Solid Waste Alternative Technologies Program:
A Solution for New York City's Garbage Problem

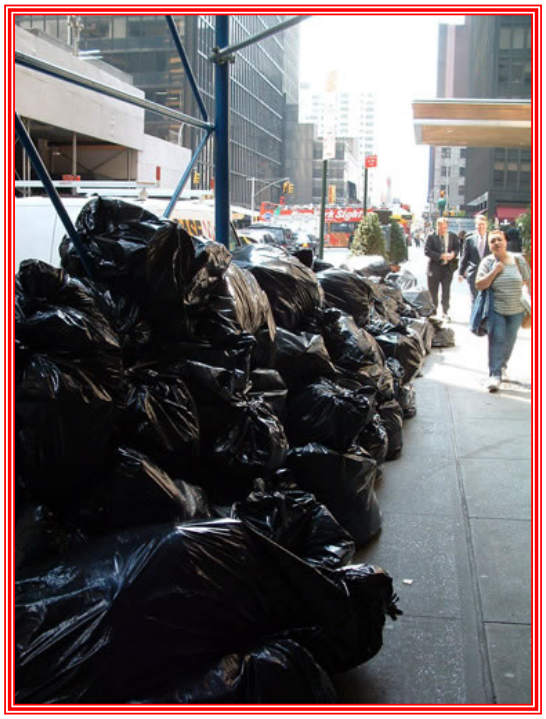

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Table of Contents

Executive Summary

New York City generates approximately 13,000 tons of residential garbage daily. Current disposal methods present economic, environmental, political, and social difficulties. This report presents a new Solid Waste Alternative Technologies Program for New York City that will address these problems.

Current policies discourage landfills and incinerators within New York City boundaries. Since 2001, the City has exported its garbage to locations as far away as Virginia and Ohio. Exportation leaves the City vulnerable to increasing costs because both transportation companies and disposal facilities are privately owned. The system is politically dangerous because other states are increasingly unwilling to accept the City's garbage and are seeking legal means of excluding outside garbage. Additionally, both landfilling and incineration pollute the air and groundwater. Finally, emissions from trucks used in transportation are detrimental to human health and the environment.

Introduction 95 is a proposed amendment to New York City's administrative code. This introduction specifies that the City must dispose of 5,000 tons of garbage daily by a method other than landfilling or incineration by July 15, 2015. While it is unlikely that this bill will become law, we conducted a management simulation of the bill's implementation to assess its feasibility. We conclude it is feasible along technical, financial, and managerial criteria. Its political feasibility would be a function of leadership and the rate of cost increase of the current system.

Research indicates that there are two viable alternative technology options. The first, gasification, involves the heating of garbage to extreme temperatures in an atmosphere with little to no oxygen. The second technology is anaerobic digestion; this process accelerates natural decomposition through the aid of chemicals within an enclosed, oxygen-free environment. Both processes produce gases that can be combusted to produce electricity.

The program outlined in this report proposes the construction of four dual technology facilities, which include units that process waste through both gasification and anaerobic digestion. The program also proposes the construction of two stand-alone gasification facilities. These two facilities and one of the dual technology facilities would be situated within New York City, while the other facilities would be located in upstate New York if communities were willing to accept these sites. Communities would be compensated for siting these facilities with lower priced electricity and waste disposal. A pilot phase (2005-2010) will involve the siting, design, permitting, and construction of one gasification facility and one dual technology facility. Following successful

operation of these facilities, the remaining plants will be developed between 2011 and 2015.

We propose that the program be managed by a new division within New York City's Department of Sanitation and consist of six divisions: Project Management, Facilities, Siting and Permitting, Community Affairs, Financial Administration, and Quality Assurance. During the first year of the program, the main project goals will be hiring an initial staff of 23 people, beginning the process of facility siting and community outreach, soliciting bids from private companies for facility design and construction, and initiating the process of capital acquisition. The total first-year budget is $1,895,000. The operation and capital costs of these facilities would be funded by savings generated by lower waste transport and disposal fees. First year operations will keep the program apace with the long-term goals. The proposed program will provide for the final disposal of 5,000 tons of garbage by means other than landfilling or incineration by July 15, 2015.

Part I: New York City's Current Residential Garbage Disposal Program Problems & Proposed Legislative Solution

1. History of Residential Garbage Disposal Programs

Since its early days, New York City has experienced difficulties disposing of its garbage. Until the Department of Street Cleaning was formed in 1881, the City was without any waste management infrastructure and garbage was thrown into the streets[1]. The Department of Street Cleaning, which later became the Department of Sanitation (DOS), intermittently dumped garbage into the nearby waters and also practiced some landfilling and incineration[2]. Ocean dumping was stopped in 1935, in response objections from polluted neighboring coastal cities[3]. From then on, the City disposed of garbage through landfills and incineration.

At the height of incinerator usage in the 1960's, the City burned garbage in more than 17,000 apartment building incinerators and twenty-two large municipal incinerators[4]. Extensive incineration of large quantities of waste often left New York City covered in a haze. Alarmed by the air pollution, residents pressured city officials to phase out incineration. No new incinerator has been built since the 1960's, and the last local incinerator closed in 1994[5].

Municipal landfills, which the City heavily relied upon as well, experienced a similar fate. Between 1965 and 2001, six local landfills accommodating New Yorkers' garbage reached capacity and closed[6]. The last of the functioning landfills, Fresh Kills, located in Staten Island, was the world's largest unlined dump. Fresh Kills epitomized landfill pollution problems and generated substantial public opposition. Since then, no new landfill has been constructed in the City due to the lack of available space and public opposition.

Since Fresh Kills' closure, New York City has been without a local place to dispose garbage, Currently, the City transports residential garbage to land-based waste transfer buildings within the City, and then to landfills and incinerators located outside of the City. This approach is unlikely to change in the near future. The DOS recently published a Draft Comprehensive Solid Waste Management Plan (October 2004) which outlines a twenty-year waste management plan where the City will rely more heavily on barges and trains to transport municipal garbage. The plan proposes the construction of marine transfer stations distributed more equitably throughout the City, and emphasizes increased levels of recycling. However, the final destination for residential garbage will remain the same: out-of-state landfills and incinerators.

2. Current Problems: Disposal Methods' Economic, Environmental, Social, and Political Impacts

The DOS Draft Comprehensive Solid Waste Management Plan (Draft SWMP) aims to reduce the current economic, environmental, and social impacts of garbage disposal. However, the Draft SWMP falls short of addressing the cause of many effects: without local means of garbage disposal, the City has little control over its waste management. Consequently, the exportation of garbage out of the City will continue and many negative effects of the current plan, especially long-term impacts, will not be addressed.

A) Economic

The DOS spends almost $1 billion every year disposing of residential garbage outside of the City[7]. The cost of disposal will continue to increase as landfill space closest to the City becomes scarcer and garbage is transported farther away. Without disposal means, New York City has little control over waste disposal prices set by outside operators.

