and Carver). Any change in operations required approval by the district, and town legal advisors agreed that approval from all three towns was needed as well. Although Energy Answers offered favorable waste disposal contracts, concerns about air pollution and ground water contamination, led to the proposal's rejection by two of the towns, Whareham and Carver.

Forced to negotiate with the Tri-Town Regional Refuse Disposal District, Energy Answers agreed to reconstruct the Tri-Town landfill. Separate, lined cells were constructed with monitoring systems. Ash is placed in a double-lined cell with alarm systems and monitoring equipment, and the non-processible MSW (large items, etc.) is disposed of separately. With the help of a chemical engineer, Whareham and Carver also convinced the company to exceed state and federal standards for stack emissions, and SEMASS has continued to stay ahead, employing the best available technologies. With the new concessions, the cities agreed to the use of the Tri-County landfill and entered into twenty-year waste disposal contracts at \$12 per ton with annual CPI increases and "change in law" provisions. The contract continues into 2009.

The ash has been determined to be non-hazardous. The waste does not require testing as frequently as was required earlier. Mercury is a problem. SEMASS records data every three months for mercury. Massachusetts has very stringent standards and SEMASS actively recycles and removes mercury at the front-end of the plant. Many of the contracted customers have created mercury-bearing waste collection recycling programs. SEMASS has frequent meetings with representatives of its municipal contract holders to help develop the plan.

SEMASS has been awarded numerous operational and environmental prizes, including the American Academy of Environmental Engineers' Honor Award for EAC's ash technology. SEMASS has a campaign to clean up paper around the facility, and spray odor-eliminator in the vicinity of the plant. This helps ensure that there are no complaints from the nearby residents, and they can work in partnership with the local community. At the time SEMASS started accepting waste in the 80's, the initial tipping fees were \$12/ton. Today the tipping fees stand at almost \$75/ton. In comparison, those cities that entered into long-term contracts are paying tipping fees of only \$18/ton, while the city of Rochester does not pay tipping fees at all.

SEMASS is a private enterprise that has used the market approach effectively and provided a good alternative to landfilling of waste. They have been successful in making their waste-to-energy project a reality and are providing electricity to almost 75,000 homes. The facility also recovers and recycles approximately 50,000 tons of metal per year.

A-C.4 Solid Waste Authority Integrated Waste Management Facility, West Palm Beach, FL

The West Palm Beach Integrated Waste Management Facility is owned by the Solid Waste Authority, a division of the County. The facility runs a Waste to Energy (WTE) facility that uses refuse to dry fuel (RDF) technology to generate electricity from its municipal solid waste (MSW). It also manages two landfills (Class I landfill (double-lined) where ash is dumped, and a class III landfill used for MSW), five transfer stations, a 300ton/day composting facility using wastewater sludge, a Multi-Stream Materials Recovery facility, and a ferrous-metal recovery facility.

The West Palm Beach site is a County owned site. In the early 1970's, municipal and county officials formed a county-wide Solid Waste Authority (SWA). The SWA had no money and no way of generating funds. It was decided that three county landfills would loan the SWA \$50,000 per year from their proceeds.

In 1975, the County Commissioner insisted that the SWA hire their own Executive Director and subsequently, Tim Hunt was appointed first Executive Director of the SWA. Hunt and a consulting firm put together a plan for the county which included two landfills, a series of transfer stations (TS) and a waste-to-energy facility. The county had no taxing authority and no money, so the only way to generate revenue was to get into operations.

In 1977, the SWA negotiated a 40 year lease on land and a contract with the city of Del Rey Beach and Southern Sanitation guaranteeing delivery of waste from city to its transfer station. Later, the SWA acquired the transfer station from Southern Sanitation and reengineered the transfer station site. They secured their first operation delivering 200-300 tons of waste per day. SWA also started delivering waste to the Bel Glade Landfill transfer station. The SWA further negotiated with the County Commissioner in order to take over a landfill in Pahoke, and began sending waste from the Bel Glade Landfill transfer station to the Pahoke Landfill.

The City Manager and Mayor of West Palm Beach decided to lease the southern portion of the city's water and wastewater treatment facility, a huge portion of land, for construction of the WTE facility. They were met with stiff opposition from the local retirement community and the plan was shelved. The County Commissioner had to intervene and find an alternative site. The site chosen was a 1,400 acre area west of the northern most landfill in the county. The John D. MacArthur foundation owned the land and the County negotiated a purchase agreement. The County's WTE facility plan was opposed by the city of Riviera Beach, as well as local communities and environmental groups.

Meanwhile, in 1982, the SWA took over landfills (and their equipment and employees) on the east coast of the county. The SWA had become an organization with more than 60 employees owning two transfer stations and two mega landfills. Based on their capital and revenues, the SWA issued a bond generating \$43 million in revenues. They then closed the old Pahoke and Lantana Landfills, closed out a portion of Northern Landfill, upgraded the balance of Northern Landfill, and got the permitting to convert the site to a large integrated solid waste management site.

The SWA, however, had no money to construct the WTE, so the SWA issued a Resource Recovery Bond generating \$320 million in funds between 1982 and 1989. The SWA sought a design and build, and operation contract, from private companies. The contract was won by Babbcock and Wilcox and Natural Ecology. Construction started in 1986 and the WTE came into operation in 1989, 13 years after the project was first proposed.

The WTE, Multi-Stream Materials Recovery facility, and the ferrous-metal recovery facility are contracted out by the SWA. The landfills, transfer stations and the composting facility are managed by the SWA. The SWA has a recycling program with a community outreach program where local residents and school children are educated about the program. Recent studies showed that the community strongly approved work undertaken by the SWA. The facility rarely receives complaints from residents and the SWA focuses strongly on issues like odor control. The facility has always been within limits prescribed by the EPA with no violations to date. Nitrogen oxides levels are at times close to the permissible limit but SWA is looking at methods to control those emissions. The facility has had no problems with mercury.

Initially, the SWA charged a tipping fee to every person, residential as well as commercial, for dropping waste in the landfill. Later, the County came up with a "special assessment plan" which subsidizes tipping fees for residential customers. Based on county-wide income, and family and waste generated data, the county charges a fixed residential subsidized tipping rate that shows up in the taxes. Commercial customers have to pay tipping fees for only the waste that exceeds their base waste quota. This policy has proved effective in encouraging commercial clients to recycle their waste.

Part B:

Technical Considerations

Earth Engineering Center, Columbia University
December 1, 2001

Part B : Summary

This report is the second part of a joint study by the Earth Engineering Center and the Urban Habitat Project of Columbia University that examined the policy and technology implications of alternatives that may be used for managing the municipal solid wastes (MSW) of New York City (NYC). The principal means for processing MSW are recovery of materials (by recycling), recovery of energy (by combustion), composting, bioconversion or gasification to fuel, and landfilling. At this time, NYC DOS, after mounting a very effective campaign for several years are recycling 0.75 million tons (paper and metal-glass-plastic streams) of the 4.5 million tons of MSW collected annually. Since the closing of the Fresh Kills landfill, 3.2 million tons of the black-bag (“wet”) stream are transported, mostly by truck, to Pennsylvania (62.1 percent), Virginia (32.4 percent) and New Jersey (5.5 percent) landfills. Another 0.56 million tons of the black-bag stream go to New Jersey (97.3 percent) and New York (2.7 percent) Waste-to-Energy power plants.

Increased rate of recycling

The rate of recycling can be increased by a) modifying the existing three-stream collection system so as to increase the “dry” (blue-bag) stream and reduce the “wet” (black-bag) stream; and b) implementing an automated, modern Materials Recovery Facility (MRF) that separates the blue bag stream to “recyclable”, “combustibles”, and “landfillables”. In the first stage of implementation, these measures may increase the recycling rate from the present 0.75 million tons to 1.2-1.5 million tons.

Landfilling vs. Waste-to-Energy

With respect to the estimated 60 percent of NYC MSW that is not recyclable under any circumstances, the only viable technologies in the foreseeable future are landfilling and Waste-to-Energy (WTE). As noted above, both of these technologies are already used by private firms to dispose the MSW of NYC. A thorough investigation of these technologies has shown that WTE is environmentally preferable to landfilling on several counts:

- a) WTE generates a net of 550 kWh per ton of MSW. This reduces dependence of the state on coal mining (about 0.25 tons of coal less per ton of MSW combusted) or on oil imports (45 gallons of oil less per ton of MSW). At this time, 36 million tons of MSW are combusted annually in U.S. WTE plants and generate electricity that reduces the use of fuel oil by 1.6 billion gallons per year.
- b) The gas emissions from landfills contain methane, a gas that is 21 times more potent as a greenhouse gas than carbon dioxide. Thus, including the advantage of electricity production from the combustion of MSW, the landfill greenhouse gases are several times greater than for WTE. With regard to other emissions, such as mercury and dioxins, this report documents the progress that the U.S. WTE industry has made in this sector towards the end of the 20th century. At this time, all modern WTE plants are equipped with advanced gas control systems, such as dry scrubbing, activated carbon injection and bag filters, that are superior to the gas handling systems of most coal-fired power plants.
- c) In modern landfills, during the life of the landfill and for a mandated period after that, the generated aqueous effluents are collected and treated chemically. However, reactions within the landfill can continue for decades and centuries after closure. Thus, there is potential for future contamination of adjacent waters.
- d) WTE recovers ferrous and non-ferrous metals, thus conserving natural resources.
- e) Landfilling practically condemns for any future use a large amount of land per ton of MSW disposed. A rough estimate for the direct use of land for landfilling the present amount of NYC MSW is about 90 acres per year. Of course, a much larger surface area is required between landfills and inhabited areas or parks.

- f) A modern WTE plant for processing the NYC MSW should be at a location to which NYC MSW can be transported by covered barge or railcar. The present transport of MSW to out-of-state landfills requires an estimated 10 million gallons of fuel per year and results in additional gas emissions.

In recognition of the above factors, some other developed nations, like France and Germany, have phased out the use of landfills, except for the disposal of inorganic materials (e.g. ash) that cannot be recycled or combusted. From an economic point of view, landfilling is at present less costly in the U.S. because land is inexpensive. However, "tipping" fees depend on current environmental regulations and also on the distance over which MSW must be transported. For New York City, in the last few decades tipping fees have increased manifold to the present rate of \$70/ton. They are bound to increase further as landfills come under further public and state scrutiny.

On the basis of the above considerations, there are technical and environmental arguments that support the diversion of MSW from landfills to WTE plants. In summary, the results of this study indicate that the modern MRF and WTE technologies should be considered as tools of integrated waste management and offer various technical and environmental advantages over landfilling. Of course, any future determinations need to balance both technical and broader policy considerations.

Table of Contents : Part B

B-1	Introduction	B-1
B-2	Integrated Waste Management of MSW	B-1
B-3	Means of Disposal of MSW in the U.S.	B-1
B-4	Composition of NYC MSW	B-2
B-5	Current Disposition of NYC MSW	B-4
B-6	Out-of-State Transportation of NYC MSW	B-6
B-7	Ideal Disposition of NYC MSW Materials	B-7
B-8	Potential for Increased Recycling in NYC	B-9
B-8.1	A Modern Materials Recovery Facility for NYC	B-9
B-8.2	Economic Benefits of a NYC Modern MRF	B-12
B-8.3	Collection of a "Paper," a "Dry" and a "Wet" Stream	B-12
B-9	Bioconversion of "Wet" Stream to Natural Gas	B-13
B-10	Generation of Electricity by Combustion of MSW	B-14
B-10.1	Chemical Characterization of Combustible Fraction of MSW	B-14
B-10.2	Effect of Moisture and Inert Materials on Available Heating Value	B-16
B-11	Waste-to -Energy Power Plants vs. Incinerators of the Past	B-18
B-12	Electric Energy from MSW	B-20
B-12.1	Moving Bed Combustion: "Mass Burning"	B-20
B-12.2	Refuse-Derived Fuel (RDF)	B-20
B-12.3	Combined Flash and Moving Bed Combustion	B-21
B-12.4	Gas Emissions from WTE Plants	
B-12.5	Decrease of WTE Mercury Emissions in the Nineties	B-25
B-12.6	Decrease in Dioxin Emissions from WTE Plants	B-26
B-12.7	Existing New York and New Jersey WTE Facilities	B-27
B-12.8	Recovery of Metals in Waste-to-Energy Plants-GHG Credits	B-27
B-12.9	Private Financing of a New Waste-to-Energy Plant	B-27
B-12.10	Potential for Development of an Eco-Industrial Park	B-28
B-13	The Landfilling Alternative	B-29
B-13.1	Use of Land	B-29
B-13.2	Gas emissions from Landfills	B-29
B-13.3	Liquid Emissions of Landfills	B-29
B-13.4	Life Cycle Assessments of Landfilling vs Waste-to-Energy	B-30
B-14	Conclusions	B-31
B-15	References	B-33

List of Tables

Table B-1	Means of Disposal of MSW in the U.S.	B-2
Table B-2	Comparison of constitution of U.S. and New York City MSW	B-2
Table B-3	Detailed Characterization of NYC MSW	B-3
Table B-4	Population and Collection of MSW in five boroughs of NYC	B-5
Table B-5	Classification of NYC MSW by most appropriate method of disposal	B-8
Table B-6	1998 recycling rate of paper, metal, plastics and glass	B-9
Table B-7	Manual Sorting Rates and Efficiencies	B-10
Table B-8	Automated Sorting Rates and Efficiencies	B-10
Table B-9	Proximate Analysis of Components of MSW	B-15
Table B-10	Ultimate Analysis of Dry Stream before Materials Recovery	B-16
Table B-11	Comparison of emissions from WTE plant with EPA standards	B-24
Table B-12	Mercury emissions from New Jersey WTE plants, 1991-1999	B-25
Table B-13	1999 Mercury emissions from Waste-to-Energy plants	B-26
Table B-14	Projected costs and revenues for 1-million t/y WTE plant	B-28

List of Figures

Figure B-1	Collection and disposition of non-recyclable MSW from the five boroughs of NYC	B-7
Figure B-2	Schematic diagram of modern NYC MRF of 150 tons/hour capacity	B-12
Figure B-3	Effect of moisture on heating value of MSW materials	B-18
Figure B-4	Schematic diagram of mass-burning WTE facility	B-20
Figure B-5	Aerial photo of SEMASS (Rochester, Mass.) Resource Recovery Facility	B-21
Figure B-6	Illustration of sequence of unit operations in SEMASS WTE plant	B-22
Figure B-7	Process flow sheet of one of three SEMASS WTE units	B-23
Figure B-8	Mercury concentration in SEMASS fly ash	B-25

B-1 Introduction

Economic development and prosperity are accompanied by the generation of large amounts of wastes that must be re-used in some way, or disposed in landfills. The generation of wastes can be reduced to some extent by improved design of products and packaging materials and by increasing the intensity of service per unit mass of material. However, even after such measures are taken, there remains a large amount of solid wastes to be dealt with.

