University Transportation Research Center - Region 2

Final Report

ELIMINATING TRUCKS ON ROOSEVELT ISLAND FOR THE COLLECTION OF WASTES

Performing Organization: University Transportation Research Center (UTRC), CCNY/CUNY

July 2013

Sponsor:
New York State Energy Research and Development Authority (NYSERDA)

University Transportation Research Center - Region 2

The Region 2 University Transportation Research Center (UTRC) is one of ten original University Transportation Centers established in 1987 by the U.S. Congress. These Centers were established with the recognition that transportation plays a key role in the nation's economy and the quality of life of its citizens. University faculty members provide a critical link in resolving our national and regional transportation problems while training the professionals who address our transportation systems and their customers on a daily basis.

The UTRC was established in order to support research, education and the transfer of technology in the field of transportation. The theme of the Center is "Planning and Managing Regional Transportation Systems in a Changing World." Presently, under the direction of Dr. Camille Kamga, the UTRC represents USDOT Region II, including New York, New Jersey, Puerto Rico and the U.S. Virgin Islands. Functioning as a consortium of twelve major Universities throughout the region, UTRC is located at the CUNY Institute for Transportation Systems at The City College of New York, the lead institution of the consortium. The Center, through its consortium, an Agency-Industry Council and its Director and Staff, supports research, education, and technology transfer under its theme. UTRC's three main goals are:

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NYSERDA Contract No: 21193

UTRC-RF Project No: 55819-00-01

Project Date: July, 2013

Project Title: Eliminating Trucks On Roosevelt Island For The Collection Of Wastes

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ELIMINATING TRUCKS ON ROOSEVELT ISLAND FOR THE COLLECTION OF WASTES

FEASIBILITY STUDY

Final Report

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Project #21193

July 2013

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2.Government Accession No.	3. Recipient's Catalog No.

4. Title and Subtitle	5. Report Date
Eliminating Trucks On Roosevelt Island For The Collection Of Wastes	July 2013
	6. Performing Organization Code
7. Author(s)	**8. Performing Organization Report No.**
Camille Kamga, Benjamin Miller, Juliette Spertus, Lisa Douglass, Brian Ross, Penny Eickemeyer	
9. Performing Organization Name and Address	**10. Work Unit No.**
University Transportation Research Center, Region 2 Marshak Hall - Suite 910 The City College of New York New York, NY 10031	11. Contract or Grant No. NYSERDA Contract 21193 UTRC-RF Grant No: 558190001
12. Sponsoring Agency Name and Address	**13. Type of Report and Period Covered**
New York State Energy Research and Development Authority (NYSERDA), 17 Columbia Circle Albany, NY 12203	Final Report 14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

This study examined alternatives for improving the efficiency of the pneumatic system that has been used for collecting residential municipal solid waste on Roosevelt Island, New York since 1975. Alternatives included a basic equipment upgrade; expansion to include separate recyclables streams (metal/glass/plastic; paper); and a further expansion of the system to include commercial and litter-bin waste. These three scenarios (plus the No-Action alternative, representing a continuation of the status-quo system) were compared to conventional truck collection. The No-Action alternative produced the greatest adverse economic and environmental impacts. Compared to conventional collection, all of the pneumatic scenarios offered advantages in terms of service frequency and reliability, labor and space requirements, and quality-of-life benefits. Because containers of pneumatically collected waste need to be drayed from the terminal to a transfer station or processing facility, some truck miles are still required. The simple equipment upgrade would generate 15% more truck miles than the conventional alternative, but when recyclables are included, overall truck miles would be reduced by 10%, and when commercial and litter-bin waste is included, by 70%, while diesel fuel use for the three pneumatic scenarios would decline by 10 to 90%. Since reductions in diesel fuel require increased use of electricity, and since the pneumatic scenarios collect 8 times more often, overall energy demand for these expanded systems would increase by 25% to 70% relative to manual collection. Likewise, greenhouse gas emissions for pneumatic collection would be up to twice as high as for conventional collection. Since up to 90% of the energy demand for pneumatic systems may be supplied by electricity rather than diesel fuel, electricity generated by low-carbon sources could reduce these greenhouse gas emissions. These pneumatic scenarios cost 10 to 25% less to operate, including the truck dray of containers from the pneumatic terminal to the long-haul transfer station, but when debt service for capital investments is included, overall operating costs for the pneumatic alternatives are 40 to 90% higher than for conventional collection. On a Net Present Value basis, this difference could be equalized if annual externality benefits on the order of $255,000 to $1,140,000 were realized. Given the value of potential savings by waste-generators (in space and labor costs) and of potentially monetizable public benefits (public-health and quality-of-life improvements), the pneumatic alternatives may achieve these levels of benefits.

17. Key Words	18. Distribution Statement
pneumatic waste collection; municipal solid waste; urban freight transport; urban goods movement; solid waste management; low-emission freight transport	

19. Security Classif (of this report)	20. Security Classif. (of this page)	21. No of Pages	22. Price
Unclassified	Unclassified		

Form DOT F 1700.7 (8-69)

NOTICE

ABSTRACT

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Keywords: pneumatic waste collection; municipal solid waste; urban freight transport; urban goods movement; solid waste management; low-emission freight transport

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The University Transportation Research Center, Region 2, acknowledges the significant engineering support made to this study by Envac, A.B., the current corporate form of the Swedish firm that installed the world's first pneumatic waste collection system (still in operation today) at a hospital in Solleftea, Sweden in 1961, as well as the systems still in operation on Roosevelt Island, New York City (1975) and in Jersey City, New Jersey (1972), and which has since developed hundreds of other systems throughout Europe, Asia, and North America. The research team would particularly like to recognize the technical contribution made by Albert Mateu, P.E., former Envac sales vice-president for the Americas and South Europe. We also acknowledge with appreciation the insightful review comments offered by Tammy Gamerman of the Citizens Budget Commission and Amy Marpman and Richard Fuller of Great Forest.

TABLE OF CONTENTS

TABLES

FIGURES

EXECUTIVE SUMMARY

Roosevelt Island is a planned community of 14,000 residents in the middle of the East River between Manhattan and Queens in New York City. Since it opened in 1975, its residential municipal solid waste (MSW) has been collected "auto-pneumatically" via a network of pneumatic tubes that extend under much of the Island. This automated vacuum ("AVAC") system has functioned reliably for the past 38 years. The quality-of-life benefits it provides--decreased traffic, noise, and aesthetic nuisances, for example--are generally highly appreciated by the Island's residents (to the extent that they are even aware that this nearly invisible system exists).[1] But the AVAC system, one of the first full-scale pneumatic installations in the world, has not had its component parts replaced on an ongoing basis (as is the practice with some other pneumatic installations) and this original equipment is now reaching the end of its expected life. Maintenance costs are increasing. Its energy and labor demands are considerably greater than those of a digitally controlled, high-efficiency modern system. A rational management plan would suggest that it is time for an upgrade.

In 1975, New York City collected only one refuse "stream." New Yorkers called it "garbage." Now they are required to separate their metal, glass, and plastic from their other discards so that these materials can be collected as one separate stream, and their cardboard and mixed paper, so that they can be collected as another. On Roosevelt Island, these "source-separated" materials are handled as they are in the rest of New York City: the old-fashioned way, by truck. So are the wastes generated by the businesses that line the Island's narrow Main Street, the waste from its hospitals, and the material from its litter baskets. More discards will be produced by the residents of three new apartment towers that are planned but not-yet built, and by the thousands of students, staff, and visitors who will populate the two-million-square-foot university campus now being designed for the Island's southern end. If the AVAC system is upgraded, what would be the most rational overall plan for dealing with all of the wastes generated on the Island? Could these other materials also be collected auto-pneumatically, to further reduce truck traffic? Or would it be less expensive simply to shut down the antiquated AVAC plant and collect the Island's trash by truck? Which option--one of the pneumatic alternatives designed to handle some or all of the Island's waste streams, or conventional truck collection--would be most environmentally efficient, requiring the least energy and releasing the least greenhouse gas emissions?

These were the questions this study was designed to answer.

We found that it would be practicable to collect all of the waste materials generated on the Island auto-pneumatically, and that doing so would produce significant quality-of-life benefits (increased frequency and reliability of waste collection, for instance) and environmental improvements (such as reduced traffic congestion, noise, and air emissions). It might produce significant savings for waste generators--directly, for building managers, and indirectly for their tenants--through reduced labor and space costs. It would advance New York City's and New York State's goals of reducing the region's reliance on carbon-based fuels by replacing them, in part, by electricity that could be generated from renewable resources.[2] And if automated pneumatic collection were accompanied by automatic metering of the quantities of waste introduced into the system, so that unit-based pricing could provide a financial incentive to reduce waste generation and increase recycling, there could be a beneficial effect on the overall waste-management system due to the reduced need for long-distance transport and disposal.

We found that the most practicable pneumatic solution would be separate (but coordinated) networks for the Island's residential population, for the university campus, and for the hospital. Each network would have its own pneumatic terminal.

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[1] See interviews with Island residents in the video "Nature Abhors A Vacuum" http://fasttrash.org/exhibition/roosevelt-islands-avac/ accessed 01-31-13, and survey data in Appendix A.
[2] E.g., PlaNYC, "Energy," http://www.nyc.gov/html/planyc2030/html/theplan/energy.shtml, last accessed 01-27-13; Andrew M. Cuomo, State of the State Address, 01-09-13, https://www.governor.ny.gov/press/01092013sostranscript, accessed 01-27-13.

Any of the pneumatic-upgrade alternatives we considered would be considerably less expensive to operate than is the current AVAC system and would offer significantly greater environmental benefits. All of the pneumatic alternatives would also be less expensive to operate than would be a conventional truck-based system--*not* including the cost of debt service. When debt service is included--the initial costs of installing long-term infrastructure are relatively high, as New Yorkers discovered a century and a half ago when they first installed pipelines for supplying water and removing sewage--total operating costs are 40 to 90% higher than those of truck-based collection. The Net Present Value (NPV)[3] costs of pneumatic and conventional collection could be balanced, however, if annual externality benefits on the order of $255,000 to $1,140,000 (depending on the number of fractions and waste sources included in the system) were achieved. Given the value of potential generator savings (space and labor) and of potentially monetizable public benefits (public-health and quality-of-life improvements) this may be possible.[4]

Since pneumatic systems would still require trucks to move containers of refuse and recyclables from the AVAC terminal to off-Island transfer stations or processing facilities, overall truck miles would be reduced (relative to conventional collection) only in the pneumatic systems that included other waste streams in addition to residential refuse. In these pneumatic systems that also include recyclables, or recyclables and commercial and litter-bin waste, diesel-fuel use would decrease by 35% or 85%, respectively. Electricity would replace a portion of the energy that is supplied by diesel fuel in conventional collection, but because pneumatic systems collect waste multiple times per day, energy use is increased relative to low-frequency truck-based collection. Per-ton energy demand for the pneumatic systems (measured in British Thermal Units, BTUs) would be between 25% and 70% higher than for manual collection, depending on how many waste fractions are handled pneumatically. Total greenhouse gas (GHG) emissions would range from about 35% higher to twice as high as for manual collection, again depending on how many streams are pneumatically collected. Because the system is powered by electricity, low-carbon sources would reduce GHG emissions.

[3] "NPV can be described as the "difference amount" between the sums of discounted cash inflows and cash outflows. It compares the present value of money today to the present value of money in the future, taking inflation and returns into account." http://en.wikipedia.org/wiki/Net_present_value, accessed 07-03-13.
[4] Among the externalities that might be considered (but whose quantification was beyond the scope of this study) are such mileage-based impacts as pavement wear due to truck traffic, health effects of local particulate emissions from diesel engines, the cost to society of increased congestion and accidents, and reductions in health, productivity, and property value due to increased noise. Another category of impacts are those associated with the staging of waste for manual collection, such as rodents, odors, and visual nuisances.

Section 1

INTRODUCTION

THE PROBLEM

Urban solid waste management is a quintessential *local* problem. The heterogeneous discards of our cities are generated at the household and individual-business level, stored on-site in apartments and offices until they are removed to the street, collected from curbs or loading-docks by heavy-duty trucks, then driven over local streets to nearby materials-recovery, composting, waste-to-energy, or landfill facilities, or taken instead to local transfer stations at which they are reloaded onto other conveyances for long-hauls to distant disposal sites.

And yet, to the extent that waste-management issues are generally recognized to be of environmental and economic significance, this awareness tends to focus on “global” issues associated with resource depletion, air and water pollution, and global warming. The “last-mile” issues associated with waste disposal (which, in the US, generally means landfilling) are considered of paramount import; the production issues (resource extraction, depletion of non-renewable fossil fuels, impacts associated with metallurgical and petrochemical refining) receive somewhat less attention. But the “first-mile” issues—the widely dispersed local-level impacts that affect all urban dwellers most directly—are scarcely recognized. (Perhaps this is because municipal solid wastes are considered inert, like stationary potholes, and unlike moving currents of polluted air or water that transcend local boundaries, so that they are seen as being outside the purview of state or federal government, deserving instead the attention only of the lowest levels of local administration.)[5] Most citizens--and their elected and appointed officials--thus fail to understand the highly consequential effects of waste *collection* on the overall waste-management system and on the entire urban environment.

More specifically, the significance of the transportation component of waste management—waste as freight; the place of waste in urban goods-movement and passenger networks—is under-appreciated. And in this regard solid waste is once again an anomaly, since significantly more-efficient and less-environmentally-degrading systems have long been in place to meet other such elemental urban goods-movement needs. Sewers have been used to transport liquid wastes away from cities for almost as long as water pipes have been used to bring water into them. Gas and oil lines have long-since replaced rail or truck deliveries and are now as ubiquitous as any other kind of underground utility system for delivering electricity, steam, or information.

In addition to the obvious externalities associated with the way most of us currently store, stage, and ship off our solid wastes—adverse impacts that include wasted space, visual nuisances, odors, congestion, noise, diesel particulates, service interruptions due to snow storms and hurricanes, worker injuries, and rats—the way waste is collected has *direct* effects on the rate of energy use and on the volumes of GHG released into the atmosphere. It also has *indirect* effects on GHG emissions associated with landfilling, since truck-based collection of urban waste from multi-family buildings makes it difficult to charge individual apartment-dwellers on a unit basis (a system that has been widely documented to significantly reduce the volumes of waste requiring disposal[6]), difficult to collect source-separated organics for composting or anaerobic digestion, and more difficult to source-separate metal, glass, plastic, and paper for recycling.

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[5] Or is this relegation to the lowest levels of governmental attention, as has been suggested by anthropologist Mary Douglas, a reflection of the cultural blinders that limit our perception of daily matters associated with dirt? (*Purity and Danger: An Analysis of Concepts of Pollution and Taboo*, Psychology Press, 2002.)

[6] Average reductions in generation for the U.S. (16-17%) are presented at: http://www.paytnow.org/PAYT_CO_faqpaytSERA_v6.pdf, 2008, accessed 12-14-12.

Figure 1-1. Pipelines in New York City Have Replaced Trucks for Centuries
(Source: sewerhistory.org) [7]

An alternative to conventional truck-based collection systems is the pneumatic-tube technology that has been used in various European and Asian cities for the past fifty years—and on Roosevelt Island (RI), in New York City, since it opened as a New York State-managed residential housing complex in 1975.

When residents first began moving into Roosevelt Island's apartment towers, New York City did not yet require that recyclables be separated from other refuse.[8] The waste generated by businesses on Roosevelt Island, like all other commercial waste in the city, was (and still is) picked up by private carters rather than by the municipal Department of Sanitation. Recyclables and commercial wastes, therefore, are handled manually, with conventional truck-based collection, rather than in the Island's automated vacuum system. Likewise, waste generated by the hospitals on the Island is collected by truck, as is the waste deposited in park and sidewalk litter baskets.

But in the decades since AVAC went into operation, technological advances now in use elsewhere allow source-separated fractions to be collected for recycling (via separate inlets that feed into the common trunk pipes on a pulsed basis) and allow waste inputs to be automatically measured for billing purposes (so that businesses—and, if so desired, residents—could be charged on a unit basis just as they now are by private carters). In addition, more-energy-efficient equipment and advances in digital control technology now allow the terminals to which the waste is pneumatically delivered to use less energy and less labor and to occupy a smaller footprint.

If the AVAC system could be upgraded to accept these waste streams that it does not currently handle, while taking advantage of the labor-, space-, and energy-saving technological advances of recent decades, the modernized Roosevelt Island system might produce a variety of economic, environmental, and quality-of-life benefits for the residents of Roosevelt Island, as well as more-generalized economic and environmental benefits for the rest of New York City.

What system-upgrade options might be physically, operationally, and economically feasible? What would be the costs and impacts of various system alternatives? What practicable form of system re-design might offer the most effective balance between overall costs and benefits—so that Roosevelt Island could again serve as a global model for sustainable waste-management practices?

This was the problem this project was designed to address.

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[7] Source: J. F. Springer, "Iron and Steel Sewer Pipe," *Municipal Engineering*, Volume LI, No. 3 (September 1916), p. 87.
[8] Local Law 19 of 1989 mandated source-separation of two recyclable streams: metal/glass/plastic and mixed paper/old corrugated cardboard.

BACKGROUND

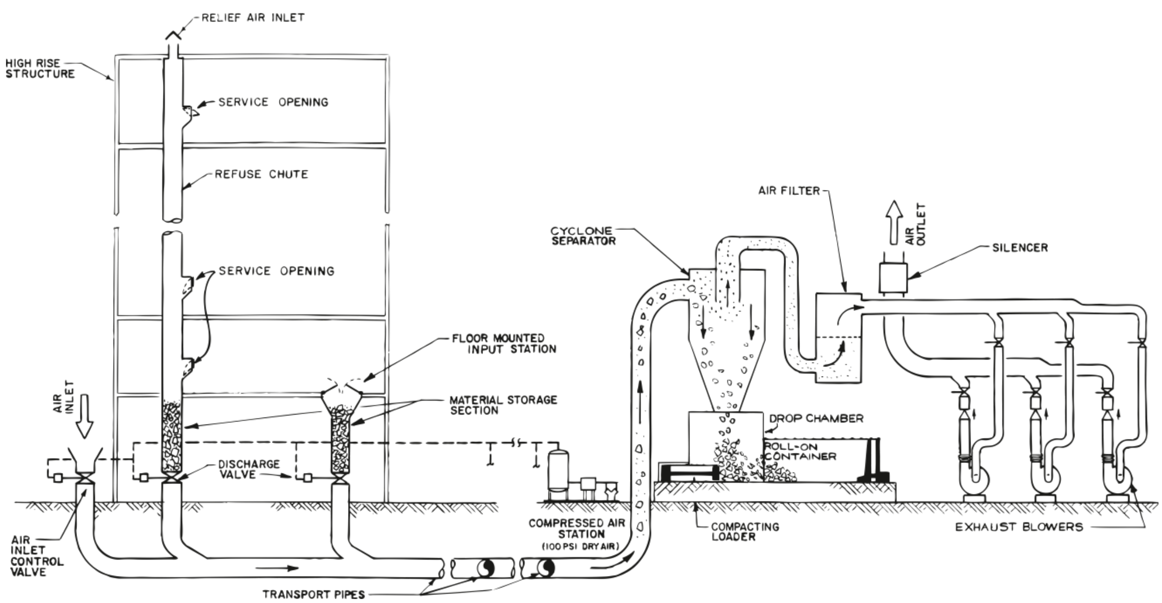
Pneumatic Tube Overview

Pneumatic collection systems use negative air pressure to pull solid waste through a network of pipes to a central collection point (terminal) where the waste is compacted and sealed into containers for transport to a processing or disposal facility.

Wastes are deposited into gravity-fed garbage chutes inside buildings, or into specialized exterior receptacles. The wastes collect inside the chute, or in a reservoir underneath the exterior receptacle, until the fans that produce the pneumatic vacuum are turned on and valves connecting the inlets to the pipe network are opened to release the accumulated waste into the airstream flowing into the terminal.

Pneumatic collection systems are designed to run automatically on a predetermined or as-needed schedule. Roosevelt Island's 40 operating inlets, for example, are opened 4 times a day 7 days a week 365 days a year.[9]

Figure 1-2. Roosevelt Island AVAC Operations Diagram
(Source: Gibbs and Hill Engineers, 1971)



When the material reaches the terminal, it enters a cyclone-separator that sends the heavier-than-air waste spiraling down into a 40-cubic-yard compactor, while the air in which the waste was entrained rises into a fabric filter. The fabric filter removes dust and impurities before the air is circulated through the exhausters (on Roosevelt Island there are six 300-horsepower turbines, as shown in Figure 1-5) and then out through the stacks.[10] The compacted waste is rammed into shipping containers, as shown in Figure 1-6.

[9] Forty-four valves connect to Roosevelt Island's network but only 40 are in use. Phone conversation with NYC Dept. of Sanitation engineer Jerry Sorgente, 10-28-11.

[10] This is pretty much the same principle by which any household vacuum cleaner operates: vacuum-cleaner bags are fabric filters. Note that only three turbines are used at a time.

Figure 1-3. RI Cyclone-Separator (left) and Dust Filter (lower right)
(Source: Milford, 2010)

Figure 1-4. Base of RI Inlet Chutes, Diverter Valves[11]
(Source: Ross, 2011)

Once the compactor container is full, it is replaced by an empty container that is delivered by a bridge crane, roller-tracks, or other means. Roosevelt Island's facility can store up to 10 containers for transport.

[11] In the valve from 1975, shown on the left in the closed position, a horizontal plate slides open to allow the waste into the pneumatic network. The newer valve shown on the right (installed in 2003) is always sealed. A butterfly valve spins open within the tube to allow waste into the network.

Figure 1-5. RI Turbine-Exhausters
(Source: Milford, 2010)

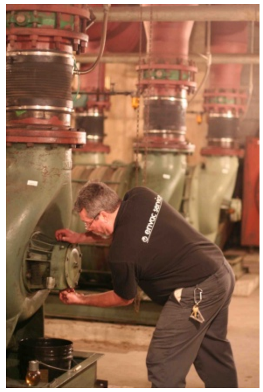
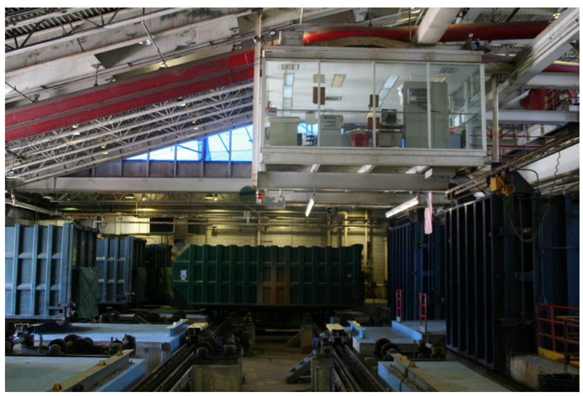


Figure 1-6. RI AVAC Terminal, Showing Roller Tracks and Container Storage
(Source: Milford, 2010)



There are two types of pneumatic networks: stationary systems with dedicated terminal facilities such as Roosevelt Island's and mobile systems (Figure 1-7). Mobile installations require a specialized vacuum truck to suction waste via docking stations that are connected to a pipe network. The vacuum truck, which can serve several networks, compacts the waste and transports it for treatment or disposal.

Both types of network can be used to collect multiple source-separated waste streams or fractions. A single trunk pipe can transport these various fractions by pulling them at different times from their separate collection tanks (as shown in Figure 1-8). A dedicated cyclone-separator and compactor-container, or in the case of a mobile system, a dedicated truck run, allows for the separate collection of each fraction. In stationary systems, a switching valve connects the trunk line to the appropriate cyclone-separator before each new fraction is collected (as shown in Figure 1-9).

Multi-fraction pneumatic systems require extra equipment and, since each separate pneumatic pull consumes additional energy, capital and operating costs are higher than for single-stream systems. The size of the terminal and the energy efficiency of the system depend on the length and geometry of the pipe network, the number of inlets connected to it, and the types and volumes of waste to be handled.

Figure 1-7. Mobile Pneumatic System
(Source: Kogler, 2007)

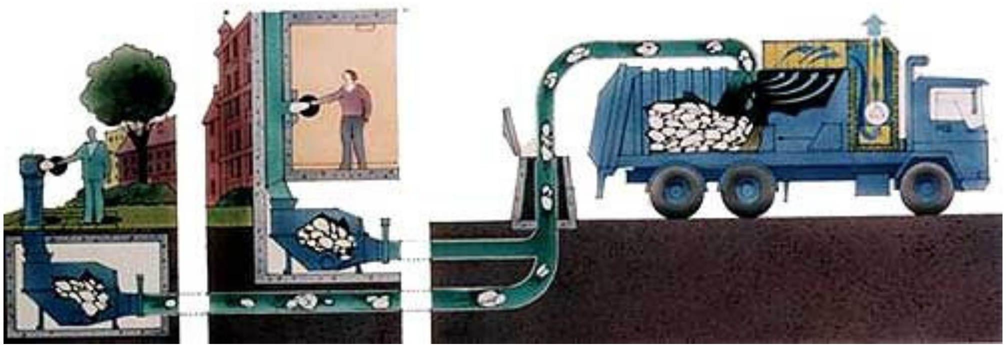


Figure 1-8. Schematic Stationary Pneumatic System Collecting 3 Fractions
(Source: Envac, 2007)

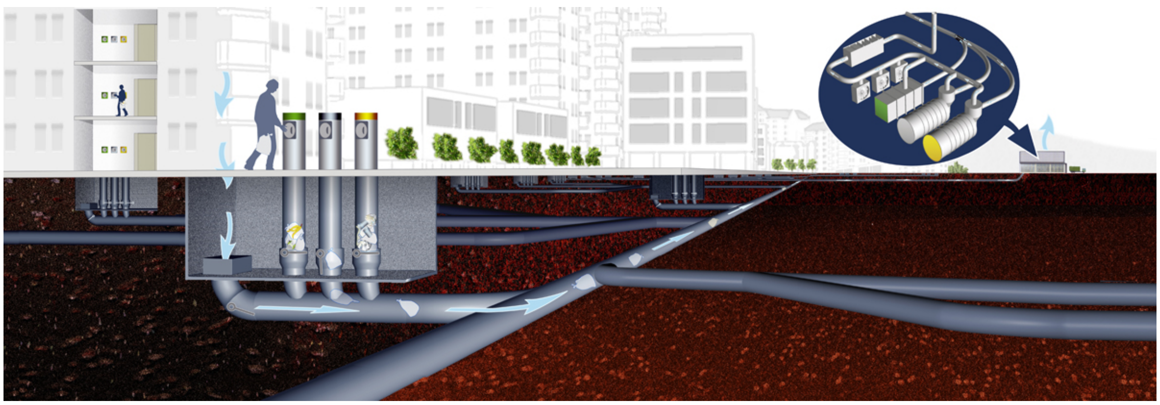


Figure 1-9. Three-Way Diverter Valve
(Source: Kogler, 2007)

In installations built within the last decade or so, inlets are commonly equipped with key systems (magnetic cards with a unique identifier for each business or household) and with monitors that automatically register the volume of material introduced by the specific generator, or the number of times the generator accesses the inlet. This information can be used to automatically generate bills to be sent to each generator each month. In this way, at a relatively modest incremental cost, unit-based pricing systems can be integrated with pneumatic systems. Since it is otherwise relatively difficult to charge individual households in high-rise buildings based on the volume of waste they dispose of, and since unit-based pricing has been widely demonstrated to produce significant reductions in the volumes of wastes set out for disposal,[12] such metered inlets can provide a significant system-wide benefit.

Figure 1-10. Inlet Equipped with Magnetic Card-Reader
(Source: Envac, 2012)

Pneumatic Tube Waste Collection Integrated Into the Development of Roosevelt Island as a Residential Community

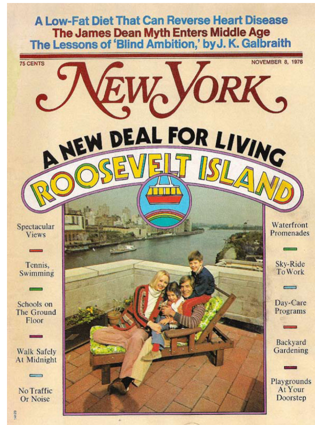
"The development of Welfare Island [renamed Roosevelt Island in 1973] is the first attempt in the United States to create for all income levels an urban environment where the primary consideration is the quality of the urban environment itself….When completed, the development will demonstrate that new approaches to the organization of public resources, which in turn lead to new approaches to planning and design, can restore to its inhabitants many of the lost pleasures of city life."[13]

Figure 1-11. Roosevelt Island: A Planned "New Town in Town"
(Source, NYS Urban Development Corporation, 1974)

The New York State Urban Development Corporation (UDC) planned a 20,000-resident "new town in town" as a model for a high-rise alternative to the suburbs that were drawing the middle-classes away from cities in the late 1960s. The master plan proposed a pedestrian neighborhood in which residents would leave their cars in a central parking garage and take electric shuttle buses along a single village "Main Street" lined with apartment buildings and surrounded by parks and water. Without cars and trucks to worry about, parents could let children could run freely.

[12] E.g., Kogler, "Waste Collection." ISWA Working Group on Collection and Transportation Technology, 2007. 61. http://www.iswa.org/uploads/tx_iswaknowledgebase/ctt_2007_2.pdf, last accessed 06-14-13.
[13] New York State Urban Development Corporation & Welfare Island Development Corporation, *Welfare Island: An Interim Report*, 1970.

Figure 1-12. Roosevelt Island: "No Traffic or Noise"
(Source: *New York Magazine*, 1976)



Gibbs and Hill, the engineering firm responsible for infrastructure and transportation on the island, recommended the new pneumatic collection strategy because even containerized collection would require truck-accessible service areas and compacting stations that would be incompatible with the pedestrian orientation of the island. The engineers calculated that the pneumatic system would cost about the same as conventional collection, but without trucks the City's share of the costs would be cut in half. The 20-inch-diameter steel tubes for pneumatic collection were laid with the other service lines and the system was inaugurated as the first residents moved in in early 1975.

Literature Review

Literature on pneumatic collection of municipal waste falls into several categories: engineering and waste-management-policy articles in academic journals; consultant or vendor reports and recommendations to potential system owners; and municipal plans and regulations written by system owners.