New York City heavily relies upon landfills to dispose of municipal non-recyclable garbage—roughly three-quarters is landfilled[8]. Consolidation of ownership is a current trend in landfill management; this is due to rising management costs and increasing regulations that make it difficult for smaller firms to operate landfills. Current estimates show that nationwide seven privately held firms control approximately 61% of the total available landfill capacity[9]. The concentration of ownership decreases the City's bargaining power when negotiating contracts for landfilling the nearly 10,000 tons per day of garbage. Moreover, the shortage of landfill capacity is worrisome. New York, Vermont, and Massachusetts have less than 10 years of landfill capacity remaining, limiting the amount of available space and putting upward pressure on the costs of disposal[10]. Owners are steadily increasing tipping fees (fees levied by the landfill on all trash it accepts) to reflect the decreasing capacity. The cost of dumping garbage in the Northeast has increased from $12.66 per ton in 1985 to $69.07 in 2002; the highest tipping fees in the U.S. In 2002, the Mid-Atlantic Region, including Pennsylvania and Virginia, had the nation's second highest tipping fees at $45.26 per ton, more than doubling since 1985[11].

Furthermore, proposed legislation in Pennsylvania and Virginia, two states that New York depends on for disposal of its garbage, may also affect the economics of solid waste disposal by limiting the expansion of existing landfills and the construction of new facilities[12]. With increasing costs for landfill management and operation and fewer companies offering disposal services, New York City faces definite increases in future landfilling costs.

Without the ability to dispose of garbage locally, New York City will continue to export it. Currently, the City experiences high transportation costs due to consolidation of the industry and the political influence of major transport companies[13]. The Draft SWMP attempts to address the rising costs of transportation by decreasing truck usage through renewed emphasis on and use of the City's barge and rail systems. However, the reality is that the City cannot avoid future increases in transportation costs associated with shipping garbage farther away as current landfills reach capacity. Moreover, projected increased consumption will also contribute to the cost of transporting greater quantities of garbage longer distances.

B) Environmental

i. Transportation

Garbage disposal generates inherent environmental effects. New York City's long distance export of garbage and the use of landfilling and incineration for final disposal are projected to continue indefinitely. The Draft SWMP emphasizes that decreasing truck usage for garbage exportation will improve air quality. This will mean a considerable reduction in air pollution since traveling one mile generates approximately 22 lbs. of carbon dioxide (CO_2) and approximately 1,000 diesel trucks carrying 10 tons of garbage each leave the City daily.[14] However, the Draft SWMP ignores the future reality that garbage will be hauled over longer distances as landfills reach capacity. Non-rail transportation, whether barges or trucks, still use diesel engines which emit nitrogen oxides (NO_x), carbon dioxide (CO_2), and particulate matter (PM). Serious respiratory health effects such as asthma, chronic bronchitis, and forms of cancer are associated with these air pollutants. Furthermore, the air pollutants contribute to greenhouse gases impacting the climate, acid rain, groundwater contamination, and smog[15].

The probability of a transportation accident also greatly increases with the distance traveled. All transport methods involve some risk; trucking being the most risky. Though accidents involving barges and trains are not as frequent, they may pose an even greater environmental threat due to the higher volume of garbage being transported. Should an accident occur using any method of transport, cleanup costs would be large, especially if the spill were to occur on a waterway[16].

ii. Landfilling

Research indicates that there are significant environmental problems associated with traditional final disposal methods. Landfilling, the most commonly used method, can seriously degrade the environment through groundwater contamination and air emissions. The EPA requires municipal landfills to install plastic liners and systems to collect polluting liquid run-off, or leachate, a byproduct of decomposition. The systems are

often undermined by their tendency to deteriorate, puncture, or crack, leading to the release of leachate into groundwater systems. Over 150 different volatile organic compounds (VOCs) are found in landfill leachate, some of which are carcinogenic and cause respiratory problems, dizziness, visual disorders, or memory impairment. The sources of VOCs in municipal solid waste are paints and lacquers, cleaning supplies, building materials, glues, and adhesives. There are also many dangerous heavy metals originating from batteries, pigments, plastics, ceramics, paint, and thermometers, which accumulate in landfills and are sometimes found in high concentrations in leachate. Some of the most harmful metals are cadmium, lead, mercury, arsenic, and chromium. When ingested, they can lead to stomach irritation, vomiting, weakening of bones, nervous system disorders, reproductive problems, anemia, and kidney and immune system damage.[17]

Landfill gas also pollutes the air. The decomposition of garbage in landfills creates a gas that is 54% methane, a greenhouse gas more harmful to the planet than CO_2; the remainder of landfill gas emissions is composed of CO_2 and VOCs.[18] Pressure forces gas to escape from landfills through the surrounding soil. The gas can carry toxic chemicals such as solvents, paint thinner, pesticides, and other hazardous VOCs[19]. In 1996, the EPA made the installation of gas collection and control systems, sometimes used for energy production, mandatory for all new and modified landfills. However, the systems are often inefficient and gas continues to be released into the atmosphere[20].

Landfill pollutants have been shown to affect human health through increased cancer rates. For example, a 1990 study found an increased incidence of bladder cancers in northwestern Illinois where a landfill had contaminated a municipal water supply with VOCs.[21] A 1989 study by the EPA, examining 593 solid waste sites in 339 U.S. counties, revealed increased occurrences of bladder, lung, and stomach cancers in counties with the highest concentration of waste sites[22].

iii. Incineration

Incineration is an effective method of garbage disposal. Through high temperature combustion, water found in organic materials is evaporated, altering the physical and chemical properties of the waste. Consequently, when incinerated, the total volume of garbage is reduced and the toxicity of garbage is generally reduced as well. Post-incineration residues such as ash are landfilled and ash accounts for up to 25% of all unprocessed landfill waste[23]. However, due to the presence of things like household cleaning supplies, ash can sometimes be hazardous and need to be disposed of in a hazardous waste facility. Disposing of the toxic byproduct can contribute to overall environmental impacts and is expensive.

Many toxins are present in incineration byproducts including cadmium, lead, mercury, dioxin, sulfur dioxide, hydrogen chloride, nitrogen dioxide, and particulate matter[24]. Ash is a major component of post-incineration residue. Following EPA mandates, incinerators are equipped with pollution reduction devices to collect PM, remove acids, and filter dioxins during the combustion process. Air pollution control devices for incinerators are capable of filtering PM that is 0.25 microns or more in diameter. However, it is the smallest PM particles that are most damaging. Currently, filtering devices only trap larger particles and tend to only have a 5% to 30% efficiency level[25]. The following table contains a list of some incineration produced toxins and their related illnesses. Despite these impacts, a well managed high temperature incineration facility pollutes much less than a system relying on diesel trucks and landfills.

Table 1: Health threats associated with incinerator derived chemicals

Incinerator Emission Constituents and Their Health Threats	
Chemical	**Health Threats**
Cadmium	Pulmonary irritation, kidney disease, possible carcinogen[26]
Lead	Brain damage, kidney damage, gastrointestinal distress[27]
Mercury	Central nervous system disorders, kidney damage[28]
Dioxin	Possible carcinogen, possible liver damage, skin irritation[29]
SO_2	Respiratory illness, aggravated heart disease[30]
HCl	Respiratory and pulmonary disorders[31]
NO_x	Respiratory illness, lung damage, aggravated heart disease[32]
PM	Respiratory illness, aggravated asthma, decreased lung function[33]

C) Social

The City has a tumultuous history with respect to incinerators, landfills, and waste transfer stations, punctuated by considerable public opposition to siting facilities. Growing national and local environmental awareness and public health scares in the late 1970's created a heightened sense of not-in-my-backyard (NIMBY) sentiment for disposing of and handling the City's waste. Hostility escalated over the years to the point where managing the City's garbage has become a politically delicate issue, not only for city officials, but for the residents affected by DOS policy.