Solid wastes can be classified into various categories. The broadest classification is in municipal (residential and commercial), industrial, construction, and demolition wastes. The municipal solid wastes (MSW) are the most non-homogeneous since they consist of the residues of nearly all materials used by humanity: Food and other organic wastes, papers, plastics, fabrics, leather, metals, glass and other inorganic materials. Everything wears out eventually and then becomes MSW or is discarded on land or water. All tonnage are reported in U.S. tons (2,000 lb.; 1.1 short tons= 1 metric ton)

B-2 Integrated Waste Management of MSW

Next to the production of cement, municipal solid wastes represent the largest mass of solids generated in the U.S. Integrated Waste Management (IWM) requires that MSW be separated into a number of streams, which are then subjected to the most appropriate method of resource recovery. The separation of MSW components can take place at the source, i.e. households or businesses, or at Materials Recovery Facilities (MRFs) where manual and electromechanical methods are used. The principal means for managing MSW are:

- **Recovery of materials:** Recovered paper, plastics, metals, and glass can be recycled to produce similar materials.
- **Recovery of energy:** Recoverable energy is stored in chemical form in all MSW materials that contain natural or man-made organic carbon; this includes everything except metals, glass, and other inorganic materials (ceramics, plaster, etc.). The combustion of organic compounds generates electricity and steam.
- **Bioconversion:** The natural organic components of MSW (food and plant wastes, paper, etc.) can be composted aerobically (i.e., in the presence of air) to generate carbon dioxide, water, and a compost product that can be used as soil conditioner. On the other hand, anaerobic digestion or fermentation (i.e. in the absence of air) produces methane or alcohol and a compost product; this method provides an alternate route for recovering some of the chemical energy stored in the organic fraction of MSW.
- **Landfilling:** A small fraction of MSW that cannot be subjected to materials or energy recovery, plus any residuals from recycling or combustion (e.g., ash) must be disposed in properly designed landfills.

B-3 Means of Disposal of MSW in the U.S.

The present rate of generation of MSW in the U.S. is estimated at about 220 million tons, i.e. about 0.8 tons per capita. The Council for Environmental Quality (1997) reported that of the 210 million tons of MSW generated in 1996, 22 percent was collected in the form of recyclable (paper, plastics, metals, glass), 5.4 percent was composted, 17.2 percent was combusted and 55.4 percent (117 million metric tons) was landfilled (Table 1). It is interesting to note that in the period from 1980-1996, the fractions of MSW recycled or combusted nearly doubled; and the fraction of materials composted (consisting mostly of yard wastes) increased to 5.4 percent of the total MSW. Landfilling remains the principal mode of MSW disposal in the U.S. although it has been phased out in countries like France and Japan that place a high value on land use and environmental quality.

Table B-1 Means of disposal of MSW in the U.S.A (Council for Environmental Quality, 1997)

	1980		1990		1996	
	MILLION TONS*	% OF TOTAL	MILLION TONS*	% OF TOTAL	MILLION TONS*	% OF TOTAL
Gross discards	151.64		205.21		209.66	
Recycling	14.52	9.6	29.38	14.3	46.01	21.9
Composting	<0.5	0.0	4.2	2.0	11.32	5.4
Combustion	13.7	9.0	31.9	15.5	36.09	17.2
Landfilling	123.42	81.4	139.73	68.1	116.24	55.4

*In U.S. tons; for metric tons, divide by 1.1.

The MSW composition varies amongst communities, and even within one community from year to year, but the overall differences are not substantial. Table 2 compares the major components in the “typical” U.S. composition of MSW (Tchobanoglous, 1993; EPA, 1997) with the composition of the New York City waste stream (SCS Engineers, 1992).

Table B-2 Comparison of constitution of U.S. and NYC MSW

	“Typical” U.S. MSW (1)	“Typical” U.S. MSW (2)	New York City MSW (3)
Paper	34.0	33.7	26.6
Cardboard	6.0	5.5	4.7
Plastics	7.0	9.1	8.9
Textiles	2.0	3.6	4.7
Rubber, Leather, “Other”	1.0	2.9	0.2
Wood	2.0	7.2	2.2
Yard Wastes	2.0	14.0	4.1
Food Wastes (mixed)	9.0	9.0	12.7
Glass and metals	17.5	13.1	16.4*

(1) Tchobanoglous, et al., 1993.; (2) EPA 530-S-97-015. 1997; (3) SCS Engineers, 1992.

*on assumption that 2/3 of weight of NYC “bulk items” is metal

B-4 Composition of New York City MSW

The composition of the NYC MSW was studied in great detail by the Department of Sanitation of New York City in 1990 (NYC DOS; SCE Engineers 1992).

Table B-3 Detailed Characterization of New York City MSW

WASTE COMPONENT	% WEIGHT*
Paper (31.3%)	
Corrugated Cardboard	4.7
Newspapers	9.2
All other paper	17.4
Plastics (8.9%)	
HDPE (clear & color)	1.1
Films and Bags	4.8
PET	0.5
Polypropylene, polystyrene	0.9
PVC	0.1
All other plastics	1.4
Wood	2.2
Textiles	4.7
Rubber & Leather	0.2
Fines	2.3
Other Combustibles	2.3
Food Waste	12.7
Grass/Leaves	3.4
Brush/prunings/stumps	0.7
Disposable Diapers	3.4
Miscellaneous Organics	7.8
Glass	5.0
Clear Glass Containers	2.9
All other glass	2.1
Aluminum	0.9
Ferrous Metal	3.9
Hazardous Waste	0.4
Bulk Items (appliances, furniture, etc)	9.9

* Adapted from: SCS Engineers, 1992, by Brady 2000

Table 3 shows that the largest constituent of MSW is paper. Other low-moisture combustible materials are plastics, textiles, rubber, leather, and wood. These materials can be called “dry combustibles”, in distinction to the “wet combustibles” of food, yard and other wastes that contain 50-70 percent water. The “non-combustible” wastes of Table 3 are metal, glass and other inorganic compounds that have no heating value. Hazardous wastes, such as paints, oils, and chemicals constitute only 0.4 percent of the total waste stream and must be handled separately. Large items such as appliances and furniture can be broken down to recyclable metal or combustible wood scrap.

B-5 Current Disposition of NYC MSW

As described in detail in the report of New York City’s Department of Sanitation (NYC DOS) *Comprehensive Waste Management Plan*, New York City has shifted in recent years from disposing all of its MSW at the Fresh Kills landfill in Staten Island to exporting it to out-of-state landfills and to Waste-to-Energy (WTE) plants, through facilities owned and managed by private companies. At the present time, NYC DOS collects three streams, separated at the household level: “Paper” (green bags), “metal-glass-plastics” (MGP, blue bags) and “trash” (black bags). As of the beginning of 2001, the City’s MSW of 4.5 million tons per year is collected by 10-ton sanitation trucks and is disposed as follows:

- a) NYC DOS (2001) reports that 750,000 tons of recyclable materials are collected in two streams: A paper stream consisting of mixed paper, newspapers, magazines, phone books, and corrugated cardboard; and a metal, glass, and plastic (MGP) stream. There has been a 6 percent annual growth in recycling from the 638,000 tons of paper and MPG collected in 1998. These materials are delivered to private processing facilities located primarily within the city. The paper stream represents about 60 percent of the municipal recyclable collected and is contracted to six private companies: Visy Paper receiving materials from Manhattan and Staten Island; Pacific Forest Resources and Paper Fibre Corporation receiving materials from Bronx and Queens; Potential Industries and Rapid Recycling Paper Corporation receiving materials from Queens and Brooklyn; and A&R Lobosco receiving materials from Queens. Processing of the MGP stream is contracted to A&R Lobosco, BFI of New York, Waste Management of NY, and Hunts Point Recycling (Dubanowitz 2000).
- b) 287,000 tons of Bronx “black bag” waste (“trash”) is transported by rail via Albany to Virginia landfills and an equal amount (286,900) by truck to Pennsylvania landfills.
- c) 969,000 tons of Queens black bag waste is transported to Pennsylvania landfills and 15,000 tons to the Hempstead, NY, Waste-to-Energy plant.
- d) 544,000 tons of Manhattan waste is transported by NYC DOS to a TransRiver Marketing facility in Newark, New Jersey, and then processed in the Essex County WTE plant; another 178,000 tons goes to New Jersey landfills.
- e) 392,600 tons of Brooklyn waste is transported to Pennsylvania landfills and another 755,000 goes to Virginia landfills.

Table 4 shows that the NYC generation of “black bag” waste amounts to 0.47 tons per capita. Adding the recycled wastes of 750,000 tons per year (i.e. 0.09 per capita) brings the per capita figure to 0.56 tons which is lower than the U.S. average of 0.8 tons. The difference is due to the fact that part of NYC’s solid wastes is col-

lected by private carter's ("commercial" waste). In the conduct of this study, it was not possible to determine the amounts of solid wastes that are collected by the private carter's who take care of the commercial and institutional sectors. However, the NYC Department of Sanitation reported that as of June 1999 it collected 13,000 tons per day of MSW and the commercial sector collected an equal amount. On the basis of this estimate (www.ci.nyc.ny.us/html/dos/html/dosfact.html), NYC in total generates

0.47 (DOS, black bag) + 0.09 (DOS, recycled) + 0.47 (commercial) = 1.03 tons per capita, which is higher than the national average (0.8 tons per capita), as would be expected from a major center of business activity and tourism.

Table 4 also compares the tonnage of "black bag" MSW collected by NYC DOS in the five boroughs with their respective population. Brooklyn and Manhattan generated 0.47 tons per capita, Bronx 0.43, Queens 0.4, and Staten Island 0.78 tons per capita. A possible explanation is that there is less collection of commercial solid wastes by private carter's on Staten Island and most of the solid wastes is collected by NYC DOS.

Table B-4 Population and collection of MSW in five boroughs of NYC

(Population data: www.census.gov; MSW generation data: NYC DOS 2001)

BOROUGH	POPULATION	COLLECTED "BLACK BAG" MSW, TONS	TONS OF MSW PER CAPITA
Bronx	1,332,650	573,800	0.43
Brooklyn	2,465,326	1,147,600	0.47
Manhattan	1,537,195	721,780	0.47
Queens	2,229,379	984,520	0.44
Staten Island	443,728	347,300	0.78
NYC, DOS "black bag"	8,008,278	3,775,000	0.47
NYC, DOS recycled	8,008,278	750,000	0.09
NYC, DOS total MSW	8,008,278	4,525,000	0.56
NYC, commercial waste*	8,008,278	3,775,000	0.47
NYC, total MSW			1.03

*(www.ci.nyc.ny.us/html/dos/html/dosfact.html)

To summarize the current situation, NYC DOS collects 4.5 million tons of MSW. The recycled stream (0.75 million tons) represents 16.6 percent of the total MSW and corresponds to 20 percent of the black bag ("trash") stream (3.8 million tons). Since the closing of the Fresh Kills landfill, 3.24 million tons of the black bag waste is transported (7.6 percent by rail, 92.4 percent by truck) to other states for landfilling: 62.1 percent to Pennsylvania, 32.4 percent to Virginia, 5.5 percent to New Jersey; landfilling represents 71 percent of the total NYC MSW. The remaining 0.56 million tons of black bag waste collected by NYC DOS, representing 12.4 percent of the total NYC MSW, is combusted in NJ (97.3 percent) and NY (2.7 percent) Waste-to-Energy (WTE) power plants.