The 1970s and the First Pneumatic Waste Systems. Engineering articles from the early 1970s describe the context in which the first pneumatic systems for municipal waste in the US, including Roosevelt Island's system, were built.[14] Manufacturers targeted large-scale publicly funded urban-renewal and housing programs similar in scale to the European new towns, the satellite developments where the strategy was first implemented. With the shift to disposable packaging and the banning of in-building incinerators, waste management was becoming increasingly cumbersome for municipalities such as New York City, where labor costs were rising and the tax base was eroding. We are aware of three systems in the U.S. that are still in operation: Disney World (1971),[15] Summit Plaza in Jersey City (1972)[16] and Roosevelt Island (1975). The strategy is also mentioned in reference to several other contemporary projects, the status of

[14] BT Kown/EA Kass of Gibbs & Hill Inc. 1973."Put refuse in a pipe; let air do the work," *American City*, June 1973.
[15] Bravo, Arthur C., "Environmental Systems at Walt Disney World." *Journal of the Environmental Engineering Division*, (December 1975): 887-95.
[16] U.S. Department of Housing and Urban Development, *Feedback: Operation Breakthrough Phase 1 Planning and Design*. Report prepared by HUD Office of Policy Development and Research with RTKL Associates Inc., Washington DC: U.S. Government Printing Office, 1976.

which the study team has not ascertained.[17] A 1974 article reported that over a dozen hospitals had incorporated pneumatic collection of waste or soiled linens.[18]

Recent General Literature on Pneumatic Tubes. Reports with recommendations for or against the installation of a pneumatic collection system by a developer or city agency highlight the importance of individual urban contexts in evaluating this technology. The 1972 report by Gibbs and Hill for Roosevelt Island recommended a pneumatic system to the Welfare Island Development Corporation as a means of avoiding the adverse environmental impacts associated with collection trucks.[19] Other reports focus on the administrative issues. For example, a 2008 report by Toronto's deputy city manager explained that the City could not support a pneumatic-collection proposal for a major waterfront renewal project without an implementation plan "where the City is not the owner/operator after the pilot project is completed."[20] A 2010 statement by the Traffic Administration in Stockholm, where the city's 400 pneumatic systems are owned by private developers, asked the City Council to retrofit the city center with a municipally owned system. In the Stockholm case, the primary motivation was worker safety in dense neighborhoods where storage areas in existing buildings did not meet current accessibility standards for waste handlers, and where making the modifications necessary to meet these standards was either impossible or costly.[21] In Saudi Arabia, engineers recommended a pneumatic network for the pedestrian plazas around the Grand Mosque in Mecca to handle high waste volumes and reduce congestion during pilgrimages.[22]

Administrative documents from cities that have publicly owned pneumatic systems offer useful implementation models. For example, Barcelona developed criteria that it used to produce a master plan for pneumatic collection; this plan designated all of the areas within the city to be served by pneumatic collection.[23] City ordinances describe the responsibilities of property owners with respect to the portion of the system that extends onto private property.[24] To ensure that networks built within the city meet technical

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[17] Dellaire mentions two projects in development: a housing complex in East Harlem developed by the East Harlem Redevelopment Corporation (system designed by ECI Air-Flyte) and the Empire State Plaza office complex and meeting center in Albany New York (system designed by Trans-Vac). Gene Dellaire, "Pneumatic waste collection on the rise." *Civil Engineering ASCE*, (August 1974): 83-4.
[18]Dellaire, 84
[19] Gibbs & Hill Inc. 1970. "Research Study on Refuse Collection for Welfare Island for New York State Urban Development Corporation," September, 1970.
[20] Deputy City Manager, City of Toronto. 2008. "Vacuum Waste Collection Systems." March 19, 2008. Unpublished staff report. www.toronto.ca/legdocs/mmis/2008/ex/.../backgroundfile-11780.pdf, accessed 07-18-12.
[21] "Service Statement C. No. E2008-702-01621, C. No. T2008-702-02200, Authority for vacuum systems for waste. Response to commission from the City Development Committee and the Traffic and Waste Management Committee, dated October 2008," City Development Administration Traffic Administration, p.2. http://fasttrash.org/library/archival-materials/ Reproduced by permission from the Traffic Administration of Stockholm, accessed 07-18-12.
[22] Al-Ghamdi, Abdullah Saeed and Abu-Rizaiza, Asad Seraj, "Report: Pipeline transport of solid waste in the Grand Holy Mosque in Makkah." *Waste Management & Research* 1, no. 5, (October 2003): 474-9. (This 600-ton-per-day pneumatic project, the largest in the world, is currently under construction. It is expected to open in 2013. The technology-provider is MariMatic. http://www.finlandtimes.fi/business/2013/02/18/358/MariMatic-to-build-wastepipe-system-in-Mecca; http://www.metrotaifun.com/automatic_solid_waste_collection_system/index.php/en/news-media/metrotaifun-news-and-media/8-news/26-marimatic-2011-11-08-marimatic-oy-delivers-to-saudi-arabia-world-s-largest-automatic-solid-waste-collection-system-awcs, accessed 06-05-13.)
[23] "Pla Tècnic 2006 de Recollida Pneumàtica de Residus: Avanç Econòmic," Clabsa and Ajuntament de Barcelona, 2006. http://fasttrash.org/library/archival-materials/, accessed 07-18-13. http://w110.bcn.cat/portal/site/MediAmbient/menuitem.37ea1e76b6660e13e9c5e9c5a2ef8a0c/?vgnextoid=a94b25921cd1a210VgnVCM10000074fea8c0RCRD&vgnextchannel=a94b25921cd1a210VgnVCM10000074fea8c0RCRD&lang=en_GB, accessed 07-18-13.
[24] "Ordenanza general del medio ambiente urbano de Barcelona (OMA)" Chapter 3 Article 63-6 "Recogida neumática," Chapter 4. Condiciones de los edificios y locales Article 64-2 "Edificios con sistema neumático" Ajuntament de Barcelona.

standards and are properly documented, Barcelona developed its own design specifications for pneumatic collection.[25]

Recent Literature Comparing the Costs, Environmental Impacts, and Life Cycle Assessment of Pneumatic Tubes to Conventional Collection. Several recent studies compare pneumatic and conventional collection along a number of dimensions. These studies show a fair degree of similarity in their findings.

Jackson presents a variety of environmental, public-health, and quality-of-life arguments in favor of pneumatic vs. conventional collection. He acknowledges the high capital costs of pneumatic systems relative to truck-based collection and recommends "[c]ontinued research into the development of low-cost, wear-resistant composite pipe materials…As improvements are achieved in the durability, workability, and manufacturing of various pipe materials, further reductions will in turn be realized in both the initial construction and long-term-maintenance costs for pneumatic waste collection systems; Thus [sic] making them less cost prohibitive and more attractive."[26] Other researchers comparing these systems also point to the role of the steel pipe in the overall economic and environmental costs of pneumatic systems.

Kogler focuses on the reductions in traffic congestion, worker accidents, exposure to pathogens and other sanitary hazards, noise (a one-quarter reduction in levels, a two-thirds reduction in duration), animal and insect pests, and odors, while documenting the relatively high capital costs of such systems ("nearly twice as high as traditional waste collection"). He notes, however, that these initial costs may be recovered: in addition to relatively modest operational savings (on the order of 20%), there could be savings of over 80% from renting out ground-floor space that conventional systems require for waste storage and handling, producing a net annual savings from pneumatic collection of over 25%.[27]

Three recent studies, a pair of parallel studies by Teerioja et al. and Punkkinen et al.,[28] and a study by Iriarte et al.,[29] compare the relative GHG emissions and other environmental impacts of hypothetical pneumatic collection systems with those of conventional collection, adding these factors to the analysis of direct capital and operating costs. The Teerioja and Punkkinen studies consider a four-fraction terminal-based pneumatic system, while Iriarte evaluates a mobile system using vacuum trucks. These studies use Life Cycle Assessment (LCA) to compare total greenhouse emissions and other environmental impacts. Impacts associated with the manufacture and installation of all of system components (in the case of pneumatic collection: steel pipe, mechanical equipment, buildings) are added to those from operations

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http://w3.bcn.es/V04/Serveis/Ordenances/Controladors/V04CercaOrdenances_Ctl/0,3118,200713899_200726005_2_169473778,00.html?accio=detall, accessed 07-27-12.

[25] Ajuntament de Barcelona and Clabsa. "Plec d'Especificacions per a Installacions de Recollida Pneumàtica a l'Interior dels Edificis." http://www.clabsa.es/PDF/RECOLLIDA_PNEUMATICA/PLEC_ESPECIFICACIONS.pdf, accessed 07-27-13.

[26] Stephen B. Jackson, "An In-Depth Report on the Development, Advancement, and Implementation of Pneumatic Waste Collection Systems and A Proposed Program for the Practical Evaluation of such a System in Terms of Waste Disposal Parameters, Engineering Design, and Economic Costs," 2004, pp. 28, 30; http://www.dtic.mil/dtic/tr/fulltext/u2/a471879.pdf, accessed 12-27-12. Note that his report assumes a system handling 100 tons a day, which is well above the demonstrated capacity of any system known to us, and an economic break-even point of 7 years, which is similarly unsupported by any experience of which we are aware.

[27] Kogler, op. cit.

[28] Nea Teerioja, Katja Molia, Evelliina Kuvaja, Markku Ollikainen, Henna Punkkinen, Elina Merta, "Pneumatic vs. door-to-door waste collection systems in existing urban areas: a comparison of economic performance" *Waste Management*, Volume 32, Issue 10, October 2012, Pages 1782-1791; Henna Punkkinen, Elina Merta, Nea Teerioja, Katja Moliis, Evelliina Kuvaja, "Environmental sustainability comparison of a hypothetical pneumatic waste collection system and a door-to-door system," *Waste Management*, Volume 32, Issue 10, October 2012, Pages 1775-1781.

[29] Alfredo Iriarte, Xavier Gabarrell, Joan Rieradevall, "LCA of selective waste collection systems in dense urban areas," *Waste Management*, 29 (2009) 903-014.

(manufacture and consumption of fuels including electricity, maintenance, etc.) to assess the strategy's overall environmental impact.

In her base case--a pneumatic system handling just 5.3 tonnes/day, which is below the tonnage volume commonly thought to be economically practical--Teerioja found that capital expenditures for pneumatic collection were 10.4 times greater than those for conventional systems, and overall costs 5.6 times greater. But when the assumed tonnage was increased to 21.2 tonnes/day--since (unlike with conventional collection) fixed costs do not increase with additional tonnage--the overall cost differential decreased to 2.6 times more than conventional collection. Teerioja also found that "Environmental Costs" (these primarily reflect GHG emissions in the form of the costs of carbon dioxide equivalents [CO2-eq]) were 2.5 times higher for pneumatic than for conventional collection.

Teerioja notes that in addition to the unquantified (and undocumented, but probable) benefits due to "social aspects" ("Whether and how much the pneumatic system could reduce the possible negative amenity effects of the prevailing system, such as congestion, noise, and odor, and whether their economic value is crucial for the analysis, are questions that are left for future research."), the economic equation might well be reversed in situations where the value of land freed up by pneumatic collection from waste use can be taken advantage of, especially in areas where land values are high. Finally, Teerioja emphasizes that her findings pertain only to retrofit installations in existing developments. For pneumatic installations in new complexes, cost differences are likely to be less for three reasons: first (as is the case in New York City, due to the recent passage of Local Law 60 of 2012, which designates the minimum amount of space that must be set aside in residential buildings for recyclable storage), because "in new residential areas, the costs of traditional waste collection increase due to modern requirements with regard to, for example, larger and more convenient waste sheds [i.e., waste rooms];" second, the cost of installation is lower in new construction; and third, "the saved space from waste collection activities can be easily put to alternative, more efficient uses."[30]

Teerioja does not mention other likely savings on the pneumatic side of the equation that could accrue from rationalization of the system design and operating conditions. For example, depending on the value of land in the neighborhood Teerioja analyzed, a subterranean terminal in one of the immediately adjacent parks (as have been installed in Stockholm, for example) could have produced both real-estate savings and capital and operating savings over the costs associated with her hypothesized more-distant terminal location. Teerioja et al. might also have included a calculation of the economic and environmental benefits that could be expected from the volume-based pricing systems which "pneumatic systems enable" and which, they note, have been shown to be "efficient in reducing MSW generation."[31]

Punkkinen examined in greater detail the carbon dioxide-equivalent (CO2-eq) emissions from the same hypothetical stationary pneumatic installation in the same central-Helsinki already-developed neighborhood that Teerioja et al. had considered. She found that these per-tonne emissions, overall, were 3.2 times higher for pneumatic collection than for conventional collection. But while the relative emissions from the collection-and-transport component were only 2.2 times higher for the pneumatic system, the emissions from the manufacture of the fixed system components were 11.2 times higher than those for the "manufacture of waste containers"--the only conventional-system equipment component considered in her comparison. Given the major influence of the manufacture of the pneumatic system's long-lived steel (and cement) components, it is a striking omission on Punkkinen's part not to have included the GHG emissions associated with the manufacture and disposal of the major (primarily steel) components of the conventional system: short-lived (say 7 years) heavy-duty compactor trucks. Nonetheless, given the magnitude of the emissions associated with the steel pipes alone, it is unlikely that the parallel inclusion of the manufacturing and disposal impacts associated with conventional collection equipment would have significantly changed the relative magnitudes of the respective impacts.[32] Another infrastructural factor not included on the

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[30] Teerioja et. al., 2012, p. 1790.
[31] Pp. 9-10.
[32] Extrapolating from data published by the National Research Council of the National Academies (*Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use*), adding the impacts of truck production and disposal to the equation might increase CO2-equivalent GHG emissions of conventional

conventional side of the equation were the costs and emissions associated with the replacement of asphalt, concrete, and steel due to the more-frequent reconstruction of roads and bridges necessitated by the additional miles traveled by heavy-duty compactor trucks.

Iriarte et al. also found higher overall costs, GHG emissions, and BTU use when a mobile-pneumatic system was compared to conventional collection. In this study, however, a significant component of the relatively high BTU and GHG figures was the relatively low loading capacity of the mobile pneumatic equipment vs. the high load capacity of conventional trucks. Increased mobile loading capacity would significantly reduce the differential between the two types of systems.

Eisted et al. also compare GHG emissions associated with pneumatic collection to those from conventional systems. They find that emissions from different systems vary greatly, depending on material densities, compaction rates, and transport distances, but that pneumatic systems may produce emissions an order of magnitude higher than those from truck-based collection.[33]

Comparative findings from these studies are summarized in Tables 1-1 and 1-2. Table 1-1 compares Kogler's Stockholm example with projected costs from two hypothetical New York City systems.[34]

Table 1-1. System Cost Including Space Savings
(Source: Kogler, 2007; Kamga, 2013)

Relative Space Costs (Annual)	Conventional	Pneumatic	**Multiplier**
Sodra Station, Stockholm, Per Apartment	€ 104	€ 18	**0.17**
High Line/Chelsea Market, Total	$378,000	$194,500	**0.51**
SAS/Second Avenue 92nd-99th Streets	$4,731,974	$81,900	**0.02**

Table 1-2. Life-Cycle GHG Emissions from Pneumatic and Conventional Systems
(Source: Punkkinen, 2012; Eisted, 2009)

CO2-eq (kg/tonne)	Manual	Pneumatic	**Ratio, P/M**
Manufacture	1.86	20.74	**11.2**
Collection + Transport	16	35.66	**2.2**
Total (Helsinki)	17.86	56.4	**3.2**
Total (Copenhagen)	7.9	47.3	**6.0**

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collection by about half, so that there would still be a disparity of nearly two to one in favor of the conventional system. Studies that have included the GHG emissions from the production of trucks and other equipment, and from the construction of roadway infrastructure, in the calculation of net GHG emissions associated with freight transport in general have found that these factors contribute between 5% and 30% to this total (M. Spielmann and R. W. Scholz, "Life cycle inventories of transport services--background data for freight transport, The EcoInvent Database," *International Journal on Life Cycle Assessment,* (2005), 10, 85-94; C. Facanha and A. Horvath, "Evaluation of life-cycle air emission factors of freight transportation," *Environmental Science & Technology*, (2007), 41, 7138-44; both cited in Rasmus Eisted, et al., "Collection, transfer and transport of waste: accounting of greenhouse gases and global warming contribution," *Waste Management & Research* (2009), 27: 738-45.)

[33] Rasmus Eisted, Anna W. Larsen and Thomas H. Christensen, "Collection, transfer and transport of waste: accounting of greenhouse gases and global warming," *Waste Management & Research*, 2009: 27: 738-745.

[34] C. Kamga, B. Miller, and J. Spertus, "A Study of the Feasibility of Pneumatic Transport of Municipal Solid Waste and Recyclables in Manhattan Using Existing Transportation Infrastructure," July, 2013. A feasibility study for the New York State Energy Research and Development
Authority prepared by the University Transportation Research Center, Region 2.

RESEARCH SETTING

Roosevelt Island, New York is a full-service community on a skinny, 2-mile-long island in the East River between Manhattan and Queens. It has a current estimated population of 13,935 residents living in 4,353 apartment units[35] and 2,000[36] hospital patients living in two hospital complexes, one of which will be closed within the next few years. The residents live in 16 high-rise apartment complexes[37] that tower on either side of the single narrow street that runs north-south along the Island's spine. Although all the residents live in towers, the population density for the Island overall is a relatively modest 95 people per acre (23,500 people/km^2; 60,900 people/mi^2) since two-thirds of the 147-acre (.59 km^2) island is reserved for open space. Forty-two shops and restaurants serve the community.[38] The Island's main employers are the long-term-care hospital and the public-benefit corporation that runs the Island for New York State, the Roosevelt Island Operating Corporation (RIOC).

Over the next 25 years the Island will see substantial increases in population and commercial activity. Planned future development includes 3 residential towers (800 units) and a 2-million-square-foot university campus for applied engineering which is scheduled to be completed in phases over the next 25 years. The first phase, adding 800,000 square feet of academic research, residential, and hotel and conference space, is expected to open in 2017. At completion, the campus will bring 2,200 residential units and 450 hotel rooms to the Island. All together the size of the community will grow by 3,000 residential units--to 7,600 in total--and the density will increase to 133 people/acre.[39] The new campus will also add 500 parking spaces, doubling the current number.[40] The Franklin D. Roosevelt Four Freedoms Park, which opened in October, 2012,[41] is expected to draw well over 150,000 visitors per year.[42]

Since 1975, when it opened, the AVAC system has been operated under a joint agreement between RIOC and the City of New York. RIOC, which owns the facility, paid the capital cost of building the plant and is responsible for paying for equipment maintenance and replacement. The New York Department of Sanitation (DSNY) operates the facility, supplying the personnel and paying for the electricity to run the

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[35] Roosevelt Island had 9,520 residents according to the 2000 census and an additional 1,705 units built since. At NYC average 2.59 people/household the additional units= 4,415 people, for a total of 13,935. 14,000 is used by several news sources: http://www.wnyc.org/articles/wnyc-news/2012/feb/16/roosevelt-island-feature/; http://www.nytimes.com/2012/05/02/realestate/commercial/roosevelt-island-to-upgrade-shopping-strip.html?pagewanted=all, last accessed 06-14-13

[36] http://www.nyc.gov/html/hhc/html/facilities/colergoldwater.shtml, accessed 06-30-12.

[37] Building count: Octagon 1, Manhattan Park 5, Westview 1, Island House 1, Rivercross 1, Roosevelt landings (Eastwood) 1, Riverwalk 6

[38] http://www.dnainfo.com/new-york/20120420/upper-east-side/new-shops-coming-roosevelt-islands-sleepy-main-street 34 on Main Street plus 8 retail spaces in Southtown. FYI: Currently more than ¼ of the 34 on Main Street are vacant. http://www.hudsoninc.com/roosevelt-island-gains-favor-as-residential-spot/#more-741, accessed 06-30-12.

[39] 7,600 units * 2.59=19,684/147 acres

[40] Scoping document: 12DME004M_Draft_Scope.pdf .http://www.nyc.gov/html/oec/html/ceqr/12dme004m.shtml, accessed 06-30-12. This calculation of parking spaces for cars traveling around the Island does not including the 1700 spaces in the Motorgate garage, at the western end of the Roosevelt Island Bridge. http://www.correctionhistory.org/rooseveltisland/html/rooseveltislandtour_garage.html, accessed 6-12. The existing 500 spaces beyond those at the end of the bridge are: Octagon, 260, www.rioc.com/pdf/octagon-section7.pdf, accessed 06-30-12, plus 250 on-street parking spaces, http://americancity.org/daily/entry/feeding-the-hungry-parking-meter, accessed 6-30-12.

[41] http://www.fdrfourfreedomspark.org/about, accessed 06--30-12.

[42] FDR Park-EAF; SEQRA Reports 2009-05-12.pdf p24. After 6 months of operation officials project far more than 150,000 visitors. The Island Voice blog, April 22, 2013. http://www.10044.com/content/view/144/, accessed 06-14-13.

system, and draying filled waste containers from the terminal off the Island to a long-haul transfer station in Queens.

Section 2
DATA COLLECTION

To develop the data necessary to devise alternative potentially practicable scenarios for managing Roosevelt Island's waste via pneumatic collection, the research team conducted an initial reconnaissance of Roosevelt Island's current waste management systems. The team collected relevant data from all available public and private sources and conducted field surveys to fill in remaining data gaps. The primary goals of the initial reconnaissance were to discover

1. how much waste is being handled by the AVAC system, at what cost, and with what impacts;
2. how much waste, of what types and from what sources, is being handled by conventional (manual-truck) means, at what cost and with what impacts; and
3. how much waste, of what types and from what sources, is projected to be associated with planned developments on the Island.

To these ends, the research team collected data from the Roosevelt Island Operating Corporation, the Department of Sanitation, the Coler Hospital, Four Freedoms Park, Cornell University, and confidential private-carting industry sources; conducted a field survey of all businesses on the Island, which included interviews as well as visual observation; conducted a field survey of all residential buildings on the Island, which included interviews with building managers and maintenance staff and tours of their buildings; conducted a ground survey of the Island to map the location of all litter bins; and used a variety of proprietary commercial databases and other resources to assemble as complete an inventory of waste volumes, types, and related impacts as was practicable.

These data were the basis for developing detailed engineering recommendations for both near-term and long-term options for improving the operation of the AVAC system. The team assessed the costs and environmental impacts of three improvement scenarios in order to provide RIOC with a firm basis for making decisions that could reduce costs, provide environmental benefits, and improve the quality of life not only on the Island but beyond its shores.

The field-data component included:

1. a survey of businesses
2. mapping and photographing all litter bins
3. observational visits to all residential buildings and interviews with staff
4. a survey and assessment of residents' operational preferences
5. an observational tour of RIOC's waste collection on streets and in parks
6. an engineering survey to assess the current state of the existing AVAC system

A detailed description of each of these components is presented in Appendix A, along with the survey instruments and raw data.

All engineering and operational data for the pneumatic alternatives were provided by Envac, A.B., the firm that built the original Roosevelt Island system. It has since installed hundreds of other pneumatic waste-collection facilities, primarily in Europe and Asia.

Section 3
FINDINGS

WASTE SOURCES

Current Sources

AVAC currently handles only trash from residential buildings: 5.8 tons per day (tpd).[43] These other materials could potentially be managed by an upgraded system:

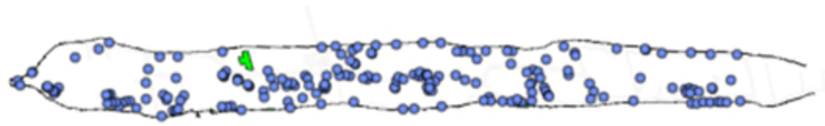
- Residential recyclables: 2.62 tpd (1.59 tpd cardboard/paper; 1.03 tpd metal/glass/plastic).

Figure 3-1. Recyclables Next to an AVAC Inlet on Roosevelt Island
(Source: Douglass, 2011)

- Hospital waste (non-hazardous): 11.89 tpd (8.57 tpd refuse; 3.32 tpd recyclables)
- Business waste: 4.7 tpd (2.8 tpd refuse; 1.2 tpd compostables; 0.7 tpd recyclables)
- RIOC facilities: 0.1 tpd (refuse and recyclables combined)
- Street and park litter bins: 0.2 tpd (0.1 tpd refuse; 0.09 tpd recyclables)

Figure 3-2. Photo and Geographic Documentation of Litter Bins on Roosevelt Island
(Source: Ross, 2011)

[43] Note that throughout this document, "per day" means for each of the 365 days a year—not "per weekday" or "per working day."



There are 172 litter bins on the Island, of 21 different kinds.

In total, 19.51 additional tons currently generated on the Island could be accessible to an upgraded system.

In addition, 1.6 tpd of residential compost, which is currently handled by AVAC, could be managed as a separate fraction if the upgraded system had separate inlets for organics.[44]

<u>Future Sources</u>

Planned additions to the Island include three apartment towers with 795 residential units and ground-level retail, which are being developed by the Hudson Companies in its Southtown complex; a 2-million-square-foot campus complex that is being developed by Cornell and Technion Universities; and the FDR Four Freedoms Park, which is being developed by a non-profit corporation.

- Future Southtown buildings: 2.14 tpd (1.53 tpd refuse; 0.61 tpd recyclables)
- Cornell/Technion campus: 8.3 tpd[45]
- Four Freedoms Park: 0.2 tpd

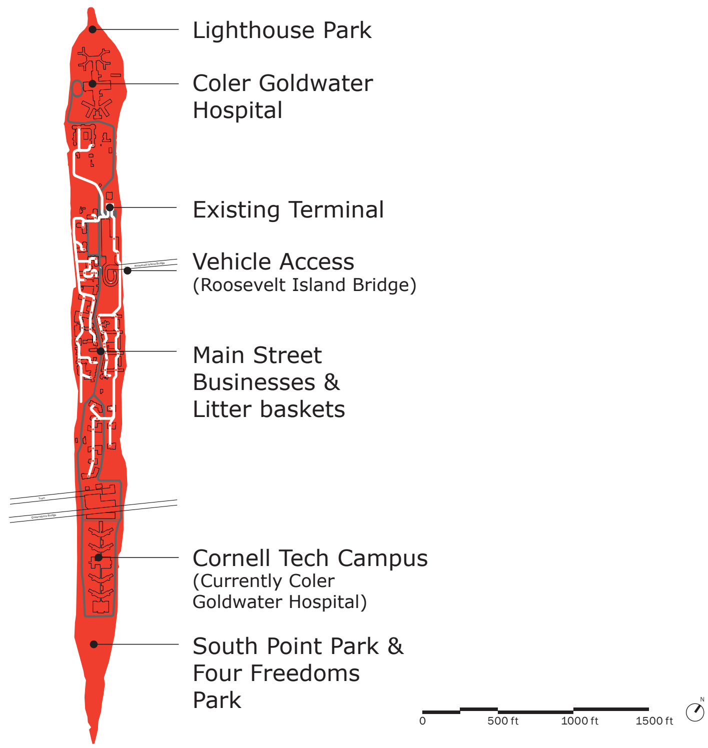
With all the current and future sources combined, 35.95 tpd could potentially be handled pneumatically (25.31 tpd current; 10.64 tpd future).

Figure 3-3. Future Waste Sources: Four Freedoms Park; Southtown: Riverwalk; Cornell-Technion

(Source: FDR Four Freedoms Park, 2011; Riverwalk, 2010; SOM, 2011)

[44] See Appendix A for details on all data presented in Section 2.
[45] Cornell NYC Tech, Draft Environmental Impact Statement, Chapter 12, Solid Waste, October, 2012, http://www.nycedc.com/sites/default/files/filemanager/Projects/Applied_Sciences_NYC/DEIS_PDFs/12DME004M_DEIS_12_Solid_Waste.pdf, accessed 6-11-13.

Figure 3-4. Locations of Potentially Accessible Additional Waste
(Source: Spertus, 2013; Map: Project Projects, 2010)



ENVIRONMENTAL AND MANAGEMENT IMPACTS OF CURRENT WASTE HANDLING[46]

Impacts of Waste Not Handled by AVAC[47]

The current system for managing those wastes that are not collected by AVAC involves the same basic method used since the beginning of the 20th century: manual staging and loading of waste into motorized, gasoline- or diesel-burning vehicles for transport to a transfer or disposal site.

Current manual-and-truck collection produces a range of adverse economic and environmental impacts, in addition to negative quality-of-life and public-health impacts. These include GHG emissions, fuel use, and labor and space costs.

- GHG emissions: 0.3 tpd

- Fuel use: 27 gal/day

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[46] Impacts of current waste handling are in 2011 dollars unless otherwise noted. Projected impacts in Section 4 are inflated to 2013 dollars.
[47] Waste from Coler Hospital is included in the inventory of impacts from current manual waste handling listed below, but is not included in the scenarios presented later in the report because the study team assumed that it would be treated separately. (Waste from the Goldwater campus is not included anywhere because it will be closed soon).

Figure 3-5. Current On-Island Transport of Recyclables
(Source: Douglass, 2011)

- Labor time expended by building management company, business and RIOC employees: 71+ hours/day (as reported by individuals surveyed: residential, 53 hrs/day; commercial, 9; litter bins/parks, 8; RIOC facilities, 1)). Time expended by residents sorting or carrying materials from their apartments to their hallway waste closets is not included in this tabulation. Nor is time spent by DSNY personnel to operate the facility and to haul containers from the terminal (these labor costs are identified separately below). Nor are private-carter labor hours included here (fees paid to private carter by Island commercial and institutional waste generators are listed below). (See Appendix Table B-6 for projected labor savings under the various pneumatic alternatives considered.)

- Minimum recoverable space used for non-AVAC waste-handling (includes only space currently required for exterior waste container storage and access): 2,641 sf. (Note: spaces such as waste rooms on each floor and waste-staging areas may not be necessary in newly constructed buildings, but it is not assumed that this space could be recovered for other use in existing buildings. See Appendix Table B-6 for projected space savings.)

Figure 3-6. Recoverable Space Currently Used For Waste Management
(Source: Ross, Douglass, 2011)

- Equipment costs for non-AVAC waste handling: $313,050 (litter bins, carts, motorized vehicles and containers used by surveyed management company, business and RIOC employees; does not include cleaning products and bags, or equipment used by businesses and hospitals, which is provided by private carting companies. See Table B-6 for projected equipment costs.)

- Private carting fees for commercial waste (estimated): $800/day ($300,000/yr) (commercial waste charges, $150/day, $50,000/yr; hospital charges [Coler only], $600/day; off-Island residential recycling, $30 [one management company sends recyclables off the Island; all others bring them to a DSNY container at the AVAC facility yard])

- Truck trips: 7 (commercial carter) compactor truck trips/day onto and off of the Island (6 trips for business waste and 1 trip for hospital waste).

Impacts of Waste That Is Handled by AVAC

- GHG emissions:
    - For off-Island transport: 0.07 tpd (by DSNY roll-on/roll-off [Ro-Ro] trucks, including RIOC refuse, to transfer station)
    - For electricity: 0.92 tpd

- Fuel use: 6.6 gpd

- Electricity use: 2,674kwh/day (976,000 kwh/yr); $1351.24/day ($493,204/yr)

- Labor:

    - Hours: 41 hours/day (40 hrs/day AVAC;   0.79 hrs/day DSNY Ro-Ro pick-ups [of AVACed and RIOC refuse only] for off-Island transport)

    - Cost: $6,298/day ($2,229,036/yr[48])

Figure 3-7. DSNY Stationary Engineers Turn on Exhaust Fans and Open Diverter Valves From Terminal Control Room

(Source: Milford, 2010)

- Maintenance costs: $216.30/day ($78,950/yr)[49]
- Equipment replacement: $890.41/day ($325,000/yr)[50]
- Truck trips (round trip): 3 (DSNY) Ro-Ro trips, 3 days a week (1 trip/day)

[48] One senior stationary engineer; 3 stationary engineers; 1 HPPT; 1 oiler; 2 machinists; 0.1 MWM/Electrician, plus 35 Ro-Ro collection shifts per year (for refuse).
[49] DSNY: $12,000/yr; RIOC: $66,950/yr. Maintenance costs do not include RIOC costs for equipment replacement.
[50] Average annual costs for AVAC building maintenance, pipe and facility equipment replacement. See Appendix Table B-08.

<u>Quality-of-Life Impacts Due to Manual Handling of Waste That Does Not Enter the AVAC System</u>

- Truck traffic:

Among the adverse public-health, environmental, economic, and quality-of-life impacts caused by heavy trucks are particulate and gaseous emissions, noise, accidents, congestion, and pavement wear.

- Rats:

"The addition of more restaurants and outdoor eating options in the Southtown Riverwalk area is a welcome amenity for Roosevelt Island but it has also resulted in a notable increase in rats brazenly scampering all over the place particularly on the lawn in front of Starbucks, near the new fruit stand and elsewhere. While sitting at the Starbucks outdoor patio recently, I noticed out of the corner of my eye what I thought (hoped?) was one of the black squirrels scampering nearby but soon realized it was a huge rat. Very, very disgusting!"
--Roosevelt Islander, Wednesday, October 1, 2008

- Odors (and Rats):

"Even bigger GARBAGE SHED is placed next to […] store. The stench is unbearable, garbage stored forever, vermin love it !! The resident cat takes care of vermin inside the store, they have to go somewhere - it's RAT PARTY TIME on RI. It's AMAZING that we supposedly went to the MOON, but, on RI ALL is a big problem, rats rule!"
--Anonymous comment, Roosevelt Islander blog[51]

- Visual aesthetics (see also figure 3-6):

Figure 3-8. Current Waste Staging
(Ross, Douglass, 2011)

[51] http://rooseveltislander.blogspot.com/2008/10/roosevelt-island-rats-infesting.html, accessed 10-6-11.

OPERATIONAL PREFERENCES ASSESSMENT

With regard to system-design and operations, there are three major issues associated with how an upgraded system for discarded residential materials might be managed.