New Yorkers have a great mistrust of City waste management policy. Many incinerators and waste transfer stations have been concentrated in low-income neighborhoods. In 2000, more than 50% of all waste transfer stations were located in four communities (South Bronx; Jamaica, Queens; Greenpoint-Williamsburg and Red Hook, Brooklyn); this distribution raises questions of environmental injustice[34]. Emissions from diesel garbage trucks have contributed to air pollution in the areas. In fact, the South Bronx has one of the nation's highest children's asthma rates; 20-25% of children suffer from asthma compared to the New York State

average of approximately 10%[35]. Local residents have become increasingly well organized against siting facilities in their neighborhoods and have created action groups like New York Public Interest Research Group, Organization of Waterfront Neighborhoods, and Community Alliance for the Environment. Successful protests in the mid 1980s to early 1990's against the Brooklyn Navy Yard Incinerator typified well organized citizen opposition.[36]

The Draft SWMP addresses environmental injustice by having waste transfer stations distributed equitably among the boroughs, with the intention to reduce residents' distrust of City policy. Still, New York City's 20-Year Plan does not solve facility siting problems; it exports them to communities outside of New York. In the future, outside communities importing the garbage could exhibit the same reactions New Yorkers have had to City policy, making it more difficult to continue exporting garbage.

D) Political

New York City's garbage exportation increases visibility of the City's disposal issues in other counties and states. Increased visibility generates political challenges that could lead to even higher disposal costs than predicted due to the economic, environmental, and social factors discussed previously. The main political challenges are federal regulation of interstate garbage disposal and the creation of new landfills; resistance to siting garbage disposal and transfer facilities; and further incentives for waste management consolidation.

Pressured by constituents who are upset about New York City's garbage being disposed of in their communities, legislators have begun to take action. Two bills that are currently in the United States Senate would authorize local and state entities to prohibit or limit the receipt of out-of-state garbage[37]. The proposed legislation would give states that receive garbage the authority to make imports more difficult. This could have a direct and adverse economic impact on New York City and could be a political nightmare for city officials.

Many New York City mayors have considered addressing the City's lack of capacity to dispose of garbage. However, heavy public opposition in the mid 1980's for siting incineration facilities, like the proposed Brooklyn Navy Yard Incinerator, made city officials shy away from the issue. After various public protests, both Mayors Dinkins (1990-1993) and Giuliani (1994-2001) decided against trying to site a facility at the Navy Yard, viewing it as a political liability[38]. In fact, in 1996, Governor Pataki signed a bill prohibiting not only the facility's inception, but also garbage disposal at Fresh Kills[39]. Garbage disposal management as a political issue has

remained fairly static and unresponsive to the City's needs. In the absence of new DOS facilities, the City will be forced to renegotiate contracts with private waste management companies that will likely capitalize on the City's lack of alternatives by increasing their rates.

Mayor Bloomberg's recent changes to the City's SWMP fall short of addressing long-term needs and present threats, exemplifying the political difficulty of tackling such a hotly contested issue. The Draft SWMP does not focus on future economic costs or the City's lack of control of waste management, nor does it address how the City will dispose of garbage as landfills reach capacity.

3. City Council's Proposed Solution: Introduction 95, Legislative Amendment to City Code

In February 2004, City Council member Michael McMahon proposed Introduction 95, an Amendment to City Code, as a way to change New York City's current waste management system. The amendment reads:

> *"The Commissioner shall be required to provide for the final disposal of no less than five thousand tons per day of non-recyclable waste by a method other than landfilling or incineration no later than July 1, 2015."*

As a frequent critic of the DOS, McMahon has urged capable parties to begin examining alternatives to environmentally unfriendly, finite, and obsolete disposal methods: landfilling and incineration. McMahon is quoted as saying, "The city has to take a serious look at developing technologies for long-term planning[40]." His proposed legislation mandates innovative waste management strategies by specifying the disposal methods the City can employ, the quantity of garbage to be disposed of through alternative means, and the deadline by which new disposal methods must be established. While this technology forcing proposal will probably never be enacted, our analysis indicates that if facility siting issues could be overcome, new technologies could reduce the financial and environmental costs of waste disposal. The presence of municipal owned facilities could stabilize the projected rate of cost increases and enhance the long-term reliability of the City's waste management system.

Part II: Solid Waste Alternative Technologies Program Design

1. Alternative Disposal Technology Options

The proposed legislation requires the implementation of a technology other than landfilling or incineration. Garbage disposal technologies can be divided into three categories: chemical, biological, and thermal. Each of these is outlined below.

A) Chemical

Chemical technologies employ a chemical reaction to render harmless hazardous or otherwise dangerous components of waste. This type of technology relies on specific chemical reactions such as pH neutralization or oxidation. Because these reactions rely on specific chemical interactions, they require a homogenous waste stream[41]. New York City's municipal waste is heterogeneous; therefore, this type of technology is not an option.

B) Biological

Biological technologies rely on the biological decomposition of organic components of garbage. These processes can be subdivided into aerobic digestion (in the presence of oxygen) and anaerobic digestion (in the absence of oxygen). The decomposition of organic waste through both processes produces organic compost and methane gas, which can be combusted to create electricity. Anaerobic digestion is the more common process for garbage disposal because it is conducted in smaller facilities and decomposition occurs more quickly. Anaerobic digestion has been implemented to treat waste in multiple countries including the U.S., Italy, Sweden, Switzerland, Austria, Denmark, and the Netherlands[42]. The commercial implementation of these systems has been proven to treat a capacity of 300 tons per day. Anaerobic digestion technology represents a viable option for treating a portion of New York City's waste stream.[43]

C) Thermal

Thermal technologies use high temperatures to convert garbage into combustible gases. This type of technology includes incineration, gasification, and pyrolysis. Incineration is not permitted in the proposed

legislation. Gasification and pyrolysis differ from incineration in that the temperatures are significantly higher, and they are both conducted in an oxygen-deprived atmosphere[44]. Pyrolysis is a subset of gasification; it takes place in the absence of oxygen[45]. Gasification produces a carbon-rich solid material that can be used in the creation of concrete or asphalt. The process also produces combustible gases that can be burned to create electricity. Gasification has been implemented successfully to treat garbage in many countries including the U.S., Japan, Germany, U.K., France, and Switzerland[46]. The implementation of these systems has been proven to treat a capacity of up to 700 tons per day[47]. Gasification represents a viable option for New York City.

In sum, both anaerobic digestion and gasification are commercially proven technologies that can be employed by New York City. However, anaerobic digestion can only be used on the organic component of garbage. The organic component is about one fifth of the City's total municipal waste stream (roughly 2,600 tons)[48]. Therefore, anaerobic digestion alone cannot be used to meet the proposed legislative requirement of 5,000 tons per day.

2. Solid Waste Alternative Technologies Program

Given the commercially available garbage disposal technologies, this report outlines a program for New York City that will meet the proposed legislative disposal requirement of 5,000 tons per day by July of 2015. The Solid Waste Alternative Technologies Program proposed in this report outlines gasification and anaerobic digestion facilities located inside and outside of New York City.