B-6 Out-of-State Transportation of MSW

Prior to the closing the Fresh Kills landfill, the NYC DOS sanitation trucks collected the black-bag MSW and traveled relatively short distances within the City to unload at marine transfer terminals; the only exception were Staten Island trucks that unloaded at Fresh Kills. From there, the MSW was transported by barges to the Fresh Kills landfill in Staten Island. Since the closing of Fresh Kills, six of the thirteen transfer stations are located outside New York City and the DOS trucks must travel distances up to thirty-seven miles to unload. It has been estimated (Lipton 2001) that at least 550 trucks cross to New Jersey each working day: 300 over the George Washington Bridge, 130 through the Lincoln Tunnel, 50 through the Holland Tunnel, and 70 over the Goethals Bridge. However, since 11,500 tons of waste per day are transferred to NJ by truck, it is more likely that the number of daily trips by 10-ton trucks is close to 1,000.

From the New Jersey transfer stations (Newark, Jersey City, Paterson, Totowa and Elizabeth), the NYC waste is transported to Pennsylvania and Virginia landfills by means of 20-ton tractor trailers. Figure 1 shows the present flow of MSW from the five boroughs of New York City to the final deposition of these materials. The total miles traveled by the NYC DOS 10-ton trucks crossing to NJ (assumed average of 40 miles per round trip) are estimated at 40,000 miles per working day. The miles traveled by the estimated 450 daily trips of the 20-ton trucks (average of 300 miles per round trip), are estimated at 135,000 miles. Wang et al (2000) have estimated a fuel consumption of 4 to 6 miles/gallon for various types of heavy trucks. Assuming a consumption of 6 miles/gallon for the 10-ton trucks and 5 miles/gallon for the 20-ton trucks, results in an overall fuel consumption of 33,700 gallons for the 9,000 tons of MSW transported daily to Pennsylvania and Virginia landfills. Accordingly, the fuel consumption for transporting NYC MSW to other states by truck is estimated at 3.7 gallons per ton of MSW or 10.2 million gallons per year.

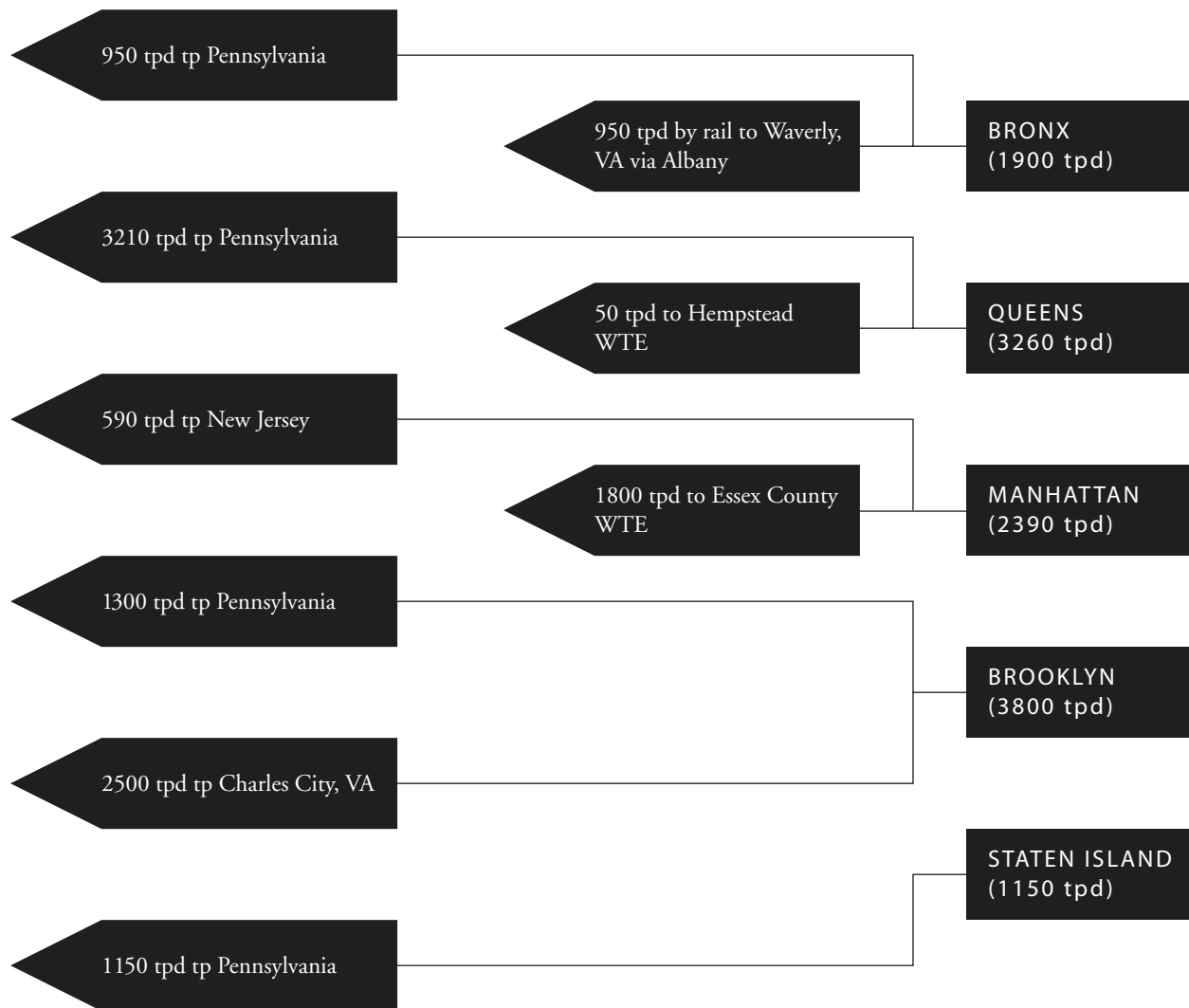


Figure B-1. Collection and disposition of non-recyclable MSW from the five boroughs of NYC (all figures in tons collected per NYC DOS working day; 302 days per year)

B-7 Ideal Disposition of NYC MSW Materials According to Properties and Inherent Value

As noted earlier, MSW consists of many materials with entirely different properties. Under ideal circumstances of sorting, processing, and recycling, these materials should go to different destinations. For example, metals and glass are not combustible or compostable; also, they have some residual value and should not be landfilled; therefore, “recycling” would be the most appropriate route for such materials. Also, a certain fraction of plastic materials, such as PET and PE can be readily identified and recycled. The non-recyclable plastics contain a useful heating value, close to that of fossil fuels; therefore, the best route for such materials is combustion in a properly designed power plant to generate electricity and steam. Finally, the only materials to be landfilled are inorganic compounds such as a small fraction of non-recyclable glass and ashes from the WTE power plants.

Table 5 shows how the NYC MSW may be classified under the four categories of “recyclable”, “combustible”, “compostable”, and “landfillable”, on the basis of available and foreseeable technologies for packaging materials,

waste collection and sorting. However, the ideal situation outlined in Table 5 is not easily realizable because of social, economic and market factors. For example, New York City citizens are already asked to separate three streams: Paper, plastic, metal and glass (PMG) and trash (black bags). One way to attain “ideal disposition” is to institute a fourth collection stream of food and plant wastes (“wet stream”). Yet, despite an intensive campaign by the Recycling Bureau of NYS DOS, some areas of NYC are not doing as well with paper and MPG separation as others; that is one reason why the present rate of city-wide recycling is less than one half of the projected maximum (Table 5). Adding one more stream might not go well with the citizenry. Also, the cost of collection is a major item in MSW management: As of 1999, it cost NYC DOS about \$114 to collect one ton of MSW (Dubanowitz 2000); adding a fourth stream would increase the cost of collection considerably.

Table 5 also shows that the maximum “compostable” fraction is 19 percent. However, in addition to the need for instituting a “wet-dry” collection system in New York City (see following section), composting of the “wet” fraction will require the development of a regional market for nearly 0.5 million tons of compost product. In the absence of a “wet-dry” system of collection, the compostable fraction will remain commingled with the other materials in the black bag stream. Under these circumstances, the two alternatives for the black bag stream are combustion or landfilling.

Table 5 shows that under the “ideal” case, only 5.5 percent of the NYC MSW needs to be landfilled, vs. the present 71 percent. The following sections will discuss the possibilities for bringing the actual case closer to the ideal one.

Table B-5 Classification of NYC MSW by most appropriate method of disposal

(in thousands of tons/year; total: 4.525 million tons; numbers in parenthesis show the assumed maximum percent recyclable for each material)

	COLLECTED	RECYCLABLE	COMBUSTIBLE	COMPOSTABLE	LANDFILLABLE*
Cardboard (90%)	229	206	23		2
Newsprint (90%)	446	401	43		5
All other paper (50%)	869	434	414		41
Plastic bags/film (50%)	252	126	229		23
All other plastics (50%)	193	97	78		8
Wood, textiles, leather, rubber (20%)	608	122	513		51
Food and plant wastes (0%)	879			879	80
Disposable diapers (0%)	178		161		17
Miscellan. Organics (0%)	409		372		38
Glass (90%)	234	210			24
Aluminum scrap (100%)	42	42			
Ferrous scrap (100%)	185	185			
Total:	4,525	1,824	1,799	879	247
Fraction of NYC MSW	100.0%	40.3%	39.7%	19.4%	5.5%

*Landfillable is assumed to consist of 10% ash from all combustible streams and 10% of non-recyclable glass

B-8 Potential for Increased Recycling in NYC

In recent years, the Bureau of Waste Prevention, Reuse and Recycling of NYC DOS has conducted a very effective campaign to increase the fraction of MSW recycled to the current level of 750,000 tons per year. The paper stream ("green bag") goes to privately owned materials recovery facilities (MRF) where newsprint and cardboard are separated manually and recycled. The residue is mostly landfilled. The metal-glass-plastic (MGP) stream goes to other MRFs where about two-thirds of these materials are sorted and recycled and the residue is landfilled. These materials are presently sorted mostly by hand, baled and shipped to various plants as raw materials for manufacturing and processing. Table 6 is based on 1998 NYC DOS recycling data (Dubanowitz 2000) and the constitution of the total NYC MSW as determined by SCS Engineers (1992). High percentages for collection are indicative of the ease of collection. It can be seen that the recovery of materials from the MPG stream in the present MRFs is only 70 percent; the residue has to be landfilled.

Table B-6 1998 recycling rate of paper, metal, plastics and glass (in short tons per year)

MSW GENERATED	TOTAL GENERATED*	COLLECTED BY NYC DOS**	% OF MSW COLLECTED BY NYC DOS	MRF RESIDUE	% OF COLLECTED MATERIALS THAT WERE RECYCLED
Newsprint	358,000	249,000	69.6%		
Cardboard	183,000	82,600	45.1%		
Other paper	677,000	25,100	3.7%		
"Paper" residue		21,800			
Total "Paper" stream	1,218,000	378,500	31.1%	21,800	94.2%
Aluminum metal	35,000	1,700	4.9%		
Ferrous metal	152,000	52,400	34.5%		
Total glass	195,000	93,800	48.1%		
Total plastic	346,000	15,500	4.5%		
"MGP" unsold mat'l		15,200			
"MGP" residue		79,800			
Total "MGP" stream	728,000	258,400	35.5%	79,800	69.1%

* SCS Engineers (1992); ** 1998 NYC DOS data; Dubanowitz (2000)

B-8.1 A Modern Materials Recovery Facility for NYC

In the summer of 1999, the NYC Recycling Bureau initiated an investigation of the technical and economic aspects of an automated modern MRF. A MRF separates, processes and stores solid wastes for later use as raw materials for remanufacturing and reprocessing. Its main function is to maximize the yield of recyclable materials that will generate the highest possible revenues in the market. An additional advantage of an automated modern MRF is that it can reduce the number of streams that are collected separately at the source; for instance it is possible to collect a single stream of paper and MPG at the household level and do all separations at the MRF.

It has been shown at other communities that by collecting all recyclable wastes together at the source, the

cost of collection decreases and a higher fraction of materials is diverted from “trash” to the recycled stream. For instance, Barlaz et al (1995) reported that city-wide collection of recyclable in Los Angeles increased by 140 percent when the two-stream collection was changed to a single-stream with subsequent separation at a MRF; furthermore, the change to the single stream reduced collection costs for the city by about 25 percent. However, the overall rate of L.A. residues is estimated at about 30 percent vs. the average rate of NYC residue of less than 10 percent; this indicates that some of the material collected in L.A. is not recyclable

A critical issue in the design of a MRF is the choice between electromechanical and manual separation techniques. Older, traditional MRFs, such as those used presently by private contractors in NYC, rely heavily on manual sorting and are very labor-intensive (Tables 7 and 8). Of course, there are trade-offs between operating and capital costs but, generally, automated processes are more cost effective (Dubanowitz 2000). In addition to improved economics, automated sorting reduces health and safety risks to workers. Furthermore, machines can usually be retrofitted to target new materials, thus increasing material yields as new markets for recycled products develop.