The first, and most significant, is whether residents would directly insert their recyclable materials into the proposed new exterior inlets—which would require residents (some of whom are elderly and/or disabled)[52] to carry their discarded materials via elevator or stairway to the outside and insert their discards (which might include potentially embarrassing or distasteful materials such as liquor bottles or food wastes) into inlets in public view—or whether building maintenance staff would perform this function as they currently do (by removing these materials from the "AVAC"/utility rooms on each floor). There are strong grounds for recommending that residents manage these materials directly, as is done in most places in the world where there are outdoor recycling receptacles of various kinds. The advantages of having residents manage discarded materials directly include significant labor savings as well as increased diversion of materials from the refuse stream due to increased awareness of recycling. Our initial contacts with management personnel, building staff, and building residents, however, suggested that Islanders, as well as building managers, had a strong preference for allowing building residents to continue to deposit their recyclables in the hallway closets for building staff to remove. Since the effectiveness of a recycling program depends in part on the population's willingness to participate in it—and because outdoor recycling systems are not something to which US citizens are generally accustomed—the study team thought it important to assess the views of both building managers/support staff and residents on this issue.

A related question, the answer to which depends in part on the answer to the first question, is whether the new exterior inlets should be placed near the front doors or the rear doors of the residential buildings. Placing the inlets as near as practicable to building entrances is considered important for minimizing the inconvenience associated with inclement weather. If they were in front, they would be conveniently placed for residents carrying discarded materials out of their buildings on their way to work, errands, or other purposes. If they were in the rear, residents might have to make a special trip to access them, but the composition and quantities of their recyclables would not be as publicly visible. If porters were to handle these materials, our expectation was that most parties would prefer rear-door inlets. On the other hand, if residents were to handle these materials, we expected that most residents would prefer front-door locations, for reasons of convenience. Although residents also expressed concern that their neighbors would not use inlets properly, leaving bottles and paper on the ground around them, and thus creating an eyesore near the public entrances, highly visible front-door locations may in themselves encourage proper use.

The final question is whether there should be two additional inlets (one for each of the two streams legally required to be separated: paper; metal/glass/plastic) or whether there should also be a third new inlet (for kitchen wastes and other compostable organics). If porters are responsible for inserting recyclables—so that the two dry recyclable streams, metal/glass/plastic and paper, can be inserted at different specified times—only one additional inlet could be installed for these two fractions. This would produce a modest savings in initial capital costs, but this savings would be outweighed in the long-run by increased operating costs. However, if extra tee-joints are installed, at a relatively small incremental cost, when the system is first built, additional inlets for additional fractions could be added at some future point without incurring a significant cost penalty.

If porters rather than residents are responsible for inserting materials into the new inlets, designating source-separated food waste as a fourth fraction could be problematic from an operational perspective, since it would involve frequent manual collection, transport, and bin-cleaning, and could increase the potential for nuisances.

[52] European citizens typically are required to carry their own discarded materials to street-level receptacles. In Wembley City, England, where an auto-pneumatic tube system has been in operation for several years, caretaking staff handle waste only for elderly or disabled residents who are designated as needing "assisted collection." (Julian Gaylor, Managing Director, Envac UK Ltd. to Jonas Tornblom, Director, Corporate Marketing & Information, Envac AB, 1-26-12.)

The finding from the qualitative research reported above was that both Island residents and building managers and staff share a strong preference for a porter-managed recycling system. This would suggest that new exterior inlets for recyclable fractions--insofar as would be consistent with the objective of minimizing capital and operational costs by locating the inlets at an appropriate grade near existing trunk lines--might best be located in places most convenient for the building staff in relation to their other operational responsibilities (provided, of course, that these locations do not interfere with building or landscape features or with flows of people or materials). Such locations are likely to be at the rear of buildings, near existing vehicle-storage and -loading areas. This preference for porter-managed inlets also suggests that a third new exterior inlet for food waste and other compostable organics is unlikely to be installed, at least at the present time.

It should be noted, however, that there are no engineering, construction, or operational constraints that would require that this decision on how the inlets are operated (i.e., by residents or porters) be made on an Island-wide basis. One building complex may choose to operate one way and another the other. Likewise, there is no engineering or operational reason why operating patterns could not change over time, so that a building complex might begin with porter-operation and then shift at some future point to resident-operation. Finally, a decision to install a fourth inlet for source-separated food waste and organics could also be made at a later time, since there would not be a significant cost-penalty associated with such a later retrofit, provided that relatively low-cost modifications are installed at the outset. Note also that there would be significant operational savings (in labor costs to waste-generators/building managers) if residents managed their recyclables directly, rather than relying on building staff to handle them.

(See "Qualitative Assessment of Operational Preferences" in Appendix A-4 for further details.)

ON-SITE ENGINEERING ASSESSMENT

Envac's on-site engineering inspection found air leaks in several of the buildings' diverter valves (the valves that connect the gravity-fed trash chutes to the pneumatic trunk line). Those valves will need to be replaced in order to achieve maximum energy efficiency. The remaining valves are in satisfactory condition and can continue to be used in an upgraded system.

The most significant finding was that the final section of the eastern trunk pipe—the 800-meter section along the east side of the Island leading into the terminal—is severely eroded. This section of pipe will need to be replaced. Replacing it in its present position, since part of this section runs below buildings, would be difficult. From an engineering/construction standpoint, as well as from the standpoint of accessing the pipe for future maintenance and repair, a new alignment within a permanent right of way such as along Main Street or along the steam line on the eastern shore might be preferable to the existing alignment. (A new alignment along Main Street would also offer other operational advantages, as discussed below.) Other sections of pipe can continue to be used, with local repairs as required.

COSTS OF THE NO-AVAC OPTION

In order to assess the costs and benefits of the full range of potentially practicable alternatives, we needed to consider, in addition to the various AVAC-upgrade scenarios and the "No-Action alternative" (i.e., continuing to operate and maintain the current AVAC facility in the same way that it has been managed to date but with the increased refuse volume from the planned build-out of the remaining Southtown residential towers)--the all-truck (i.e., No-AVAC) alternative.

The current AVAC system, which has been operating continuously since it opened in 1975, was designed and built in the pre-digital era, when generators, fans, and other equipment were much less energy-efficient than they now are and before current electronic technology increased the ability to automate system monitoring and operation. Furthermore, after 38 years of continuous use, much of the equipment—notably the steel trunk pipes—is either at or near the end of its useful life. As a result, not only are labor and electricity costs much higher than they would be in a newly-built facility using contemporary technology, but maintenance costs to replace worn-out parts have escalated dramatically in recent years. But comparing only the costs of an upgraded-AVAC option to the No-Action alternative does not represent the universe of alternatives that a real-world decision-maker would face. This real-world set of alternatives would also include the option of shutting down the current AVAC system and replacing it with the kind of conventional manual-and-truck collection used everywhere else in the City.

Calculating the actual, complete cost of collection (including the appropriate share of the NYC Department of Sanitation's administrative costs, fully loaded labor costs, facility costs, etc.) is notoriously difficult. This is particularly true with regard to apportioning these costs to the various source-separated streams that the Department collects (i.e., metal/glass/plastic; paper; refuse), since these various streams vary in volume and density, and hence in collection efficiency.

In the AVAC case, there would be much less variation in collection efficiency between the different waste fractions, since all fractions would be collected through the same trunk tube and since the frequency of valve openings and the electricity consumed by the suction fans would vary based on the volumes and densities of the materials involved. Therefore, rather than assigning a separate value to the cost of collecting each fraction, one per-ton value is used across-the-board for all AVAC-collected materials.

We believe that the best data source developed to date for determining the full costs for DSNY's collections is a study produced for the Natural Resources Defense Council (NRDC) by DSM Environmental, in cooperation with DSNY, in May, 2008, using data for FY 2005.[53] Inflating 2005 dollars to 2013 dollars, our analysis shows a weighted cost of collection for Roosevelt Island, based on its proportions of refuse and recyclables, of $230/ton (including debt service for trucks and garages). (Details of this cost analysis are presented in Appendix B.)

[53] Analysis of New York City Department of Sanitation Curbside Recycling and Refuse Costs, http://docs.nrdc.org/cities/files/cit_08052801A.pdf, last accessed 7-27-12.

Section 4
ALTERNATIVE SCENARIO DEVELOPMENT AND ANALYSIS

DESIGN CONSIDERATIONS

These design considerations guided the development of the universe of alternative design scenarios to be considered:

1. Waste sources

a. Hospital waste. Based on an analysis of the data outlined above, we made an initial decision to exclude hospital waste from plans for an Island-wide system. A single trunk line (and its associated terminal equipment) can handle a maximum of about 18-20 tons a day. Since the hospital by itself generates some 12 tons a day, which would be enough to meet the economies of scale for a typical facility, hospital waste is not included in the Island-wide analysis. A decision to develop its own terminal for its own use would be made by the hospital itself. We would recommend that the hospital consider the costs and benefits of developing its own, separate, pneumatic waste-management system, which could be tailored to its own specific needs for regulated and unregulated medical waste.

b. Litter bins. All other potential waste sources were considered in the next iteration of scenario-development. Litter bins that are some distance from the major buildings along Main Street would be the most expensive waste source to include in the system, on a per-ton capital and operating cost basis (due to the length of pipe that would need to be installed, the number of inlets, and the relatively small volumes of waste). One alternative we considered was using a mobile pneumatic system to collect bins in the parks at the southern and northern extremities of the Island. The costs of such a system, since it would require two specially-equipped collection trucks (in order to provide redundancy in the event of a break-down), were still disproportionately high. We therefore decided to exclude bins at any significant distance from the central Main Street area from our scenario alternatives. Bins in the park at the north end of the Island could more efficiently be linked to a separate system that the hospital might establish. Bins in the park at the south end of the Island could be more efficiently connected to a separate Cornell-Technion campus system.

c. Commercial waste. Provided that institutional agreements could be reached to include commercial waste in the pneumatic system, commercial waste collection would be practicable--combining commercial inlets with pedestrian litter bins on central Main Street--since mechanisms for metering commercial waste for billing purposes could be installed and since the new pipe for the abraded section requiring replacement could be aligned along Main Street.

2. Number/location of terminals

The projected volumes from the remaining waste sources (current and future, including waste from the planned Cornell campus) dictate the need for at least two separate terminals. A “terminal” is defined as one trunk line plus associated operating equipment, i.e., at least one cyclone-separator and air filter, at least one compactor/container configuration, and at least one generator/fan set. Although a single terminal has only one trunk line, it may have more than one set of ancillary equipment, depending on the number of waste fractions collected. The question then becomes whether the two terminals should be co-located within the footprint of the current AVAC facility, which offers significantly more space than would be required for two terminals, or whether one terminal should be located at the site of the current terminal, to handle waste from the northern part of the Island (the section currently served by AVAC), and a second terminal located at the southern end of the Island, to handle waste from the planned Cornell campus.

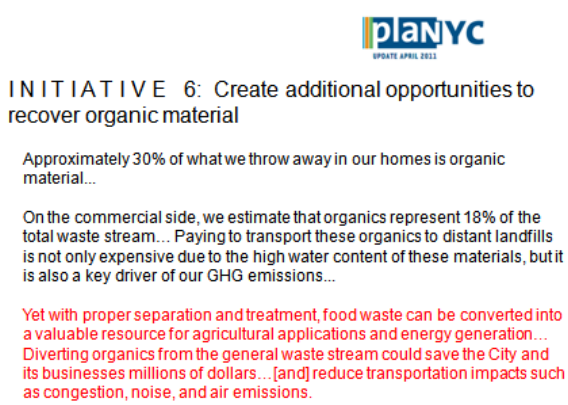
While it would be theoretically possible to draw waste to the northern terminal, through one tube, from all of the new buildings planned at the southern end of the Island (the practical distance for transporting waste pneumatically is just over one mile), pulling this volume of waste that far would impose significant economic penalties. Energy demands for transporting waste this distance would be higher. And wear on the final sections of the steel pipe, through which all waste to the terminal passes, would be greater. (This extreme wear on the final section of pipe is demonstrated by the relatively severe abrasion of the final 800 meters of the existing trunk line.)

It would therefore be preferable to locate a terminal in the south, to serve the campus, in addition to a terminal in the north, to serve all the residential buildings on the Island. This arrangement would have the additional advantages of allowing different fractions to be handled in the respective terminals, and of providing greater flexibility in the planning and construction schedule for the Cornell facility. A disadvantage would be the fact that containers from the southern terminal—to the extent that off-Island disposal would be required, as it is in the current system—would have to be transported to the northern terminal (for removal by truck along with the containers from that terminal).

3. Waste fractions

Given the incremental capital and operating costs associated with each additional waste-stream fraction--each of which requires separate inlets, equipment trains, and separate time-separated transport through the central trunk line, thus requiring additional energy plus constraining the capacity of the line--a balance must be achieved between, on the one hand, the economic and environmental benefits realized by including additional waste fractions, and on the other, the incremental costs of building and operating a larger system. Four fractions is considered the practicable limit. A one-fraction system—for refuse only—would simply replicate the current system, without eliminating separate truck trips for the two additional fractions that NYC requires to be collected separately from refuse: metal/glass/plastic and paper. A three-fraction system, then, would be the minimum required to eliminate trucks for non-bulk waste. In order to introduce bulky cardboard (OCC), it must be cut to size by hand or shredded and densified into appropriately sized cubes by a specialized “bricking” machine. Since we are assuming that all paper, including OCC, will be transported via the AVAC system, we are assuming that building owners will install this bricking equipment on their properties. A fourth inlet, for food waste and other compostable organics, would meet the objectives of PlaNYC (see Figure 4-1) by allowing the separate collection of an organics stream suitable for processing, either on the Island or at some nearby location--thus avoiding the need for disposal in a remote landfill. Given the need for frequent collection of putrescible food wastes (which is particularly acute during the summer months), and the adverse economic and environmental impacts of an additional separate collection, collection of source-separated organics from high-density residential areas by truck would pose substantial economic and environmental costs. Pneumatic collection would provide a practicable solution for source-separated compostable organics from a densely populated neighborhood.

Figure 4-1. New York City’s Policy Commitment to Source-Separate Organics
(Source: New York City Mayor’s Office of Long-Term Planning and Sustainability, 2012)[54]


planYC

INITIATIVE 6: Create additional opportunities to recover organic material

Approximately 30% of what we throw away in our homes is organic material...

On the commercial side, we estimate that organics represent 18% of the total waste stream... Paying to transport these organics to distant landfills is not only expensive due to the high water content of these materials, but it is also a key driver of our GHG emissions...

Yet with proper separation and treatment, food waste can be converted into a valuable resource for agricultural applications and energy generation... Diverting organics from the general waste stream could save the City and its businesses millions of dollars... [and] reduce transportation impacts such as congestion, noise, and air emissions.

[54] http://nytelecom.vo.llnwd.net/o15/agencies/planyc2030/pdf/planyc_2011_solid_waste.pdf, p. 140, last accessed 01-22-13.

4. Single-fraction or multi-fraction inlets

A single inlet could be used for two or more fractions if only one fraction were inserted during a particular time interval and this fraction were pneumatically pulled into the terminal prior to the time interval specified for the next fraction. Such a system would not be practicable for use by a general residential or pedestrian population, since the inconvenience entailed would be expected to significantly reduce compliance with source-separation recycling mandates, decreasing the volumes source-separated from non-recyclable refuse and/or increasing cross-contamination rates between the specified fractions.

However, if all material was inserted into the inlets by building porters, residents would deposit their source-separated materials in a staging area (as they now do) at any time, where the separation between materials would be maintained, and porters would schedule their tasks so that one fraction would be removed from the staging area during one specified time window and the other at another. Thus a porter-mediated system—the preference indicated by virtually all survey respondents—would allow the capital-cost savings associated with a multi-fraction inlet. If separate cyclones and compactor lines were installed for each of the two fractions, the incremental capital cost savings[55] associated with multi-fraction inlets would be relatively modest (and offset in the long run by increased operating costs).

5. Metering

Because commercial establishments are required to pay for waste disposal on a unit basis (by unit of volume or weight), through a contractual arrangement with a private carter (according to current regulations) introducing commercial waste into the pneumatic system would require a metering mechanism so that individual businesses could be billed based on the volume or weight of the specific waste fractions that they introduced.

Such systems are now in common use in European installations. Businesses are issued plastic key-cards with unique identifiers that enable them to open the large-sized openings on outdoor inlets. The volume is measured by sensor and automatically generated bills are then sent monthly. (Smaller openings on each inlet, which do not require key-cards, are accessible to any passing pedestrian.)

This metering system could also be used to measure residential waste-fraction inputs, ideally at the household level. Rather than measuring input volume, the simplest systems for measuring residential waste track the number of times each resident opens the inlet and charges per use according to the average input volume. Since unit-based waste charges (with lesser or no charges for recyclable fractions) have been widely demonstrated to reduce waste generation (in the US, by an average of 16%),[56] it would be desirable to install this equipment in inlets for residential buildings as well, so that a Save-As-You-Throw[57] system could be implemented in the near-future. Alternatively, the installation could be designed in such a way that meters could readily be added at a later point.

The fees collected through metering, both for residential and for commercial generators, would not represent new charges to them. Rather, for residential generators, the concept is that other charges that they currently pay would be reduced by roughly the amount that is currently spent on managing the waste they generate. That is, since New York City's current waste-management budget, well over $1 billion/year,

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[55] The incremental opex for the system operators (RIOC, DSNY) would be modest. The additional labor costs for building managers/residents, however, could be significant.

[56] This US average includes a 6% reduction in yard waste, which, in general, would not be applicable in New York City. As shown in Appendix B, our calculation, applying national reduction percentages to RI's waste proportions produces an expected reduction in RI's case of about 12%.

[57] Unit-based pricing schemes are often called "Pay-As-You-Throw" systems. But since conscientious households could reduce their current costs by switching to a system that allowed them to pay less if they discarded less refuse and increased their recycling rates, "Save-As-You-Throw," some have suggested, provides a more accurate indication of the system's effects.

represents about 20% of the city's residential property tax receipts,[58] Roosevelt Island's apartment-renters could expect to receive a reduction in their rental fees equivalent to the property-tax (or other) reductions (or rebates) provided to the Island's building owners in exchange for their participation in what could be the City's first Save-As-You-Throw metering program. If, as expected, the Island's refuse-generation-rate decreased in response to this economic incentive, there would be a win-win situation, with the City experiencing reduced disposal costs and the residents experiencing reduced disposal fees. Commercial generators already pay for waste collection on a unit basis. Under a metering system, these charges would not be expected to change significantly and would remain, per current NYC regulations, below the rate-cap established by the City's Business Integrity Commission.[59]

CONCEPTUAL ENGINEERING DESIGNS, RIOC NETWORK

General Considerations. Certain general design principles were assumed for any of the alternative scenarios considered.

Terminal. A new terminal facility was assumed for all scenarios. The current terminal building occupies 17,760 sf and the truck access and bulk and recyclables material staging area occupies 24,218 sf, for a total occupied area of 41,978 sf.[60] The new terminal building will require between 3,000 and 10,000 sf, depending on the complexity of the system, while the truck-maneuvering and bulk-staging area will require about 12,120 sf. Thus approximately 20,000 sf (half an acre) could be available for new use if the existing building were demolished or repurposed (rather than simply putting the new equipment inside the existing building) and a new terminal building, in which recyclables were handled pneumatically, were constructed. If recyclables continued to be handled manually, approximately the same amount of space would be available for re-purposing, since the additional outdoor area required for staging these materials would be roughly offset by the decreased space required for the terminal building.

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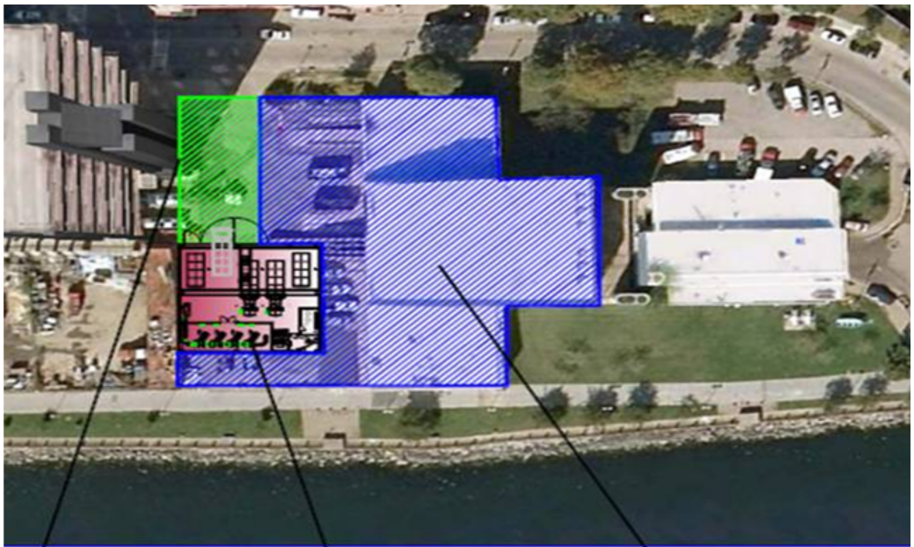
[58] The City's waste-management budget is taken from the City's general fund, to which property tax is simply one of the revenue sources.

[59] Questions about whether fees for commercial generators would be collected by the City, as the AVAC system operator, or by private carters, as at present, would be resolved during final system design, along with related questions related to private carters' participation in the system and their continued role, if any, in off-Island transport and disposal. Given the potential operating savings (assuming that capital costs are primarily absorbed by the AVAC system owner [RIOC], perhaps with grant or other assistance from other government agencies), the division of private-carter and public roles and revenues could also be structured in a win-win fashion.

[60] Envac, "Draft Counter Proposal for the AVAC Facility, Roosevelt Island-RIOC," 06-11-10.

Figure 4-2. New Terminal Floor Plan Superposed Over Existing Facility (Shaded)
(Source: Envac, 2011)



Inlets. Retrofitting existing buildings to install additional inlets for recyclable materials would be physically and economically impracticable. Therefore new inlets to accommodate additional fractions would have to be installed on the exterior of the residential towers, as is the norm in most European and Asian pneumatic installations.

The new inlets for residential recyclables would be installed as close as practicable to the apartment buildings' service entrances, with the exact locations to be determined by specific local conditions (e.g., depth to trunk line, grade, obstructions due to built structures or landscaping features, pedestrian and/or vehicular flows).

Figure 4-3. Illustrative Residential Inlet Location Plan Indicating Relationship to Building and Main Trunk Line
(Source: Envac, 2010)

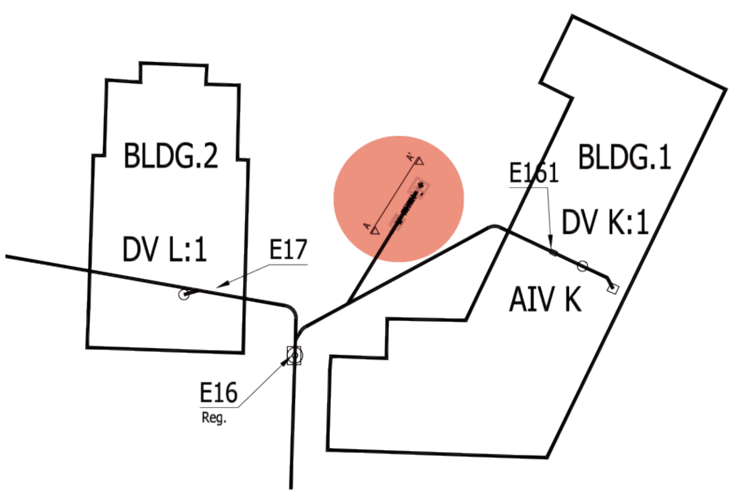
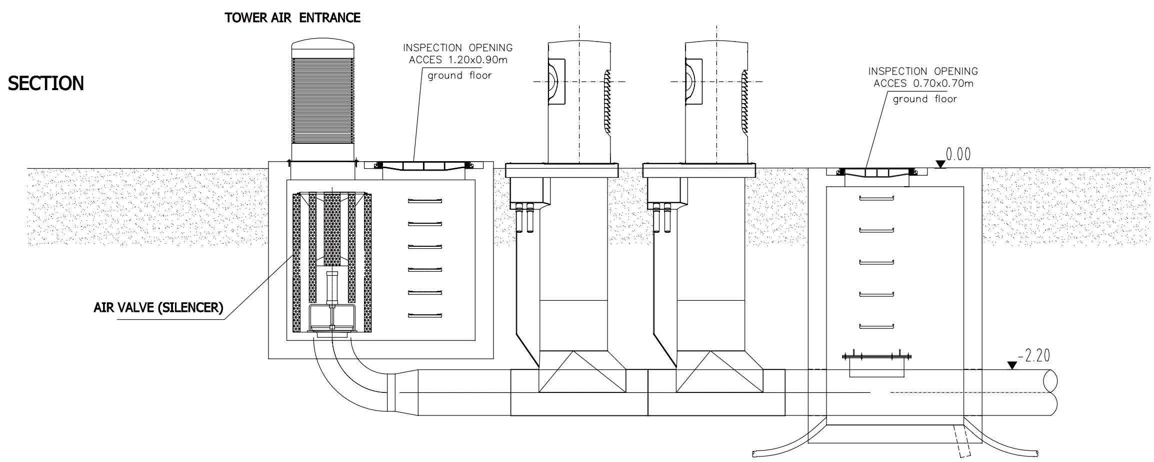


Figure 4-4. Typical Section View: Residential Inlets
(Source: Envac, 2010)



Inlets for commercial waste would be installed somewhere between the building faces and the curb line on either side of Main Street, at intervals of approximately 30 meters, staggered on either side of the street (i.e., with 30 meters between inlets on one side of the street, but about 15 meters between inlets on opposite sides of the street). These inlets would also serve as receptacles for pedestrian litter, thus eliminating the need for the conventional litter bins currently used on the street. There would be separate inlets for as many fractions as were managed in the rest of the network, with separate smaller, non-metered openings for pedestrian waste and larger, metered openings for commercial waste, so that volume-based bills could be automatically generated and sent to individual businesses each month.

These sidewalk inlets could serve multiple functions in addition to collecting commercial and pedestrian discards. They could also be used for signage, lighting, and various kiosk-like applications. Their design should be consistent with other street furniture along Main Street.

Alternative Scenarios. Through an iterative process, multiple alternative scenarios were considered. These included scenarios with one Island-wide system--including the Cornell campus--and one set of co-located terminal facilities located near the north end of the Island at the site of the current terminal, and scenarios with two separate terminals for the RIOC and Cornell portions of the Island. For the reasons outlined above, we early-on eliminated the single-network option in favor of a dual-network system (with a separate system to handle the hospital should the hospital decide to move to pneumatic collection).

We also considered the possibility of one, two, or three fractions for the RIOC-only network. For the reasons outlined above, we had previously determined that adding a fourth/organic fraction at this time would be impracticable. It might well be desirable, however, when the new inlets for the two recyclable fractions are installed, to include tee-joint connections to allow for the future installation of a fourth fraction at minimal incremental cost.

A pneumatic system that included commercial waste was the final option considered. As noted above, the new commercial inlets along Main Street would double as pedestrian litter baskets.

These alternative scenarios are presented below. Note that these alternatives could also be considered as a sequential plan for implementation. That is, RIOC could decide to start with the simplest case (Refuse-Only) and add additional fractions for recyclables later. In this simplest case, the system would begin by collecting only refuse from residents and RIOC facilities, and add refuse from commercial generators and litter bins at a later point.

Figure 4-5. Comparison of Scenarios Considered Based on Waste Fractions and Sources Handled

Scenario	Residences	Main Street Businesses	Cornell Tech Campus
Current	●		
Upgrade Only	●		
Upgrade + Recyclables	●●●○		
U + R + Commercial	●●●○	●●●○	
Cornell Tech Campus			●●●●

- ● Refuse
- ● Metal Glass Plastic (MGP)
- ● Paper
- ● Organics
- ○ Potential to add organics

Figure 4-6. Upgrade, Refuse Only

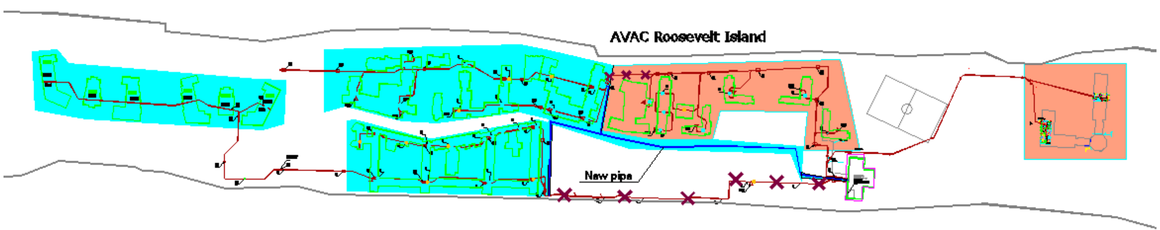


Figure 4-7. Upgrade + Recycling (New Pipe extends length of Main Street)

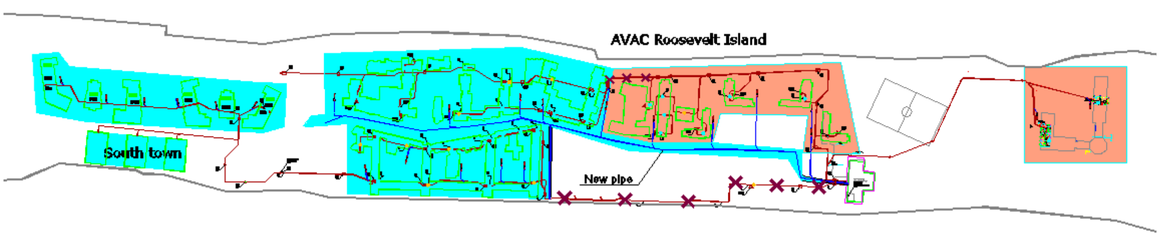
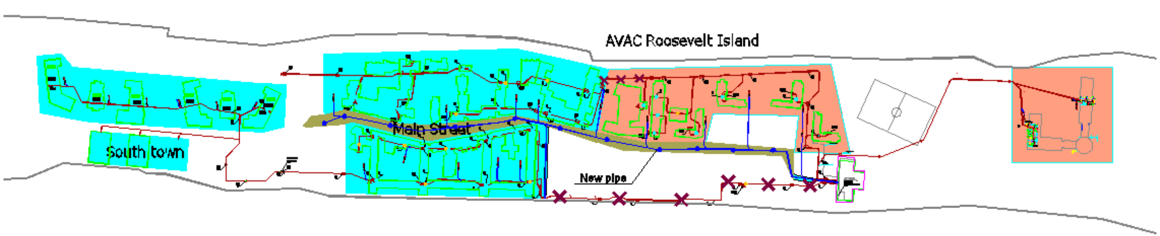


Figure 4-8. Upgrade + Recycling + Commercial + Main Street Litter Bins



COST, ENERGY USE, AND GREENHOUSE GAS EMISSIONS[61]

In comparing the costs and environmental impacts of the alternative scenarios, we used two benchmarks. The first is the "No-Action" alternative: continuing to operate the current system, assuming actual 2011 per-ton costs,[62] but increasing the number of refuse tons to reflect the projected contribution from the three planned Southtown towers. In the No-Action alternative, recyclables would continue to be managed manually, as at present, and there would be no change in current commercial-waste or litter-bin collections. The second benchmark is the "Manual" alternative, which represents the hypothetical situation in which the current AVAC facility would be closed and no new terminal built. The assumption for this benchmark is that DSNY rear-loader trucks would collect both refuse (which is currently handled by AVAC) and recyclables from the curb (since this service is offered everywhere else in the city). Commercial waste would continue to be collected by private carters and RIOC would continue to collect litter-bin waste in its small compactor truck.