A) Type of Facilities Included in the Design

The program includes a combination of facilities, to maximize the use of both gasification and anaerobic digestion as disposal methods. Specifically, the program includes dual technology facilities and gasification facilities, as described below.

i. Dual Technology Facilities

Dual technology facilities will consist of a sorting building that will separate the organic component of the garbage. This organic stream will be fed to one anaerobic digestion building with a capacity of 200 tons per day. The remainder of the waste will be processed in two on-site gasification buildings, each with a capacity of 500 tons per day. A single dual technology facility will likely process 1,000 tons per day. This quantity exceeds the theoretical maximum of 1,200 tons per day because the organic component of the waste stream is variable, and only the organic component can be sent to the anaerobic digester. These facilities are

advantageous because anaerobic digestion requires separation of the organic component; the non-organic component can then be processed through gasification at the same facility without additional transportation.

ii. Gasification Facilities

Gasification facilities will consist of one gasification plant with a capacity to treat 500 tons per day. Because gasification does not require any sorting of waste, these facilities will resemble the size and structure of a municipal incinerator.

B) The Solid Waste Alternative Technologies Program Design

The Solid Waste Alternative Technologies Program Design will combine the two types of facilities, as described in Table 2. The construction of these facilities is divided into two stages. The first is the pilot phase, which will include the construction of one dual technology facility outside of the City and one gasification facility inside New York City. Following successful operation of these facilities, the final stage of the project will include the construction of two additional dual technology facilities located outside of the City, and one dual technology facility and one additional gasification facility inside of New York City.

Table 2: Categories of Program Design Facilities

Solid Waste Alternative Technologies Program Design Facilities				
Type of Facility	**Location**	**Number of Facilities**	**Capacity per Facility (tons per day)**	**Total Capacity (tons per day)**
Dual Technology	Outside of New York City	3	1000	3000
Dual Technology	New York City	1	1000	1000
Gasification	New York City	2	500	1000

C) The Solid Waste Alternative Technologies Program Schedule

Specifically, the design, permitting, and construction of the pilot facilities will occur between 2005 and 2010. Then, following one complete year of operation, the final stage of the project will commence in 2011. The final facilities will be designed, permitted, and constructed between 2011 and 2015. The schedule is summarized in Table 3. All facilities will be fully operational by July 15, 2015, with the combined capacity to process 5,000 tons per day of New York City's garbage.

Table 3: Proposed Program Schedule

Summary of Solid Waste Alternative Technologies Program		
Project Stage	**Activity**	**Timeframe**
Both Stages	Community Outreach	Ongoing
Pilot Stage	Site Identification	2005-2006
	Permitting	2006-2008
	Facility Design	2006-2008
	Facility Construction	2008-2010
	Begin Facility Operation	2010
Final Stage	Site Identification	2011-2012
	Permitting	2012-2013
	Facility Design	2012-2013
	Facility Construction	2013-2015
	Begin Facility Operation	2015

D) Projected Program Savings

Currently, New York City pays $95 for transportation and disposal of municipal solid waste[49]. The cost of waste transport and disposal under the proposed program is estimated at $75 per ton. This estimate reflects the capital annuity, operation and maintenance fees and potential revenue from sale of byproducts; these costs were obtained from case studies of operational anaerobic digestion[50] and gasification facilities[51]. Additionally, the cost estimates include transportation (an estimated travel distance reduction of 200 miles round-trip), and potential side-payments to communities (estimated at 10% of the total cost). Based on these cost estimates, the Program will save the City $25 per ton, or $45,625,000 per year.

3. Rationale Behind the Program Design

In designing a feasible program, options to be considered included: the type of technology, number of facilities, facility location, and facility ownership. All possible combinations were considered with respect to their relative economic, environmental, political, and social impacts. The rationale behind each choice is presented below.

A) Type of Technology

As noted above, anaerobic digestion alone will not meet the disposal requirements of the legislation. Therefore, the available options are to use only gasification or to combine gasification and anaerobic digestion technologies. A combination of technologies is optimal because anaerobic digestion is a more familiar process to average people: effectively the

process speeds up natural decomposition. Hence, the anaerobic digestion process will be easier to explain to the public and facilities will be easier to site. A combination of the technologies is also wise because anaerobic digestion is most efficient on organic waste while gasification is most efficient on a dry, inorganic stream. Combining the technologies enables New York City to use each technology as efficiently as possible. Finally, utilizing a combination of facilities diversifies the City's waste disposal methods, thereby enabling the City to benefit from advances in both technologies. For these reasons, the proposed program uses a combination of gasification and anaerobic digestion.

This aspect of the program design seeks to alleviate the environmental and social problems with New York City's current disposal methods. Specifically, the technologies produce fewer harmful emissions and yield non-toxic and potentially useful byproducts. Additionally, the use of anaerobic digestion makes the program more socially acceptable than incineration or landfilling.

B) Number of Facilities

Neither technology has yet been implemented at a scale of 5,000 tons per day in one location. As such, multiple smaller facilities are preferable. Moreover, multiple facilities are wise because if there is a technological mishap at one facility and it is unable to process the garbage, the trash can be rerouted to another facility. This option will prevent a large trash build up at one location, which could create a substantial public health risk. Also, multiple facilities are better than one large facility because they create a more equitable distribution of the garbage. It would be politically infeasible to locate one large facility in a single community, as that could raise concerns of environmental injustice. Hence the proposed program includes multiple smaller facilities which can be sited in several communities.

This aspect of the program design addresses the social, political, and environmental problems with New York City's current disposal methods. Smaller facilities allow for an equitable distribution among various communities and present less of a risk in the event of an emergency. They also allow the City to use technology that has been proven to have a low environmental impact.

C) Facility Location

Locating the facilities within New York City is problematic due to the City's tumultuous garbage disposal history. In addition to political opposition,

facilities in densely populated areas present a greater risk in the event of a technological mishap. A technical failure at a plant, like a fire or an accumulation of garbage, has the potential to impact many local residents if a facility is located in a densely populated area. However, the program aims to reduce the City's waste management expenses. Thus, locating facilities within the City presents a substantial cost savings in transportation fees. Consequently, the program divides the facilities between locations in and outside of the City.

This aspect of the program design benefits the City from an economic, environmental, and political perspective. Locating the facilities in New York City and close to New York City will result in a substantial reduction in transport distance, which will reduce transportation costs and the negative environmental impacts associated with transportation. Additionally, by keeping garbage within New York State, the City will likely not be subject to as much political pressure or potential regulations barring or restricting the export of garbage from out of state.

D) Facility Ownership

A major problem with the DOS's current waste management system is that New York City has little control over the fees levied by private landfills. For this reason it would be in the City's best interest to either own the new facilities or own them in partnership with a private company. Because a private company offers technical expertise and potential cost advantages, the program specifies a public-private partnership for ownership of the facilities.

This aspect of the program design addresses the economic and political concerns associated with the current disposal methods. Public-private ownership provides economic security for New York City, which will have control over the costs of disposal.

Part III: The First Year of Program Implementation

One part of our management simulation is to identify the staffing, budget, and organizational and management systems to be used to begin the program. This section of the report details the first year of this proposed program and long-term staffing plans.