Table B-7 Manual Sorting Rates and Efficiencies (Peer 1991)

MATERIAL	UNIT DENSITY (CONTAINERS/TON)	SORTING RATE (CONTAINERS/ HOUR/PERSON)	SORTING RATE (TONS/HOUR/PERSON)	RECOVERY EFFICIENCY (%)
Newspaper	–	–	0.75 – 5	60 – 95
Corrugated	–	–	0.75 – 5	60 – 95
Glass (mixed)	3,000 – 6,000	1,800 – 3,600	0.45 – 0.9	70 – 95
Glass (by color)	3,000 – 6,000	900 – 1,800	0.45 – 0.9	80 – 95
Plastic (PET, HDPE)	9,000 – 18,000	1,800 – 3,600	0.15 – 0.3	80 – 95
Aluminum (from plastic)	45,000 – 54,000	1,800 – 3,600	0.05 – 0.06	80 – 95

Table B-8 Automated Sorting Rates and Efficiencies (Peer 1991)

SYSTEM	TARGETED MATERIALS	SORTING RATE (TONS/HR)	REMOVAL EFFICIENCY (%)
Glass Separation (MSS ColorSort)	3/8" to 2" Clear, Brown, Green, Blue, and Yellow glass	5.0	> 95
Plastic Separation (MSS BottleSort)	PVC, Clear PET, Colored PET Natural HDPE, Mixed Color HDPE, PP, and PS (up to 7 colors)	2.5	99 – PVC 90 – other resins

As illustrated in Figure 2, a state-of-the-art MRF includes a series of separation processes:

- A tipping floor where mixed recyclable are unloaded from trucks onto conveyor belts and large items are removed.
- A pre-sort area where manual workers can remove hazardous and non-recyclable materials. Hazardous materials require appropriate treatment. Non-recyclable materials are deposited on a conveyor leading to a

collection bin for combustible material.

- Screening operations, such as trommels, to remove small-size contaminants (dirt, small pieces of glass, etc.). These materials have little heating value and are conveyed to a holding area for landfillable materials.
- Central sorting machines, such as inclined sorting tables, that separate paper and containers based on density.
- Electromagnets to remove ferrous metals.
- “Air knife” or “chain curtain” to separate glass containers from aluminum and plastic.
- Optical glass sorting system, as implemented in Newark, NJ, glass recycling facility, to separate glass by color.
- Eddy current separator to remove aluminum materials.
- Manual plastic sorting station. Recyclable plastics are positively sorted; all others are conveyed to holding area for combustible materials.
- Screening mechanism to separate small paper items from newspaper and large cardboard pieces.
- Manual paper sorting station. Recyclable papers are sorted out; all others are conveyed to holding area for combustible materials.
- Balers to compact recyclable materials.
- Storage areas for recyclable, combustible, and landfill materials.
- Shipping dock for removal of end products.

The non-recyclable, combustible residues of this MRF would go to a Waste-to-Energy plant of the type described in detail later. The non-recyclable, non-combustible residues of the MRF would go to a landfill.

B-8.2 Economic Benefits of a NYC Modern MRF

Dubanowitz (2000) presented detailed estimates of the projected cost and revenues of a proposed MRF. It was estimated that a facility with capacity of 150 tons per hour (two-shift operation, 302 days per year, 0.725 million tons of recyclable per year) would require approximately 16 acres (684,000 square feet) and, including a 10 percent contingency, would cost \$ 60 million; the corresponding annual capital charges (20-year, 10 percent interest) were estimated at \$6.5 million. The site lease costs were \$2 million and the annual operating and maintenance costs were projected at \$7 million. Therefore the total annual capital and operating charges were \$13.6 million or \$18.7 per ton of recyclable.

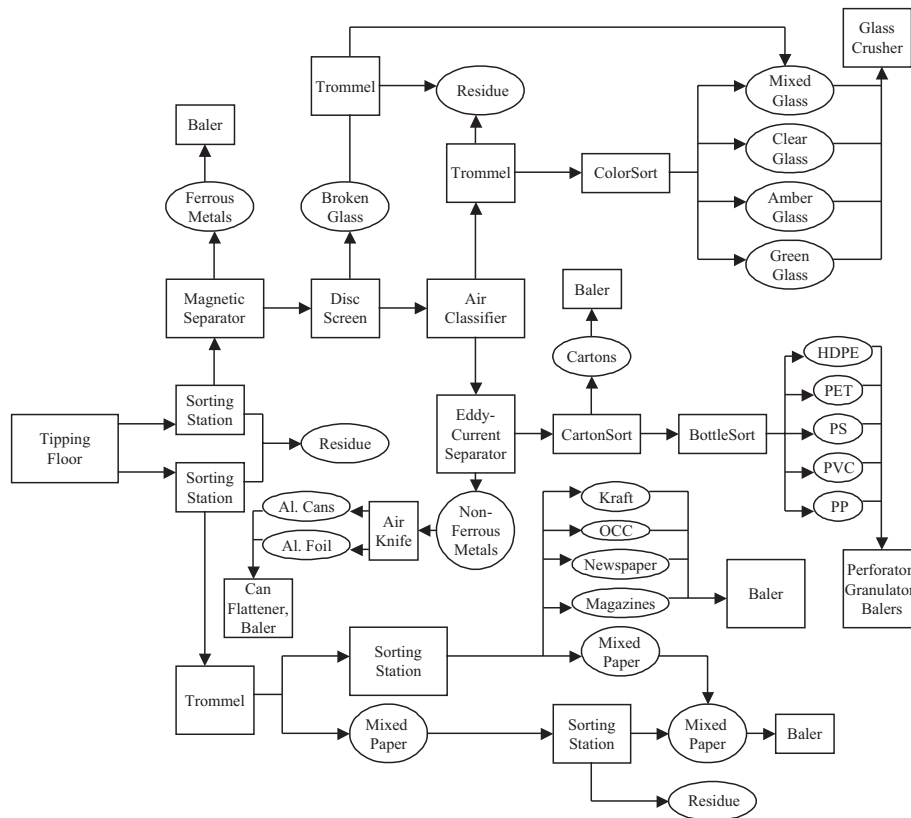


Figure B-2. Schematic diagram of modern NYC MRF of 150 tons per hour capacity (Dubanowitz 2000)

Dubanowitz estimated that the yield of salable products from this MRF would be 86 percent of the feed material, the average value of the salable products \$36/ton, and the material revenues of the 0.725 million-ton plant \$22 million. However, since the City in 1999 paid private MRF operators disposal costs of up to \$50 per ton of recyclable, the modern MRF proposed by Dubanowitz (2000) would have a payback period of a few years, even if the MRF salable products were to be given away. It would appear that this option should be examined further by NYC.

B-8.3 Collection of "Paper," "Dry" and "Wet" Streams

If an automated modern MRF were to be implemented in NYC, it would make sense to modify slightly the present three-stream collection system to the following three-stream system:

- a) Keep the present “paper” stream as is but limit it to the types of paper (newsprint, corrugated cardboard, etc.) that under the MRF processing result in very high recovery (96 percent). Since mixed paper has a very low yield, it would not be included in this stream. The rest of the “paper” stream would continue to be collected and processed through private contractors as at present. This stream is estimated at about 380,000 tons per year of newsprint paper and 120,000 tons of corrugated cardboard, i.e., a total of 0.5 million tons. It would continue to go to the present processors like Visy with whom the City has long term contracts.
- b) Collect a second stream, called “dry”, that will include all other materials except food, plant wastes, disposable diapers, and miscellaneous organics. In effect this stream would be similar to the present metal-glass-plastic (MGP) stream but would also include any kind of paper, plastic, metal and other “non-wet” solid. This stream would be destined to the new MRF proposed above. In the projected first phase (150 ton/hour MRF, Dubanowitz 2000), this stream would be 0.7-1 million tons per year (depending on two-shift or three-shift operation). However, if the Waste-to-Energy (WTE) option discussed in Section 12 (1 million tons per year) were to be pursued simultaneously, the dry stream would supply feed material both to the new MRF (0.7-1. million tons) and also to the WTE plant (1 million tons), thereby diverting from landfills 1.7-2 million tons per year. As shown in Table 5, and assuming no change in the current rate of MSW generation, the “dry” stream could increase up to 2.6 million tons per year (i.e., everything in the NYC MSW except the “paper” stream, food and yard wastes, disposable diapers and miscellaneous organics).
- c) The third stream, called “wet”, would in effect be similar to the present black bag stream, except it would contain much less paper, metal, plastic, glass, and other dry materials, since most of these would go with the “dry” stream. The “wet” stream would go to landfills or to Waste-to-Energy plants, until such time that the composting options and markets are developed (see next section on Bioconversion). As shown in Table 5, the minimum size of this stream would be 1.4 million tons (food and yard wastes, disposable diapers, miscellaneous organics).

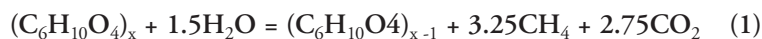
The proposed separation of “wet” from “dry” materials would help all facets of waste management. The odors and liquids associated with “garbage” are due to the putrescible organic components of food and plant wastes in the “wet” stream. These materials are less than 20 percent of the total MSW; yet they contaminate and complicate the transport, transfer and processing of the rest of the MSW. Therefore, it is generally preferable to separate the “wet and “dry” components at the source. This is already done at some forward-looking communities in Canada (Guelph, 2000; Halifax, 2000), Australia (Wollongong, NSW 2000), and elsewhere (www.columbia.edu/cu/earth). It is interesting to note that the citizens of New York City were also separating “wet” from “dry” in the first part of the 20th century and recovered useful products from both streams. However, this system was made uneconomic by the creation of the giant Fresh Kills landfill on Staten Island.

B-9 Bioconversion of “Wet” Stream to Natural Gas or Ethanol

In addition to combustion or aerobic composting of the food/plant wastes fraction of the MSW to a compost material, or combustion, there is a third option of converting it anaerobically in a bioreactor to methane gas and a compost material. This option was examined in great detail by the Earth Engineering Center and was the subject of two Master of Science theses (Bernreuter 2000, Verma 2002). Also, EEC contacted Valorga, one of the major companies operating this technology in Germany and France and visited an operating facility in Freiburg, Germany (www.columbia.edu/cu/earth)

The quantity of natural gas generated during anaerobic decomposition can be determined by considering the

simplified molecular formula of organic waste discussed in a later section of this report and assuming that the anaerobic biodecomposition reaction proceeds as follows:



According to the above chemical equation, the product gas contains about 54 percent methane and 46 percent carbon dioxide. If it is assumed that the $(C_6H_{10}O_4)_x$ component is 50 percent by weight of the “wet” stream, the maximum amount of natural gas that can be produced from the “wet” fraction of the MSW is calculated from Equation (1) to be 8,600 standard cubic feet per short ton of food/plant wastes (268 standard cubic meters per metric ton). However, in the Valorga process, the biodecomposition reaction is stopped at about 75 percent completion.

Although composting the organic fraction of New York City MSW would divert nearly 0.9 million tons of the city’s waste from landfills (Table 5), there is currently no regional capacity available for composting this amount of material. Composting facilities often encounter stringent regulatory barriers, especially when processing food waste, and collection and transportation of the wet, heavy, putrescible organic fraction poses a significant problem to the waste management system already in place. The introduction of composting into New York City’s waste management system will be a slow process. However, if a “wet-dry” source separation system were implemented, it would increase greatly the amounts of potentially compostable materials. The “wet” organic fraction could be landfilled until the waste-to-energy and recycling capacities of the city are well-established.

There are two obstacles to near-term implementation of bioconversion technologies for processing the NYC wastes, either to methane gas or to alcohol: a) Such technologies have not been implemented on a large scale in the U.S.; b) they would require a sizable market (estimated at 0.5 million tons) for the compost product; c) they are bound to meet with siting challenges.

B-10 Generation of Electricity by Combustion of MSW

Nearly all MSW materials, with the exception of inorganic materials such as glass and metals, contain chemical energy that is released during combustion. For example, plastics contain the same heating value, kilogram per kilogram, as fuel oil. Table 9 shows the “proximate analysis” of the combustible materials (percent moisture, volatile matter, fixed carbon, and non-combustible “ash”) and also their experimentally determined heats of combustion.

B-10.1 Chemical Characterization of Combustible Fraction of MSW

Table 9 shows that wood has nearly the same heating value per unit mass as paper, while yard and food wastes contain less energy because of their high moisture content. For example, food wastes contain about 70 percent moisture and their calorific value is only 5350 kJ/kg (2300 BTU/lb). Thus, high-moisture food wastes contain enough heat to burn “autogenously” (i.e. without fuel addition) but cannot generate much electricity.

The chemical thermodynamics of the MSW combustion reaction can be modeled by representing the composite combustible MSW by an established organic compound. On the basis of the composition data for the “typical” U.S. MSW by Tchobanoglous (1993), and the atomic weights of the respective elements, Themelis and Kim (2002) calculated the molecular formula corresponding to each of the combustible components of MSW:

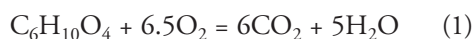
Mixed paper:	$C_6H_{9.6}O_{4.6}N_{0.036}S_{0.01}$
Mixed plastics:	$C_6H_{8.6}O_{1.7}$
Mixed food wastes:	$C_6H_{9.6}O_{3.5}N_{0.28}S_{0.2}$
Yard wastes:	$C_6H_{9.2}O_{3.8}N_{0.01}S_{0.04}$

Table B-9 Proximate Analysis of Components of MSW (% weight)*

	MOISTURE	VOLATILE MATTER	FIXED CARBON	NON- COMBUSTIBLE	KJ/KG AS COLLECTED
“Dry” Combustibles					
Paper	10.2	75.9	8.4	5.4	15814
Cardboard	5.2	77.5	12.3	5.0	16380
Mixed Plastics	2.0	95.8	2.0	2.0	32800
Textiles	10.0	66.0	17.5	6.5	17445
Rubber	1.2	83.9	4.9	9.9	25330
Leather	10.0	68.5	12.5	9.0	18515
Wood	20.0	68.1	11.3	0.6	15445
NYC mix of “dry” combustibles**					18470
“Wet” Combustibles					
Yard Wastes	60.0	30.0	9.5	0.5	6050
Food Wastes	70.0	21.4	3.6	5.0	5350
NYC mixed “dry” and “wet”	21	52	7	20	11630

*Adapted from data in Tchobanoglous et al., 1993, by Brady 2000

The same authors showed that the molecular formula $C_6H_{10}O_4$ most closely approximated the mix of organic wastes in MSW. This formula corresponds to that of at least ten organic compounds, such as adipic acid, ethylene glycol diacetate, and others. The heat of formation of most of these $C_6H_{10}O_4$ compounds is about -962 kJ/mol (Roinen, 1999). Representing the NYC dry stream by the $C_6H_{10}O_4$ formula results in the following combustion equation:



This reaction is highly exothermic and at the combustion temperature of 1000°C generates about 27000 kJ/mol. Since the molecular weight of $C_6H_{10}O_4$ is 146, the “theoretical” heat of reaction (i.e. in the absence of inert or moisture) per unit mass of MSW is calculated to be 18400 kJ/kg (7900 BTU/lb). Similarly, if the MSW combustibles are simulated by the less oxidized compound $C_6H_{10}O_3$, the combustion reaction is:



and the “theoretical” heat generated 23000 kJ/kg (9900 BTU/lb). A computation by Brady (2000) of the molecular formula of NYC wastes resulted in the hypothetical compound $C_6H_{9.3}O_{3.5}$ that lies between the two organic compounds shown above (Table 10).