Capital and operating costs for the upgrade alternatives were developed by Envac. Detailed cost assumptions are presented in Appendix B. The staffing levels specified by Envac were matched to actual DSNY labor rates for the labor titles required, including fringe and overhead.[63] Electricity costs for upgrade scenarios were calculated by multiplying the projected kilowatts and kilowatt hours for the upgrade scenarios by the actual rate paid by DSNY in 2011 (total payments/total kilowatt hours).[64][65]

In Table 4-1, different numbers of tons are assumed for each pneumatic-system alternative: The No-Action alternative shows the number of tons currently handled by the AVAC (refuse-only) system, plus the refuse(-only) tonnages projected from the three not-yet-built Southtown apartment towers. The Upgrade + Recycling pneumatic scenario includes those current and projected tons, plus current and projected recyclables. The Upgrade + Recycling + Commercial + Litter Bin scenario would handle all discards currently generated or projected to be generated on the Island, other than those for the planned Cornell-Technion campus and those generated by the hospital.[66] Details on how these figures were derived are provided in the spreadsheets in Appendix B. In Table 4-2, the per-ton operating costs of each of these alternatives--both with and without debt service--are compared to those for conventional manual collection. Direct per-ton operating costs, including the container dray from the AVAC terminal to the transfer station, when debt service for initial capital expenses is not included, are less expensive for all pneumatic alternatives than are the ongoing costs of manual collection; these savings range from about 10 to 30%. But due to the relatively high initial capital costs of pneumatic systems, when debt service is included the annual operating costs of the various upgrade alternatives are between 40 and 80% greater than those of manual collection. The Net Present Value costs of the pneumatic alternatives are 4.8 to 9.1 times greater

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[61] See Appendix B for documentation of all the results discussed in this section.
[62] Actual 2011 costs were inflated to 2013$ to match the 2013$ used for the other scenarios.
[63] See Table B-9 in Appendix B-2. Envac staffing levels are specified as per standard Envac operating agreements; they differ considerably from standard DSNY staffing levels, which involve 2-3 individuals to cover one shift on-site, given weekends, vacations, and sick days. Current Envac operations are digitally controlled and can be done remotely, with personnel used for monitoring, maintenance, and trouble-shooting. We conducted a sensitivity analysis of higher staffing projections. If Envac staffing projections were tripled, the effect on NPV would be an increase of 50 to 80% depending on the scenario.
[64] See Table B-10 in Appendix B-2. Again, all 2011 actual costs were inflated to 2013$ for consistency.
[65] Note, as shown in Table B-10, that the tariff structure under which DSNY service falls does not allow time-of-day pricing for facilities whose peak demand is below 1500kw, as any alternative AVAC terminal's would be. Another factor not considered in our analysis, although it is something that should be considered for possible implementation, is electricity that might be contributed by solar panels installed on a new terminal, or other alternative energy sources, such as Verdant Energy's East River turbines, which are virtually adjacent to the AVAC terminal.
[66] Bulk waste, construction-and-demolition debris, hazardous wastes, and yard wastes are excluded from all systems, since they are not amenable to pneumatic collection, nor are they collected in standard DSNY or private-carter collections. Litter bins not located along Main Street are excluded from all scenarios. (Litter bins at each end of the Island could be incorporated into plans for the hospital and campus networks, respectively.)

than those of conventional collection.[67] To equalize these costs, annual externality benefits of about $0.3 to $1.1 million would be required.[68]

Table 4-1. Comparison of Cost Components of Alternative Pneumatic Scenarios

Capital Components	2013$							
	No-Action		**Upgrade**		**Upgrade+R**		**Upgrade+R+Comm'l+Litter**	
	Units	Cost	Units	Cost	Units	Cost	Units	Cost
Tons/Y:	2,675		2,675		3,854		5,672	
Terminal Bldg Construction (SF)	17,760		2,500	$875,000	4,700	$1,750,000	8,300	$2,850,000
Terminal Equipment Cost				$2,862,595		$4,282,329		$7,723,312
Trunk Pipe Installation (meters)	1,800		1,800	$855,000	4,000	$1,900,000	6,000	$2,850,000
Pipe Cost				$1,866,736		$1,866,736		$3,595,380
Interior Inlets (Diverter Valves)	41		41		41		41	
Exterior Inlets (Diverter Valves)					117		150	
Total				**$6,459,331**		**$16,987,777**		**$26,265,050**
Capital Cost Per Annual Ton				$2,414		$4,407		$4,631
Debt Service (34yrs)/Y				$382,088		$1,004,876		$1,553,653
Debt Service/T				$143		$261		$274
Expense Components								
	No-Action		**Upgrade**		**Upgrade+R**		**Upgrade+R+Comm'l+Litter**	
	Units	Cost	Units	Cost	Units	Cost	Units	Cost
Tons/Y:	2,675		2,675		3,854		5,672	
Labor (Facility) Employees	**10.2**	**$1,391,828**	**1.2**	**$181,191**	**1.5**	**$226,203**	**2.0**	**$302,366**
Electricity (kwh)	**1,222,088**	**$643,334**	**193,974**	**$104,919**	**548,935**	**$126,897**	**837,017**	**$237,644**
kwh/T	457		73		142		148	
Minor repairs+Spare Parts/Y		$15,653		$22,573		$39,676		$72,347
Employee vehicle			1	$10,345	1	$10,345	1	$10,345
Office Supplies				$2,748		$2,748		$3,208
Telephone/Water				$3,483		$3,483		$3,483
DSNY Total/Y (-Dray)		**$2,050,815**		**$325,260**		**$409,352**		**$629,394**
DSNY Cost/T (-Dray)		**$767**		**$122**		**$106**		**$111**
RIOC Component Replacement/Y		$410,733		$55,727		$157,162		$242,323
Total Opex(-Dray) (-Debt Service)		**$2,461,548**		**$380,987**		**$566,514**		**$871,716**
Opex Cost (-Dray) (-Debt Service)/T		**$920**		**$142**		**$147**		**$154**
Dray Components (Refuse, MGP, Paper included)								
	No-Action		**Upgrade**		**Upgrade+R**	**Upgrade+R+Comm'l+Litter**		
	Units	Cost	Units	Cost	Units	Cost	Units	Cost
Tons/Y:	2,675		2,675		3,854		5,672	
Labor Shfits/Y	183	$86,125	164	$77,251	50	$23,711	69	$32,460
Collections/Y	733		658		200		275	
Diesel Fuel (gals/Y)	3,032	$10,159	2843	$8,790	1306	$4,374	1856	$6,217
Vehicle cost + Maintenance/Y		$38,424		$34,413		$9,940		$11,397
Total Dray/Y		**$134,708**		**$120,454**		**$38,024**		**$50,074**
Total Dray/T		$50		$45		$10		$9
Cost Summary								
	No-Action		**Upgrade**		**Upgrade+R**	**Upgrade+R+Comm'l+Litter**		
	Units	Cost	Units	Cost	Units	Cost	Units	Cost
Tons/Y:	2,675		2,675		3,854		5,672	
Total$ (Opex, Debt Serv, Dray)		$2,596,256		$883,528		$1,609,414		$2,475,443
Annual Savings v. No-Action		NA		$1,712,727		$986,841		$120,813
Debt Service/T		NA		$143		$261		$274
Opex/T		$920		$142		$147		$154
Total Opex w Debt Serv/T (W/Dray)		$970		$330		$418		$436
Total RIOC/T (Debt Serv, Repl.)		**$154**		**$164**		**$301**		**$317**
Total DSNY/T (Opex+Dray,-DS, -Repl.)		**$767**		**$167**		**$116**		**$120**
DSNY Savings/Y v. No-Action				**$1,739,809**		**$1,738,147**		**$1,506,056**

67 Assuming a 34-year bond life, 4.75 percent interest, and a 3% discount factor. Sensitivity tests in Appendix B, for different discount rates do not significantly affect the results. Nor does including the fees currently charged by private carters to Island businesses (about $50,000 in 2011) significantly change the results, as also shown in Appendix B.

68 Note that this NPV calculation covers only the 34-year bond period. This is conservative insofar as after the initial capital cost is amortized, the facility has an indefinite useful life (unlike truck-based collection) since ongoing replacement of all facility components is included in the annual operating costs.

Table 4-2. Cost Comparison of Alternative Pneumatic Scenarios With Manual Collection

	2011 AVAC	No-Action	Upgrade	Upgrade+R	Upgrade+R+ Comm'l+ Litter	Manual	Upgrade+ Meter
Scenario-Specific T/Y	2,117	2,675	2,675	3,854	5,672	3,891	2,675
CapEx			$6,459,331	$16,987,777	$26,265,050	$1,381,319	$7,403,331
CapEx/T/Y			$2,414	$4,407	$4,631	$355	$2,767
OpEx/Y, w/Dray, w/o DEBT SERVICE	$2,004,768	$2,596,256	$501,505	$604,597	$921,805	$817,089	$501,505
OpEx/Y w/Dray w/o DEBT SERVICE/T	$947	$970	$187	$157	$163	$210	$187
Ratio Opex w/o DS v. No-Action			**19%**	**16%**	**17%**	**22%**	**19%**
Annual Debt Service			$382,088	$1,004,876	$1,553,653	$97,117	$437,928
Debt Service/Ton			$143	$261	$274	$25	$164
OpEx/Y w/Dray+DS			$883,593	$1,609,473	$2,475,459	$914,206	$939,433
OpEx/Y w/Dray+DS/T			$330	$418	$436	$235	$351
Ratio Opex W DS v. No-Action			**34%**	**43%**	**45%**	**24%**	
Ratio, AVAC W DS/Manual		**413%**	**141%**	**178%**	**186%**		
NPV Ratio, AVAC/Manual			**4.8**	**8.3**	**9.1**		**5.7**
Externality Benefits/Y to Balance NPV			$255,000	$700,000	$1,140,000		$310,000
OpEx/Y W/DS Incl Transp-Disp			$1,266,182	$1,992,063	$2,858,048		$1,276,112
Net Incremental Cost of Metering							$9,930
NPV/Y Cost of Metering							$55,000

If metering equipment were installed to provide unit-pricing capability, a reduction in waste-generation on Roosevelt Island of over 5% would be expected, while some refuse would also be shifted into the recyclable streams, thus producing about a 12% reduction in the amount of material requiring disposal. Since most of New York's waste is disposed of via long-distance transport to remote landfills, at an average cost of $143/ton,[69] this would produce a savings of about $46,000/year, as shown in Table 4-3. As Appendix Table B-11 shows, this savings does not entirely offset the cost of installing metering equipment: the net annual operating expenses for the metered system (including long-distance transport and disposal) would still be about $10,000 more per year than they would be for the Upgrade without metering (not including any additional net processing costs for recycling). To produce an equivalent NPV, an additional $100,000 per year (over a 34-year bond period) would be required to offset the initial capital cost of installing metering equipment. But the additional benefits associated with reduced transport and landfilling requirements (a savings of about 820 gals of diesel fuel with an energy equivalent of about 114,000,000 BTUs and 43 tons of GHG), as shown in Table 4-3, would at least partially offset this cost, as would reductions in collection costs and impacts associated with a 5% reduction in waste generation, which are not tallied here. (There would be no additional metering costs associated with the Upgrade + Recycling scenario, since only refuse inlets would be fitted with meters. Commercial collection is already unit-based, so no benefits from reductions in waste-disposal needs would be expected from commercial metering.)[70]

[69] Citizens Budget Commission, *Taxes In, Garbage Out*, May, 2012, p. 30, http://www.cbcny.org/sites/default/files/REPORT_SolidWaste_053312012.pdf, last accessed 12-17-12.

[70] Note that no additional revenues would be projected for a system that included residential metering since the purpose of metering is to substitute fees from metering for other fees (residential property taxes or any other revenue stream entering the NYC General Fund) that are currently collected. It is proposed as a revenue-neutral system that merely charges on a use basis rather than on a blanket basis, and it is expected that costs would go down system-wide, for generators as well as for the sanitation-service provider, due to the reduction in waste volumes produced by this economic incentive.

Table 4-3. Expected Waste Tonnage, Fuel, BTU, and GHG Reductions From Metering/Unit-Pricing With an Upgraded Pneumatic System on Roosevelt Island

	No-Action OR Manual	Upgrade
Residential Refuse TPD	7.33	6.45
Residential Paper TPD	1.96	2.20
Residential MGP TPD	1.27	1.48
Total	10.56	10.14
W/ Avg 6% Source Reduction		9.93
REFUSE		
Transport+Disposal Cost/Yr	$382,589	$336,679
Transport+Disposal Savings/Yr		$45,911
Transport Fuel/Gals Yr	6,827	6,008
Transport Fuel Savings/Gals Yr		819
Transport GHG/Yr	88	78
Transport GHG Savings/Yr		11
Disposal GHG/Yr	270	237
Disposal GHG Savings/Yr		32
Total Transport+Disposal GHG	358	315
Total Transport+Disposal GHG Savings		43
Transport BTUs/Yr	948,271,737	834,479,128
Transport BTU Savings/Yr		113,792,608
Transport Truck Miles/Yr	1,264	1,113
Transport Truck Mile Savings/Yr		152

Potential economic benefits can be expected from the value of building and exterior space recovered from waste-management use and from labor savings by building managers as well as savings in their equipment and supplies. These potential savings are presented in Table 4-4. If these potentially recoverable space and labor and equipment savings were captured, building managers could save over $1m per year in the Upgrade-Only alternative, thus more-than-compensating for the capital investment vs. a truck-only system. Adding recyclables to the pneumatic system could provide another quarter-million dollars a year of revenue benefits.[71]

Table 4-4. Annual Savings from Space Potentially Recoverable Through the Use of Pneumatic Collection (2012$)[72]

Annual Cost to Building Managers for Refuse Handling Space, Labor & Equipment				
	Space	Labor	Equipment	**Total**
Manual (No AVAC) (Refuse & Recycling Staging)	$1,134,231	$837,096	$295,524	$2,266,851
No-Action or Upgrade-Only ""	$343,142	$711,971	$125,488	$1,180,601
Upgrade +Recycling	$104,452	$711,971	$0	$816,423
Savings, Upgrade v. No-AVAC	$791,089	$125,125	$170,036	$1,086,250
Savings, Upgrade v. No-AVAC (labor & equipment only)		$125,125	$170,036	$295,161
Additional Savings, Upgrade + Rec v. No-Action or Upgrade-Only	$238,691		$125,488	$364,178
Annual Cost to RIOC of AVAC Terminal Space				
	As Land Lease	#Parking Spaces	Rent as Parking Lot	
No-Action	$63,425	120	$338,231	
No-AVAC	$36,591	69	$195,128	
Upgrade-only	$40,368	76	$215,271	
Upgrade +Rec	$25,413	48	$135,521	
Upgrade+Comm+Litter	$30,852	58	$164,527	

[71] The savings presented here quantify the real estate and building management benefits of shifting waste storage and staging from individual buildings to a neighborhood-scale collection terminal, as discussed in Section 1. While these savings may be readily achieved in new buildings, it would be difficult to capture the value of no-longer-needed waste rooms and staging areas in existing buildings.

[72] See tables in Appendix B-6 for source calculations.

The relative energy demand in the various system alternatives is shown in Table 4-5. Because of its specific combination of electric BTUs (for pneumatic collection) and diesel BTUs (for manual collection), the Upgrade + Recycling alternative is the most energy-intensive, using 68% more energy than would be used by Manual collection.[73][74]

Table 4-5. Comparative Environmental Impacts

		No-Action	Upgrade	Upgrade+R	Upgrade+R + Comm'l+ Litter	Manual
Waste Tons	Scenario-Specific Tons/Y	2,675	2,675	3,854	5,672	3,891
	North-Island Total Tons/Y	5,672	5,672	5,672	5,672	5,672
Electricity	KWH/Y (000s)	1233	194	549	837	
	KWH/T (Tons Collected Pneumatically)	461	73	142	148	
Truck Miles	DSNY+Commercial Collection Miles/Y	38,960	38,011	30,302	9,305	32,897
	DSNY+Commercial Collection Mi/Y/T	6.87	6.70	5.34	1.64	5.80
	Multiple v. Manual	**1.18**	**1.16**	**0.92**	**0.28**	
Fuel	DSNY+Commercial Collection Gals/Y	13,112	12,922	9,384	1,861	14,096
	DSNY+Commercial Collection Gals/Y/T	2.31	2.28	1.65	0.33	2.49
	Multiple v. Manual	**0.9**	**0.9**	**0.7**	**0.1**	
GHG Emissions	DSNY+Commercial Collection Tons CO2eq/Y	571	211	303	313	157
	DSNY+Commercial Collection Tons CO2eq/T (Wtd Avg)	0.10	0.04	0.05	0.06	0.03
	Multiple v. Manual	**3.63**	**1.34**	**1.92**	**1.99**	
Energy Use	DSNY+Commercial Collection BTUs/Y (Millions)	5,968	2,434	3,245	3,115	1,931
	DSNY+Commercial Collection BTUs/Y/T (Wtd Avg) (Millions)	1.05	0.43	0.57	0.55	0.34
	Multiple v. Manual	**3.09**	**1.26**	**1.68**	**1.61**	
	Electric BTUs/Y (Millions)	4,170	662	1,873	2,856	
	Electric BTUs/T (Tons Collected Pneumatically) (Millions)	1.56	0.25	0.49	0.50	-
	Diesel BTUs/Y (Millions)	1,798	1,772	1,372	258	1,930
	Diesel BTUs/T (Wtd Avg) (Millions)	1.81	1.76	1.25	0.49	1.02
	Multiple v. Manual	**1.78**	**1.73**	**1.23**	**0.48**	
	Diesel/Electric	0.43	2.68	0.73	0.09	
	Electric as % of Total Energy Use	70%	27%	58%	92%	

All system alternatives require trucks, since even the pneumatic scenarios require drayage of containerized waste from the AVAC terminal to a transfer station or recyclables-processing facility. The most-inclusive pneumatic option (Upgrade + Recycling + Commercial + Litter) would produce 70% fewer truck miles than Manual collection. The No-Action AVAC option would produce 20% more truck miles than Manual collection; the Upgrade would produce about 5% more, and the Upgrade + Recycling about 10% less. Diesel fuel use, of course, directly tracks truck-miles traveled. All AVAC alternatives would displace diesel fuel via the use of electricity. In the Upgrade + Recycling alternative, electricity would account for over half the energy use; in the All-AVAC option, electricity use would be 10 times greater than diesel use.

[73] To test the sensitivity of our results to lower-than-projected energy efficiency, we increased electricity use by 20% and 50%. From a cost perspective, a 50% increase in electricity use for the simple upgrade raised the NPV by 17%. For the most-inclusive scenario, the same increase in electricity consumption had almost no effect on NPV (+2%). NPV is not changed in the all-inclusive scenario, because debt service is a larger portion of NPV than are operating costs. A 50% increase in electricity use raised overall CO2eq emissions by 16% for the simple upgrade and by 47% for the almost entirely electric all-inclusive scenario. At this rate, the all-inclusive scenario would still produce 20% fewer CO2eq emissions than the no-action alternative. If advances in pneumatic collection made it possible to achieve an energy efficiency 50% better than projected, greenhouse gas emissions for the all-inclusive scenario would be equal to those from Manual collection.

[74] The relative energy efficiency of Manual collection may be slightly greater than is shown in this analysis. The emission factors used for heavy-duty trucks, as documented in the appendix, are those used in the latest PlaNYC for NYC-specific conditions. NYC DSNY trucks are likely to achieve greater fuel efficiency than the citywide fleet, due to the Department's aggressive use of the latest low-impact technology. http://www.nyc.gov/html/dsny/downloads/pdf/pubinfo/annual/Hybrid/LL38_2013_Final.pdf, accessed 06-03-13.

Figure 4-9. Comparison of Annual Truck Miles by Vehicle Type

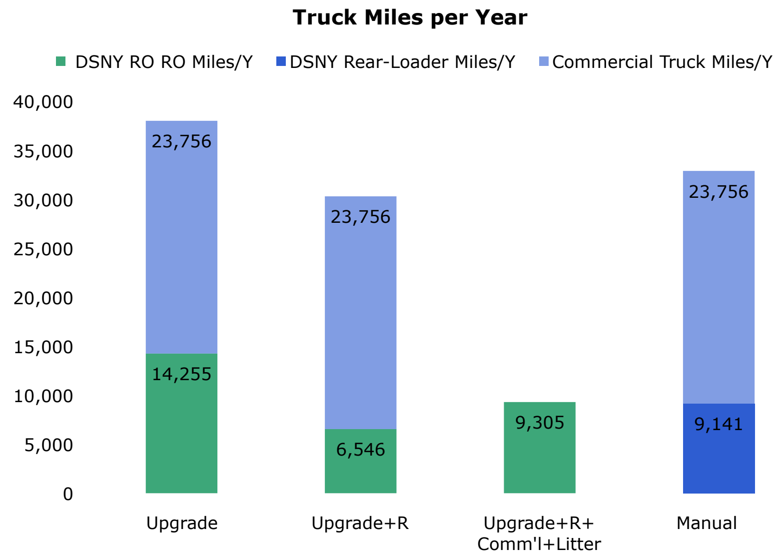


Figure 4-10. Comparative Energy Use of System Alternatives

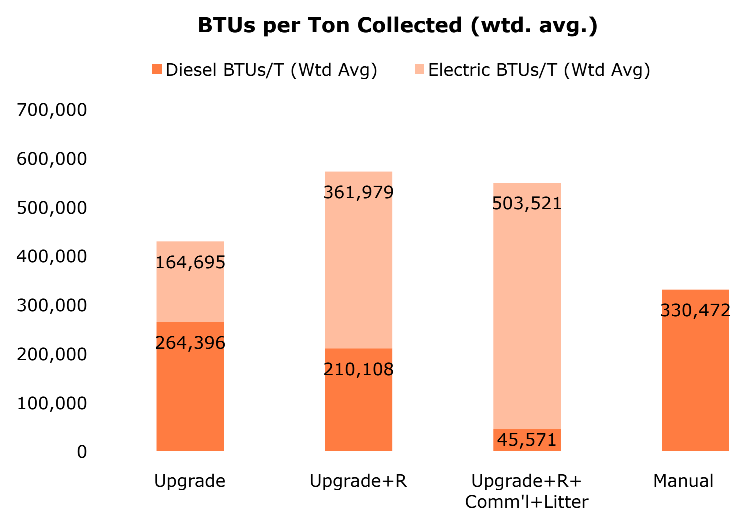
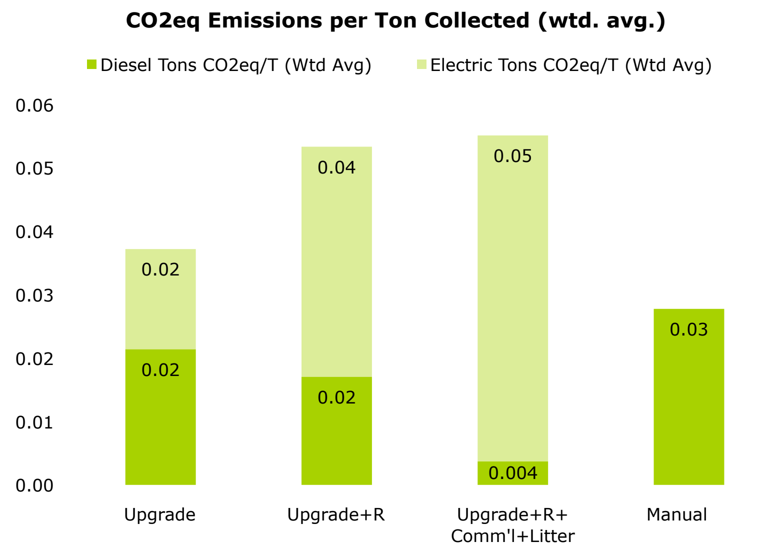


Figure 4-11. Comparative GHG Emissions of System Alternatives



GHG emissions (expressed as tons of CO2-eq per ton of waste collected) roughly track the relative BTU usage of the various system alternatives.[75]

A variety of environmental benefits are associated with the use of electricity rather than that of liquid diesel fuel. The relative amounts of electricity vs. diesel fuel used for the alternative scenarios are presented in Figure 4-11, which shows, as discussed above, that the ratio of electric to diesel power increases as the proportion of pneumatically collected waste increases. Liquid transportation fuels, when burned in internal combustion engines, produce particulates that are of public-health significance, particularly on a local scale. Electric motors emit no particulates into the air around them and electricity can be produced from renewable resources such as wind, water, solar, and bio-mass (including organic refuse). In addition to potential greenhouse-gas reductions, such renewable sources may also offer fewer adverse public-health impacts than do fossil-based fuels. For these reasons, in its programs NYSERDA promotes the use of electricity over that of fossil-based fuels. Pneumatic-based systems, for obvious reasons, use a lesser proportion of liquid transportation fuels; when considering only on-Island impacts, the use of liquid fuel is eliminated.

Fuel use, while it is an important quantifiable measure of efficiency and emissions, does not capture the extensive mileage-related impacts of truck collection or the quality-of-life impacts of manual waste-handling. The cost of truck miles traveled due to pavement damage, congestion, accidents, noise and local air pollution depends on a number of factors, including the characteristics of the roadway material, the population density, the vehicle class and, in the case of noise, the height and position of surrounding buildings.[76] Modeling these costs for Roosevelt Island-specific conditions is beyond the scope of this study, but the following examples of externalities imposed by truck collection provides a framework for evaluating the potential value of upgrades to the pneumatic system.

- Congestion: In New York City, where over a million person-hours are lost to traffic delays each day (costing an estimated over $33 million a day), each additional *automobile* mile driven has a

[75] See footnote #72. For the same reason given there, GHG emissions for the DSNY fleet are likely to be somewhat lower than those used in this analysis based on the citywide fleet.
[76] See 1997 Federal Highway Cost Allocation Study Final Report http://www.fhwa.dot.gov/policy/hcas/final/toc.htm, last accessed 06-14-13.

marginal external cost of 30 cents.[77] Since a heavy truck has a congestion impact at least three times greater than that of an automobile, the congestion cost of each mile traveled would be about a dollar.

- Pavement damage: Heavy vehicles are responsible for the majority of pavement costs. Degraded roads increase noise and reduce safety and fuel efficiency. In 2013, New York City will spend $136 million, or an average of $175,000 per lane mile, to repair and resurface its roads.[78] A 20,000-pound truck axle, which is close to the New York City DOT's legal limit,[79] consumes a thousand times the pavement life of a 2,000-pound car axle.[80]
- Air pollution: In New York City, despite strict regulation and improved emission-control technologies, motor vehicles contribute 10% of the particulate emissions and a quarter of the nitrogen dioxide emissions. Exposure to poor air quality is associated with asthma and other respiratory and cardiovascular illness and, in New York City, an estimated 6% of deaths.[81]
- Accidents: Garbage trucks are 8 times more likely to produce pedestrian fatalities than are other heavy trucks.[82]
- Worker safety: Sanitation work is one of the most dangerous occupations in the US, causing more injuries and fatalities than firefighting or policing.[83] According to the Bureau of Labor Statistics (BLS), the fatality rate for sanitation work is ten times higher than the overall fatality rate for all other BLS categories: a sanitation worker has a 1 in 50 chance of dying from a work-related injury over a 45-year career.[84] Non-fatal injuries from hurling up to seven tons of bagged waste into a truck on a given collection route, operating heavy equipment in traffic, or exposure to the elements, are common.[85]
- Noise: Medical researchers have established a wide range of adverse health impacts due to noise pollution.[86] Economists have found that residential properties on noisy streets are worth less than properties on quiet streets.[87] According to the New York City Department of Environmental Protection, noise is the number one quality-of-life issue for city residents.[88] New Yorkers file

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[77] Marginal external congestion cost for peak auto travel in New York City (31 cents/vehicle mile). Ian Parry, "Pricing Urban Congestion," Resources for the Future, Nov. 2008. Table 2. Marginal External Congestion Costs for Selected Urban Centers. See also Jose Holguin-Veras et al., "Integrative Freight Demand Management in the New York City Metropolitan Area" USDOT 2010 p.17 http://www.transp.rpi.edu/~usdotp/DRAFT_FINAL_REPORT.pdf, last accessed 06-14-13.

[78] FY2013 Executive Budget, Office of the Mayor, p. 151. http://www.nyc.gov/html/omb/downloads/pdf/mm5_12.pdf, last accessed 06-14-13.

[79] DSNY 3-axle 25-cubic-yard rear loaders have a gross vehicle weight rating (GVWR) of 72,000 pounds. New West Technologies, "LLC Multi-Fleet Demonstration of Hydraulic Regenerative Braking Technology In Refuse Truck Applications, Final Report" December 2011. p. 19. , last accessed 06-14-13.

[80] South Dakota DOT Briefing, "Truck Weights and Highways" September 24, 2003. p.2 http://www.sddot.com/transportation/trucking/docs/SDDOT_Truck_Briefing_2d.pdf, last accessed 06-14-13.

[81] NYC DEP, "Air Pollution" http://www.nyc.gov/html/dep/html/air/index.shtml, last accessed 06-14-13.

[82] Charles Komanoff and Members of Right Of Way, "People Killed by Garbage Trucks, 1994-97" Killed by Automobile: Death in the Streets in New York City 1994-1997," March 1999. p.35. http://www.cars-suck.org/research/kba_text.pdf, last accessed 06-14-13.

[83] See Robin Nagle's discussion of the risks of the job in *Picking Up: On the Streets and Behind the Trucks with the Sanitation Workers of New York City,* Farrar, Straus and Giroux, 2013. p. 57.

[84] Dino Drudi, "Job Hazards in the Waste Industry" Bureau of Labor Statistics, June, 1999. http://www.bls.gov/iif/oshwc/cfar0030.txt, last accessed 06-14-13.

[85] Nagle, p.53.

[86] E.g., http://www.who.int/docstore/peh/noise/Comnoise3.htm., last accessed 06-14-13.

[87] E.g., Jon Nelson, "Hedonic Property Value Studies in Aircraft and Road Traffic" in Baranzini et al eds. *Hedonic Methods in Housing Markets: Pricing Environmental Amenities and Segregation*. Springer, 2008. p. 67; also http://www.econ.psu.edu/papers/COST-BENEFIT%20ANALYSIS%20AND%20TRANSPORTATION%20NOISE2.pdf, last accessed 06-14-13.

[88] http://www.nyc.gov/html/dep/html/noise/index.shtml, last accessed 06-14-13.

more official noise complaints related to garbage trucks than to any other noise source; in 2012, 5% of all the 311 noise complaints filed with the City were caused by garbage trucks.[89]

Storage, handling and set-out of waste in bags or containers adversely affects the health and well-being of residents and building employees, and negatively affects the use of public space.

- Pest control: Rats spread disease and cause property damage.[90] Eradicating established nests involves poison and traps, which are costly and pose potential hazards to humans and wildlife. Researchers agree that the only long-term solution for minimizing rodent populations is to eliminate access to their primary food supply: garbage. The plastic bags (and pedestrian litter baskets) used for the collection of New York's waste do not prevent rats from ready access to a moveable feast of mammoth proportions. But when garbage is sealed in rigid containers, rat populations subside.[91]
- Odors: The sight and smell of litter and trash pushed New York to the top of the heap in *Travel and Leisure*'s 2011 list of the dirtiest major cities in the country (while its garbage trucks helped it achieve first place in noise).[92] These quality-of-life issues have significant economic impacts for a city in which tourism is a 55-billion-dollar industry.[93] Conventional means of reducing odors from decomposing garbage, such as storage in refrigerated waste rooms with set-out in close coordination with scheduled collection, mechanical air purifiers, or increased collection frequency, are costly and energy-intensive.
- Building-employee safety: About half of the injuries to New York City Housing Authority building staff are due to handling garbage; the Authority's cost for dealing with these injuries is $2.5 million a year.[94]

In addition to avoiding mileage-based adverse impacts due to truck collection, built-in waste transport systems offer the further potential advantage that the heat produced by generators, fans, and other components may be captured in certain situations and used for productive purposes. One example of such an adaptation in connection with a pneumatic-waste-collection system has recently been implemented in a neighborhood in Stockholm. Heat captured from the system's generators and fans is distributed via coils in the sidewalk to provide snow-melting capability--thus avoiding the need for mechanical or manual snow-removal.