1. Organizational Structure and Staffing Plan

The Organizational Structure and Staffing Plans are designed for quick implementation of the Solid Waste Alternative Technologies Program Design. The program will be implemented as a new division within the existing structure of the New York City Department of Sanitation (DOS). Effective implementation requires the creation of six distinct divisions: Facilities, Siting and Permitting, Community Affairs, Financial Administration, Program Management, and Quality Assurance.

A) Program Divisions

i. Facilities

The facilities division will be centrally located in the first year. Full staffing will consist of three offices, each directed towards achieving a distinct program goal. Staff members will be hired with engineering expertise in advanced waste management technology to expedite pilot plant construction and any subsequent needed expansions.

- **Sanitation Engineering and Technology Office**
  A team of engineers will be responsible for providing engineering support, researching best available technology, and customizing technology to satisfy program needs. In-house engineers and contracted engineers will be employed and will report to the chief engineer. In-house engineers are responsible for reviewing all technical recommendations submitted by private engineering consultants. This office will also be responsible for ensuring equipment maintenance and optimal operational performance.

- **Facilities Design and Construction Office**
  This office is responsible for managing all stages of construction. The Program Management Division, working closely with the Chief Engineer, will determine DOS partnerships with general contractors and architectural and structural design firms. Architects and structural engineers will examine the selected sites, considering all technical

criteria, to produce final facility designs. During the construction phase, this office will oversee the progress of construction and report any concerns to the division manager.

- **Functional and Operations Office**
  This office is in charge of collection and transportation of solid waste to disposal facilities. Facility operations are dependent on the quality and type of the delivered waste stream. Technical as well as health and safety factors require close monitoring of the process. Staff will also handle logistical issues including ensuring that waste collection and delivery schedules are designed to match the requirements of the new facilities.

ii. Siting and Permitting

Efficient preparation of needed documentation is crucial for keeping the program on schedule. The Siting and Permitting Division will be responsible for initiating and tracking all permitting activities as well as the selection of appropriate sites both inside and outside of New York City. This division will evaluate all potential sites through on-site visits and investigations. Once the viability of a site is assessed, a division representative will begin the negotiation for land purchase if deemed needed. This division will also work with the Mayor's Office and other units of city government working on the review process required to site these new facilities.

iii. Community Affairs

A strong emphasis is placed on staffing the Community Affairs Division because of its crucial role in successful program implementation. Community support and consent is vital for the success of the Solid Waste Alternative Technology Program. Expert employees will establish educational programs to inform the public of current waste disposal technologies. Community Affairs staff will initiate a campaign promoting gasification and anaerobic digestion as innovative and safe long-term waste treatment solutions with minimal social impact. Staff members will also address all community concerns through public hearings and town-hall meetings. The purpose of this division is not simply to disseminate information, but to work with communities to ensure that facilities are designed to address community concerns and compensate communities for inconveniences stemming from the siting and operation of waste facilities.

iv. Financial Administration

Staff members in the Financial Administration Division have the crucial responsibility of keeping the program financially on track. Obtaining needed capital for program implementation will be the responsibility of the division director, working with the Mayor's Office and other appropriate

units of city government. The staff will support this effort as well as all program accounting and budgetary needs.

v. Program Management

The Program Management Division will oversee the entire program and report directly to DOS officials. Staff will be responsible for keeping the program on schedule in order to meet program milestones. This team will be staffed with experienced DOS employees in order to expedite program progress.

vi. Quality Assurance

An outside consulting firm will be contracted in order to verify program performance. This team of experts will assist the Program Management Division in monitoring program progress, engineering design, and facility operations. The institution of monthly meetings between the Quality Assurance and Program Management Divisions will guarantee efficient compliance with program goals.

B) Staffing Plan

The comprehensive staffing plan located in Appendix I includes divisional goals, staffing patterns, and required positional skill sets. The plan addresses first year and long-term goals. In addition to hiring experts with specific technical skills, administrative assistants will be staffed to provide support. The size of the support staff is based on the function and resources needed for each program. For example, Community Affairs will be staffed with two assistants in the first year. These assistants will help begin the community informational program as well as assist in the planning for needed Town-Hall meetings. By the fifth year of the program the division will be fully staffed with four assistants, one for each community relations expert. A large staff will be secured to handle the demands of local community groups and the media. Other programs were staffed according to projected needs. A brief description of the skill sets mandatory for each established position is listed in Appendix I.

During the first year of the Solid Waste Alternative Technologies Program the staff will consist of 23 employees. Each division is staffed with the minimum number of employees needed to accomplish first year goals. Existing DOS employees will be transferred into crucial positions in order to expedite program implementation. The program will be fully staffed by the fifth year and consist of 38 employees in headquarters. Of course many more employees will be hired to operate these new facilities.

2. First Year Budget

The first year budget for New York City's Solid Waste Alternative Technology Program is designed to operationalize the goals outlined in the six areas delineated by the staffing plan. The budget accounts for startup costs associated with implementing a new program and first year operational expenses. Total first year budget costs are estimated for 2004, with an added 3% adjustment for inflation. This adjustment should be carried over annually throughout the program's lifetime. Total first year budget costs are $1,895,000. A program and line item budget is segmented by division into the areas of Personnel Services, Other than Personnel Services, and Contract which are included in Appendix II.

A) Program Budget—Personnel Services

All salary estimates are based on current DOS staffing values[52]. A total of 25% has been added on top of salaries to account for fringe benefit costs[53], and 3% has been added on top of the total to account for inflation. New employees are allocated at 75% for the first year accounting for a minimal estimate of three months to complete the hiring process. The Director of each division as well as one Public Administrative Assistant (PAA) will be transferred from within DOS in order to expedite the hiring of new employees and the initiation of divisional work. These staff members need to be familiar with existing DOS procedures and possess a clear understanding of the Solid Waste Alternative Technology program goals as well as DOS goals. The total first year Personnel Services cost is $1,442,000.

i. Facilities Division

The Facilities Division will be responsible for assessing the technical and structural feasibility of implementing the disposal technologies into existing and/or new facilities to begin pilot plant construction. Staff includes one Chief Engineer and two Staff Engineers. The salary level for the Facilities Director is at the high end of the DOS pay scale, reflecting needed experience in the engineering field. The Staff Engineers consist of one junior level hire and one mid-level hire. Total first year personnel services cost for Facilities is $346,000.

ii. Siting and Permitting Division

During the first year of the Program, Siting and Permitting will assess the facility locations of and if needed begin the process of land acquisition. This division will evaluate permitting needs and initiate the permitting process. The Director will be supported by an attorney shared with the Department of Legal Affairs and General Counsel, who will be budgeted

as one half of a FTE. This position requires a high level of experience and has been budgeted at $82,000 annually. The staff is complete with a Computer Programmer/Analyst and Staff Analyst. The Computer Programmer/Analyst will receive a salary of $46,000 annually, which is a mid-level salary for the title's pay scale[54]. This level is justified because of the special computer skills required, such as Geographical Information Systems expertise. Total first year personnel services cost for the division is $275,000.