Table B-10 Ultimate Analysis of Dry Stream before Materials Recovery (Brady 2000)

COMPONENT OF WASTE STREAM	% IN NYC	WEIGHT OF COMP. (TPD)	% BY WEIGHT**				
			CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR
Paper	26.6	3458	43.5	6.0	44.0	0.3	0.2
Cardboard	4.7	611	44.0	5.9	44.6	0.3	0.2
Plastics	8.9	1157	60.0	7.2	22.8	–	–
Textiles	4.7	611	55.0	6.6	31.2	4.6	0.2
Rubber & Leather	0.2	26	69.0	9.0	5.8	6.0	0.2
Wood	2.2	286	49.5	6.0	42.7	0.2	0.1
Glass	5.0	650	0.5	0.1	0.4	<0.1	–
Metals	4.8	624	4.5	0.6	4.3	<0.1	–
Other	4.6	598	26.3	3.0	2.0	0.5	0.2
Total:		8021	3151	409	2413	46	11
Atomic Weight (kg/kmol)			12.01	1.01	16.00	14.01	32.07
Number of Moles			262	405	151	3.29	0.33
Molar Ratio (For C=6)			6.0	9.3	3.5	0.1	~0.0

Approximate Chemical Formula: $C_6H_{9.3}O_{3.5}$

B-10.2 Effect of Moisture and Inert Materials on Heating Value

The inclusion of moisture and non-combustible materials in the MSW decreases the available heat for combustion in Waste-to-Energy (WTE) plants that produce electricity and steam. To quantify these effects, it is assumed that the WTE plant provides steam to a standard power plant and that the exhaust gases leave the boiler at 120°C and 0.135 MPa (20 psi). Accordingly, the amount of heat wasted per kg of water in the feed, as water vapor in the exhaust gases, is calculated to be 2636 kJ/kg.

The non-combustible materials in the feed, mainly glass and metals, end up mostly in the bottom ash. If it is assumed that the ash leaves the grate at about 700°C and using the known specific heats of each material, the corresponding heat loss of for each inorganic material in the MSW is estimated to be as follows:

- Glass and other siliceous materials: 628 kJ/kg (270 BTU/lb)
- Iron: 420 kJ/kg
- Aluminum: 134 kJ/kg

Considering that the iron/aluminum ratio in MSW is about 4 (Table 10), the average heat loss per kg of metal is estimated to be 544 kJ/kg (234 BTU/lb). Accordingly, the effects of non-combustibles on the heating value of RDF can be expressed as follows:

$$\begin{aligned} \text{Heating value of mixed MSW} &= (\text{heating value of combustibles}) * X_{\text{comb}} - \\ &\bullet (\text{heat loss due to water in feed}) * X_{\text{H}_2\text{O}} - (\text{heat loss due to glass in feed}) * X_{\text{glass}} - \\ &\bullet (\text{heat loss due to metal in feed}) * X_{\text{metal}} \end{aligned} \quad (3)$$

and substituting numerical values for the heat value of combustion (Equation 3) and the above heat losses

$$\begin{aligned} \text{Heating value of mixed MSW} &= \\ &= 18400X_{\text{comb}} - 2636X_{\text{H}_2\text{O}} - 628X_{\text{glass}} - 544X_{\text{metal}} \text{ kJ/kg} \end{aligned} \quad (4)$$

where X_{comb} , $X_{\text{H}_2\text{O}}$, etc. are the fractions of combustible matter, water, etc. in the RDF.

As discussed earlier, it is preferable to separate the “wet”, putrescible materials that contain a lot of water and also complicate manual and mechanical sorting of the rest of the waste, from the non-combustible fraction (metal, glass, other inorganic materials). Of course, separating the non-combustible fraction also increases the thermal efficiency and ease of operation of the combustion plant. However, this requires collecting a dry and a wet stream and increases the cost of collection.

Table 9 showed that the experimentally determined heating value of the “dry” stream, after separation of the “wet” and the non-combustible fractions, amounts to 18470 kJ/kg. This value is fairly close to the thermochemical value calculated on the basis of Equation 4 and in the range of lignitic and sub-bituminous coals that are still used in many power plants. Therefore, using the “dry combustible” MSW as an RDF fuel in a conventional power plant can reduce, by as much as ton per ton, the need for mining coal. Due to the fact that the present energy conversion efficiency of WTE plants is about 65 percent that of coal-fired power plants and the MSW combusted consists of the mixed “wet” and “dry” fractions, the actual replacement ratio is 0.25 tons of coal per 1 ton of commingled MSW. The replacement value for fuel oil amounts to 45 gallons of oil per ton of mixed MSW.

Figure 3 shows the effect of moisture on the heating value of MSW. The bold line represents the heating value calculated from Equations 4. It can be seen this line is fairly representative of the heating value of several waste materials reported in that literature, as well as of the New York City MSW (Table 9). Of course, wastes consisting mostly of plastics cannot be represented by $\text{C}_6\text{H}_{10}\text{O}_4$ but by lower oxygen organic materials that have higher heating values. The opposite is true for wastes that contain only papers where cellulose ($\text{C}_6\text{H}_{10}\text{O}_5$) is the prevalent compound. Figure 3 shows the projected heating values for a number $\text{C}_6\text{H}_{10}\text{O}_x$ compounds.

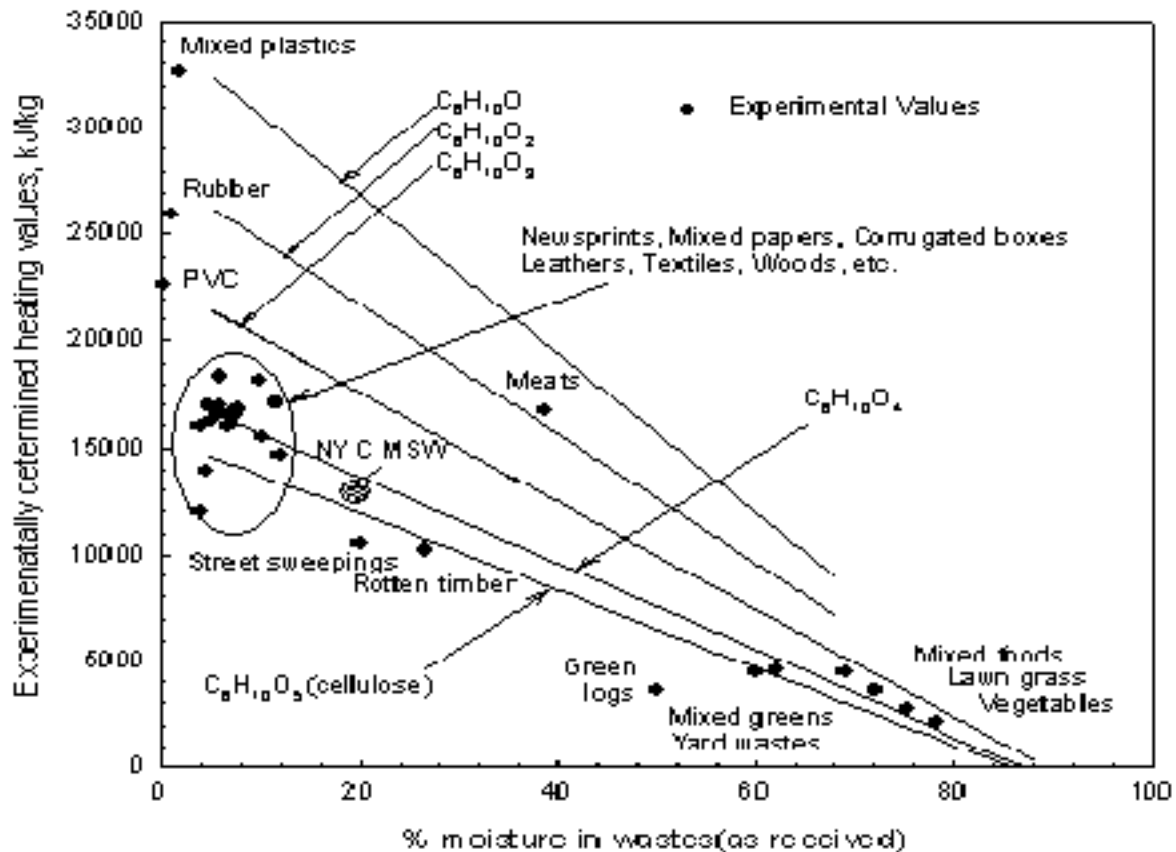


Figure B-3. Effect of moisture on heating value of MSW materials (points shown are experimental values; solid lines show thermochemical calculations for various organic compounds)

B-11 Waste-to-Energy Power Plants vs. The Incinerators of the Past

Thirty six million tons of MSW are combusted annually in U.S. Waste-to-Energy (WTE) plants (Berenyi, 1998) to generate about 20 billion kWh per year (Berenyi, 1998). The equivalent amount of fuel oil that would have to be imported to produce this amount of electricity in conventional power plants would be 1.6 billion gallons per year. Despite this obvious advantage of combustion, an estimated 117 million tons of municipal wastes (CEQ, 1997), plus at least an equal amount of commercial and industrial combustibles (e.g. plastic residues from car shredding) are discarded annually in landfills. Also, as noted above, New York City (NYC) is sending about 3.2 million tons of MSW per year to landfills and only 0.56 million tons to combustion.

The main reason for the dominance of landfills is that, due to the relatively low value of land, landfilling is in many cases less costly. Also, in the past, environmentalists have rightly opposed combustion of MSW, due to the adverse effects of past incineration practice that goes back to the nineteenth century. For example, as documented by Walsh et al (2000), between 1910 and 1968 there were in NYC approximately 17,000 apartment/house incinerators, with no emission controls, and 32 municipal incinerators, with rudimentary controls. During this period, the NYC municipal incinerators processed about 73 metric million tons of MSW and the soot emissions to the atmosphere amounted to an astounding 1 percent of the MSW feed (Walsh et al, 2000).

However, by the end of the 20th century, MSW was combusted in modern power plants that generated electricity, recovered metals, and were equipped with gas emission control systems that were superior to those used in many coal-fired thermoelectric plants. For example, the particulate emissions from the modern WTE plant

described later in this report amount to only 0.003 percent of the MSW feed. Therefore, a clear distinction must be made between the incinerators of the past and the modern Waste-to-Energy (WTE) plants.

Any plant designed to solely burn municipal solid wastes is anachronistic and environmentally indefensible. With present day technology, the combustion of municipal wastes must be accompanied by the generation of electricity and process steam. It is this combination that has led to the burgeoning new industry of Waste-to-Energy (WTE). There are nearly one hundred WTE plants in the U.S. (Berenyi, 1998). In contrast to coal-fired power plants, WTE plants have two sources of revenue: the generated electricity and the disposal (“tipping”) fees paid by municipalities to get rid of their wastes. Also, WTE plants do not have to buy their fuel or transport it over long distances. The value of electricity produced in WTE plants provides a financial resource that can be used to clean the combustion gases to a degree that was never practiced in the incinerators of the past and is even higher than many of the older coal-fired power plants. If combustion of MSW has advanced to the point that it offers an environmentally superior option for managing part of the U.S. MSW stream, should it be opposed on the basis of past experience with obsolete technology? This question was examined in great detail during this study.

It is widely understood that any technology or product, in addition to the benefits it provides, has a certain downside. Therefore, it is important in any particular case to compare the advantages and disadvantages of a given technology against those of the alternatives. What are the alternatives to the combustion of municipal wastes? Some people say “avoidance of wastes” or “recycling” but inspection of the composition of MSW (Table 3) and the accumulated experience in the U.S. and abroad show that even under the best recycling scenario, society will still have to dispose a large part of its MSW. With time there will be fewer types of non-recyclable plastic, paper, and composite materials. However, after all possible waste-avoidance and recycling methods are attained, there will still be a large amount of used materials to be disposed. Table 5 showed that even when the NYC recycling rate increases to the maximum attainable of 40 percent, from the present level of less than 20 percent, there will still be close to 2.7 million tons of MSW per year to be disposed either by combustion or by landfilling.