Another factor with regard to comparing AVAC and truck-based collection is the level of service offered--i.e., collection frequency. Manual/truck-based systems inherently involve the costs and inconveniences of staging and storing residential waste materials for at least several days at a time, since it is not practicable in New York City for municipal truck-based collections to be done more frequently than a few times a week (due to the inherent costs and adverse environmental and congestion impacts).[95] And manual/truck-based collections are necessarily suspended over holidays or during storm events or other forms of natural or unnatural disasters.

Also to be considered are the benefits associated with reduced waste disposal that may be associated with pneumatic collection (along with reduced long-haul transport to remote disposal facilities). As noted above, reductions on the order of 12% in waste volumes requiring disposal would be expected with the

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[89] http://www.theatlanticcities.com/neighborhoods/2013/04/yo-im-trying-sleep-here-new-yorks-wonderful-map-noise/5279/, last accessed 06-14-13.
[90] http://www.cdc.gov/rodents/., last accessed 06-14-13.
[91] Sullivan, Robert *Rats: Observations on the History and Habitat of the City's Most Unwanted Inhabitants.* Bloomsbury. 2004. p.17.
[92] http://www.travelandleisure.com/articles/americas-dirtiest-cities/2, last accessed 06-14-13.
[93] http://www.mikebloomberg.com/index.cfm?objectid=99248E01-C29C-7CA2-F7836024BB447AC6, last accessed 06-14-13.
[94] New York City Housing Authority Journal, "NYCHA Talking Trash: When It Comes to Garbage, Do the Right Thing: A message to residents from Deputy General Manager Carlos Laboy-Diaz on behalf of Property Management staff." March 2012. p. 1.
[95] Private collection of commercial wastes may be as frequent as 7 times a week.

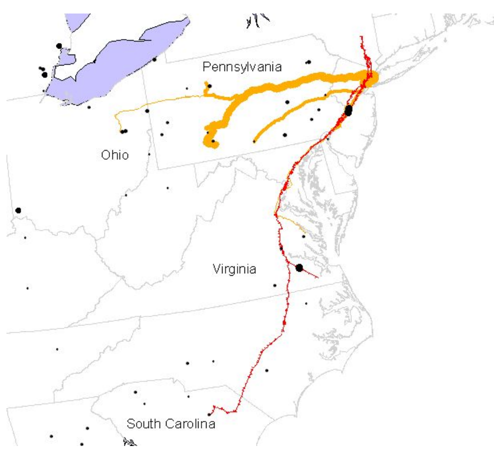
economic incentives provided by pneumatic-based metering. With or without metering, to the extent that recycling is enhanced because of more-convenient generator-participation opportunities, and because of reduced cross-contamination between materials, less material would need to be remotely landfilled. In addition, the use of recycled as opposed to virgin materials in remanufacturing processes has significant energetic and greenhouse-gas benefits, as many researchers have found.[96] Another potentially significant benefit is that it is difficult to collect source-separated organics system-wide in a dense urban environment by truck (for the storage/frequency reason mentioned above). The fact that tube-based systems make the possibility of such collection practicable means that organic-processing technologies such as anaerobic digestion, which could provide cost-effective, locally based disposal options, while also producing energy and reducing GHG emissions, represents another environmental and economic benefit (as discussed in greater detail below).

While it is difficult to economically quantify these benefits, they do have an economic component which is not reflected in the tables and graphs presented above.

INTEGRATED WASTE PROCESSING

Waste collection--the process that starts with source-segregated set-out of discarded materials by the generator, continues with the introduction of these materials into a collection vehicle or device, and ends after the materials have been transported to the initial "dump site"--is only the first step in the waste-management process.[97] And it involves only a relatively small fraction of the overall GHG emissions associated with the management of discarded materials. The majority of GHG emissions--and fuel use--may be due to long-distance transport to a remote disposal facility and to the effects of disposal. This is certainly the case for discarded materials generated within New York City, since most of the city's non-recycled materials are exported to remote landfills where the decomposing waste releases more GHG than did the long-distance transport vehicles that carried it an average of three hundred miles (a six-hundred-mile round trip for a truck or train).[98]

Figure 4-12. New York City's Remote Landfill Network
(Source: Miller, 2007)



[96] E.g., Tellus Institute, *More Jobs, Less Pollution: Growing the Recycling Economy in the U.S.*, November, 2011, http://www.recyclingworkscampaign.org/2011/11/more-jobs-less-pollution/#more-160, accessed 01-23-13.

[97] This can be a transfer station, a facility for the initial processing of recyclable materials, or a disposal facility.

[98] Norman Steisel and Benjamin Miller, "Power From Trash", *New York Times*, 4-27-10; New York City Mayor's Office of Sustainability and Long-Term Planning, *PlaNYC*, April, 2012, http://www.nyc.gov/html/planyc2030/html/theplan/solid-waste.shtml, last accessed 01-27-13; Citizens Budget Commission, *Taxes In, Garbage Out*, May, 2012.

If the non-recyclable waste generated on Roosevelt Island could be processed for ultimate disposal on the Island, these adverse environmental and economic impacts would be avoided, while beneficial, locally usable products (e.g., biogas, steam, electricity, compost) could be produced. The fact that a pneumatic tube system allows the possibility of collecting source-separated kitchen waste and other compostable organic materials at a relatively small incremental cost increases the range of potentially practicable on-site processing options.

The Island's projected waste generation--some 36 tons per day overall, of which about 11 tons is expected to be recyclable and about 9 tons compostable--provides the initial screen for determining which, if any, on-site processing technologies might be practicable without importing additional material from off the Island (which, depending on the specific circumstances, might also be feasible). Given the relatively low volume of recyclables, and the variety of materials involved (metals, glass, plastics, mixed paper), it is unlikely that any on-Island processing of recyclables would be economically feasible--particularly for materials whose economic end-processing requires large-scale facilities (e.g., paper, metal), except, perhaps, at a bench-scale for academic purposes associated with the Cornell-Technion engineering campus (especially for plastics and glass). There are, however, potentially available technologies for on-site management of the non-recyclable waste fractions.

These technology alternatives can be divided into those that could accept most or all of the non-recyclable stream (either with or without pre-processing) and those that could accept only a source-separated, compostable organic fraction (i.e., a fraction collected via separate inlets). The first category includes conventional waste-to-energy technology (mass-burn or refused-derived-fuel incineration) and gasification. The second category includes in-vessel (aerobic) composting and anaerobic digestion as well as emerging technologies such as pyrolysis and hydrolysis.

Conventional waste-to-energy plants are unlikely to be considered practicable for the Island, given the waste volumes usually considered to be economically feasible (generally 100 tpd or more) as well as the general lack of public and political enthusiasm for such facilities, as evidenced by the paucity of new plant installations in the US since the 1980s. Gasification technologies, which produce even fewer GHG and air-pollutant emissions than do current-generation waste-to-energy facilities, are beginning to be used in small-scale installations with input volumes comparable to those produced on the Island.[99] The capital and operating costs of these facilities are significantly greater than those of landfilling or of the alternative disposal technologies (waste-to-energy incineration and composting/digestion), but when they are compared to the all-in costs of remote transport and landfilling, and the energy and environmental benefits are considered, these costs may be acceptable over the long-term.

The biological and chemical (non-gasification) technologies have the disadvantage of being able to treat only the organic fraction of the waste stream (which, depending on the process, can constitute somewhere between a third and two-thirds of the overall non-recycled waste stream), leaving the remainder for incineration or remote landfilling. But when all costs and benefits are considered, these technologies may be less-costly than gasification and, depending on the circumstances, less-costly than landfilling or incineration.[100] They have the further advantage of being the most generally acceptable from a public point of view, which is one reason for the current level of interest in these technologies from businesses and localities in North America and Europe. They also have a significantly longer and broader record of demonstrated experience than do the alternative non-incineration technologies.

One way of providing an organics-only input stream would be to pre-process incoming mixed waste to separate out the processible stream using mechanical equipment designed for the purpose.[101] It is highly unlikely, however, that installing and operating such sorting equipment would be cost-effective at a

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[99] E.g., *Waste Management World*, "Mobile Waste Gasification Units for Military Applications," 12-29-11.
[100] E.g., S.E. Nayono, *Anaerobic Digestion of Organic Solid Waste for Energy Production*, Karlsruher Institut fur Technologie, 2010, p. 34.
[101] The "mixed waste" stream would not include recyclable metal, glass, plastic, or paper: it is assumed that these materials will have been separately collected via separate inlets.

Roosevelt Island scale. (This would be particularly true for conventional, in-vessel [aerobic] composting, since its economics are driven primarily by the avoided cost of disposal, rather than by the relatively insignificant potential sales price of the primary product--compost.) A more practicable alternative--especially given the existence of a trunk-line pneumatic tube and terminal--would be to install separate inlets and container facilities for this fraction.

As noted above, it seems unlikely that source-separated organic collection will be considered practicable in the near term for the northern end of the Island. This is due to the infeasibility of retrofitting that existing development with interior inlets for organics, which would make such a system most convenient for use by building residents, as well as to the apparent preference of both residents and building managers to have building porters handle the transfer of source-separated materials from apartment hallways to the proposed new exterior inlets.[102] However, as also noted above, by pre-installing tee-joints with the proposed new exterior inlets for metal/glass/plastic and paper, a third source-separated stream (organics) could be added at a later time at relatively low cost. For the as-yet-unbuilt Cornell campus, separate interior inlets could be installed in order to collect an organics fraction that would be suitable for composting or anaerobic digestion.

If an organics-processing facility handled only organics from the southern end of the Island, the expected daily input would be on the order of 3.5 tpd (about 30% of the projected 10.6 total tpd). If organics from the northern end of the Island were someday added, the total would be on the order of 6.5 tpd, and if food waste from the hospital were added, the total would be about 9.5 tpd.

This volume of waste is generally considered near the lower limit of economic viability for conventional anaerobic digestion of MSW.[103] There are, however, a number of relatively new anaerobic digestion technologies that are designed to handle smaller volumes than this, and the development of economically viable small-scale anaerobic-digestion equipment is one of the current foci for global R&D efforts in this field. A number of U.S. universities, among them the University of California, Davis and the University of Wisconsin, Madison, have successfully piloted facilities at this scale. Another possibility for managing such relatively small volumes of organic MSW would be to combine their processing with a nearby anaerobic digestion facility for waste-water solids. Anaerobic digestion of sewage sludge is recommended in PlaNYC. Anaerobic digestion of sewage sludge is conducted at the nearby waste-water treatment plant in Greenpoint, Brooklyn (a distance of 3 miles from Roosevelt Island). Since MSW organics have more BTUs per pound than does sewage sludge, the addition of small fractions of MSW to a sewage-digestion facility could be economically beneficial, at a relatively small incremental cost.

The other type of technology that may be appropriate to Island-size waste volumes could be gasification. A gasification system could manage all non-recyclable waste projected for the Island (about 25 tpd) and would not require separate collection of organics. Gasification has been demonstrated over the past decade for MSW in applications ranging from cruise-ship lines to military installations, at scales ranging from 10 to 350 tpd. The capital cost of a 25 tpd-gasification facility might be around $10 million.

It is likely that the most cost-effective energy product of the biogas or synthetic gas produced by an anaerobic digester or gasifier would be heat, rather than electricity or liquid fuel, given the costs of conversion technology for this relatively small volume of gas. The most cost-effective use for this heat, given the year-round demand for it, might well be water heating.

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[102] See survey results in Appendix A-5.

[103] E.g., DSM Environmental Services, Inc., *Hunts Point Food Distribution Center: Organics Recovery Feasibility*, 12-30-2005, http://www.nycedc.com/ProjectsOpportunities/CurrentProjects/Bronx/HuntsPointVisionPlan/Documents/HPOrganicsRecoveryFeasibilityStudy.pdf, last accessed 04-11-11.

Section 5
IMPLEMENTATION

1. RIOC: We recommend that Roosevelt Island officials view investment in an upgraded AVAC system within the larger Roosevelt Island development context as a way to:

- reduce budget demands and make expense-planning more predictable
- free staff time for other uses
- save limited road access for buses, ambulances, and deliveries
- save sidewalks and courtyards for pedestrians, cafés, and gardens
- create space to serve new functions, e.g., a freight distribution facility which could help mitigate the street-congestion problems that the Cornell-Technion campus will produce
- prevent noise and traffic-related impacts for the dense Northtown area between the Roosevelt Island bridge and the south-Island developments
- reduce the Island's carbon footprint by cutting fuel use and GHGs
- promote the Island as a model for 21st-century urban design

To accomplish these ends, RIOC would need to work with Cornell-Technion, Coler Hospital, and the Department of Sanitation to develop a long-term waste-management plan for the Island, including upgrades to the AVAC system within those plans.

The operational savings that could be obtained by replacing the existing terminal with an Upgrade-only system would pay back the upgrade capital costs within a few years. Operational savings from an Upgrade + Recyclables system would also provide a reasonable payback period. This would not be the case with a comprehensive upgrade (Upgrade +Recyclables +Commercial +Litter): the relatively modest operational savings would not in themselves support the required investment. However private-sector savings and potentially monetizable public externality benefits might support the required long-term investment. With help from NYC, RIOC could seek funds from the Empire State Development Corporation as well as from other State and federal agencies to augment contributions from RIOC's capital budget.

Any upgrades to the terminal might be accompanied by an analysis of the potential for more efficient land use, since a new terminal could free for other uses up to half an acre of land adjacent to the Motorgate Garage and the Island's only bridge. This land might support a freight-distribution center for handling not only the transport waste containers from the RIOC, Cornell, and Coler AVAC facilities, but for other inbound and outbound materials.

RIOC might also seek to power the AVAC facility with low-cost, sustainable electricity from sources such as Verdant Energy's East River tidal turbines, solar panels that could be placed on a new terminal building, and biogas from on-Island organic processing,

Our analysis of existing conditions showed that, except for an 800-meter section of trunk line, the original pipes could continue to be used. Whether or not RIOC expands the network, we recommend that the replacement pipe be relocated along Main Street, rather than along the East Channel. Locating the new section along Main Street would make it possible to add new waste sources such as recyclables or commercial waste without impacting the original pipes, many of which run underneath buildings where major repairs would be difficult. Locating the new pipe along Main Street would require opening the street, but locating a vital infrastructure underneath a permanently accessible right-of-way would simplify future maintenance. An installation along Main Street could be coordinated with other infrastructure upgrades, which are likely to occur during the construction of the Cornell-Technion campus, in order to reduce its cost.

When this suggestion for pipe relocation was presented to RIOC executives, they cautioned that construction projects that restrict vehicle access along Main Street, the island's only vehicular access, must be avoided if at all possible. RIOC suggested that there may be room for the replacement pipe inside the existing utility corridor that carries a steam pipe along the East Channel. Another alternative might use parking spaces along Main Street instead of the main roadway, or a portion of the sidewalk on one side of the street. Whether the replacement trunk line is laid along Main Street or along the East Channel sea wall or in another location, new pipe will need to be installed to connect new inlets to the system. The impacts of this construction, like those of all infrastructure improvements, must be weighed against the potential benefits. Whether or not the system is expanded, the diverter valves connecting the gravity-fed chutes to the system must be replaced in order to realize the energy savings projected in this report. RIOC would need to coordinate with building management companies to arrange for these repairs.

Currently, RIOC owns the equipment and the Department of Sanitation pays the operating costs. The equipment upgrade would provide an opportunity to revisit this arrangement. Should Sanitation make a capital contribution to the upgrade costs in order to realize the net savings that reduced operating expenses would provide? Should RIOC take over operations? Should RIOC contract operations to a private carter? If Cornell builds a system, should RIOC and DSNY and Cornell share the cost of maintenance personnel?

We found that residents and business owners have a limited understanding of the AVAC system. RIOC could consider the equipment upgrade as an opportunity to create a thorough education campaign for all system users. RIOC could also consider offering ongoing performance feedback by including card readers and metering for residential refuse. If recyclables are included, RIOC could consider encouraging building managers to create a pilot program that made able-bodied residents responsible for putting recyclables into new exterior inlets so that recyclables bins could be removed from garbage rooms and staff time could be used for other purposes.

2. Cornell-Technion: As discussed above, it would be inefficient to add the new campus to the existing RIOC network because sending the anticipated volume of material to RIOC's terminal would drive up energy use and maintenance costs. It would, however, be efficient for Cornell to build its own terminal on or near its campus in order to: avoid collection-truck traffic; reduce adverse quality-of-life impacts due to conventional waste-staging and -storage; capture space savings by reducing the need for waste rooms and staging areas; contribute to the hardening of the campus to potential flood threats by reducing the need for open truck bays below the flood-line on the building walls along the shoreline; deploy labor saved from not driving or carting waste to containerized compacting equipment for other grounds-keeping tasks; facilitate source-separation and onsite processing of material (further reducing the impacts of transport and disposal); and facilitate research by metering and tracking waste flows. In addition, Cornell could consider coordinating with RIOC to collect material from South Point and Four Freedoms Parks and other adjacent sources. While we found that Roosevelt Island residents are not currently supportive of the idea of disposing of source-separated food waste in outdoor inlets, the new buildings on the Cornell campus could include inlets for organics alongside those for refuse and recyclables. By processing this food waste on-site, Cornell could reduce its off-Island waste transport by about a third, while greatly reducing the number of truck trips through the community.

a. We recommend that Cornell consider pneumatic collection not merely as a strategy for handling waste, but as a way to integrate waste-management into the design process for the new campus as well as into its engineering curriculum. The possibility of analyzing inputs with keyed inlets and volume-measuring tools, as well as the ability to design and control collection cycles, could allow students and faculty to test and analyze innovative waste-management techniques.

b. We recommend that Cornell work with RIOC to find synergies between their respective waste-handling systems. One possibility might be using organics or recyclables from the North end of the Island as inputs to on-site processing facilities that Cornell may develop. Another possibility might be coordinating off-Island transport of all of the Island's discarded materials.

c. We recommend that Cornell encourage its engineers to consider pneumatic collection in conjunction with their design of the campus power supply, delivery logistics, telecommunications routing, and heating, ventilation, and cooling systems in order to take full advantage of potential synergies between systems (e.g., recovering waste heat, employing shared service corridors) to reduce the overall environmental impact of the campus.

d. We recommend that Cornell make the pipe network and waste-processing facilities legible on campus by encouraging its master planners and designers to integrate the pneumatic network with the landscape of the new campus. Tubes could be incorporated into canopies and walkways, sculpture, lighting, seating or other features as landscape infrastructure.[104] And since the facilities are clean and essentially automated, the processes could be made visible to campus visitors, students and employees with large windows and explanatory signage.

e. We recommend that Cornell work with RIOC to explore a flat-car electric shuttle, or similar innovative technology, for transport of deliveries to the campus, and containerized waste away from the campus. This on-Island shuttle system could be used in conjunction with a freight distribution/receiving facility that could be built on the extra space inside the current AVAC footprint. Cornell and/or RIOC may also want to consider a barge-freight system to address the needs for handling outbound waste containers and inbound freight.

3. Department of Sanitation: No new funding would be required on the part of DSNY. Rather, a new terminal would significantly reduce the current cost of operation for the Department of Sanitation. An even more important benefit for the Department may be the opportunities offered by the Roosevelt Island installation to test not only the possibilities offered by pneumatic technology, but related techniques that may prove beneficial in other New York City situations even where pneumatic systems are not installed. Innovations potentially associated with an upgraded pneumatic system may include: (a) unit-pricing; (b) processing of source-separated organics; (c) combined collection of residential and commercial waste. All of these components, in themselves, may provide useful New York City-specific experience that may be of benefit in other City locations, whether or not pneumatic collection is also used in those other locations. We recommend that DSNY cooperate with RIOC and Cornell-Technion to develop an Island-wide waste-management plan that could provide such a citywide model. DSNY could cooperate with the Business Integrity Commission (BC) to pilot an integrated public-and-commercial waste collection program on the Island. DSNY may also want to consider modifying the current RIOC/NYC cost-share arrangement in order to obtain mutual reductions in current and projected costs.

4. Mayor's Office/PlaNYC: The Mayor's Office is the appropriate entity to play a lead role in encouraging coordination between RIOC, Cornell-Technion, DSNY, and BIC to achieve PlaNYC's goals of waste-avoidance and -diversion, as well as to minimize the City's waste-management costs. And it could assist RIOC in accessing supplemental City, State, and federal funding sources.

[104] Contemporary designers recognize the importance of infrastructure: "By revealing the multi-dimensional complexities, externalities and cross-dependencies within the infrastructures of waste and water, energy and mobility, food and fuel…[the] landscape…can be cultivated as both a system and a strategy for contemporary urbanism that is flexible, contingent, and multidimensional" http://www.gsd.harvard.edu/#/events/landscape-infrastructure.html, accessed 02-01-13.

Section 6

METRICS

Because of New York's population density and attendant waste volumes, as well as the severity of its surface-transport congestion, the value of its real estate, the volume of its air and noise pollution, and the negative aesthetic impacts of the garbage bags heaped on its streets (with accompanying litter, odor, and rats--all of which also have adverse economic consequences for tourism), much of the City offers the kind of situation where pneumatic collection has been found to be desirable, practicable, and economically viable in other countries. However, since most areas of New York City are already built-up, and since retrofitting existing developments with pneumatic equipment is generally more costly and logistically complicated than is the case with installing pneumatic tubes during the construction phase of new developments--and also because the economically important space-savings associated with pneumatic systems are less likely to be captured in already-built buildings--it is likely that pneumatic systems will spread only gradually in the City as new developments are built. One possible such new development, where the possibility of a pneumatic system has been suggested by its sponsor, is the newly launched Hudson Yards project in Manhattan.[105]

New York's rural and suburban areas are unlikely to meet the density criteria that would make them suitable candidates for pneumatic collection. To the extent that New York State's other large cities do offer areas where pneumatic collection, at least of the stationary-terminal sort, might be economically and operationally practicable, it is highly likely that this development pattern--pneumatic installations in new projects rather than retrofits in already built-up areas--will hold true for them as well.

Almost any pneumatic installation could be expected to produce safety and public-health benefits due to reduced particulate emissions, noise emissions, accidents, and disease vectors. Quality-of-life benefits could be expected from reduced congestion, visual nuisances, and improved levels of service and reliability. Economic benefits in the form of space and labor savings, as well as enhanced marketability, can be expected on the part of waste generators. And energetic and environmental benefits can be expected due to the substitution of electrical energy for fossil-derived transportation fuel. But the question of overall reductions in BTU use or GHG emissions will depend on the specific characteristics of the given pneumatic installation in relation to conventional collection options.

Because of the relatively higher costs associated with the installation of pneumatic systems, the development of new pneumatic-waste-collection facilities is not expected to be a significant source of new economic activity in New York in the near-term.

[105] http://www.cityrealty.com/new-york-city-real-estate/carters-view/related-posts-new-renderings-information-hudson-yards-project/carter-b-horsley/39962, accessed 10-11-11.

Section 7

CONCLUSIONS

This study compared three options for updating an existing pneumatic waste-collection system on Roosevelt Island with the alternative of conventional, truck-based collection.

- An Upgrade-Only alternative (one waste stream) that would continue to accept only one waste fraction, refuse, from residential sources only;
- an Upgrade + Recycling alternative (three streams) that would include, in addition to refuse, the two separate recyclable streams required by New York City local law to be source-separated: metal/glass/plastic and mixed paper/old corrugated cardboard;
- an Upgrade + Recycling + Commercial + Litter alternative (three streams) that would also accept material from commercial generators (businesses along Main Street) and from sidewalk litterbins along Main Street.

These upgrade scenarios did not include:

- Organics: We eliminated the separate collection of a fourth fraction, compostable organics, as a near-term option due to a variety of logistical, cost, and public-preference hurdles. It is possible (and it may be conceptually desirable) to include separate organics collection at a future stage; this might be accomplished at a relatively modest cost penalty (vs. the cost of installing inlets for a fourth fraction at the same time as the initial upgrade) if tee-joints that could accommodate this fourth fraction were installed at the same time as inlets for the additional recyclable fractions.
- Waste from the Cornell-Technion campus: We dismissed the option of including material from the planned Cornell-Technion university campus at the Island's southern end due to the energetic and economic inefficiencies that would be associated with transporting that amount of additional material (a projected 8.3 tons per day at full build-out)[106] that distance. The Cornell-Technion campus will generate enough material to make practicable a separate pneumatic system, and a separate system would offer planning flexibility and operational advantages over a system combined with waste from the northern, residential end of the Island.[107]
- Waste from Coler Hospital: Because the volume of non-hazardous waste generated by the one hospital that will remain on the Island after the Cornell-Technion campus is built also makes a separate terminal both practicable and desirable, we rejected the option of including Coler Hospital waste in the center-Island system.
- Park litter: Litter baskets from the two parks at either end of the Island were also eliminated from detailed consideration because it would be much more economically and environmentally efficient to include that material with separate Cornell-Technion and hospital terminals.

We compared the pneumatic upgrade options to conventional, truck-based collection (the Manual Alternative) and to the operations of the current, 38-year-old pneumatic system (the No-Action Alternative).

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[106] Full build-out is expected to be completed in 2038. Cornell NYC Tech, op. cit.

[107] While containerized waste from a campus-based terminal would need to be transported to the bridge located across the Island, this should be addressed with RIOC as part of a larger strategy for handling all freight traffic to the campus.

We found that:

- Energy demand and GHG emissions for all of the pneumatic alternatives would be higher than they would be with conventional collection. Depending on the pneumatic alternative, incremental BTU use would be between 25% and 70% higher, while GHG emissions would be between 35% and 100% greater.

- Truck miles would not be reduced when only residential refuse is collected by pneumatic tube, but they would be cut by 10% if residential recyclables were included and by 70% if all Main Street commercial and litter-bin wastes were managed pneumatically. In this last scenario, there would be no on-Island collection-truck miles traveled.

- Performance and quality-of-life improvements would be produced by the pneumatic systems due to: multiple daily collections versus collections several times a week; containerization of waste at the terminal eliminating the need for an intermediate dray and additional handling at a transfer station; reductions in local truck emissions; the potential use of low-carbon energy sources to provide the electric power for the system.

- The costs of all the alternatives considered would be significantly less than those of the existing (No-Action) AVAC system. This is due to the fact that the still-operating original equipment is experiencing significant maintenance costs as it nears the end of its expected life, and also to the fact that it is energy- and labor-intensive relative to current technology.

- Relative to the costs of conventional collection, the direct operating costs for the pneumatic upgrade alternatives--*not* including debt service--would be 10 to 25% less expensive, while per-ton capital costs would be 7 to 13 times higher. Net Present Value Costs are therefore 4.8 to 9.1 times higher than those of conventional collection.

- These NPV differences could be offset if externality benefits on the order of $0.3 to 1.1 million per year could be achieved. Potential savings to waste generators (building owners) from decreased space, labor, and equipment costs, as well as other possible public benefits (e.g., economic and environmental savings from reduced public-health and public-safety impacts, from reduced congestion- and roadway-maintenance costs, from quality-of-life improvements, and from reduced long-distance transport and disposal) may make this level of savings practicable. Space and labor savings for waste generators, alone, might produce savings of $1m per year. A range of other environmental, public-health-and-safety, and quality-of-life benefits associated with pneumatic collection might offer other monetizable savings to add to this calculus.

The costs and efficiencies of conventional collection vary greatly depending on whether the waste is in bags or containers (for pickup by rear-loader or roll-on/roll-off truck); the ratio of refuse to recyclables; the waste-generation density of the route (how much waste is collected at each stop, how many stops per mile); and the length of the travel distances from the truck's garage of origin to the collection route and from the end of the collection route to the dump site. The costs and efficiencies of pneumatic collection vary greatly depending on the length of the network; the volume of material collected; the number of waste fractions; and the number of inlets. The comparative economic and environmental impacts of the two system types therefore will depend on specific local conditions. In the case of Roosevelt Island, trucks--if it were possible to use them for residential refuse collection given the severe space and operational constraints imposed by the Island's development plan--would require less energy and produce fewer greenhouse gas emissions than would tubes, while operating at a lower net cost. But the other impacts conventional collection would produce also need to be considered. In addition to the effects of this collection method on the overall waste-management system (the lost opportunities for waste-reduction via the incentive of metering, less-effective source-separation for recycling, and the greater difficulties of separate organics collection), and in addition to the quality-of-life impacts of truck collection outlined in this study, the various public health and economic benefits due to a reduction in truck miles and the elimination of set-out and staging of waste on city streets would need to be calculated. This is an area in which further research is needed.

Another area meriting further investigation is the optimization of pneumatic-system design and operation. The material used for fabricating the tube, the diameter of the tube, and various other design and operational characteristics could have a significant effect in reducing energy consumption, costs, and life-cycle emissions. As in the case of automobiles, computers, and other electronics, the expanded adoption of pneumatic systems will doubtless produce innovations in system efficiencies.

This study finds that new equipment, combined with ongoing preventive maintenance for the replacement of system components as needed, would extend the life of the existing tube network indefinitely while permitting the currently under-utilized facility to be expanded for the collection of source-separated recyclables and commercial and litter-bin waste. Perhaps more importantly, this study provides a basis for RIOC, the Department of Sanitation, the Mayor's Office of Sustainability and Long-term Planning, and Cornell-Technion University to consider the relative cost of pneumatic collection within a larger waste-management, transportation, and urban planning context. Seen from this larger perspective, the existing AVAC network presents a unique opportunity to create a New York City model for sustainable civic design.

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Appendix A: Data Collection A-1: Volumes, Types, Sources

Roosevelt Island Costs to Convert to 25 Yard Truck Pick-up

Roosevelt Island Containerized Tonnage for Calendar Year 2009

Commodity	Refuse (24)	Bulk (25)	Paper (27)	MGP (29)
Totals	2069.81	835.73	391.61	295.52
tpd 365	5.6707123			

Roosevelt Island Containerized Tonnage for Calendar Year 2008
(January 1 2008 through December 31 2008)

Commodity	Refuse (24)	Bulk (25)	Paper (27)	MGP (29)
Totals	2129.18	780.36	423.59	240.82

Roosevelt Island Containerized Tonnage for Calendar Year 2007:
(January 1 2007 through December 31 2007)

Commodity	Refuse (24)	Bulk (25)	Paper (27)	MGP (29)
Totals	2113.76	832.21	390.69	241.78
tpd 365	5.7911233			

CY 2007-2009 Average Tonnage

Commodity	Refuse (24)	Bulk (25)	Paper (27)	MGP (29)	ratio paper/total gen
Totals	2104.3	816.1	402.0	259.4	0.145
tpd 365	5.7650685	2.23589	1.101269406	0.71061	0.094

Weekly Amount

Commodity	Refuse (24)	Bulk (25)	Paper (27)	MGP (29)	ratio mgp/tg
					ratio ref-bulk/tg
Totals	40.5	15.7	7.7	5.0	0.761

Costs of adding a Truckshift per year.

1) Each Truck needs 2 posts which become 3 FTE due to the absence factor

Posts	FTE
2	3

2) The average Sanworker costs calculation as of 6/1/2010

Average Cost	Benefits Costs @ 67.12%	Total Costs per Sanworker
$65,532.00	$43,985.08	$109,517.08

3) Additional Costs

25 Cubic Yard Differential @ $43.44 per Day for 300 day year per post
$13,032.00
Prod Ref 10.7/Recy 6.2 tons Differential @ $12.72 for 300 day year per post
$3,816.00

4) Dump on Shift $5.80 per load

Costs of 45 Cubic Yard Container RO/RO per year.