iii. Community Affairs Division

During the first year of operation, Community Affairs will establish relationships with communities and the media as well as initiate a Community Information Program. The staff will be complete with a Director experienced in public affairs related to waste management, two PAAs, a Staff Analyst, a Public Relations Assistant, and an Attorney. The Attorney's time is shared equally with the Department of Legal Affairs and General Counsel. Total first year personnel services cost for Community Affairs is $304,000.

iv. Financial Administration Division

The first year goal of the Financial Administration Division is to plan for acquiring needed capital, serve as a liaison to the DOS Financial Management and Administration Division, and manage the budget and operational expenses for the entire program. First year staff consists of a Staff Analyst, a Bookkeeper, and a PAA. The Staff Analyst is shared with DOS Financial Administration, and thus is budgeted as one half of a full-time equivalent (FTE). The total first year personnel services cost for the Financial Administrative Division is $259,000.

v. Program Management Division

The Program Management Division consists of three executives who will all be transferred from existing DOS positions. They will be responsible for overseeing all operations and reporting to DOS. Total first year personnel services costs for the Program Management Division is $258,000.

vi. Quality Assurance Division

The Quality Assurance Division will be contracted from an outside firm. They will begin monitoring the program after the first six months. The division will be responsible for assessing program processes and progress, and reporting to the management division monthly.[55] Total first year cost for the Quality Assurance division is $109,000.

B) Program Budget—Other Than Personnel Services

The Other Than Personnel Services (OTPS) budget for each program is composed of all needs other than personnel required for each program in order to meet first year goals. Included in OTPS are startup costs, overhead, office supplies, communications, training, and travel[56]. Overhead costs consist of rent, utilities, and building service fees. These costs are calculated by using an on-line office space calculator and by consulting with a New York City small business owner. Startup costs include all furniture and equipment needed to create and support first year activities for each program. Each total is calculated by estimating the needs of the particular division in accordance with staffing and pre-calculated office space totals. Office supplies and communications (telephone and internet) costs are estimated from a comparably sized New York City office. Travel is estimated in accordance with the Program's first year goals. For example, the facilities division is expected to make trips by car to possible sites and by air to evaluate plants currently using disposal technologies intended for pilot plants. The division is budgeted for air trips and weekly car rentals for a total of $6,000. The total first year OTPS cost adjusted for inflation is $282,000. A detailed representation of the rationale for the OTPS budget by program is included in Appendix II.

C) Program Budget—Contract

Contracted services for the first year budget include publications, telecommunication, operational maintenance, janitorial services costs, and the addition of a Quality Assurance Division. Telecommunication, operational maintenance, and janitorial costs are estimated from a comparable New York City office[57]. Each division is responsible for covering a portion of these contracts consistent with staffing and operational needs. The Community Affairs Division has an additional contract for publication costs. In the first year of the program, Community Affairs will be responsible for producing informational pamphlets and advertising announcements of community meetings. Allowing for a six month lead time, these costs are estimated at $59,000 for the first year.[58] Total first year contract costs are $171,000. A detailed representation of contract cost is presented in Appendix II.

D) Line Item Budget

The Line Item Budget is included in Appendix II. It is a summation of the entire program needs calculated by adding each line in each program budget to a common category. This budget will successfully operationalize

the first year of the program, serving as a guide for performance management as well as goal assessment.

3. Performance Management System

In order to determine the program's success, performance measurement goals have been identified in the areas of cost, quality, and efficiency. For quick and effective reporting, measuring tools have been selected that are easy to obtain, understand, and respond to. Through this type of measurement, problems are quickly identified and the program can adjust to eliminate them. In the first year of the program, measures will address the program costs, program schedule, and community concerns. Upon pilot plant implementation, performance measurements will be used to evaluate the volume of waste processed and the level of process emissions. Table 4 contains a summary of program indicators, objectives, and methods used for analysis and feedback.

A) Costs and Scheduling

The Program Management Division will oversee data collection for cost and scheduling. Performance measurements for cost will be achieved by comparing new program expenses to those of traditional garbage disposal methods. A decrease in total cost will indicate success. The program schedule will be monitored through evaluating the timeliness of achieving program milestones. Achievement of program goals in both an economic and timely manner indicates success.

B) Community Concerns

The Community Affairs Division will address community concerns regarding program implementation using the City's 311 system. Incoming calls regarding the Solid Waste Alternative Technologies Program will be monitored. This allows the program team to evaluate the community impact of program implementation and address citizens' concerns. Successful outreach can be gauged by a reduction in the volume of incoming telephone calls.

C) Volume of Waste and Plant Emissions

Upon completion of pilot plants, the Facilities Division will implement performance measurements for volume of waste produced and level of plant emissions. Volume of waste will be measured daily and recorded in monthly reports. Success is indicated by the disposal of 5,000 tons per

day. Plant emissions will be compared to EPA standards; the success of this indicator means that emissions are within all legal requirements.

Table 4: Solid Waste Alternative Technologies Performance Management System Indicators

Performance Management System Indicators	
1. How does the program disposal cost per ton compare to conventional alternatives?	
Objective	Save on waste disposal costs.
Data Collection and Reporting	Monitor the average cost of conventional landfill and incinerator disposal paid by the DOS. Compare this figure to the estimated program cost or actual program cost (if available).
Data Analysis and Feedback	Revise the schedule for scaling up to 5,000 tons per day if conventional alternatives cost less than the program.
2. How long does it take to achieve program milestones compared to the program schedule?	
Objective	Prevent delays.
Data Collection and Reporting	Track all program milestones according to the program plan.
Data Analysis and Feedback	Revise program plan to reflect actual time taken compared to time allocated and provide additional resources for critical tasks if necessary.
3. How many 311 calls are related to the program?	
Objective	Minimize community concerns regarding the program.
Data Collection and Reporting	Collect data recording number of calls referred to the program from the 311 Citizen Service Center Report.
Data Analysis and Feedback	Identify and address areas of community concern that are reported in 311 phone calls.
4. How many tons of waste is disposed of per day?	
Objective	Dispose of 5,000 tons per day by July, 2015.
Data Collection and Reporting	Record the volume of waste processed each day. Report records on a monthly basis.
Data Analysis and Feedback	Ensure that the average per-day tonnage corresponds with the program schedule for that month. Investigate any identified delays to ensure that facility design and operation is adequate.
5. Are emissions from the facilities within the EPA requirements?	
Objective	Ensure compliance with EPA requirements.
Data Collection and Reporting	Monitor the level of emissions from each facility.
Data Analysis and Feedback	Ensure that the emissions from each facility are within the levels set by the EPA. Follow standard procedures for remediation if emissions exceed these levels.

Part IV: Conclusion

Although New York City's Draft 20-Year Solid Waste Management Plan does address some negative impacts of the City's current waste management plan, it does not address the root cause of many problems: New York City's garbage exportation. As landfills closest to the City reach capacity, the DOS will experience definite price increases as garbage is shipped farther away and the number of disposal options decreases. Landfills often contaminate nearby groundwater supplies which will likely make the disposal method more controversial and less acceptable for communities to support in the future. In fact, many communities in and outside of New York City already strongly oppose receiving the City's garbage; the amplitude of resistance could grow as communities feel threatened by decreasing land use availability and pollution. New York City needs a waste management plan that addresses future problems now, before the cost of waste management becomes prohibitive or the City must react to a garbage crisis.