The following sections examine the pros and cons of Waste-to-Energy and landfilling.

B-12 Electric Energy from MSW

The dominant WTE technologies are described in this section.

B-12.1 Moving Bed Combustion: “Mass Burning”

“Mass burning” is the dominant WTE technology in the U.S., Japan, and other countries; it can be classified under the class of unit operations called “moving bed”. Trucks carrying MSW empty their load in a large enclosed chamber (Figure 4). An overhead “claw” crane scoops material and deposits it at the feed end of a moving metal grate, or set of slowly rotating cylinders, that slowly conveys the waste materials through the combustion chamber. Many WTE operators favor the “mass burning” process because it does not require pre-processing of the feed and is a relatively simple operation. However, because of the large size of the items moving through the combustion chamber, the rates of heat, mass transfer, and combustion are relatively slow. Therefore, a very large grate and combustion chamber are required and the rate of heat generation per unit volume is correspondingly low. The temperatures generated in the combustion chamber are in the order of 900°C.

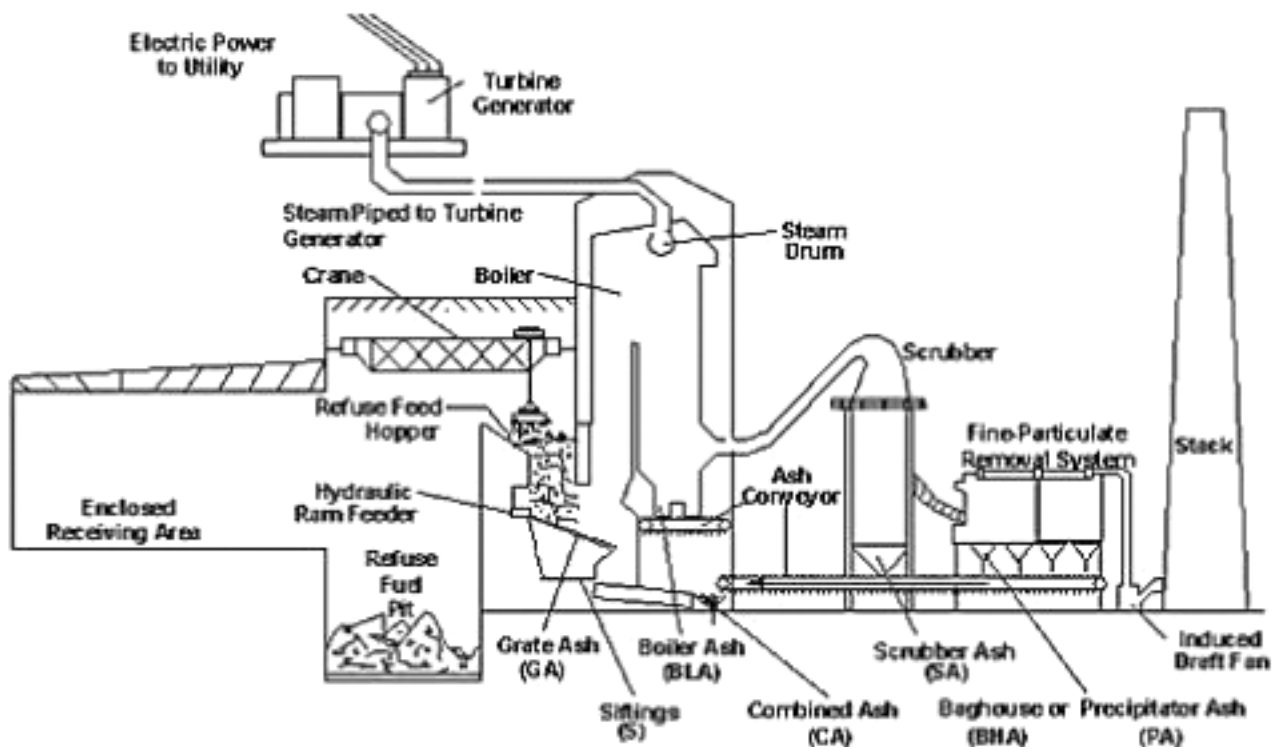


Figure B-4. Schematic diagram of mass-burning WTE facility

B-12.2 Refuse-derived fuel (RDF)

The term “refuse-derived fuel” (RDF) describes MSW that has been processed to a fairly uniform fuel, ready for combustion either in dedicated WTE plants or as complementary fuel in coal-fired power plants. The processing generally entails separation of inert materials, size reduction, and densifying (e.g., pelletizing). This allows for the removal of both recyclable and hazardous materials. The densified material is more easily transported, stored, and combusted than raw MSW. RDF can be produced on a small scale at several locations and then transported and used in a large WTE plant where the efficiencies of scale allow for effective emission controls. Also, the processing of MSW to RDF can include the addition of calcium compounds after combustion to reduce HCl emissions.

Lakeland Electric in Florida is an example of an operation that continues to make use of MSW as a co-fuel in a coal-fired power plant. The McIntosh Power Plant has been burning co-fuel since 1983, and uses 10 percent RDF to 90 percent coal. It was designed to use up to 500 tons per day of RDF (Clarke, et al., 1991). Wide adoption of RDF technologies has been hampered by the difficulties of processing a highly non-homogeneous material; also the use of RDF as a coal substitute requires modern gas control equipment that is not available at many coal-fired power plants.

B-12.3 Flash and Moving Bed Combustion: The SEMASS WTE Plant

In between the “mass burning” and RDF processes, there is a technology developed by Energy Answers Corporation (EAC 1999) and used by American Ref-Fuel at their SEMASS plant at Rochester, MA (SEMASS 2001). MSW is transported to this plant by covered railcar and truck from about 40 communities in a 65-mile radius, including the entire Cape Cod area and Martha’s Vineyard, and Nantucket. The plant consists of three parallel combustion units, processing an average of 3,000 tons per day or one million tons per year. The first two units were built in 1989 and Unit 3 in 1994. An average of 650 kWh of electricity is produced per ton of MSW, of which 100 kWh are used to operate the plant and the rest are sold to the local utility. Figure 5 is a photograph of the SEMASS plant.



Figure B-5. SEMASS Resource Recovery Facility (Rochester, MA)

SEMASS was designed and built by Energy Answers Corporation (EAC) and is presently operated by American Ref-Fuel. The feed material consists of the entire (i.e., “wet” + “dry”) MSW stream. At this time, the SEMASS combustion chamber and its products are the subject of scientific studies at Columbia University. Waste brought to plant is dumped on a tipping floor (Figure 6). The MSW is loaded from the tipping floor by front-end loaders onto conveyors that pass by inspectors who look for bulk waste that could jam the shredders, or for hazardous waste; these items constitute about 1.6 percent of the incoming material. The waste is then shredded in one of two large hammermill shredders that produce a blended material of minus 6-inch size. The shredded material is conveyed under overhead belt magnets for the first round of ferrous metal recovery and is then stored in bays in a closed building. This material is called by EAC “processed refuse fuel” (PRF) and can be stored for long periods, as it is fairly dry, does not attract rats or flies and is not malodorous.

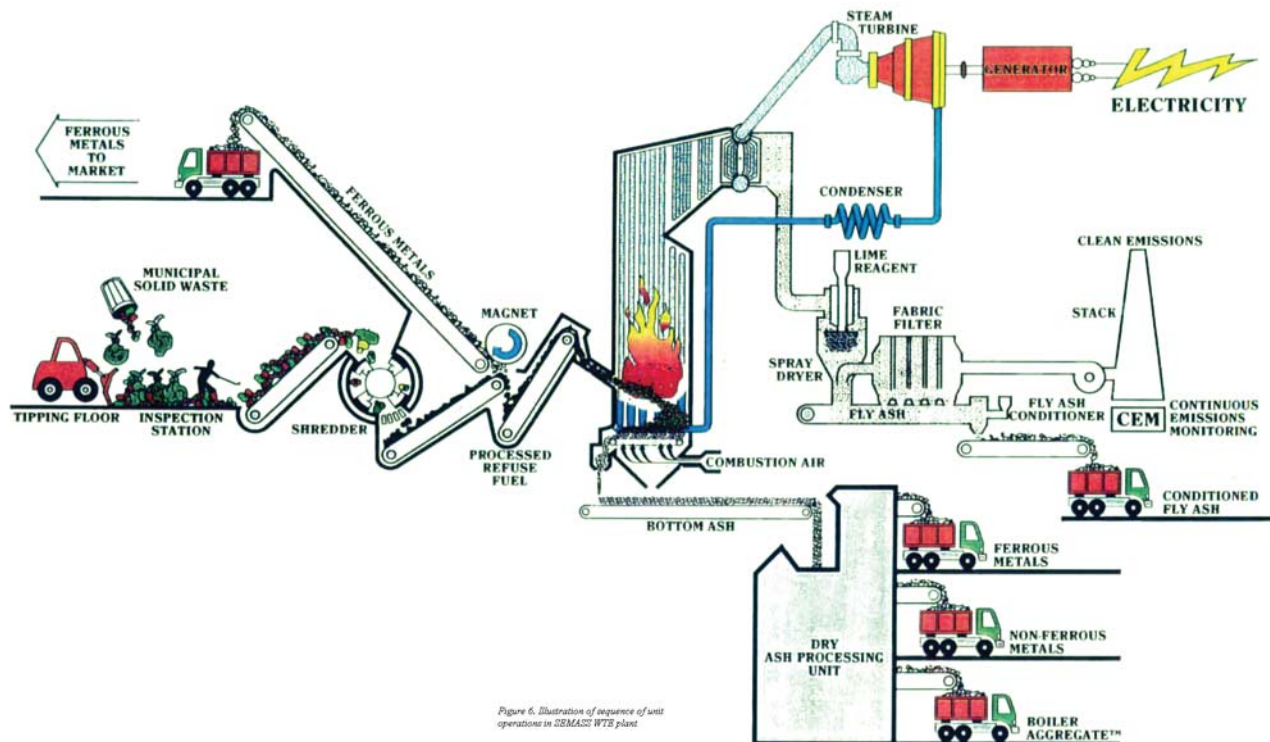


Figure 6. Illustration of sequence of unit operations in SEMASS WTE plant

Figure B-6. Illustration of sequence of unit operations in SEMASS WTE Plant

When this material is fed by conveyor into the combustion chamber, deflectors at the bottom of the chutes and high-velocity air jets, disperse the lighter particles in the hot gas where they are subjected to flash combustion. The heavier particles settle on the far end of a moving grate, located at the bottom of the combustion chamber, and slowly move towards the feed end. Thus, the SEMASS reactor combines flash and moving bed combustion. The temperatures reached in the combustion chamber and on the moving grate are about 100°C higher than in mass burning and the discharged “bottom” ash, examined by the authors in the laboratory, is semi-fused, unlike the powdery ash of mass-burning plants. Additional ferrous metals and also non-ferrous metals are recovered from this ash by means of magnetic and eddy current separators, respectively. The ash meets the EPA non-toxic criteria (TCLP test) and can be used as landfill cover and other beneficial uses.

The gas handling plant of the SEMASS Combustion Unit 3 (built in 1994) is more advanced than the first two units (built in 1989). Potential air contaminants are controlled by a variety of means. A solution of urea in

water is injected continuously into the furnace to control the level of nitrogen oxides. The combustion gases pass through water and air heat recuperators and then enter a “dry scrubber” chamber where a lime slurry is injected to neutralize acid gases and trap any chlorides and dioxins/furans that may have persisted in the high temperature atmosphere in the combustion chamber, or re-formed during the cooling stage of the gas. Activated carbon is injected in the process gas to collect mercury and other volatile contaminants. Finally, fiber fabric filters capture most of the fine particles before the gases are discharged through the stack. The fly ash collected in the fiber bag filters contains most of the heavy metals that were present in the MSW and is disposed in a monofill landfill.

The SEMASS plant recovers 4.5 percent of the feed MSW as ferrous and non-ferrous metal, and disposes 7.7 percent as fly ash to the nearby backup landfill. The bottom ash, after metal recovery, represents about 10 percent of the feed and can be used as road fill or in other beneficial uses. The process flow diagram is shown in Figure 7.