45 Cubic Yard Container Pick-up		
Amount	**Posts**	**FTE**
4 Times per week	4	1

Additional Costs

RO/RO Pickup Differential @ $92.82 per Day for 208 day year
$19,306.56

Convert to Start Trucks	Tons ZWA	Trucks ZWA	Daily Posts (2 Posts Per Truck)	FTE	Costs @ $109,517.08 per SW	Differentials per post	Dump on shift costs QW01	Total Costs
Refuse	40.5	4	1.3	2.0	$219,034	$17,376	$58.00	$236,468

Costs @ $109,517.08 per SW	Differentials per post @ $92.82	Dump on shift costs QW01	Total Costs
$109,517.08	$19,307	0	$128,823.64

Cost Benefit Analysis Conclusion using 6/10/2010 Headcount Data	
Regular House Hold Pick-up	$236,468
RO/RO Pick-up	$128,824
Saving for using EZ-Pack	$107,645

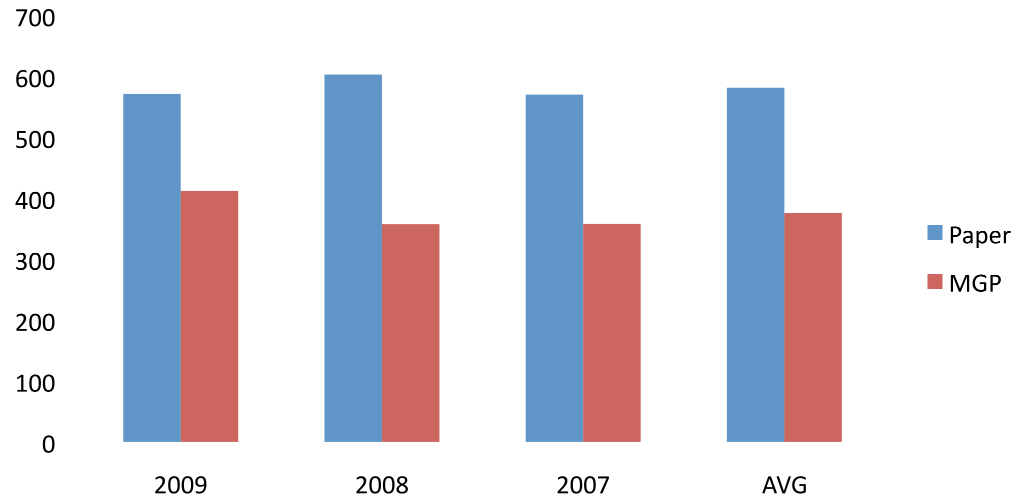
Note:
The above data was extracted from the recorded scale weights at the location via hand written 202's

In Calendar year 2007, 128.9 tons of refuse was collected by rear loader, allocated to material type 84 in section QW016, total refuse tonnage would have been 2242.66, had it been collected via containierization.
There are no such findings for calendar year 2008 or 2009.
#'s in () next to commodity name are the SCAN material code numbers
Truck Conversions uses the targeted TPTS amount and divided it into the ZWA tonnage.
Dump on shift FY2010 Average used for QW01 are 4.8% Refuse
THIS SPREADSHEET PROVIDED BY STEVEN BRAUTIGAM, NYC DSNY TO BENJAMIN MILLER, 6-30-11
Yellow cells added by Benjamin Miller

Ref 1/Rcys

*

	Paper	MGP
2009	571.11	411.89
2008	603.09	357.19
2007	570.19	358.15
AVG	581.46	375.74
TPD	1.59	1.03



*adjusted to account for South Town private carter, by adding Jan-Jun 2010 figures from confidential industry source to each DS yr (2009-2007)

Ref-1/Compostable		
	Refuse	HI/HD*
2009	2,069.81	402.37
2008	2,129.18	413.91
2007	2,242.66	435.97
avg	2,147.22	417.42
tpd	5.88	1.14

*compostable fraction based on DSNY waste composition study:
http://www.nyc.gov/html/nycwasteless/downloads/pdf/wastecharreports/wcsfinal/report/wcs_04_V1_1_studyoverview.pdf, accessed 8-5-11,
Table 1-17, pp.45ff : high density/high income—ri.compostable.xlsx [Reference 2]

Ref2/data					
Material Grp	**Material Subgrp**	**Material Category**	**% of Citywide Waste Stream**	**%Citwide REFUSE Stream**	**Rcy Subindicator**
Paper	ONP	Newspaper	7.54%	3.65%	R P
Paper	OCC	Plain OCC/Kraft P	2.44%	1.16%	R P
Paper	Mxd P	High Grade P	0.90%	0.68%	R P
Paper	Mxd P	Mxd Low Grade P	10.33%	8.35%	R P
Paper	Mxd P	Phone Bks/Paperbacks	0.94%	0.49%	R P
Paper	Mxd P	P Bags	0.62%	0.70%	R P
Paper	Bev Cartons	Polycoated P Containers	0.50%	0.40%	R Bev Cart
Paper	Compostable P	Compostable/Soiled Paper/Waxed/OCC/Kraft	5.64%	6.67%	NR P
Paper	Compostable P	Single Use P Plates, Cups	0.43%	0.52%	NR P
Paper	Other P	Other Nonrecyclable P	0.69%	0.70%	NR P
Paper Total			**30.04%**	**23.32%**	
Plastic					
Glass					
Metal					
Organics	Yard	Leaves and Grass	3.29%	4.01%	NR Other
Organics	Yard	Prunings	0.77%	0.94%	NR Other
Organics	Wood	Stumps/Limbs	0.16%	0.19%	NR Other
Organics	Food	Food	17.70%	21.40%	NR Other
Organics	Wood	Wood Furniture/Furniture Pieces	1.18%	1.42%	NR Other
Organics	Wood	Non-C&D Untreated Wood	0.19%	0.22%	NR Other
Organics	Textiles	Non-Clothing Textiles	1.36%	1.64%	NR Other
Organics	Textiles	Clothing Textiles	2.50%	3.03%	NR Other
Organics	Textiles	Carpet/Upholstery	1.23%	1.49%	NR Other
Organics	Diapers/Hygiene	Disposable Diapers and Sanitary Producs	3.20%	3.89%	NR Other
Organics	Misc Organic	Animal By-Products	1.10%	1.34%	NR Other
Organics	Misc Organic	Rubber Products	0.28%	0.33%	NR Other
Organics	Textiles	Shoes	60.00%	0.72%	NR Other
Organics	Textiles	Other Leather Products	0.10%	0.12%	NR Other
Organics	Misc Organic	Fines	3.61%	4.34%	NR Other
Organics	Textiles	Upholstered or Other Organic-Type Furniture	0.90%	1.09%	NR Other
Organics	Misc Organic	Misc Organics	0.72%	0.87%	NR Other
Organics Total			**38.89%**	**47.05%**	
http://www.nyc.gov/html/nycwasteless/downloads/pdf/wastecharreports/wcsfinal/report/wcs_04_V1_1_studyoverview.pdf,					
accessed 8-5-11, Table 1-17, pp.45ff: high density/high income					

Ref2/data					
Material Grp	**Material Subgrp**	**Material Category**	**% of Citywide Waste Stream**	**%Citwide REFUSE Stream**	**Rcy Subindicator**
Paper	ONP	Newspaper	7.54%	3.65%	R P
Paper	OCC	Plain OCC/Kraft P	2.44%	1.16%	R P
Paper	Mxd P	High Grade P	0.90%	0.68%	R P
Paper	Mxd P	Mxd Low Grade P	10.33%	8.35%	R P
Paper	Mxd P	Phone Bks/Paperbacks	0.94%	0.49%	R P
Paper	Mxd P	P Bags	0.62%	0.70%	R P
Paper	Bev Cartons	Polycoated P Containers	0.50%	0.40%	R Bev Cart
Paper	Compostable P	Compostable/Soiled Paper/Waxed/OCC/Kraft	5.64%	6.67%	NR P
Paper	Compostable P	Single Use P Plates, Cups	0.43%	0.52%	NR P
Paper	Other P	Other Nonrecyclable P	0.69%	0.70%	NR P
Paper Total			**30.04%**	**23.32%**	
Plastic					
Glass					
Metal					
Organics	Yard	Leaves and Grass	3.29%	4.01%	NR Other
Organics	Yard	Prunings	0.77%	0.94%	NR Other
Organics	Wood	Stumps/Limbs	0.16%	0.19%	NR Other
Organics	Food	Food	17.70%	21.40%	NR Other
Organics	Wood	Wood Furniture/Furniture Pieces	1.18%	1.42%	NR Other
Organics	Wood	Non-C&D Untreated Wood	0.19%	0.22%	NR Other
Organics	Textiles	Non-Clothing Textiles	1.36%	1.64%	NR Other
Organics	Textiles	Clothing Textiles	2.50%	3.03%	NR Other
Organics	Textiles	Carpet/Upholstery	1.23%	1.49%	NR Other
Organics	Diapers/Hygiene	Disposable Diapers and Sanitary Producs	3.20%	3.89%	NR Other
Organics	Misc Organic	Animal By-Products	1.10%	1.34%	NR Other
Organics	Misc Organic	Rubber Products	0.28%	0.33%	NR Other
Organics	Textiles	Shoes	60.00%	0.72%	NR Other
Organics	Textiles	Other Leather Products	0.10%	0.12%	NR Other
Organics	Misc Organic	Fines	3.61%	4.34%	NR Other
Organics	Textiles	Upholstered or Other Organic-Type Furniture	0.90%	1.09%	NR Other
Organics	Misc Organic	Misc Organics	0.72%	0.87%	NR Other
Organics Total			**38.89%**	**47.05%**	
http://www.nyc.gov/html/nycwasteless/downloads/pdf/wastecharreports/wcsfinal/report/wcs_04_V1_1_studyoverview.pdf,					
accessed 8-5-11, Table 1-17, pp.45ff: high density/high income					

% of Waste HD/HI	%REFUSE HD/HI	%RI Compostable	RI T/D	RI lbs/day
13.43%	5.53%			
2.97%	1.72%			
1.65%	1.53%			
17.95%	16.05%			
1.42%	0.84%			
1.22%	1.55%			
0.58%	0.58%			
6.28%	8.58%	8.58%	0.72	1,433
0.51%	0.69%	0.69%	0.06	115
0.69%	0.77%			
46.69%	**37.84%**			
0.99%	1.37%	1.37%	0.11	229
0.46%	0.63%	0.63%	0.05	105
0.01%	0.01%			
11.20%	15.30%	15.30%	1.28	2,555
0.86%	1.17%			
0.11%	0.15%			
1.04%	1.40%			
1.31%	1.79%			
1.29%	1.78%			
2.37%	3.26%			
1.15%	1.59%			
0.18%	0.24%			
0.35%	0.46%			
0.03%	0.04%			
2.91%	3.94%			
0.46%	0.61%			
0.64%	0.88%			
25.38%	**34.62%**	**26.57%**	**2.22**	**4,437**

		Units	Avg BRs	Tot. BRs	Est. Pop.	Cal. Pop.*	Paper/OCC**	MGP***		rms	apts
Ref3-RI_residential bldgs											
	Octagon	501	1.48	741	1000	934	46.6	30.0			
	Manhattan Park	1107	1.59	1763		2,220	110.8	71.4	1100; no studios, 586-1 BR, 390 - 2 BR; 127 3-BR, 4 - 4BR	1763	
	Westview	371	1.88	696		876	43.7	28.2	361 apartments:13 - studios; 97 - 1 BR; 167 2 - BR; 84 - 3 BR	696	
	Roosevelt Landings	1003	1.85	1851		2,330	116.3	74.9	1003 apartments total; 143 studios, 338 1-bedrooms; 264 2-bedrooms; 190 3-bedrooms; 68 4-bedrooms	1851	
	Island House	400	2.02	806		1,015	50.6	32.6	400 apartments: 34 studios; 92 -1 BR; 154 -2 BR; 108 - 3 BR; 12 - 4 BR	806	
	Rivercross	377	2.59	976	1000	1,229	61.4	39.5			
	South Town#	1278	1.90	2428		3,057	152.6	98.3	Bldg 1 has 240 units; Bldg 2 has 240 units; Bldg 3 has 216 units; Bldg 4 has 216 units, Bldg 5 has 123 units, Bldg 6 has 243 units		1278
	The Child School	NA				318					
		TOTAL		9262		11,661	582	375			
Island pop.(#BRs/tot.BRs); pop.=11,661: from table cited below.						TPD	1.59	1.03			
**402*(cal.pop./island pop.); 402 is from Brautigam, op. cit.											
***259*(cal.pop./island pop.); 259 is from Brautigam, loc. cit.											
red font=daytime pop only											
#Avg. for other bldgs since BR data not available from interview.											
Table PL-P1 CT: Total Population											
New York City Census Tracts, 2000 and 2010 in 2010 Census Tracts											
http://www.nyc.gov/html/dcp/html/census/demo_tables_2010.shtml											
units: http://www.rioc.com/housing.htm#companies, accessed 7-8-11											
*http://www.nyc.gov/html/nycwasteless/downloads/pdf/wastecharreports/wcsfinal/report/wcs_04_V1_1_studyoverview.pdf											
, gives by unit by cell annual avg generation rates by composition											
http://www.nyc.gov/html/nycwasteless/downloads/pdf/wastecharreports/wcsfinal/report/wcs_53_V4AppJ_GenerationRate											
Data.pdf, accessed 8-4-11, table j-13ff, pp. 55ff, gives household generation for refuse, paper, etc, by cell, by season											

Ref4				
	Tons Per Day			
	MSW	OCC/MxPaper	Metal/Glass/Plastic	
UTRC Survey Estimate	2.46	0.57	0.14	
Industry Survey Estimate	3.97	0.53		
Employee-Based Estimate	1.22			
Envac Factors				
SELECTED FACTORS	3.97	0.57	0.14	
	Tons Per Day			
Coler	MSW	OCC/MxPaper	Metal/Glass/Plastic	
UTRC Survey Estimate	8.57	?	0.00	
Industry Survey Estimate	8.57	3.32	0.00	
NYC Factors				
Envac Factors				
	TPD			
RIOC	MSW	OCC/MXP	MGP	
RIOC	0.10	0.00	0.00	
Source: Sylvia Giralde to JS, 7-28-10, data for mar 2008 and 2009, avg				
	TPD			
Litter Bins	0.20			
Source: Sylvia Giralde to JS, 7-28-10, data for mar 2008 and 2009, avg				

				In-Hse Hrs/Wk	Hrs/Day					
Commercial	In-Hse/Hrs/Day		Commercial(1)	9						
	8.6		Residential(2)	53						
			AVAC(3)		3					
			(1)UTRC business survey (Ref7)							
			(2)UTRC residential survey (Ref6)							
			(3)AVAC time estimated from ds-Roosevelt St Calc FY 10.xls, provided by Steve Brautigam 6-23-11: 4x45 yd							
			container pickup per week, estimated 4 hours per trip, rounded up to nearest hour							

Note: Report Analysis based on RO RO shifts, see Appendix B-13, note 4.

Ref 5		
Dedicated Storage Space (SF)		
	Interior	Exterior
Commercial	400	200
Residential (Rcys)(1)	0	891
Hospital(2)	0	300
Litter Bins	NA	0
Parks	0	0
RIOC		
AVAC(3)	15070	23251
SUBTOTALS	15470	24642
TOTAL	40112	

Space calculation here does not include all existing exterior areas listed on p16 and p7 of Appendix A. Total should be: 2055+186+2,241 SF (see also Appendix B-06, second page, cell M5.)

(1)Interior space assumed required for bulk waste and for OCC-management equipment; exterior space does not include truck parking on the assumption that a truck is needed for other purposes.

(2)Interior space not known and uncertain what space needs, if any, AVAC would eliminate; exterior space=2 parking spots used for containers

(3) from A.Mateu, "DRAFT COUNTER PROPOSAL FOR THE AVAC FACILITY ROOSEVELT ISLAND- RIOC", 6-2010, and from proposed terminal at http://fasttrash.org/exhibition/counter-proposal/:

current truck	24219
current bldg	17760
current tot	41979
saving	19859
future tot	22120
new building	2690
new truck	968
new total	3658
saving	38321

	Bins	Non-Motorized Transport Equipment	Motorized Vehicles	Subtotals			
Commercial	0	0	0	0			
Residential(1)	10,500	21,750	210,000	242,250			
Hospital(2)	0	0	0	0			
Litter/Park Bins(3)	66800						
RIOC(4)	4000						
SUBTOTALS	77300	21750	210000				
TOTAL	309050						
(1)Assume no reduction in current need for bins or bags and that private carter supplies all other set-out, storage, and collection equipment.							
(2)Bldg Survey-b-down-8-8-.xlsx							
(3)Bin number from UTRC survey. $400 each estimate based on @: http://www.industrybasics.com/outdoor-waste-receptacles.aspx, 10-7-11							
(4)http://www.govdeals.com/index.cfm?fa=Main.Item&itemid=47&acctid=1009#.TpiXyN4Uqso, accessed 10-14-11--estimate of $4k for 45cy							

Appendix A-2: Field Survey Components

APPENDIX A-2: FIELD SURVEY COMPONENTS

SURVEY OF BUSINESSES

A survey of RI businesses provided information on current waste handling practices and on the perspectives of business managers and owners.

Research team members compared various public and proprietary lists of registered businesses with actual businesses on the street. These businesses are primarily along RI's Main Street and include restaurants, grocery stores, delis, gift shops, and other small retail establishments as well as banks, and medical and other professional offices. Restaurants generate the greatest volumes of waste (including cooking oil, which is a waste stream that could not be collected by a pneumatic system), while professional offices and gift shops sometimes generated so few discards that they did not have their own carting service but instead had an arrangement with RIOC or with the management of an adjacent residential building to use their dumpsters.

Team members visited the businesses, introduced themselves as researchers studying "options for upgrading the efficiency and environmental benefits of Roosevelt Island's AVAC trash collection system" and asked to speak to the manager or owner. The businesses were not contacted ahead of time, but follow-up appointments were sometimes made at a time when a manager would be available. During the visit managers and owners were given a letter that explained the study in more detail and included contact information for the study's project managers. The explanation included the study's goals and funding sources and specified that the information gathered was for research purposes only. (See Appendix C.)

The survey instrument for businesses asked questions regarding their current waste-handling practices, including how much trash and recycling they produced, which recyclable fractions they handled and how they separated them, how many person-hours went into waste-handling, which carters they used, and sought their opinions and concerns about the current system. In some cases, the information was gathered during a tour of the business to observe waste storage areas, volumes awaiting pick-up, and waste-handling practices and conditions in general. On other occasions when the team visited Main Street, it was also possible to observe how trash and recycling was set out for carting truck pick-up and to take note of the condition of business dumpsters.

Waste-volume and waste-fraction estimates developed through the business survey were compared to waste-volume and fraction-data generated using the latest, most-relevant national generation factors based on numbers of employees by business type as well as to data from a confidential industry source. Professional judgment was then used to select the "best" estimates. Waste-fraction calculations also were based on waste-composition data developed by the New York City Department of Sanitation (as documented in Appendix A).

In some cases, even after several visits, team members were unable to meet with an owner, manager, or other individual who could provide the information we sought. Business owners sometimes seemed uncomfortable discussing their business practices with outsiders. Some may have feared that they were being inspected by regulators and might face some kind of penalty in regard to their waste-handling practices. In other cases, there appeared to be language barriers, actual or invented. But most owners or managers the team encountered were quite approachable and generously contributed observations about waste-handling issues. These observations included complaints about other businesses not complying with the rules and concerns about handling waste in an affordable and efficient manner. Some owners or managers expressed the hope that business waste could be integrated into the AVAC system.

LITTER BIN MAPPING AND PHOTO DOCUMENTATION

Research team members conducted a field survey to map the location of all public litter bins and recycling receptacles. These features were combined with plans of existing buildings and other geographic layers (e.g., curbs, sidewalks, parks) to create detailed maps. (These map files are in Appendix C.*)*

Bins were photographed to document the receptacle types currently in use and their locational context relative to building entrances, bus stops and other public amenities. The photographs also reveal problems of trash-overflow in certain locations.

TOURS OF RESIDENTIAL BUILDINGS

Team members visited residential buildings to observe waste-handling procedures and waste-collection and -storage areas, and to gain an understanding of building layouts. The visits involved an initial informational interview with the manager, followed by a tour of the building with the manager(s) and/or a superintendent or porter. Visits typically lasted one to three hours depending on the size of the complex and the number of buildings visited.

Visits were arranged by contacting each complex owner or manager by e-mail (see Appendix C for letter). Subsequently, each building owner or manager was contacted by e-mail or phone to arrange a meeting date and answer any questions regarding the study. In general, managers were interested in and supportive of the study, seemed familiar with and interested in NYSERDA, and were extremely cooperative both during the visits and in subsequent e-mail and phone interactions.

MEETING WITH RESIDENTIAL BUILDING MANAGERS

During the arranged meetings with team members, managers were asked to provide information regarding the size of the complex or building for which they were responsible, including the number of apartments of each size (studio to four-bedroom), the number of floors, and the numbers and layouts of buildings in the complex. They also indicated how many people were on staff and gave an estimate of how many work hours were dedicated to the collection, transport and staging of recyclables. They were asked to estimate the usual amount of recyclables collected, to describe the typical collection and transport practices, and to indicate how landscaping-waste was handled. Managers were also asked to assess the efficiency of the current system for handling recyclables and to describe any concerns they might have about any aspect of their buildings' waste-management operations.

Team members explained that one proposed upgrade to the system involved installing outdoor inlets for recyclables. Given their knowledge of the way foot traffic flowed through the buildings they managed, managers were asked to indicate on a map possible locations for these inlets.

Most managers declined to supply the names of residents from whom we might also solicit views on waste-management conditions and options. Instead, they suggested that we speak with people informally as we encountered them during the tour.

TOUR WITH SUPERINTENDENT OR PORTER

The tour included observation of what RI residents call "the AVAC Room," that is, the enclosed room on each residential floor with the trash chute and bins for recyclables. During these tours, the team sometimes encountered residents and other building staff and were able to informally observe their waste-management operations.

While touring with superintendents, the team observed recycling collection, the AVAC diverter valves in operation, and the areas of each residential building that are dedicated to the handling of waste. (For the most part, the areas on each floor store only recyclables, and the occasional piece of bulky waste, since residents insert refuse directly into the AVAC chute). The staging areas to which building porters take recyclables and bulk waste, typically in building basements as well as in adjacent exterior spaces, were also measured and mapped. The team observed the carts and other equipment used to collect and store recyclables and gathered information about the building-owned truck or vehicle used to transport them to the AVAC facility. During the tours, superintendents and porters were asked for their views about the current system's operation and for an explanation of any challenges or problems, whether related to the way the process was managed and carried out or to resident participation and cooperation.

In a few cases, we contacted managers and superintendents again to verify certain information or to request additional data. We visited several managers a second time to solicit their views about resident preferences, as discussed in the next section.

SURVEY AND ASSESSMENT OF RESIDENTS' OPERATIONAL PREFERENCES

Team members approached RIOC for advice and permission to ask residents for their views on possible upgrades to the AVAC system. It was suggested that the team contact the RI Residents Association (RIRA), an elected body of resident representatives.

The research team contacted the president of RIRA and arranged to give a presentation at a regularly scheduled meeting. The president indicated that there would be little time (7 – 10 minutes) for the presentation at the beginning of their meeting. The presentation made to RIRA on December 7, 2011 described the study and asked for the input of these active community members. During the presentation, the representatives were given a handout with a graphic that illustrated how the AVAC system could be adapted for recyclables. The handout also included three focused questions regarding their preferences for an upgraded system. (See Appendix) It was explained that it was impracticable to retrofit the existing buildings to include recyclables, but that these could be collected by the addition of outdoor inlets. Residents were then asked about their preferences regarding the way the inlets should be operated:

1. Did they prefer that recyclables be carried out and deposited by residents or porters?
2. Did they prefer that the outdoor inlets be located in the front or the back of their building?
3. Were they and their fellow residents interested in composting (which would require separate collection of organic waste)?

Responses from the short discussion at the RIRA meeting are included in the Findings section. The handout also provided contact information for the project team and invited these representatives to discuss these topics with their fellow residents and to report what they learned. During the meeting, a sheet was passed around so that those who were willing to be contacted could give their email and/or phone numbers. Several representatives subsequently contacted team members with questions or comments. Those who gave their emails or phone numbers were also sent a follow-up message requesting that they respond to a survey that was subsequently posted on a link found at the RIOC web site. They were also encouraged to ask the residents they represent to answer the online survey. This survey, developed in further consultation with RIOC, provided information similar to that available on the handout and asked the three questions posted above. RIOC promoted the survey, developed using Survey Monkey (see Appendix A-5), by keeping a link prominently posted on the home page of their web site.

The responses of RIRA representatives and others to the survey—at the presentation, by email, in phone conversations with several residents who preferred phone over email, and in informal interactions while touring the buildings—all contributed to the assessment of user preferences discussed in the Findings. While team members would have preferred to survey a wider sample of island residents, there were two reasons why this was not done. First, both building managers and RIOC were protective of the time and privacy of island residents: team members respected this constraint. Second, the initial responses were highly consistent; it therefore did not seem cost effective, or necessary, to conduct any further surveys in order to provide decision-makers with the information they needed. These results are discussed in the Findings section.

OBSERVATION OF RIOC WASTE HANDLING ON STREETS AND IN PARKS

RIOC collects trash and recycling from Main Street and from bins in other public areas and parks. In order to get a sense of how this is done, including how much time and effort this requires and the volume of waste collected, a team member traveled with the grounds supervisor during a collection run. The supervisor explained typical collection practices as they followed the collection truck on its rounds. This provided information about the typical truck route, collection routines and their challenges, relative waste volumes on streets and in parks, and safety practices such as collecting only on one side of the street at a time in order to avoid crossing the street and blocking traffic.

ENGINEERING SURVEY OF EXISTING AVAC CONDITION

For purposes of this assessment, it was assumed that the AVAC terminal, with all of its existing equipment (e.g., generators, fans, cyclone-separators, fabric filters, and digital control and monitoring equipment) will need to be replaced for an upgraded system. The question to be answered was to what extent can the existing inlets and trunk-line network continue to function satisfactorily as part of an upgraded system. Accordingly, an engineer from Envac's Barcelona offices conducted an on-site assessment of the condition of the existing AVAC tube network and diverter valves.

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Rensselaer Polytechnic Institute
Rutgers University
State University of New York
Stevens Institute of Technology
Syracuse University
The College of New Jersey
University of Puerto Rico

June, 2011

Dear Business Owner/Manager,

We are conducting a study to evaluate options for upgrading the efficiency and environmental benefits of Roosevelt Island's AVAC trash collection system. The study is sponsored by City University of New York's Transportation Research Center (UTRC) and co-funded by the New York State Energy Research and Development Authority (NYSERDA).

One of the alternatives we are analyzing is the possibility of using the AVAC system to collect trash and recyclables discarded by the Island's businesses. To determine whether this might be feasible, we need to know how much trash businesses produce and how they currently dispose of it.

We would like to speak with the owner, manager or other individual who is most familiar with your business's trash disposal process. Our questions will take about five minutes to answer, and we will make every effort to avoid interfering with the course of business during our brief visit.

Please be assured that all responses are confidential and will be used only for the research purposes of the above-mentioned organizations (UTRC and NYSERDA).

Please keep this letter for your records, and feel free to contact us with any questions.

We thank you for your time and attention.

Sincerely,

(signature)

Juliette Spertus, Project Co-Manager
617.308.9194
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THE CITY COLLEGE NEW YORK NEW YORK 10031 212-650-8050 FAX 212-650-8374
WWW.UTRC2.ORG

AVAC Upgrade Feasibility Study **NO.**______________

1. Business Name:

2. Address: | 3. Type of Business:

4. Days & Hours of Operation:

5: **Position** of Interviewee: Owner Manager Asst. Manager Employee (specify title: ________________

6: Which **company** collects your **trash**? ____ or Collected by Cleaning Servic
or No Collection

If **separate collectors,** indicate which items & by whom?

ITEMS COLLECTED	COMPANY
7.	9.
8.	10:

11: Do you separate any **recyclable** materials from your regular trash and set them out separately for collection? YES
If yes: what materials do you separate out from the other trash?
MetalPlasticGlass Cardboard/paper Metal Food Waste Cooking Oil
Other (specify) ____

12: **How many times a week** does your carter collect **trash**? ________________X/week
Trash and recycling collected together? Yes No
If separate, how many times a week does your carter collect **recyclables**? ____________________X/week_ or N/A

13: How many **separate trucks** does the company use to collect any types of waste? ____________ N/A
If separate trucks, how many different trucks come in total each week? ________ ____________

14: Where **inside your establishment** do you store your waste materials (including any recyclable materials) prior to collection?

Basement Closet Adjacent Shared Space Do not store inside Other ______________________

15: How many square feet does your waste **storage** take? _______________ Estimate Known N/

16. Business Square Footage: ____________ Specific Estimate

17: Where **outside your establishment** do you put your trash & recycling for collection on pick-up days?

Curb Dumpster (location?) ______________________ Elsewhere _______________________ N/A
If shared Dumpster, with (bus. names) ____

18: On average **how much trash** do you set out each pick-up? (maximum range)

Bags_______ # Boxes___________ # Bin(s)_______ (Size__________) # Dumpster(s)_______ (Size________

19: What are the **primary materials** you recycle?

20: On average **how much recycling** of each of these do you set out each pick-up? (maximum range) OCC ( )

Bags______ # Boxes_______ # Bin(s)_____(Size______) # Dumpster(s)____(Size_____) # Liq. Barrels______(Size)

21: Does the **amount** of trash or recyclables **vary** significantly depending on the day of the week or time of year? Yes
If yes, Why?

22: How much **time** does it take in an average week—in person hours—to handle the waste materials your business produc
#________ People #___ ____Hours

23: : # of Employees: Total ____ FT____ PT____

24. Does the waste your business produces create any **problems** in terms of [record any relevant details that the responden can provide]

odors insects rodents other animal scavengers litter on the street other

COMMENTS: ____

____

____

25. Hauler/carter name on business sticker: No sticker observed

UTRC Information	
Interviewer:	PHOTOS Y #____________________ N
Date:	Start Time: End time:

RI Building Site Visit - Data Sheet

Date:______________________________ Bldg Name: _________________________

Start/End Time:__________________________ Manager Name________________________

Address:____________________________ Manager Title:_________________________

Manager Phone:______________________ Manager E-mail:_____________________

Others Interviewed:

1. ____ ________________________

Name, Title *Phone*

Building Maintenance Rep/Porter Name:

1. ____ ________________________

Name, Title *Phone*

2. ____ ________________________

Name, Title *Phone*

General Questions

________________________ ________________________

Number of Apartments Number of Types of Apts (Studio, 1BR, 2BR etc)

________________________ ________________________

Number of Floors/Wings Number of Tenants

Labor Requirements:

Employees involved in managing facility's recycling:
(including transport to AVAC Yard)

FT **PT**

Culmulative number of hours/week devoted to recycling
(including transport to AVAC yard, cleaning, vehicle maintenance)

Hours/Week

Notes

Equipment Requirements:

*Number of Vehicles in Fleet*______________

Types:

______________ Motorized	______________ Gasoline, Diesel, or other	______________ Heavy Duty Truck (under 14k lbs)
______________ Small Pickup or Van	______________ Large Pickup or SUV	______________ Medium Duty Truck Under 26K lbs
______________ Large Van	______________ Small Utility	______________ Heavy Duty Truck

Transport Impacts

*Number of Trips Per Week to AVAC Yard*__________________________

*What Type of Vehicle*______________________________

*Typical Round-Trip Time*____________________________

Bins

______________ Overall Number	______________ Number per floor

Quantities of Recyclables

(if records exist or any basis for making an estimate)

___________________ Metal/Glass/Plastic	___________________ Cardboard/Paper

Vegetation

*Who manages landscaping?*_________________________

*If a contractor, where does the waste go?*____________________

If Building Manages Landscaping:

Amount of Yard Waste/Time	Disposal Location
Labor Time Involved in Disposal	How many Truck Trips
Type of Truck (see above for examples)	Amount of Space for Staging

*Are there plans to renovate the grounds?*____________________

If so, where (locate on map)?

Level of Satisfaction with Current Recycling System

Any problems and/or incidents? (e.g. tenant compliance, messes in chute rooms,…)

Locations for additional inlets to handle recyclable fraction

(cannot retrofit buildings, need to install outside building)

Where outside building would the best locations for?