The Solid Waste Alternative Technologies Plan provides New York City with the waste management tools needed for a healthy economic future. The plan outlined in this report consists of the development of gasification and anaerobic digestion facilities inside of New York City and in nearby upstate locations. This proposal will save the City a minimum of $45,625,000 annually. Also, the plan addresses the political and social difficulties involved in siting gasification and anaerobic digestion facilities, even though they are more environmentally sound disposal technologies than transporting garbage to landfills. In the Draft SWMP, the City cites gasification and anaerobic digestion as technologies that could be employed in the future after further development. New York City should not wait until tomorrow to begin planning for the future; these technologies need to be developed now.

Notes

[1] Dunson, C. (1999, December). *Waste and Wealth.* Waste Age.

[2] City of New York. (2004). *Recycling in New York: A Brief History*. Retrieved August 10, 2004, from the official web site of New York City: http://www.nyc.gov/html/dos/html/bw_recy/2body.html

[3] McCrory, J. (1998). *A History of Waste Management in New York City*. Retrieved November 28, 2004, from the Big Apple Garbage Sentinel Web site: http://www.johnmccrory.com/bags/history/history1.html.

[4] Stohr, K. (2002, April 8). *Issue of the Week: Incinerators*. Retrieved September 20, 2004, from the Gotham Gazette Web site: http://www.gothamgazette.com/iotw/recycling/doc1.shtml.

[5] McCrory, J. (1998). *A History of Waste Management in New York City*. Retrieved November 28, 2004, from the Big Apple Garbage Sentinel Web site: http://www.johnmccrory.com/bags/history/history1.html.

[6] City of New York. (2004). *Recycling in New York: A Brief History*. Retrieved August 10, 2004, from the official Web site of New York City: http://www.nyc.gov/html/dos/html/bw_recy/2body.html.

[7] City of New York, Mayor's Office of Operations. *The Mayor's Management Report Preliminary Fiscal 2003*, p. 80. Retrieved November 23, 2004, from the official web site of New York City: http://www.nyc.gov/html/ops/downloads/pdf/2003_mmr/0203_mmr.pdf.

[8] Themelis, N. (2002, May 10). Integrated Management of Solid Wastes for New York City*. American Society of Mechanical Engineers Proceedings of NAWTEC*, p. 3.

[9] Columbia University's Earth Institute, Earth Engineering Center, and the Urban Habitat Project at the Center for Urban Research and Policy of Columbia University's School of International and Public Affairs. (2001, December 1). *Life After Fresh Kills: Moving Beyond New York City's Current Waste Management Plan; Policy, Technical and Environmental Considerations*. Columbia University Earth Institute: New York. p. A-8.

[10] Ibid.

[11] Repa, E. (2002, September). *NSWMA's 2002 Tipping Fee Survey*. Retrieved on November 22, 2004, from the National Solid Wastes Management Association (NSWMA) web site: http://wastec.isproductions.net/webmodules/webarticles/articlefiles/478-2002%20Tipping%20Fees.pdf.

[12] Columbia University's Earth Institute, Earth Engineering Center, and the Urban Habitat Project at the Center for Urban Research and Policy of Columbia University's School of International and Public Affairs. (2001, December 1). *Life After Fresh Kills: Moving Beyond New York City's Current Waste Management Plan; Policy, Technical and Environmental Considerations*. Columbia University Earth Institute: New York. p. A-9.

[13] Ibid, p. A-8

[14] Ibid, p. B-6, A-11

[15] United States Environmental Protection Agency (2003). *Mobile Source Emission—Past, Present, and Future: Pollutants*. Retrieved on November 26, 2004, from the U.S. EPA web site: http://www.epa.gov/otaq/invntory/overview/pollutants/index.htm.

[16] Columbia University's Earth Institute, Earth Engineering Center, and the Urban Habitat Project at the Center for Urban Research and Policy of Columbia University's School of International and Public Affairs. (2001, December 1). *Life After Fresh Kills: Moving Beyond New York City's Current Waste Management Plan; Policy, Technical and Environmental Considerations*. Columbia University Earth Institute: New York. p. A-12.

[17] United States Environmental Protection Agency. (2004). *Municipal Solid Waste: MSW Disposal.* Retrieved August 12, 2004, from the U.S. EPA web site: http://www.epa.gov/epaoswer/non-hw/muncpl/disposal.htm.

[18] Mallin, K. (1990, July). Investigation of a Bladder Cancer Cluster in Northwestern Illinois. *American Journal of Epidemiology*, 132(1, Supplement), p. 96-106.

[19] Themelis, N.J., Kim, Y.K., and Brady, M.H. (2002) Energy Recovery from New York City Municipal Solid Waste. *Waste Management & Research, 20(3)*, p. 223-233.

[20] United States Environmental Protection Agency. (2004). *Municipal Solid Waste: MSW Disposal*. Retrieved August 12, 2004, from the U.S. EPA web site: http://www.epa.gov/epaoswer/non-hw/muncpl/disposal.htm.

[21] Mallin, K. (1990, July). Investigation of a Bladder Cancer Cluster in Northwestern Illinois. *American Journal of Epidemiology, 132(1, Supplement)*, p. 96-106.

[22] Griffith, J. et al. (1989, March). Cancer Mortality in U.S. Counties with Hazardous Waste Sites and Ground Water Pollution. *Achieves of Environmental Health 44(2)*, p. 69-74.

[23] United Nations Environment Programme, International Environmental Technology Center. (2000). *Newsletter and Technical Publications: Municipal Solid Waste Management*. Retrieved on August 10, 2004, from the U.N. Environment Programme web site: http://www.unep.or.jp/ietc/estdir/pub/msw/sp/sp5/sp5_4.asp.

[24] United States Environmental Protection Agency. (2002, June 10). *Air Quality and Planning Standards: Summary of Solid Waste Incineration Rules.* Retrieved on December 7, 2004, from the U.S. EPA web site: http://www.epa.gov/oar/oaqps/takingtoxics/p3.html.

[25] Vatavuk, W., Van der Vaart, D, and Spivey, J. (2002, January). *EPA's Air Pollution Control Cost Manual, Section 3.2—VOC Destruction Controls.* U.S. EPA Document EPA/452/B-02-001.

[26] United States Environmental Protection Agency. (2004, November 30). *Technology Transfer Network Air Toxics Website: Health Effects Notebook for Hazardous Air Pollutants.* Retrieved on December 7, 2004 from the U.S. EPA web site: http://www.epa.gov/ttn/atw/hapindex.html.

[27] Ibid.

[28] Ibid.

[29] Agency for Toxic Substances and Disease Registry (2004, November 22). *ASTDR Public Health Statement for Chlorinated Dibenzo-p-dioxins (CDDs)*. Retrieved on December 7, 2004 from the ASTDR web site: http://www.atsdr.cdc.gov/toxprofiles/phs104.html#bookmark02.

[30] United States Environmental Protection Agency. (2004, September 30). *Six Common Air Pollutants: Health and Environmental Impacts of SO_2*. Retrieved on December 7, 2004 from the U.S. EPA web site: http://www.epa.gov/air/urbanair/so2/hlth1.html.