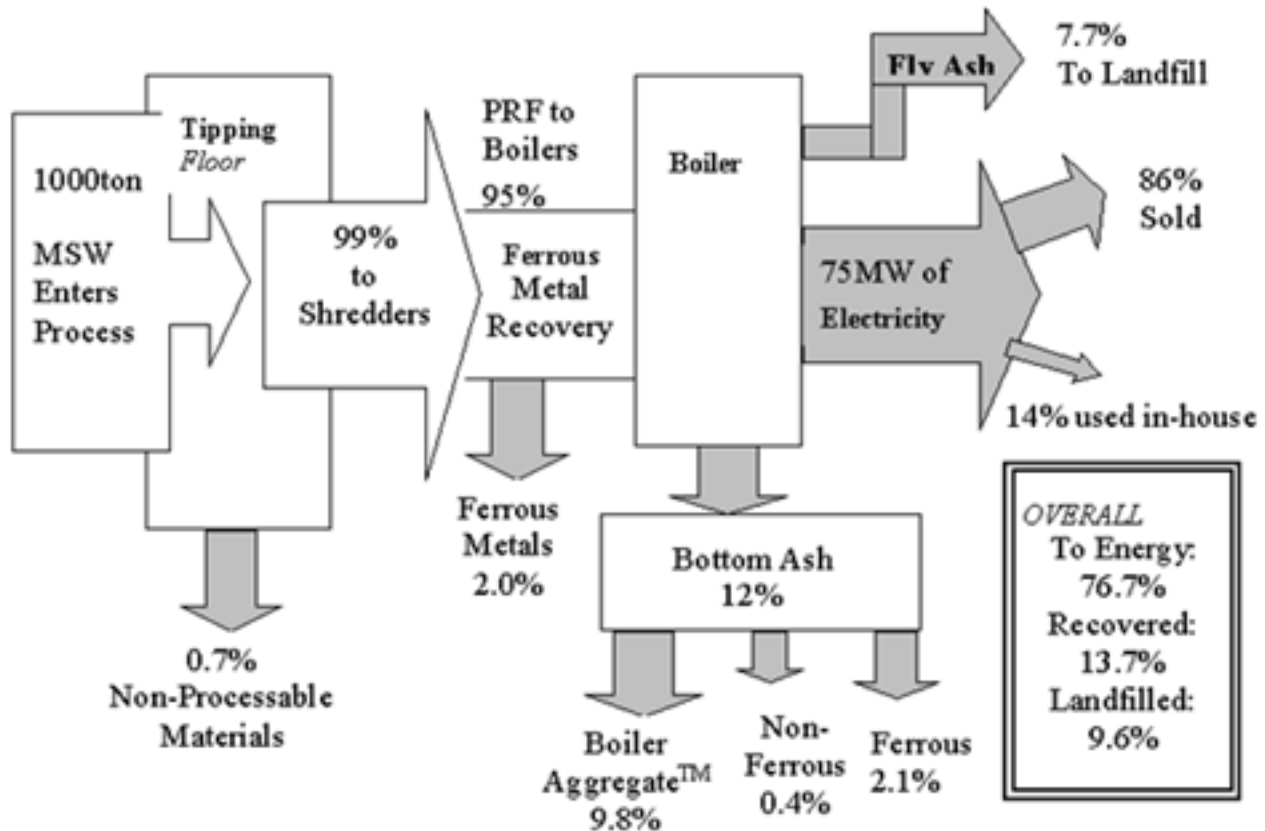


Figure B-7. Process flow diagram of one of the three SEMASS WTE units

B-12.4 Gas Emissions from WTE Power Plants

The most contentious issue regarding energy recovery from solid wastes is that of emissions to the atmosphere. Emissions of mercury, hydrochloric acid, and dioxins have been the most worrisome problems in the past. However, by the end of the 20th century, emissions in modern WTEs were reduced to extremely low levels by means of reduction of the precursors in the feed (e.g. mercury-containing products), better combustion practice, and greatly improved gas control systems that include dry-scrubbing, activated carbon injection and filter bag collection systems. For example, Table 11 compares air emission levels for the SEMASS No. 3 unit with the current EPA standards (Themelis et al 2001). A detailed tabulation of all emissions of the Onondaga, NY WTE plant can be found in their web page (www.ocrra.org)

Table B-11 Comparison of 1999 Emissions from SEMASS WTE plant with EPA standards

EMISSION	EPA STANDARD ¹	SEMASS ²
Particulate (gr/dscf)	0.010	0.002
Sulfur Dioxide*	30	16.06
Hydrogen Chloride*	25	3.6
Nitrogen Oxides*	150	141
Carbon Monoxide*	150	56.3
Cadmium**	20	1.24
Lead**	200	30.03
Mercury**	80	5.09
Dioxins/Furans (ng/dscm)	30	0.86

gr/dscf: grains/dry standard cubic foot; 1 gr/dscf=2.28 g/dscm

**ppmdv: parts per million dry volume*

***mg/dscm: microgram per dry standard cubic meter; ng: nanogram*

¹The standards and data are reported for 7% O₂, dry basis, and standard conditions.

²EAC, average of 1994-1998. Boiler No.3

Since the SEMASS combustion process produces about 6900 standard cubic meters of process gas per ton of MSW, the mercury concentration shown in Table 11 corresponds to about 34 kilograms per million tons of MSW processed. The measured concentration of mercury in the collected flue dust is 18 parts per million (Figure 3) and represents 7.7 percent of the MSW processed (Figure 9). Therefore, it is concluded that 97 percent of the mercury input in the MSW feed is captured in the flue dust. As noted earlier, the SEMASS flue dust is disposed in a “monofill” landfill where there is no organic carbon. In contrast, if the MSW that now goes to SEMASS were to be landfilled, the conditions in a landfill (organic matter, moisture, bacteria) are favorable for the formation of methyl mercury, a compound that is bioavailable and can move up the food chain (Gregory, 2001).

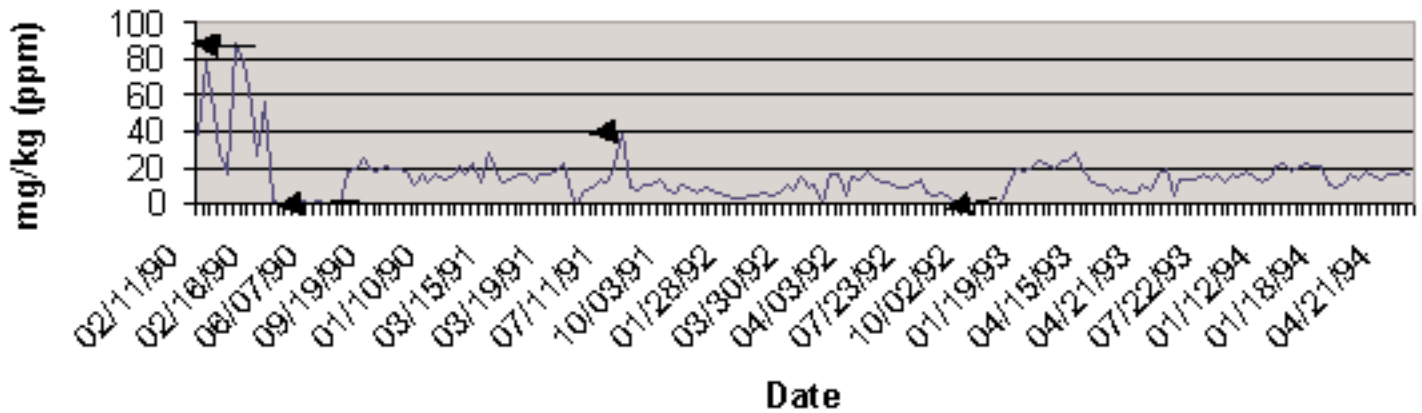


Figure B-8. Mercury concentration in SEMASS fly ash (1990-1994; from plant record of operating data)

B-12.5 Decrease of WTE Mercury Emissions in the Nineties

As the most prominent pollutant of the volatile heavy metals, mercury is a good indicator of the drastic decrease of U.S. WTE emissions in the nineties. The principal reason for this were environmental regulations that mandated much improved gas control systems; the other reason was lower input of metals in the MSW feed, due to increased recycling and reduction of mercury use in materials production. State regulations in New Jersey ensured that by the end of 1995 all WTE plants were retrofitted with activated carbon injection. Table 12 (NJ DEP 2001, Themelis and Gregory 2001) shows the decrease in mercury emissions of the NJ WTE plants between 1993 and 1999.

Table B-12 Mercury emissions from New Jersey WTE plants, 1991-1999
(New Jersey Task Force, 2001)

FACILITY	WTE CAPACITY, SHORT TONS/DAY	POUNDS OF MERCURY PER YEAR				
		1991-93	1996	1997	1998	1999
Camden	1,050	1,084	431	350	144	113
Essex	2,275	1,771	216	323	115	162
Gloucester	575	149	32	51	25	15
Union	1,440	844	84	42	24	32
Warren	400	562	4	4	3	4
Total NJ	5,740	4,410	767	770	311	326

Table 13 (Themelis and Gregory 2001) compares the 1999 mercury emissions of the five New Jersey WTE plants with the SEMASS, MA, and the Onondaga, NY, WTE plants. The last column brings all the data into a common metric: kilograms of mercury emitted per million metric tons of MSW combusted. The lower emissions shown for some of the MSW plants in Table 13 reflect both better gas control systems and the ability of some communities to divert mercury-containing objects from the MSW stream. For example, an aggressive campaign in Warren County, NJ reduced the amount of mercury in the MSW stream from 3 parts per million to less than 1 ppm (NJ DEP 2001).

To appreciate the drastic reduction in mercury emissions from WTE plants in the last decade of the 20th century, it should be noted that a study by the National Renewable Energy Laboratory (NREL 1993) reported that the 1989 emissions of U.S. WTEs amounted to 81.8 tons of mercury. A few years later, the EPA Report to the Congress (EPA 1997) showed that the 1994-1995 emissions from WTE plants had been reduced to 26.9 tons of mercury. Finally, if we apply the average value of 60 kg of mercury per million metric tons of MSW (Table 13) to the 33 million metric tons (36 million short tons) of MSW combusted in the U.S. (Berenyi, 1998), the mercury emissions from U.S. WTE plants in 1999 would amount to about 2 tons, i.e. thirteen times smaller than the EPA 1995 estimate and nearly forty times lower than the 1989 WTE emissions. In contrast, the mercury emissions from all U.S. coal-fired power plants are about 47 tons per year (EWG 2001).

Table B-13 1999 Mercury emissions from Waste-to-Energy plants

FACILITY	GAS CONTROL SYSTEM (ALL USE CARBON INJECTION)	MSW COMBUSTED, SHORT TONS PER YEAR	ANNUAL MICRO-GRAMS OF MERCURY PER DRY STANDARD CUBIC METER	MERCURY EMISSIONS Kg/y	KILOGRAMS OF MERCURY PER MILLION METRIC TONS OF MSW
Camden, NJ	ESP	451,000	25.1	51.3	125
Essex, NJ	ESP	985,000	31.8	73.5	82
Gloucester, NJ	Fabric filters	210,000	38.0	6.8	36
Union, NJ	Fabric filters	562,000	2.2	14.5	28
Warren, NJ	Fabric filters	160,000	2.4	1.8	12
New Jersey total		2,368,000		148.0	69
Onondaga, NY	Fabric filters	330,000	8.1	15.3	52
Hempstead, NY	Fabric filters	700,000	NA	NA	
Niagara Falls, NY	Fabric filters	800,000	NA	NA	
New York total		1,826,000			
SEMASS, MA	Fabric filters	1,000,000	5.1	33.0	37

B-12.6 Decrease in Dioxin Emissions from WTE Plants

Another environmental concern regarding WTE plants in the past has been the emission of dioxins. In the case of the SEMASS WTE plant, the dioxin concentration of 0.86 nanograms per dry standard cubic meter of gas (Table 11) correspond to only 4.5 grams per year, i.e. 4.5 grams per million tons of MSW. If all the U.S. WTE plants (36 million tons of MSW) were doing as well, the total WTE emissions would amount to 162 grams per year. However the Onondaga WTE reported (Jan.-Feb 2000, *www.ocrra.org*) an average dioxin concentration of 2.78 nanograms per dscm. This number is three times higher than at SEMASS and if it applied to the entire WTE industry, the annual emissions would amount to 480 grams, or about one pound per year.

A preliminary report by EPA (1998) estimated that as of 1995, the dioxin emissions of municipal waste incinerators were in the range of 492-2,460 grams and represented 40 percent of the tabulated emissions. However, the review panel of this report (EPA Review 1998) noted that “estimates for dioxin emissions from landfill fires and backyard trash burning suggest that these sources may release more dioxins to the air than do most of the sources EPA included in (their estimate”. The review panel also commented that “25,000 grams of

TEQ dioxin may be found in pentachlorophenol (PCP) used for wood treatment. This amount is over eight times greater than EPA's (total 1995) estimate." Another observation by the review panel of the EPA report was that "EPA estimates that there are 25,000,000 residential wood combustion sources in the United States, yet none have been tested for dioxin emissions."

In summary, the implementation of Activated Carbon Injection in WTE plants has helped to decrease both mercury and dioxin emissions. The dioxin emissions are specially low in flash-moving bed combustion, such as is used at the SEMASS WTE, that generates higher temperatures within the combustion chamber. At the present time, the dioxin emissions from the entire U.S. WTE industry are of the order of one pound per year.

B-12.7 Existing New York and New Jersey WTE Facilities

Several communities in New York and New Jersey (Table 13) have developed successful waste-to-energy programs to manage solid waste. The Onondaga County Resource Recovery Agency (www.ocrra.org) completed a Waste-to-Energy facility in 1994. It is a "mass burning" plant consisting of three combustion chambers of annual capacity of 330,000 tons of MSW per year. The \$15 million gas control system is of the most advanced type and includes injection of ammonia to suppress nitrogen oxide formation, dry scrubbing with lime slurry, activated carbon injection, and a fabric filter baghouse.

American Ref-Fuel operates several WTE plants in New Jersey and New York, including the ones that combust NYC MSW (Essex County, NJ; Hempstead, NY). The newest is the Niagara Falls, NY, plant. It is based on mass burning technology and has two combustion chambers of annual capacity of 0.7 million tons (www.ref-fuel.com/locations/niagarafalls.htm). The Hempstead, NY, WTE has three combustion units of 0.8 million tons capacity. The Essex County, NJ, plant consists of three mass-burn lines of annual capacity of 0.9 million tons (www.ref-fuel.com/locations/essex.htm). American Ref-Fuel also operates the SEMASS facility (1 million tons per year; www.ref-fuel.com/locations/semass.htm) that is described in more detail in this report.