(should use footprint or ground floor plan map if possible. Use space below as a key)

A. Places to avoid adding inlets

B. Entrances and outdoor access points

Locate on plan: service entries (S), entries to individual units (I), main lobby entry (L), additional lobby entries (AL), etc)

C. Certain entries not in use or for certain

D. Areas your company is resposible for and areas RIOC is responsible for

E. Where do people congregate?

Tenant Representative/Group/Committee

Name

Phone Number/Email

Site Tour

[Ask to see representative samples of each of these types of spaces, photograph them (including any recyclable materials and/or equipment, such as bins, carts, or vehicles, astertain the time period represented by that accumulation and the source of that accumulation {e.g. one hallway, seven floors,...} and estimate the volumes of each type of material {i.e. co-mingled MGP, OCC/paper}, measure them (at least approximately)]. Use the space below for notes.

AVAC ROOMS

Size of AVAC Rooms

Observations of AVAC Rooms

RECYCLING ROOMS

Number of Recycling Rooms per floor

Measurements of Recycling Room

Other Observations

*Other interior space where recyclables are collected?*______________________________

Measurements	Number of Carts

Other Exterior space where waste is stored or for transport to AVAC yard?

Measurements	Number of Carts

Interview with Building Maintenance Representative/Porter

Corrobate information collected above

Tell me how the process of collecting recycling works (step by step):

Degree of Satisfaction with Current System

Tenant behavior related to recycling

APPENDIX A-4: Qualitative Assessment Of Operational Preferences

From a system-design-and-operations perspective, there are three major issues associated with how an upgraded system for discarded residential materials might be managed.

The first, and most significant, is whether residents would directly insert their recyclable materials into the proposed new exterior inlets—which would require residents (some of whom are elderly and/or disabled)[1] to carry their discarded materials via elevator or stairway to the outside and insert their discards (which might include potentially embarrassing or distasteful materials such as liquor bottles or food wastes) into inlets in public view—or whether building maintenance staff would perform this function (as they currently remove these materials from utility rooms on each floor). Although there are strong grounds for recommending that residents manage these materials directly, as is done in most parts of the world where there are outdoor recycling receptacles of various kinds, our initial contacts with management personnel, building staff, and building residents suggested that Islanders had a strong preference for allowing building residents to continue to deposit their recyclables in the hallway closets for building staff to remove. (Advantages of having residents manage discarded materials directly include significant labor savings as well as increased diversion of materials from the refuse stream due to increased awareness of recycling.) Since the effectiveness of a recycling program depends in part on the population's willingness to participate in it—and because outdoor recycling systems are not something to which US citizens are generally accustomed—the study team thought it important to assess the views of both building managers/support staff and residents on this issue.

An associated question, the answer to which might partly depend on the answer to the first question, is whether the new exterior inlets should be placed near the front or rear doors to the residential buildings. Placing the inlets as near as practicable to the building entrance is considered important for minimizing the inconvenience associated with inclement weather. If they were in front, they would be conveniently placed for residents carrying discarded materials on their way out of their buildings on their way to work, errands, or other purposes. If they were in the rear, residents might have to make a special trip to access them, but the composition and quantities of their recyclables would not be as publicly visible. If porters were to handle these materials, our expectation is that most parties would prefer back-door inlets. On the other hand, if residents were to handle these materials, we would expect that most residents would prefer front-door locations, for reasons of convenience.

The final question is whether there should be two additional inlets (one for each of the two streams legally required to be separated: paper; metal/glass/plastic) or whether there should also be a third new inlet (for kitchen wastes and other compostable organics). (If porters are responsible for inserting recyclables—so that the two dry recyclable streams, metal/glass/plastic and paper, can be inserted at different specified times—only one additional inlet could be installed for these two fractions. This would produce a modest savings in initial capital costs, but this savings would be outweighed in the long-run by increased operating costs. However, if an extra tee-joints are installed when the system is first built, at a relatively small incremental cost, additional inlets for additional fractions can be added at some future point without incurring a significant cost penalty.)

If porters rather than residents are responsible for inserting materials into the new inlets, designating source-separated food waste as a fourth fraction could be problematic from an operational perspective, since it would involve frequent manual collection, transport, and bin-cleaning, and could present the possibility for nuisances.

We solicited the building managers' views on these questions with phone calls or meetings with the manager of each complex. We solicited residents' views via an invited presentation to the Roosevelt Island Residents' Association at which informational materials were handed out, follow-up calls e-mails were sent to representatives who agreed to give their contact information, and a Web survey via the RIOC Web site: http://rioc.ny.gov/AVAC/. (The Web pages from this survey are attached as Appendix 1.) All of these consultations were conducted in close coordination with RIOC. In consultation with RIOC, the project team

[1] European citizens are typically required to carry their own discarded materials to street-level receptacles. In Wembley City, England, where an auto-pneumatic tube system has been in operation for several years, caretaking staff handle waste only for elderly or disabled residents who are designated as needing "assisted collection." (Julian Gaylor, Managing Director, Envac UK Ltd. to Jonas Tornblom, Director, Corporate Marketing & Information, Envac AB, 1-26-12.)

determined that neither focus groups nor interviews with DSNY personnel were warranted to achieve the objectives for this task.

The findings reported below will be used as a preliminary basis for assessing physical, operational, and engineering conditions during our on-site engineering analysis. The outcome of this on-site assessment will guide the final engineering design proposal for inlet locations and waste fractions.

It should be noted in this regard that there are no engineering, construction, and operational constraints that require decisions on how the inlets are operated (i.e., by residents or porters) to be made on an Island-wide basis. That is, one building complex may choose to operate one way and another the other. Likewise, there is no engineering or operational reason why operating patterns could not change over time, so that a building complex might begin with porter-operation and then shift at some future point to resident-operation. Finally, a decision to install a fourth inlet for source-separated food waste and organics could also be made at a later time, since there would not be a significant cost-penalty associated with such a later retrofit, assuming that relatively low-cost modifications are installed at the outset.

ROOSEVELT ISLAND RESIDENTS AND THE AVAC SYSTEM

The following is a summary of resident and building manager views regarding both the current waste handling system on Roosevelt Island and a possible AVAC upgrade. The following quotations are from interviews, building tours, field observations and an online survey of operational preferences.

The findings show:

1. A Strong Preference for a Porter-Managed Recycling System
Most people we spoke with, or who responded via the Web site, expressed a preference for porter use of any additional inlet for recycling. Their reasons included their perception of a lack of resident interest and/or reliability to use the system properly and of a resident unwillingness to carry recyclables outside after becoming accustomed to the current more convenient practice of depositing them in nearby AVAC rooms for porter removal.

2. An Extremely Positive View of the AVAC System
Roosevelt Islanders are proud of their AVAC system and it works so well that they seem to forget that pneumatic tubes are at work under their streets. People we spoke with liked the idea of expanding a system they perceive as highly successful.

3. A Concern about the Cost v. Savings of an Upgrade to the AVAC System
While enthusiastic about the potential benefits of the system upgrade, people we spoke with wanted more information about its potential cost, future savings and wanted to know how the upgrade would be funded.

4. The Perception of a Low Level of Environmental Activism
Although residents express enthusiasm for the AVAC system, the people we contacted did *not* consider Roosevelt Island to be a community with a strong environmental consciousness. Most considered the interest in composting, for example, to be low, but they also felt that this could change.

5. A Desire for More Training and Education for Residents and Staff about the Proper Use of Both the Current and Future AVAC System
Building managers and residents emphasized the important of education and training to encourage the community and its employees to use the AVAC system appropriately.

Resident Views on Current State of Waste Handling

All residential buildings offer tenants an “AVAC room” with a trash chute and recycling bins. These rooms are on every floor just steps from most apartments (an exception is Roosevelt Landings/Eastwood where some residents have to travel to a different wing or floor to their nearest AVAC room).

Though the AVAC system works well for trash, some residents and managers express frustration with the current state of recycling.

"So far, I have never been convinced that our building separates recyclables correctly." –survey response

"…many residents seem to not be able to distinguish between the green and blue bins." –survey response

During a tour, one building manager pointed out examples of AVAC rooms with trash placed in the recycling bins. We observed that residents did not always place paper, cans and bottles in the appropriate bins, creating extra work for porters. And basements were often crowded with boxes that needed to be broken down and recycled.

Several residents pointed to the problem of recyclables left on the sidewalk outside of some residential buildings when they are set out for carter pick-ups. They considered it unsightly.
It is notable that there are relatively few recycling bins in public areas on the island. Adding more would help reinforce the practice generally.

"Why don't we have recycling sorting bins at present? It would easily encourage people to recycle more...."— survey respondent [presumable referring to public areas]

Reactions to Possible Exterior Inlets for Recyclables

Residents showed enthusiasm about the proposed addition of inlets for recyclables.
"I sure hope it goes," said one resident by phone interview, because ***"we all pay for those trucks."*** An additional benefit to residential buildings would be that they ***"wouldn't have to store"*** recyclables.

The following email expressed a common concern about **the cost and potential savings** of the upgrade:

"How do residents gain to benefit from this upgrade? Are there long term advantages that can be quantified ie... savings in operating expenses, faster recycling leading to building become more energy efficient etc" –resident via email

Survey respondents expressed the hope that **commercial waste** from island businesses could also be removed through use of the AVAC system:

"The AVAC should also allow commercial buildings to use it as this will remove the need to have trash and dumpsters on the street." –Web response

"New system should make all streets trash free." – Web response

"Excellent way of handling the recyclables. Especially as it gets the piles of trash off the streets. Now if we could only get rid of all the illegally parked cars…." – Web response

Resident or Porter Use of Recycling Inlet?

Almost everyone with whom we spoke or who responded via the Web expressed a preference for porter use of any additional inlet for recycling. The main reason given was a perceived lack of interest by other residents and/or a lack of confidence that other residents would use the additional inlets properly.

- ***"I wouldn't mind taking my own recyclables but I don't trust other people to do the same."—*** Web response

'Ten percent [of residents] ***are environmentally conscious and would do it*** **[take out their own recycling*'*** **–**residential building manager

"No way" [could you] ***"leave recycling to residents."*** –resident (phone conversation)

"I don't think most people would access" [the outside inlets,] ***"especially not in winter…."*** [It would be a] ***"big burden" 'especially when they are now used to depositing*** [recycling] ***inside.'*** — resident (phone conversation)

"I doubt more than a handful of people would be willing to schlep their own recyclables outside, or beyond the current collection rooms on each floor. But the porter system now could greatly benefit from an AVAC recyclables inlet." —resident, via email

One commenter fears that a resident-based recyclable disposal system might discourage recycling overall.

"If people have to carry the bags outside themselves, I think many people will just throw their recyclables in with the regular trash. I wouldn't because I think recycling is very important, but I bet a lot of people would." –survey response

Another resident preferred a system in which all waste went into the same tube (the current trash inlet?):

***"All trash and recyclables carried by AVAC, sorted at destination facility"*—** Web response
A respondent thought RI residents would not take care to use inlets properly:

"My opinion is that residents of RI are not the innately disciplined people of Stockholm or the pride-of-place people of Catalonia. The result will be that there will be a mixing of garbage types in publicly-available chutes. This is unfortunate, but it's my sense of who we are. I don't want to give people the opportunity to put a half-eaten ice cream cone in a glass bottle chute." – Web response

The same resident goes on to suggest the importance of training porters to do the separation:

***" I think the best option would be to have the building porters ensure the proper separation -- assuming that they too have a training program"*—** Web response

Another resident also thought porters should be trained in proper separation:

"Some training might be necessary to ensure that building porters are scrupulous about recycling and that building managements supervise the process." – Web response

Composting

There was no question on the survey on composting, but this was discussed informally with some residents and in meetings with building managers.

When asked if there was interest in composting, one knowledgeable and active community member commented that RI is ***"not that green."***

The greenest building is the Octagon, a LEED-certified building that may attract more environmentally conscious residents. A small group of Octagon residents has set up two composting bins and an organic garden.

One active member of that group wrote:

"As for compostables, I would imagine participation being about the same as our current composting program which I roughly estimate at about 10-20 households [in a building of 500 apartments]. ***It would***

be very similar to taking compostables out to our compost bin and not so many people do that. I don't think a compost collection bin on each floor would work as it would be too messy/smelly. I think this would be a much harder sell than the recyclables. I do think there is interest by a small percentage of people but I'm not sure if it's a critical mass yet. I mean our participation in the Octagon has the added incentive of going into our own garden and our numbers are still pretty small.” –resident, by email

One survey respondent was in favor of composting opportunities in the community:

“In addition we should also find a way to have composting stations around the island, which would turn into mulch to be used by all landscape maintenance companies, including RIOC's team.”

Roosevelt Island has a large, active community garden with a long waiting list for use of a space. Over the long run, there is potential for interest to develop in composting of yard, landscaping (RIOC), and household organic/kitchen waste.

Sources

• field observations/visits to residential buildings
• interviews and tours with residential building managers and staff
• interviews by phone and email exchange with Roosevelt Island Residents’ Association representatives
• interviews in person and by email with other active RI residents
• an online response form

How Web form was publicized

The online response form, created using SurveyMonkey, was posted with background information and a direct link on the RIOC website and on their Facebook page.
The main question on the on-line form was presented to a meeting of the Roosevelt Island Residents Association (RIRA) and a link to the form was forwarded to 9 members of RIRA who agreed to give their emails or phone numbers. Representatives were asked to spread word of the Web form to their constituents.

Dear RIRA Representative,
As part of the AVAC feasibility study discussed at the December 2011 RIRA meeting, we are seeking resident input on possible upgrades to Roosevelt Island's waste removal system. Please encourage the building residents you represent to express their preferences regarding the future of recycling on Roosevelt Island by visiting the RIOC web site:

http://www.rioc.com

Through the slide show on the home page they can click on a link to the "AVAC Feasibility Study." There they can read about the background of Roosevelt Island's AVAC system, learn about some possible upgrades to the system and contribute to the study by taking a short survey. RIOC will also make available a paper survey to those who do not have access to the Internet. Please contact me for further information.

Thank you for your participation and Happy New Year!
Lisa Douglass
Research Assistant
UTRC/NYSERDA AVAC Feasibility Study

The president of RIRA mentioned the Web form his Main Street Wire newspaper column and he forwarded the email to other island press.

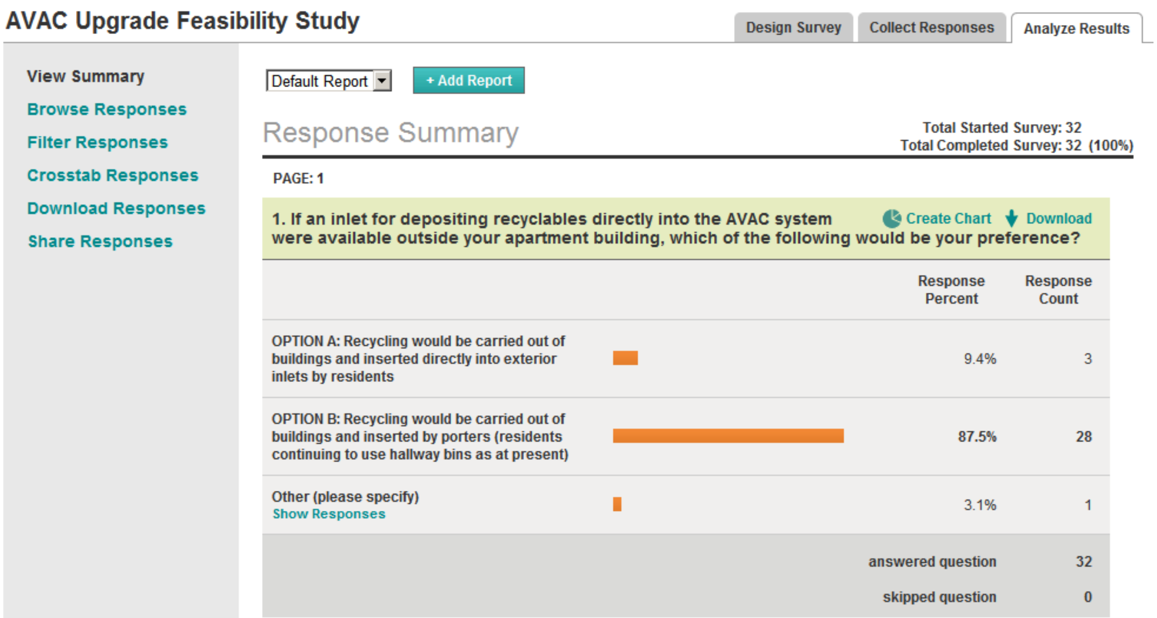
An email with a link to the Web form was also sent to residential building managers.

Some Relevant Community Characteristics

Long-term resident and newcomer mix – Nine of twelve residential buildings on Roosevelt Island are rentals. Although there are many long-term residents, there is also at any given time a large segment of the RI population that is new to the island, since apartments turn over relatively frequently.

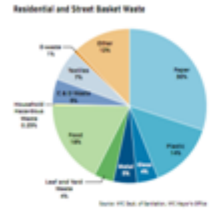
Accessibility and Ease-of-Use Issues -- RI prides itself in being highly accessible and is welcoming to people with disabilities. It also has a higher average age than elsewhere in New York City.[2] These characteristics are important in considering the ways residents might be asked to participate in a new recycling system.

Large International Community –Roosevelt Island is a popular place to live for employees of the nearby United Nations and related agencies, and therefore home to a large international community. One building manager noted that because the island has people from many different traditions, there are different attitudes and levels of awareness and interest regarding issues like recycling.



[2] Median age, NYC: 34.2. Median age, RI: 41. www.city-data.com, accessed 1-27-12.

The city's solid waste system creates 1.66 million metric tons of greenhouse gas (GHG) emissions annually, representing 3% of the city's total GHG emissions.



Solid Waste

Divert 75% of our waste from landfills

Every year, we generate more than 14 million tons of waste and recyclables in our homes, businesses, schools, streets, and construction sites. It takes a fleet of more than 2,000 City government and 4,000 private trucks to collect it all from across the five boroughs. Once these trucks are full, they are emptied or "tipped" at recycling facilities or transfer stations, where the materials are transferred to long-haul trucks, barges, or railcars for processing or final disposal. This complex system has an enormous impact on our environment, communities, and economy.

NYCTUBES

1

planYC
UPDATE APRIL 2011

Recycling, in multifamily residential buildings, is often difficult due to a lack of space to store and sort recyclables.

We will work with the City Council to require new multi-family residential buildings to provide sufficient space for recycling receptacles.

NYCTUBES

31

INITIATIVE 6: Create opportunities to recover organic material

30% of what we throw away in our homes is organic material.

On the commercial side, organics represent 18% of the total waste stream. Paying to transport these organics to distant landfills is not only expensive due to the high water content of these materials, but it is also a key driver of our GHG emissions...

With separation and treatment, food waste can be converted into a valuable resource for agricultural applications and energy generation. Diverting organics from the general waste stream could save the City and its businesses millions of dollars[and] reduce transportation impacts such as congestion, noise, and air emissions.

32

CASE STUDY: Policies to Incentivize Waste Reduction

New Yorkers pay for waste collection through local taxes regardless of how much—or how little—they generate. A growing number of cities have taken a different approach and implemented a fee-based system known as "Pay As You Throw" or "Save As You Throw" (SAYT) that varies based on how much waste a household generates.

SAYT treats waste collection just like electricity, gas, phone, and other utilities; households pay a variable rate depending on the amount of service they use.

Implementing this approach in New York City, which has a high percentage of high density, multi-family housing, would present special challenges....

33

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INITIATIVE 8: Pilot conversion technologies

We rely largely on landfills for disposal. To identify alternative disposal methods that further reduce methane emissions and transportation impacts, we have studied new and emerging technologies that convert solid waste into either electricity or fuel that can then be sold as a revenue-generating product. …

Two specific technologies, anaerobic digestion and thermal processing [technologies that produce a synthesis gas], are the most widely used and have the greatest potential for commercial applicability in New York City.

These technologies could result in significantly less waste being disposed in landfills, reducing GHG emissions.

34

Our plan for solid waste:

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Reduce waste by not generating it

- ✓ 1 Promote waste prevention opportunities
- 2 Increase the reuse of materials

Increase the recovery of resources from the waste stream

- ✓ 3 Incentivize recycling
- ✓ 4 Improve the convenience and ease of recycling
- 5 Revise city codes and regulations to reduce construction and demolition waste
- ✓ 6 Create additional opportunities to recover organic material
- 7 Identify additional markets for recycled materials
- ✓ 8 Pilot conversion technologies

Improve the efficiency of our waste management system

- ✓ 9 Reduce the impact of the waste system on communities
- ✓ 10 Improve commercial solid waste management data
- 11 Remove toxic materials from the general waste stream

Reduce the City government's solid waste footprint

- 12 Revise the City government procurement practices
- 13 Improve diversion rate for waste from City government

35

Appendix B: Cost and Environmental Calculations

	A	B	C	D	E	F
1	APPENDIX B: Cost and Environmental Calculations					
2						
3	**Table B-01. Imputed Costs of Conventional Collection for Roosevelt Island**					
4						
5	**NYC DSNY Costs, Fiscal 2005**					
6		Refuse	Recyclables	Wtd. Avg.		
7	Total cost/t (including disposal, debt service)(a)	267	294			
8	Tons collected(b)	2894455	629796			
9	Tons/truck/shift	10.6	6.2			
10	Total export costs for collected refuse/recyclables(b)©	314868000	12683000			
11	Debt service on garages/vehicles(d)	44890165	16056326			
12	Collection labor cost/t(e)	99	152			
13	Export/processing costs/t	109	20			
14	Debt service/t	15.51	25.49			
15	Debt service/t: 2011$	17.86	29.36	21		
16	RI wtd avg debt service 2013			25		
17	**Collection only (-export/processing; debt service)**	143	248			
18	RI wtd avg collection costs (2005)	0.688836105	0.311163895	176		
19	RI wtd avg collection costs w/o debt service 2011			203		
20	RI wtd avg collection costs w/o debt service 2013			210		
21	Collection w/ debt service	158	274			
22	RI wtd avg collection costs w/ debt service (2005)			194		
23	RI wtd avg collection costs w/ debt service 2011 (g)	182	316	223		
24	RI wtd avg collection costs w/ debt service 2013 (g)			230		
25	Source:					
26	http://docs.nrdc.org/cities/files/cit_08052801A.pdf, accessed 12-12-11					
27						
28	(a)p23, Table 4c without recycling revenues (with DSM adjustments, which do not include correcting for the fact that all enforcement costs are inappropriately assigned to the recycling budget and do not include parallel adjustments UTRC would recommend related to collection, e.g., not charging all Bureau of Waste Prevention, Reuse, and Recycling costs, which include a waste composition study and public education initiatives, along with processing costs for recyclables, to the cost of collecting recyclables, while not apportioning items that are related to collection, such as revenues from enforcement fines).					
29						
30						
31	(b)p20, Table 2					
32	(c)p21, Table 3a					
33	(d)p23, Table 4b					
34	(e)p25, Table 8a					
35	(f)Collection costs apportioned using Roosevelt Island relative tonnages as identified in Appendix A-1, Reference 1 (5.8tpd refuse; 2.62tpd recyclables)					
36	(g) Inflated by BLS CPI index, 2005 to 2011, http://www.bls.gov/data/inflation_calculator.htm					

	A	B	C	D	E	F	G	H
1	**Table B-02. Total System-wide Impacts (7)**							
2			**2011 AVAC**	**Projected AVAC/ No-Action**	**Upgrade**	**Upgrade+R**	**Upgrade+R+ Comm'l+Litter**	**Manual**
3	**Tons Waste (1)**	Scenario-Specific Tons/Day	5.80	7.33	7.33	10.56	15.54	10.66
4		Scenario-Specific Tons/Y	2,117	2,675	2,675	3,854	5,672	3,891
5		North-Island Total Tons/Day	13.40	15.54	15.54	15.54	15.54	15.54
6		North-Island Total Tons/Y	4,891	5,672	5,672	5,672	5,672	5,672
7	**Electricity (2)**	KWH/Day	2674	3379	531	1504	2293	-
8		KWH/Y	976,000	1,233,462	193,974	548,935	837,017	-
9	**Truck Miles (3)**	DSNY RO RO Miles/Y	12,031	15,204	14,255	6,546	9,305	
10		Commercial Truck Miles/Y	23,756	23,756	23,756	23,756		23,756
11		DSNY Rear-Loader Miles/Y						9,141
12		DSNY+Commercial Collection Miles/Y	35,787	38,960	38,011	30,302	9,305	32,897
13		**Multiple v. Manual**	**1.09**	**1.18**	**1.16**	**0.92**	**0.28**	**NA**
14	**Incl. Transport+Disposal**	DSNY Mi/Y w/ Transp-Disp	13,031	16,468	15,368	7,658	10,417	10,405
15	**(With SAYT Projected Reductions)**	Delta v. Manual	2626	6063	4963	-2747	12	NA
16		DSNY Mi/Y/T w/ Transp-Disp	4.3	4.2	3.95	2.0	1.84	2.7
17		**Delta v. Manual**	**60%**	**58%**	**48%**	**-26%**	**-31%**	**NA**
18	**Fuel (3)**	DSNY+Commercial Collection Gals/Day	33.4	35.9	35.4	25.7	5.1	38.6
19		DSNY+Commercial Collection Gals/Y	12,196	13,112	12,922	9,384	1,861	14,096
20		**Delta v. Manual**	**-13%**	**-7%**	**-8%**	**-33%**	**-87%**	**NA**
21	**Incl. Transport+Disposal**	DSNY Gals/Y w/Transp-Disp	11,104	12,020	11,011	7,473	7,869	13,004
22	**(With SAYT Projected Reductions)**	Delta v. Manual	-15%	-8%	-15%	-43%	-39%	NA
23		DSNY Gals/Y/T w/T-D	3.7	3.1	2.83	1.9	1.39	3.3
24		**Delta v. Manual**	**9%**	**-8%**	**-15%**	**-43%**	**-58%**	**NA**
25	**GHG Emissions (4)**	DSNY+Commercial Collection Tons CO2eq/Y	473	571	211	303	313	157
26		DSNY+Commercial Collection Tons CO2eq/T (Wtd Avg)	0.10	0.10	0.04	0.05	0.06	0.03
27		Electric Tons CO2eq/T (Wtd Avg)	0.08	0.08	0.02	0.04	0.05	
28		Diesel Tons CO2eq/T (Wtd Avg)	0.02	0.02	0.02	0.02	0.004	0.03
29		**Multiple v. Manual**	**3.58**	**3.63**	**1.34**	**1.92**	**1.99**	**NA**
30	**Incl. Transport+Disposal**	DSNY Tons C02eq/Y w/T-D	741	840	437	528	628	426
31	**(With SAYT Projected Reductions)**	DSNY Tons C02eq/Y/T w/T-D	0.244	0.216	0.112	0.136	0.111	0.109
32		**Delta v. Manual**	**-123%**	**-97%**	**-3%**	**-24%**	**-1%**	**NA**
33	**Energy Use (5)**	DSNY+Commercial Collection BTUs/Y	4,974,610,080	5,968,281,371	2,433,848,427	3,244,931,801	3,114,505,815	1,930,683,401
34		DSNY+Commercial Collection BTUs/T (Wtd Avg)	1,053,246	1,052,217	429,091	572,086	549,092	340,282
35		**Multiple v. Manual**	**3.10**	**3.09**	**1.26**	**1.68**	**1.61**	**NA**
36		Electric BTUs/T (Wtd Avg)	787,077	786,369	164,695	361,979	503,521	
37		Diesel BTUs/T (Wtd Avg)	266,169	265,848	264,396	210,108	45,571	330,472
38		Electric BTUs/Y	3,299,540,347	4,169,936,335	661,867,115	1,873,044,440	2,856,020,160	
39		Diesel BTUs/Y	1,675,069,733	1,798,345,036	1,771,981,312	1,371,887,360	258,485,655	1,930,112,040
40	**Incl. Transport+Disposal**	DSNY BTUs/Y w/Transp-Disp	4,625,031,851	5,816,637,079	2,168,411,527	2,979,494,900	3,948,984,944	1,779,039,109
41	**(With SAYT Projected**	Delta v. Manual	160%	227%	22%	67%	122%	NA
42		DSNY BTUs/Y/T w/T-D	1,522,995	1,494,934	557,303	765,760	696,212	457,231
43		**Delta v. Manual**	**233%**	**227%**	**22%**	**67%**	**52%**	**NA**
44	**Cost (6)**	CapEx	NA	NA	$6,459,331	$16,987,777	$26,265,050	$1,381,319
45		Annual OpEx w/ Replacement w/o Debt Service	$1,897,232	$2,461,548	$381,051	$566,573	$871,732	$817,089
46		OpEx/Ton w/o Debt Service	$896	$920	$142	$147	$154	$210
47		Annual Debt Service	NA	NA	$382,088	$1,004,876	$1,553,653	$97,117
48		Debt Service/Ton	NA	NA	$143	$261	$274	$25
49		Annual OpEx WITH DEBT SERVICE	NA	NA	$763,139	$1,571,449	$2,425,385	$914,206
50		OpEx/Ton WITH DEBT SERVICE	NA	NA	$285	$408	$428	$235
51		Dray Costs	$107,536	$134,708	$120,454	$38,024	$50,074	NA
52		Total Opex w/ DS, Dray	$2,004,768	$2,596,256	$883,593	$1,609,473	$2,475,459	NA
53		Total Opex/T w/ DS, Dray	$947	$970	$330	$418	$436	$235
54		**Multiple v. Manual**	**4.0**	**4.1**	**1.4**	**1.8**	**1.9**	**NA**
55	**Incl. Transport+Disposal**	OpEx/Y w/ DS and Dray Incl Transp-Disp	NA	NA	$1,220,271	$1,946,152	$2,812,137	$1,296,795
56	**(With SAYT Projected Reductions)**	Delta v. Manual	NA	NA	0.94	1.50	2.17	NA
57		Opex w/DS and Dray/Y/T w/T-D	NA	NA	$314	$500	$496	$333
58		**Delta v. Manual**	**NA**	**NA**	**0.94**	**1.50**	**1.49**	**NA**
59								
60		Total OpEx w/ Dray w/o Debt Service			$501,505	$604,597	$921,805	$817,089
61		Total Opex/T w/ Dray w/o DS			$187	$157	$163	$210
62		Multiple v. Manual			0.9	0.7	0.8	NA
63	Notes				0.61	0.74	1.13	
64								
65–66	(1) Tonnage calculation: Scenario-specific tons refers to the tons collected by AVAC or DSNY rear-loaders in the No-AVAC scenario. North-Island Total tons for AVAC scenarios include: residential refuse+ recyclables; RIOC facilities + park/street litterbins; business refuse & recyclables; 2011 figure based on data collected by the project team (see Appendix A-1 Ref3); All scenario calculations based on 2011 AVAC plus projected tonnage after Southtown build-out. For tpd business refuse & recyclables and RIOC facilities & litterbins, see Appendix A-1 Ref4.							
67	(2) For detailed AVAC electricity use calculation see Elec worksheet.							
68	(3) For detailed mileage calculations, garage and transfer point locations and fuel economy, see mileage worksheet.							
69–70	(4) NYC-specific emission factors for electricity and vehicle fuel from NYCPlan 2011 inventory, for this and calcuation using this coefficient see 2011 NYC Emissions Factors and CO2e coefficient worksheet.							
71	(5) For energy use calculation see current operations worksheet.							
72	(6) for cost calculation see cost-rev worksheet.							
73–74	(7) DSNY here refers to total refuse and recyclables handled by DSNY for each scenario. For tons, see current operations worksheet, cols. B-D. DSNY+Commercial Collection here refers to all waste collected on the island.							