[31] United States Environmental Protection Agency. (2004, November 30). *Technology Transfer Network Air Toxics Website: Health Effects Notebook for Hazardous Air Pollutants.* Retrieved on December 7, 2004, from the U.S. EPA web site: http://www.epa.gov/ttn/atw/hapindex.html.

[32] United States Environmental Protection Agency. (2004, February 26). *Six Common Air Pollutants: Health and Environmental Impacts of NO_x*. Retrieved on December 7, 2004, from the U.S. EPA web site: http://www.epa.gov/air/urbanair/nox/hlth.html.

[33] United States Environmental Protection Agency. (2004, September 30). *Six Common Air Pollutants: Health and Environmental Impacts of PM*. Retrieved on December 7, 2004, from the U.S. EPA web site: http://www.epa.gov/air/urbanair/pm/hlth1.html.

[34] Warren, B. (2000, May 31). *Taking Out the Trash: A New Direction for New York City's Waste*. Retrieved on December 6, 2004, from Organization of Waterfront Neighborhoods and Consumer Policy Institute/Consumers Union web site: http://www.consumersunion.org/other/trash/about.htm.

[35] Serrano, J. E. (2004, September 20). *Clearing the Air*. Retrieved on November 25, 2004, from the Gotham Gazette web site: http://www.gothamgazette.com/article/20040920/202/1121.

[36] Stohr, K. (2002, April 8). *Issue of the Week: Incinerators*. Retrieved September 20, 2004, from the Gotham Gazette web site: http://www.gothamgazette.com/iotw/recycling/doc1.shtml.

[37] Columbia University's Earth Institute, Earth Engineering Center, and the Urban Habitat Project at the Center for Urban Research and Policy of Columbia University's School of International and Public Affairs. (2001, December 1). *Life After Fresh Kills: Moving Beyond New York City's Current Waste Management Plan; Policy, Technical and Environmental Considerations*. Columbia University Earth Institute: New York. p. A-6.

[38] Miller, B. (2000). *Fat of the Land: Garbage of New York. The Last Two Hundred Years.* New York: Four Walls Eight Windows Publishing.

[39] Community University Consortium for Regional Environmental Justice Case Study: *El Puente & the Struggle Against the Navy Yard Incinerator in Brooklyn, NY*. Retrieved on September 19, 2004, from Community University Consortium for Regional Environmental Justice (CUCREJ) web site: http://newarkwww.rugers.edu/~gelobter/cucrej/html/epcase_timeline.html.

[40] Ford, R. (2003, December). *Sanitation Lights a Fire on Staten Island.* Retrieved on September 18, 2004, from the City Limits web site: http://www.citylimits.org/content/articles/articleView.cfm?articlenumber=1069.

[41] United States Environmental Protection Agency. (2004, April 22). *Wastes: Treat, Store, and Dispose of Wastes—Waste Treatment Technologies*. Retrieved on July 19, 2004, from the U.S. EPA web site: http://www.epa.gov/epaoswer/osw/treatech.htm.

[42] Regional Information Service Center for South East Asia on Appropriate Technology, Institute of Science and Technology Research and Development, Chiang Mai University. (1998, November). *Review of Current Status of Anaerobic Digestion Technology for Treatment of Municipal Solid Waste*.

[43] R.W. Beck, Inc. (2004, June). *Final Report: Anaerobic Digestion Feasibility Study for the Bluestem Solid Waste Agency and Iowa Department of Natural Resources*.

[44] Perry, R.H., Green, D.W. eds. (1997). *Perry's Chemical Engineers' Handbook, Seventh Edition*. New York: McGraw-Hill.

[45] Belgiorno, V., et al. (2003). Energy from Gasification of Solid Wastes. *Waste Management, 23*, p. 1-15.

[46] Malkow, T. (2004). Novel and Innovative Pyrolysis and Gasification Technologies for Energy Efficient and Environmentally Sound MSW Disposal. *Waste Management, 24*, p. 53-79.

[47] Ibid.

[48] Verma, S. (2002). *Anaerobic Digestion of Biodegradable Organics in Municipal Solid Wastes*. (Masters thesis, Department of Earth and Environmental Engineering, Columbia University, 2002).

[49] City of New York, Mayor's Office of Operations. *The Mayors Management Report, Fiscal Year 2004 Preliminary*. Retrieved on September 9, 2004, from the official web site of New York City: http://www.nyc.gov/html/ops/downloads/pdf/2004_mmr/0104_mmr.pdf.

[50] Whyte, R., Perry, G. (2001, October). A Rough Guide to Anaerobic Digestion Costs and MSW Diversion. *BioCycle, 42*, p. 10.

[51] Klein, A. (2002). *Gasification: An Alternative Process for Energy Recovery and Disposal of Municipal Solid Waste.* (Masters thesis, Department of Earth and Environmental Engineering, Columbia University, 2002). Retrieved on October 8, 2004, from the Fu Foundation Columbia University School of Engineering and Applied Science web site: http://www.seas.columbia.edu/earth/kleinthesis.pdf.

[52] City of New York. *Executive Budget Fiscal Year 2005: Supporting Schedules*, *Volume VI, Dept. Nos. 781-836, p. 2910*. Retrieved on October 22, 2004, from the official web site of New York City: http://www.nyc.gov/html/omb/pdf/ss4_04f.pdf.

[53] E. Franklin, New York City Independent Budget Office, New York, NY, personal interview on October 20, 2004.

[54] City of New York. *Executive Budget Fiscal Year 2005: Supporting Schedules*, *Volume VI, Dept. Nos. 781-836, p. 2910*. Retrieved on October 22, 2004, from the official web site of New York City: http://www.nyc.gov/html/omb/pdf/ss4_04f.pdf.

[55] The Monitor Group, New York, NY, personal interview on October 20, 2004.

[56] Start-up Costs: Staples Office Furniture, Computers, and Printers. Retrieved on October 22, 2004, from the Staples web site: http://www.staples.com; Xerox Copiers, Retrieved on October 22, 2004, from the Xerox web site: http://www.xerox.com.

Overhead costs: Calculated from Dr. Robert Berg, Independent Business Owner, New York, NY, personal interview on October 20, 2004; and Retrieved on October 22, 2004, from http://www.officefinder.com; and from *The City of New York Adopted Budget Fiscal Year 2005: Expense, Revenue Contract, p.146E*. Retrieved on October 22, 2004, from the official web site of New York City: http://www.nyc.gov/html/omb/pdf/erc7_04.pdf.

Communications training and office supply costs: Estimated from *The City of New York Adopted Budget Fiscal Year 2005: Expense, Revenue Contract, p.146E*. Retrieved on October 22, 2004, from the official web site of New York City: http://www.nyc.gov/html/omb/pdf/erc7_04.pdf.

Travel costs: Calculated from Orbitz Travel. Retrieved on October 22, 2004 from: http://www.orbitz.com.

[57] City of New York, Office of Management and Budget. *The City of New York Adopted Budget Fiscal Year 2005: Expense, Revenue Contract, p. 146E*. Retrieved on October 22, 2004, from the official web site of New York City: http://www.nyc.gov/html/omb/pdf/erc7_04.pdf.

[58] K. Kavenaugh, Traffic Manager Metro Newspaper Advertising Services, New York, NY, personal interview on October 20, 2004; The Village Copier, New York, NY, personal interview on October 20, 2004.

Appendix