B-12.8 Metal Recovery in WTE plants- Greenhouse gas credits

As shown in the flow sheet of the SEMASS WTE power plant, nearly 45,000 tons of ferrous and non-ferrous metals are recovered by processing one million tons of MSW per year. Also, since a WTE plant produces much lower quantities of greenhouse gases per ton of MSW than landfills, the greenhouse gas credits may be saleable internationally and used to reduce the capital costs of the projected system.

B-12.9 Private Financing of a New Waste-to-Energy Plant

The experience of the SEMASS facility at Rochester, MA, has shown that the principal lever for building a new WTE plant is the commitment of a number of municipalities to send their MSW to this plant for a stated period of years and tipping fees. In the case of SEMASS, such agreements were made by Energy Answers Corp. with several communities over an area of 65-miles radius. The plant started operations with two combustion lines in 1989 and a third was added in 1994 to bring the present capacity to one million tons of MSW per year. At this time fifty communities from southeast Boston to Cape Cod, including Martha's Vineyard and Nantucket, send their MSW to SEMASS. A corresponding number of landfills have been closed in one of the most scenic areas of the United States.

In the case of NYC, the decision to examine in depth the advantages of diverting MSW from landfills to a new WTE plant can be made by one municipal entity: New York City. Instead of planning for the entire stream that presently goes to out-of-state landfills (3.2 million tons), the City may consider, as the first stage, the diversion of only one-third of this amount, i.e. one million tons, to a new Waste-to-Energy plant to be located in the state of New York or in New Jersey. The experience of the SEMASS plant (Figure 5, aerial photo of SEMASS) shows that, for aesthetic and logistic reasons, such a plant should not be built in a densely populated area like

NYC but at a location that can be accessed easily from NYC by covered rail car or barge. As in the case of Rochester, Mass., the host community will welcome a WTE plant because of several accruing benefits (e.g., closing of local landfill, important financial benefits, increased employment, lower energy costs, and process steam for industrial or residential use).

As in the case of SEMASS, NYC would not be involved in the financing of this plant. The City would only need to provide the guarantee of MSW supply. The plant would be privately financed, owned and operated. A long-term contract would be arranged between the owner and a NY state utility for the sale of electricity (estimated at 70 MW for a one-million ton WTE plant). Since the electricity produced by a WTE facility can be considered to be “Green Energy”, it can be sold to the utilities at a higher than normal price since the utility’s selling price is also higher.

The financial aspects shown in Table 14 are based on information reported elsewhere in this report or provided by Energy Answers Corp., the builders of SEMASS.

Table B-14 Projected costs and revenues (1,000,000 tons MSW/year)

Cost of implementation (financing, engineering, land, construction, start up, contingency)	\$400 million
Total operating costs (labor, services, supplies, administration)	\$35 million per year
Revenues: Tipping fees (at assumed \$50/ton, in 2001 \$)	\$50 million per year
Revenues: Electricity (550 million kWh)	\$27 million
Other revenues: Metals, Steam	\$4+ million

B-12.10 Potential for Development of an Eco-Industrial Park

Eco-industrial parks are combinations of industrial activities where the products and by-products of one industry may be of use to another industry located nearby. An interesting possibility, to explore with the host community of the projected WTE power plant is the private development of an Eco-industrial park that would include distribution of electricity and waste steam to neighboring industries such as:

- recovered metal users, (metal ingots, reinforcing steel),
- recovered aggregate users (concrete and asphalt products),
- used tire processors (recovery of steel and crumb rubber),
- recovered glass users (ceramic tiles),
- steam users (food manufacturers, commercial laundries, paper mills),
- composting facilities (steam and electricity)
- greenhouses to take advantage of steam supply (with the added advantage of absorbing carbon dioxide and producing oxygen from plant growth)
- other industrial operations that may benefit from a steady local source of certain raw materials and low cost energy

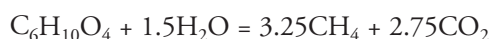
B-13 The Landfilling Alternative

B-13.1 Use of Land

As noted earlier, landfilling is the principal means of disposing of MSW in the U.S. because of the seeming abundance of land and its present low cost. However, biodecomposition of MSW in landfills can proceed over many decades or even centuries so that the ground above landfills is constantly subsiding and cannot be used for much else. To illustrate the “for ever” use for land for landfilling, it is interesting to examine the case of the city of Halifax, Canada (Halifax, 2000). They practice “wet” and “dry” separation at the household level, recycling of usable materials, composting of part of the “wet” fraction, and controlled pre-composting of the remainder of the MSW, prior to disposal in a state-of-the-art landfill. Halifax is a community of about three hundred thousand people generating 250,000 tons of MSW per year. Their recycling and composting activities result in only 60 percent (150,000 tons/yr) of the total MSW going to the landfill. The planned lifetime of this modern 80-acre landfill is twenty years, thus amounting to the use of about 16200 square meters (4 acres) per year. On this basis, the “forever” use of land for landfilling amounts to one acre for every 37,000 tons of MSW landfilled. The 3.2 million tons of landfilled NYC MSW take out of commission about 90 acres of land. Of course, a much larger area of land is affected by the presence of landfills because there cannot be any human habitation close to them.

B-13.2 Gas Emissions from Landfills

The anaerobic decomposition of MSW in landfills leads to the generation of methane and carbon dioxide as represented by the following simplified reaction (Themelis and Kim 2001):



The gas produced in this chemical reaction contains about 54 percent methane and 46 percent carbon dioxide. If it is assumed that the $(\text{C}_6\text{H}_{10}\text{O}_4)_x$ component represents 25 percent of the MSW stream, the maximum amount of natural gas that can be produced from the NYC black-bag stream is calculated from the above equation to be 134 standard m³/metric ton. However, as the organic molecule chains become shorter, they become more stable and the rate of biodegradation decreases. Franklin (1995) reported that the maximum capacity of landfilled MSW to produce methane is 62 standard m³ of CH₄ per ton of MSW, i.e. 50 percent of the amount projected by Equation 2. The actual capture of methane gas generated in landfills in the U.S. has been estimated at about 66 percent (Dennison, 1996). For the 117 million tons of MSW landfilled in the U.S. and assumed 66 percent recovery of the generated methane, the carbon loss to the atmosphere in the form of CH₄ is calculated to be about 1.5 million tons of carbon per year. Since methane is 21 times more potent as a greenhouse gas than CO₂, the methane losses from landfills correspond to about 35 million tons of carbon equivalent, or 2 percent of the total U.S. contribution to greenhouse gases.

It should also be noted that if the entire 62 m³ of CH₄ per ton of MSW were to be recovered, the contained heating value would amount to 1940 MJ per ton MSW, i.e. 20 percent of the heating value of combusted MSW (11630 MJ/ton, Table 9).

B-13.3 Liquid Emissions of Landfills

The prevailing conditions in landfills (moisture, chemicals, organic matter, evolution of heat due to bioreactions) are favorable for the leaching of metals and the formation of leachate solutions. In modern landfills, precautions are taken for collecting and treating the leachate, during operation and for several years after closing the landfill. However, the potential exists for future subsidence of the landfill, breaching in the retaining structure and liquid emissions to the environment. A material balance carried out by the authors on the SEMASS plant showed that

the flue ash collected (approximately 75,000 tons per year) contained 18 parts per million of mercury, i.e. 1350 kilograms of mercury. Adding to this amount the estimated annual emissions of about 35 kg, yielded a mercury input of about 1.5 parts per million in the MSW. If the same mercury concentration applies to the 3.2 million tons of NYC MSW that are presently landfilled, the amount of mercury going to landfills is of the order of 4.8 tons per year. This amount is equal to four times the total annual mercury deposition on the Hudson-Raritan basin, which includes New York City and the industrialized New Jersey (Gregory and Themelis 2001). Mercury metal is volatile at normal temperatures and oxidized mercury can be mobilized in the form of methyl mercury under the moist, reducing conditions existing in MSW landfills.

B-13.4 Life Cycle Assessment of Landfilling vs Waste-to-Energy

A critical analysis and comparison of the life-cycle environmental impacts of recycling, incineration and landfilling by Dennison (1996) was based on the major North American studies of these subjects. It showed that recycling of used materials is superior to either incineration or landfilling, as one might reasonably expect. However, it also showed that combustion is preferable to landfilling and offered the advantage of 28 MJ less of energy used per ton of material processed than landfilling. Of course, interstate transport of MSW, as discussed in an earlier section of this report, will increase considerably the energy usage per ton of MSW. Of equal importance was the finding that, for the 10 major air pollutants categories considered, combustion resulted in lower emissions than landfilling, with the exception of higher generation of carbon dioxide in the combustion process. However, when the generation of carbon dioxide is associated with the production of useful energy, e.g. 550 kWh/ton in the SEMASS WTE plant, one should subtract the “avoided” amount of carbon dioxide that would be produced anyway in a conventional power plant.

A more recent study by Eschenroeder (1998) indicated that, for modern landfills equipped with methane collection systems (70-year post-closure period), the time-integrated effect of greenhouse gases emitted was as much as 45 times greater than when the MSW is combusted.

B-14 Conclusions and Recommendations

At this time, NYC DOS are recycling 750,000 tons of the 4.5 million tons of MSW collected annually by NYC DOS. Since the closing of the Fresh Kills landfill, 3.2 million tons are transported mostly by truck to Pennsylvania, Virginia, and New Jersey landfills. The remaining 0.56 million tons of NYC MSW are combusted in New Jersey and New York Waste-to-Energy (WTE) power plants.

Of the available means for MSW disposal, biocomposting to natural gas, or alcohol, and compost product has not been applied on a large scale in the U.S. Also, it requires the introduction of a new collection system that separates “wet” (i.e., organic wastes) from “dry” and the development of a large regional market for the compost product.

The present rate of recycling can be increased a) by maintaining but modifying the existing three-stream collection system and b) implementing an automated, modern Materials Recovery Facility (MRF) to be operated by the City. In the first stage of implementation, these measures can increase the recycling rate from the present 0.75 million tons to 1.2-1.5 million tons. The estimated investment is on the order of \$60 million.

With respect to the estimated 60 percent of NYC MSW that is not recyclable under any circumstances, the only viable technologies in the foreseeable future are landfilling and Waste-to-Energy. Both of these technologies are already used by private firms under contract to NYC. A thorough investigation of these technologies has shown that WTE is environmentally preferable to landfilling on several counts:

- a) WTE generates a net of 550 kWh per ton of MSW. This reduces the state's dependence on coal mining (about 0.25 tons of coal less per ton of MSW combusted) or on oil imports (45 gallons of oil less per ton of MSW). At this time, 36 million tons of MSW are combusted annually in U.S. WTE plants to generate about 20 billion kWh per year. This is equivalent to a saving of 1.6 billion gallons of fuel oil per year.
- b) The gas emissions from landfills contain methane (natural gas), a gas that is 21 times more potent as a greenhouse gas than carbon dioxide. Thus, including the advantage of electricity production from the combusted MSW, the landfill greenhouse gas emissions are several times greater than for WTE. With regard to other emissions, such as mercury and dioxins, this report documents the great progress that the U.S. WTE industry has made in this sector towards the end of the 20th century. Currently, all modern WTE plants are equipped with advanced gas control systems, such as dry scrubbing, activated carbon injection and bag filters, that are superior to the gas handling systems of most coal-fired power plants.
- c) In modern landfills, during the life of the landfill and for a mandated period after that, the generated aqueous effluents are collected and treated chemically. However, reactions within the landfill can continue for decades and centuries after closure. Thus there is potential for future contamination of adjacent waters.
- d) WTE recovers ferrous and non-ferrous metals, thus conserving natural resources.
- e) Landfilling practically condemns for any future use a large amount of land per ton of MSW disposed. A rough estimate for the direct use of land is one acre for every 37,000 tons of MSW. This figure corresponds to an annual “consumption” of about 90 acres per year for the NYC MSW that is presently transported to out of state landfills. Of course, a much larger surface area is required between landfills and inhabited areas or parks.

- f) A modern WTE plant for processing the NYC MSW should be located within a relatively short distance from NYC. In contrast, if the City relies on out-of-state landfills for the long run, transport (principally by truck) requires additional use of fuel (estimated at 10 million gallons/year for the present transport of NYC MSW to Pennsylvania and Virginia landfills) and results in additional greenhouse gas emissions.

In recognition of the above factors, some other developed nations, like France and Germany, have phased out the use of landfills, except for the disposal of inorganic materials (e.g. ash) that cannot be recycled or combusted. From an economic point of view, landfilling is at present less costly in the U.S. because land is inexpensive. However, “tipping” fees depend on current environmental regulations and also on the distance over which MSW must be transported. For New York City, in the last few decades tipping fees have increased manifold to the present rate of \$70/ton. They are bound to increase further as landfills come under further public and state scrutiny.

On the basis of the above considerations, there are technical and environmental arguments that support the diversion of MSW from landfills to WTE plants. In summary, the results of this study indicate that the modern MRF and WTE technologies should be considered as tools of integrated waste management and offer various technical and environmental advantages over landfilling. Of course, any future determinations need to balance both technical and broader policy considerations.

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