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
2	**Table B-03. Pneumatic vs. Manual Energy Use and GHG Emissions**																		
3		**Tons Per Day (5)**					**KWH Per Day**							**Gallons Per Day**					
4		2011 TPD	Projected TPD	Proj'd TPD Manual	Weight		2011 Actual (6)	Existing AVAC/ No-Action (6)	**U** (7)	**UR** (7)	**URCL** (7)	**Manual**		2011 Actual (1)	Existing AVAC/ No-Action	**U**	**UR**	**URCL**	**Manual (8)**
5	AVAC System						2,649	3,348	531	1,504	2,293								
6	Residential Refuse (3)	5.80	7.33		**0.472**														
7	Residential Recyclables (3)	2.62	3.23		**0.208**									3.3	4.1	4.1			4.1
8	RIOC Street Litter Bins	0.20	0.20		**0.013**									1.4	1.4	1.4	1.4		1.4
9	RIOC Facilities & Parks (2)(4)	0.10	0.10		**0.006**									0.4	0.4	0.4	0.4		
10	Business Refuse & Recyclables (2)	4.68	4.68		**0.301**									21.7	21.7	21.7	21.7		21.7
11	Hauled Off-Island by DSNY (refuse, paper, MGP) (3)(11)	8.32	10.66	10.66										6.6	8.3	7.8	3.6	5.1	
12	Manual (No AVAC) Residential Refuse(4)																		11.4
13	Total/Day	13.40	15.54	10.66	1.000		2,649	3,348	531	1,504	2,293			33.4	35.9	35.4	25.7	5.1	38.6
14	Total/Year	4,891	5,672	3,891			967,000	1,222,088	193,974	548,935	837,017			12,196	13,112	12,922	9,384	1,861	14,096
15	**Weighted Average/Ton**						**457**	**457**	**73**	**142**	**148**			**7.224**	**7.383**	**7.383**		**0.33**	**6.543**
16	**Weighted Average/Ton Electric**																		
17	**Weighted Average/Ton Diesel**																		
18	**Delta Over 2011 Actual Baseline (12)**	100%	116%				100%	126%	20%	57%	87%			100%	108%	106%	77%	15%	116%
19	**Delta Over Projected Baseline (w/ Proj'd Tons)**		100%					100%	16%	45%	68%				100%	99%	72%	14%	108%
20	**Units Avoided v. Proj'd Baseline**								1,028,114	673,153	385,071	1,222,088				190	3,727	11,251	(985)

21 Notes:

22 (1) For fuel use see mileage worksheet.

23 (2) For tpd business refuse & recyclables and RIOC facilities & litterbins , see Appendix A-1 Ref4.

24 (3) Of 2.62 tpd recyclables, 1.59 is Paper and 1.03 is MGP. For current refuse and recyclables see Appendix A-1 Ref1, DS DATA.

25 MGP%: 0.39 OCC%: 0.61

26 See Appendix A-1 Ref4; for fuel use see mileage worksheet. Note: 0.1 tons for RIOC facilities and parks added, some of this is recycling but it is such a small amount all

27 assigned to refuse.

28 (5) "2011 Actual" figures based on data collected by the project team (see Appendix A-1 Ref3); all scenario calculations based on projected tonnage after Southtown build-out (it 15.00

29 (6) DSNY electricity use average FY 2010, 2011, for details see Elec worksheet.

30 (7) For electricity use see Elec worksheet.

31 (8) See mileage worksheet for trips and distances. In the No-AVAC case, the "RIOC facilities/litter bins" value reflects only litter bins; RIOC facilities are included in row 8

32 factors for electricity and

33 (10) http://www.onlineconversion.com/energy.htm

34 (11) For off-island collection details see mileage worksheet.

35 (12) 2011 tons for actual baseline, projected tons in the deltas.

	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK
2																		
3		**Tons CO2 Equivalent**							**Tons CO2Eq/Ton Waste**							**BTU**		
4	Coeff t CO2e/unit (9)	2011 Actual	Existing AVAC/ No-Action	**U**	**UR**	**URCL**	**Manual**		2011 Actual	Existing AVAC/ No-Action	**U**	**UR**	**URCL**	**Manual**	Coeff BTUs/unit (10)	2011 Actual	Existing AVAC/ No-Action	**U**
5	0.0003	0.92	1.17	0.19	0.52	0.80			0.16	0.16	0.025	0.050	0.051		3,412	9,039,837	11,424,483	1,813,335
6																		
7	0.0099	0.03	0.04	0.04			0.04		0.012	0.012	0.012			0.013	125,000	413,190	509,391	509,391
8	0.0113	0.02	0.02	0.02	0.02		0.02		0.078	0.078	0.078	0.078		0.078	138,900	193,468	193,468	193,468
9	0.0099	0.004	0.004	0.004	0.004				0.042	0.042	0.042	0.042			125,000	53,464	53,464	53,464
10	0.0113	0.24	0.24	0.24	0.24		0.24		0.052	0.052	0.052	0.052		0.052	138,900	3,013,469	3,013,469	3,013,469
11	0.0113	0.07	0.09	0.09	0.04	0.06			0.007	0.009	0.008	0.004	0.004		138,900	915,641	1,157,181	1,084,951
12	0.0113						0.13							0.02	138,900			
13		1.29	1.57	0.58	0.83	0.86	0.43									13,629,069	16,351,456	6,668,078
14		473	571	211	303	313	157									4,974,610,080	5,968,281,371	2,433,848,427
15									**0.099**	**0.101**	**0.037**	**0.053**	**0.055**	**0.028**				
16									**0.078**	**0.079**	**0.016**	**0.036**	**0.051**					
17									**0.021**	**0.022**	**0.021**	**0.017**	**0.004**	**0.028**				
18		100%	121%	45%	64%	66%	33%		100%	101%	37%	54%	55%	28%		100%	120%	49%
19			100%	37%	53%	55%	27%			100%	37%	53%	55%	28%			100%	41%
20				360	269	259	415				0.06	0.05	0.05	0.07				3,534,432,944
21																		
22																		
23																		
24																		
25																		
26																		
27																		
28																		
29																		
30																		
31																		
32																		
33																		
34																		
35																		

	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU	AV	AW	AX	AY	AZ
2															
3	**s/Day**				**BTUs per Day/Ton Waste**							**Diesel BTUs/Day**			
4	**UR**	**URCL**	**Manual**		2011 Actual	Existing AVAC/ No-Action	**U**	**UR**	**URCL**	**Manual**		2011 Actual	Existing AVAC/ No-Action	**U**	**UR**
5	5,131,629	7,824,713			1,558,593	1,558,593	247,385	485,950	503,521						
6															
7			512,068		157,706	157,706	157,706			158,535		413,190	509,391	509,391	
8	193,468		1,565		967,339	967,339	967,339	967,339				193,468	193,468	193,468	193,468
9	53,464		174,107		534,645	534,645	534,645	534,645		1,741,071		53,464	53,464	53,464	53,464
10	3,013,469		3,013,469		643,904	643,904	643,904	643,904		643,904		3,013,469	3,013,469	3,013,469	3,013,469
11	498,195	708,180			110,053	108,554	101,778	46,735	45,571			915,641	1,157,181	1,084,951	498,195
12			1,588,335							216,690					
13	8,890,224	8,532,893	5,289,544									4,589,232	4,926,973	4,854,743	3,758,596
14	3,244,931,801	3,114,505,815	1,930,683,401									1,675,069,733	1,798,345,036	1,771,981,312	1,371,887,360
15					**1,053,246**	**1,052,217**	**429,091**	**572,086**	**549,092**	**340,282**		**1,702,169.47**	**1,807,545.66**	**1,757,998.35**	**1,249,622.50**
16					**787,077**	**786,369**	**164,695**	**361,979**	**503,521**						
17					**266,169**	**265,848**	**264,396**	**210,108**	**45,571**	**330,472**					
18	65%	63%	39%		100%	100%	41%	54%	52%	32%					
19	54%	52%	32%			100%	41%	54%	52%	32%					
20	2,723,349,570	2,853,775,556	4,037,597,970				623,126	480,131	503,125	711,935					
21															
22															
23															
24															
25															
26															
27															
28															
29															
30															
31															
32															
33															
34															
35															

	BA	BB	BC	BD	BE	BF	BG	BH	BI
2									
3				**Electric BTUs/Day**					
4	**URCL**	**Manual**		2011 Actual	Existing AVAC/ No-Action	**U**	**UR**	**URCL**	**Manual**
5				9,039,837	11,424,483	1,813,335	5,131,629	7,824,713	
6									
7		512,068							
8									
9		174,107							
10		3,013,469							
11	708,180								
12		1,588,335							
13	708,180	5,287,978		9,039,837	11,424,483	1,813,335	5,131,629	7,824,713	0
14	258,485,655	1,930,112,040		3,299,540,347	4,169,936,335	661,867,115	1,873,044,440	2,856,020,160	0
15	**485,791**	**1,015,085.12**		**3,912,765**	**5,388,768**	**855,324**	**2,420,517**	**3,690,807**	
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									
26									
27									
28									
29									
30									
31									
32									
33									
34									
35									

	BJ	BK	BL	BM	BN	BO	BP	BQ	BR	BS	BT	BU	BV	BW
2	**Table B-03A. Sensitivity Analysis Effect of Electricity Use On Energy Use and GHG Emissions for Upgrade, Recycling, Commercial & Litter**													
3			**KWH Per Day**					**Gallons Per Day**					**Tons CO2 Eq**	
4		**Tons Per Day (5)**	**50% URCL**	**75%URCL**	**URCL 120%**	**URCL 150%**		**50% URCL**	**75%URCL**	**URCL 120%**	**URCL 150%**	Coeff t CO2e/unit (9)	**50% URCL**	**75%URCL**
5														
6	Residential Refuse (3)	7.33	1,146.60	1,719.90	2,752	3,440						0.0003	0.3995	0.5993
7	Residential Recyclables (3)	3.23										0.0099		
8														
9	RIOC Facilities & Parks (2)(4)	0.10										0.0099		
10	Business Refuse & Recyclables (2)	4.68										0.0113		
11	Hauled Off-Island by DSNY (refuse, paper, MGP) (3)(11)	10.66						5	5	5	5	0.0113	0.0575	0.0575
12	Manual (No AVAC) Residential Refuse(4)											0.0113		
13	Total/Day	15.54			2,752	3,440		5.10	5.10	5	5		0.46	0.66
14	Total/Year	5,672.10			1,004,420	1,255,526		1,861	1,861	1,861	1,861		166.81	239.72
15	Weighted Average/Ton		**73.78**	**110.68**	**177.08**	**221.35**								

	BX	BY	BZ	CA	CB	CC	CD	CE	CF	CG	CH	CI
2												
3	**uivalent**					**BTUs/Day**				**Tons CO2Eq/Ton Waste**		
4	**URCL 120%**	**URCL 150%**	Coeff BTUs/unit (10)	**50% URCL**	**75%URCL**	**URCL 120%**	**URCL 150%**		**50% URCL**	**75%URCL**	**URCL 120%**	**URCL 150%**
5												
6	0.96	1.20	3,412	3,912,356	5,868,535	9,389,655	11,737,069		0.03	0.04	0.06	0.08
7			125,000									
8												
9			125,000									
10			138,900									
11	0.06	0.06	138,900	708,180	708,180	708,180	708,180		0.004	0.004	0.004	0.004
12			138,900									
13	1.02	1.26		4,620,536	6,576,714	10,097,835	12,445,249		0.03	0.04	0.07	0.08
14	371	458		1,686,495,735	2,400,500,775	3,685,709,847	4,542,515,895					
15									**0.03**	**0.04**	**0.07**	**0.08**

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	**Table B-04. Pneumatic vs Manual Mileage Factors**														
2		**Total System (on RI and off RI)**													
3		**No AVAC Scenario:**													
4		**Recyclables, DSNY 1-bin rear-loader(1,3,12):**	Tons/Wk	Trips/ Wk	Miles/ Wk	Miles/ Day	Gals/ Wk	Gals/ Day							
5		Paper: garage-Island-rte-paper dump-garage	13.7	2	39.4										
6		MGP: garage-Island-rte-MGP dump-garage	8.9	1	23.4										
7		*Subtotal*			62.8	9.0		4.1							
8		**Refuse, DSNY rear-loader(3):**													
9		Garage-Island-rte-refuse dump-garage(12,13):	51.3	5	112.5										
10		*Subtotal*			112.5	16.1		7.3							
11		*Total*			175.3	25.0		11.4							
12		**Current DSNY Off-Island Transport from AVAC & AVAC yard:**													
13		Roll-On Roll-Off pick-up from AVAC facility(11):		trips/Wk	Miles/ Wk	Miles/ Day	Gals/ Wk	Gals/ Day (15)					**Refuse**	**MGP**	**OCC**
14		Round trips garage-AVAC(2)		6.00	141.6				**Current**	% Total RO RO miles by fraction			0.39	0.17	0.44
15		Round trips AVAC-dump(7)		2.75	34.7					Total miles per week			90	40	101
16		Round trips AVAC-mgp (7)		2.48	15.4					Total miles per year			4,665	2,071	5,263
17		Round trips AVAC-OCC(7)		5.92	39.1					Total gallons per year			933	414	1,053
18		*Subtotal*			230.7	33.0		6.6							
19		**Future DSNY Off-Island Transport (15):**							**No-Action**	% Total RO RO miles by fraction			0.39	0.17	0.44
20	**No-Act.**	Round trips garage-AVAC(2)		7.58	179.0					Total miles per week			113	50	128
21	(Proj'd T)	Round trips AVAC-dump(7)		3.48	43.8					Total miles per year			5,895	2,617	6,651
22		Round trips AVAC-mgp (7)		3.14	19.4					Total gallons per year			1,179	523	1,330
23		Round trips AVAC-OCC(7)		7.49	49.4										
24		Subtotal			291.6	41.7		8.3	**U**	% Total RO RO miles by fraction			0.27	0.21	0.52
25	**U**	Round trips garage-AVAC(2)		7.58	179.0					Total miles per week			74	56	143
26		Trips AVAC-dump (6)		2.03	25.6					Total miles per year			3,852	2,926	7,437
27		*Subtotal*			204.5	29.2				Total gallons per year			770	585	1,487
28		*Total trips MGP-mgp and occ, same as No-Action*		8.40	273.4	39.1		7.8							
29	**UR**	Round trips, garage to AVAC per week		3.77	88.9				**UR**	% Total RO RO miles by fraction			0.69	0.15	0.15
30		Round trips AVAC-dump (6)		2.02	25.4					Total miles per week			87	19	19
31		Round trips AVAC-MGP		0.91	5.7					Total miles per year			4,535	1,011	982
32		Round trips AVAC-OCC		0.83	5.5					Total gallons per year			907	202	196
33		*Subtotal*			125.5	17.9		3.6							
34	**URCL**	Round trips garage to AVAC		5.28	124.7				**URCL**	% Total RO RO miles by fraction			0.75	0.12	0.13
35		Round trips AVAC-dump (6)		3.21	40.5					Total miles per week			134	21	23
36		Round trips AVAC-MGP (8)		1.02	6.3					Total miles per year			6,991	1,089	1,199
37		Round trips AVAC-OCC		1.05	6.9					Total gallons per year			1,398	218	240
38		*Subtotal*			178.4	25.5		5.1							

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
39		**Current Private Carter(14)**													
40		Commercial Waste, rear-loaders, E-Z Paks(1)(3)	Trash/Recy												
41		Carter 1	T	7	46.2		15.4								
42			R	5	37.0		12.3								
43		Carter 2	T	3	65.4		21.8								
44		Carter 3	T	2	11.2		3.7								
45			R	1	8.1		2.7								
46		Carter 4	T	6	81.0		27.0								
47			R	6	81.0		27.0								
48		Carter 5	T	3	24.0		8.0								
49			R	3	19.2		6.4								
50		Carter 6	T	3	39.6		13.2								
51			R	3	42.9		14.3								
52		TOTAL		42		65.1	151.9	21.7							
53		Trips/day		6											
54	Hospital	Carter 1	Coler	1			25	3.6							
55		**Current Litter Bins**(4)				8.4	9.75	1.4							
56		**Current RIOC/Parks**(5)				7.1	3.0	0.4							
57		*Subtotal*				15.5		1.8							
58		**Current Residential Recyclables**(9)(10)													
59			Rivercross			1.2	0.6								
60			Octagon			0.4	0.3								
61			The Child School			0.0	0.0								
62			Roosevelt Landings			0.2	0.2								
63			IS/PS 217			0.0	0.0								
64			Southtown			2.4	5.7								
65			Island House/Westview			4.0	1.7								
66			Manhattan Park			0.8	0.4								
67			Cornell/Related		42.4	6.1	14.1								
68			TOTAL			15.1	23.1	3.3							
69	**Locations(12)**														
70		DSNY garage, Queens N7	120-15 31st Avenue, College Point												
71		DSNY refuse dump (Tully)	127-20 34th Avenue, College Point												
72		DSNY paper dump (Rapid Processing)	860 Humboldt Street, LIC												
73		DSNY MGP dump (Sims Recycling)	30-27 Greenpoint Ave., Brooklyn												
74															
75	**Distances (miles)**														
76		DSNY garage-RI	11.8												
77		RI DSNY collection route	2.8												
78		RI-DSNY refuse dump	6.3												
79		DSNY refuse dump-garage	1.6												
80		RI-DSNY paper dump	3.3												
81		DSNY paper dump-DSNY garage	1.8												
82		RI-DSNY MGP dump	3.1												
83		DSNY MGP dump-DSNY garage	5.7												
84	**Notes:**														

85		
86	(1) Total RI curbside route distance incl. parks at south end (2.8 miles):576 Main St. to 1 Main Street .8 mi;405 Main St. to 888 Main Street 1.4 mi;888 Main St. to 576 Main Street .6 mi. Distances calculated using Google maps.	
87	(2) For current off-Island transport, an avg of 2 container pickups per day of varying fractions (11.15 avg total pick-up trips/wk), therefore assume just 6 round-trips/wk between	
88	garage and AVAC. Same assumption made for future U scenario, on same grounds.	
89	(3) Manhattan Rear-loader fuel economy from Multi-Fleet Demonstration of Hydraulic Regenerative Braking Technology In Refuse Truck Applications, Final Report prepared for NYSERDA, 2011, p44 Table 26. http://bit.ly/13b9Wd0, last accessed 02/21/13:	**2.19**
90	Fuel economy assumed for private carters (assumed higher than DSNY because some collections use ro-ros and trips may involve fewer stops than for DSNY collections):	**3**
91	(4)(route distance*trips per week)/mileage=5-mile pick-up route * 5 times a week + 14-mile round-trip to dump once a wk, 6mpg. Trip information from UTRC Field Survey	
92	(Fernando Vargas, RIOC, interview and tour Lisa Douglass, 11/28/11 and 12/5/11 (tour)	
93	Assumed mpg for RIOC 10 cy rear-loader (imputed from Cell M88, for a 25cy rear-loader)	**4**
94	Economy using: http://www.mpgbuddy.com/index.php, accessed 9-6-11;)http://www.epa.gov/otaq/fetrends.htm, accessed 9-5-11, 2010 report, full tables, table 1, assumes 2010	
95	LD truck. ((route distance*trips per week)+(off-island disposal*trips per week))/mileage. Trip information and fuel economy from Sean Singh, RIOC, telecon Juliette Spertus, 10-13-	
96	11	
97	RIOC pick-up truck mpg	**16.7**
98	(6) Although it would be most efficient for AVAC refuse containers to go to the rail transfer yard at 123 Varick Avenue since the need for containerization and barge transport would be	
99	eliminated, for consistency we are assuming that refuse containers would still be taken to Tully. As in all other cases, empty containers would be picked up at the dump site with each	
100	drop-off, and returned to RI.	
101	(7) Current DSNY truck trips from terminal to dump or recycling facility from DSNY Collection Data (SCAN) FY2012.	
102	(8) Commercial OCC=.57tpd; MPG=.14tpd. (Appendix A-1, Ref4)	
103	(9) Fuel economy for light trucks: NYC-specific emission factors from NYCPlan 2010 inventory, http://home2.nyc.gov/html/om/pdf/2010/pr412-10_report.pdf, table 3	
104	(10) Total-system version uses 2011 actual (e.g., actual mix of private carters and building porters)--private carters get 3mpg and have to drive to and from the Island; hypothetical	
105	on-Island-only version assumes all light-trucks.	
106	(11) Assumed fuel economy for Ro-Ro trucks, mpg:	**5**
107	(12) DSNY locations:Brautigam to Miller, 10-11-11. The North Shore MTS (adjacent to the DSNY garage, and near the present (Tully) transfer station, will be used when construction	
109	is completed, but the Tully transfer station is used in all cases in order to have an even comparison based on actual data (SCAN DSNY). Per SCAN FY 2012 & DSNY Web site (3-22-13), Q7 gets refuse collection 2x wk and recycling collection 1xwk; Q7 generally uses 2-compartment trucks, but given RI's recyclables volume, it is assumed that 1-bin trucks would	
110	be used. It is assumed that in each case (refuse and recyclable fractions), the truck's RI route represents a full load. In the case of paper, 13.7 tons is too much for 1 trip. A typical DSNY 1-bin paper load is somewhat under 7 tons.	
111	(13) Projected refuse tonnage=51.3tpwk. Per DSNY protocol (Brautigam to Miller, 6-30-11), number of Start Trucks based on targeted tons divided by ZWA tonnages, =5 Truck	
112	Starts/wk.	
113	(14) Reconnaissance Report, Reference Documents, Reference 5: Fuel. Estimated distances based on the distance between the farthest RI customer and the carter's transfer station	
114	for that fraction, 1-way, x the maximum number of collections per week on RI for that carter. Round-trip distances (from the carter's garage to RI, or from the dump site to the	
115	garage) are not included, since the volumes collected on RI never represent a full load. On the assumption that the truck also collects waste at other stops, only this portion of the	
116	truck's miles is attributed to the RI portion of the load.	
117	(15) All future scenarios assume projected tons, or relative to current 2011 tons, a projected increase of:	**1.26**

Table B-05. PlaNYC Emissions Coefficients

Source: http://nytelecom.vo.llnwd.net/o15/agencies/planyc2030/pdf/greenhousegas_2011.pdf Last accessed 2-5-13.

Appendix H

Electricity Emissions Coefficients

2005 ELECTRICITY EMISSIONS COEFFICENT

	Generation (GJ)	CO_2 (Mg)	CO_2/GJ (kg)	CH_4 (Mg)	CH_4/GJ (kg)	N_2O (Mg)	N_2O/GJ (kg)	CO_2e (Mg)	CO_2e/GJ (kg)	Source energy (GJ)	Source GJ/GJ
In-city	88,618,432	13,939,008	157.292	274.78	0.00310	29.72	0.00034	13,953,992	157.462	233,463,499	2.634
Contract	63,154,249	2,045,234	32.385	38.57	0.00061	3.86	0.00006	2,047,240	32.417	221,522,697	3.508
NYISO Zone A	13,308,192	1,358,448	102.076	15.04	0.00113	21.85	0.00164	1,365,536	77.907	16,451,345	1.236
NYISO Zone D	5,613,408	170,458	30.366	3.22	0.00057	0.32	0.00006	170,625	102.609	3,849,636	0.686
Market procurement (Zone G, H, I)	23,730,919	3,753,034	158.150	84.58	0.00356	44.94	0.00189	3,768,740	30.396	68,670,819	2.894
Total	194,425,200	21,266,182	109.380	416.20	0.00214	100.68	0.00052	21,306,134	109.585	543,957,994	**2.798**
Total 2005 NYC consumption	185,030,541		Coefficient with transmission and distribution losses								
Transmission and distribution loss rate	-4.83%		114.665		0.00224		0.00054		115.149		

2006 ELECTRICITY EMISSIONS COEFFICENT

	Generation (GJ)	CO_2 (Mg)	CO_2/GJ (kg)	CH_4 (Mg)	CH_4/GJ (kg)	N_2O (Mg)	N_2O/GJ (kg)	CO_2e (Mg)	CO_2e/GJ (kg)	Source energy (GJ)	Source GJ/GJ
Total	191,145,600	16,238,006	84.951	328.16	0.00172	84.47	0.00044	18,207,698	95.256	581,737,144	**3.043**
Total 2006 NYC consumption	181,779,844		Coefficient with transmission and distribution losses								
Transmission and distribution loss rate	-4.90%		89.113		0.00180		0.00046		100.163		

2007 ELECTRICITY EMISSIONS COEFFICENT

	Generation (GJ)	CO_2 (Mg)	CO_2/GJ (kg)	CH_4 (Mg)	CH_4/GJ (kg)	N_2O (Mg)	N_2O/GJ (kg)	CO_2e (Mg)	CO_2e/GJ (kg)	Source energy (GJ)	Source GJ/GJ
Total	197,100,000	17,370,651	94.809	329.64	0.00175	69.212	0.00046	17,399,030	94.989	572,790,221	**2.906**
Total 2007 NYC consumption	188,202,200		Coefficient with transmission and distribution losses								
Transmission and distribution loss rate	-4.51%		99.090		0.00182		0.00048		99.480		

2008 ELECTRICITY EMISSIONS COEFFICENT

	Generation (GJ)	CO_2 (Mg)	CO_2/GJ (kg)	CH_4 (Mg)	CH_4/GJ (kg)	N_2O (Mg)	N_2O/GJ (kg)	CO_2e (Mg)	CO_2e/GJ (kg)	Source energy (GJ)	Source GJ/GJ
Total	197,406,000	18,097,970	91.679	322.32	0.00163	91.96	0.00047	18,133,245	91.858	566,884,779	**2.872**
Total 2007 NYC consumption	186,150,634		Coefficient with transmission and distribution losses								
Transmission and distribution loss rate	-5.70%		96.906		0.00173		0.00049		97.412		

2009 ELECTRICITY EMISSIONS COEFFICENT

	Generation (GJ)	CO_2 (Mg)	CO_2/GJ (kg)	CH_4 (Mg)	CH_4/GJ (kg)	N_2O (Mg)	N_2O/GJ (kg)	CO_2e (Mg)	CO_2e/GJ (kg)	Source energy (GJ)	Source GJ/GJ
In-city	83,690,030	10,784,766	128.866	204.98	0.00245	20.79	0.00025	10,795,517	128.994	214,179,004	2.559
Contract	51,125,157	1,630,338	31.889	30.75	0.00060	3.07	0.00006	1,631,937	31.920	215,435,675	4.214
NYISO Zone A	13,308,192	1,035,413	77.803	11.08	0.00083	17.35	0.00130	1,041,025	78.224	11,969,363	0.899
NYISO Zone D	5,613,408	102,679	18.292	1.94	0.00035	0.19	0.00003	102,780	18.310	2,043,149	0.364
Market procurement (Zone G, H, I)	34,899,058	2,481,293	71.099	38.66	0.00111	36.12	0.00104	2,493,303	71.443	97,101,617	2.782
Market procurement (ROS)	2,524,154	133,372	52.838	0.96	0.00038	0.90	0.00036	133,802	53.009	4,440,372	1.759
Total	191,160,000	16,167,861	84.578	288.37	0.00151	78.44	0.00041	16,198,364	84.737	545,169,181	**2.852**
Total 2009 NYC consumption	182,649,671		Coefficient with transmission and distribution losses								
Transmission and distribution loss rate	-4.45%		88.343		0.00158		0.00043		88.685		

2010 ELECTRICITY EMISSIONS COEFFICENT

	Generation (GJ)	CO_2 (Mg)	CO_2/GJ (kg)	CH_4 (Mg)	CH_4/GJ (kg)	N_2O (Mg)	N_2O/GJ (kg)	CO_2e (Mg)	CO_2e/GJ (kg)	Source energy (GJ)	Source GJ/GJ
In-city	86,233,586	11,021,449	127.809	209.44	0.00243	21.24	0.00025	11,032,431	127.937	218,888,739	2.538
Contract	48,658,118	1,805,308	37.102	34.05	0.00070	3.40	0.00007	1,807,079	37.138	217,473,479	4.469
NYISO Zone A	13,308,192	1,149,229	86.355	12.37	0.00093	19.13	0.00144	1,155,420	86.820	13,169,352	0.990
NYISO Zone D	5,613,408	41,261	7.350	0.78	0.00014	0.08	0.00001	41,302	7.358	820,968	0.146
Market procurement (Zone G, H, I)	38,229,527	2,318,993	60.660	39.13	0.00102	31.53	0.00082	2,329,591	60.937	107,223,986	2.805
Market procurement (ROS)	6,367,569	375,193	58.922	2.35	0.00037	1.90	0.00030	376,333	59.102	11,365,231	1.785
Total	198,410,400	16,711,433	84.227	298.12	0.00150	77.29	0.00039	16,742,155	84.381	568,941,755	**2.867**
Total 2010 NYC consumption	190,667,806		Coefficient with transmission and distribution losses								
Transmission and distribution loss rate	-3.90%		87.647		0.00156		0.00041		87.808		

Appendix I

Fuel Emissions Coefficients

2010 FUEL EMISSIONS COEFFICIENTS							
	UNIT	GREENHOUSE GAS (Kg/UNIT)					FUEL EFFICIENCY (Km/UNIT)
		CO_2	CH_4	N_2O	CO_2e	GJ/UNIT	
Stationary source							
Natural gas (buildings)	GJ	50.25326	0.00474	0.00009	50.38216	0.99995	
Natural gas (industrials)	GJ	50.25326	0.00095	0.00009	50.30254	0.99995	
#2 fuel oil (buildings)	liter	2.69627	0.00040	0.00002	2.71147	0.03846	
#2 fuel oil (industrial)	liter	2.69627	0.00011	0.00002	2.70534	0.03846	
#4 fuel oil (buildings)	liter	2.89423	0.00042	0.00002	2.91031	0.04069	
#4 fuel oil (industrial)	liter	2.89423	0.00012	0.00002	2.90383	0.04069	
#6 residual fuel oil (buildings)	liter	2.97590	0.00044	0.00002	2.99242	0.04181	
#6 residual fuel oil (industrial)	liter	2.97590	0.00012	0.00002	2.98576	0.04181	
100% biodiesel*	liter	2.49683	0.00004	0.00000	2.49876	0.03567	
Propane (industrial)	liter	1.47748	0.00007	0.00001	1.48346	0.02536	
Kerosene (industrial)	liter	2.68187	0.00011	0.00002	2.69075	0.03762	
Mobile source							
On-road							
Diesel - buses	liter	2.69720	0.00002	0.00002	2.70253	0.03849	5.38
Diesel - light trucks	liter	2.69720	0.00000	0.00000	2.69851	0.03849	4.38
Diesel - heavy-duty vehicles	liter	2.69720	0.00001	0.00001	2.70082	0.03849	3.65
Diesel - passenger cars	liter	2.69720	0.00000	0.00000	2.69854	0.03849	6.73
Gasoline - light trucks	liter	2.31968	0.00012	0.00017	2.37403	0.03484	6.21
Gasoline - passenger cars	liter	2.31943	0.00015	0.00016	2.37200	0.03484	8.72
100% biodiesel (B100) - heavy trucks*	liter	2.49710	0.00004	0.00000	2.49903	0.03568	3.65
100% ethanol (E100) - passenger cars*	liter	1.51899	0.00022	0.00027	1.60857	0.02342	6.58
Compressed natural gas - bus	GJ	50.28833	0.10395	0.00925	55.33978	1.00000	0.37
Off-road							
Aviation gasoline	liter	2.19527	0.00186	0.00003	2.24333	0.03350	
Diesel, locomotives	liter	2.52840	0.00007	0.00008	2.55529	0.03763	
Diesel, ships and boats	liter	2.69720	0.00021	0.00007	2.72293	0.03866	
Jet fuel	liter	2.69749	0.00020	0.00007	2.72289	0.03866	

* Per the LGOP, CO_2 from biofuels is considered biogenic and is reported as a Scope 3 source

** Per the LGOP, building usage here is identified as residential, commerical, or institutional

	A	B	C	D	E	F
1	**Table B-05 PlaNYC Emissions Coefficients (unit conversion)**					
2	**PlaNYC Factors**	**kg CO2e/GJ(1)**	**kwh per Giga Joule**	**kg CO2e/kwh**	**kg per ton (US)**	**t CO2e/kwh**
3	electricity	87.808	277.77	0.316117651	907.18	0.000348462
4						
5						
6						
7						
8		**kg CO2e/liter (2)**	**liters per gallon**	**kg CO2e/gallon**	**kg per ton (US)**	**t CO2e/gallon**
9	gasoline ld truck	2.37	3.78541	8.986676902	907.18	0.009906167
10	diesel hd truck	2.70	3.78541	10.22371104	907.18	0.011269771
11						
12	Notes:					
13	(1) See 2011 NYC Emissions Factors worksheet, Appendix H, Coefficient with transmission and					
14	distribution losses					
15	(2) See 2011 NYC Emissions Factors worksheet, Appendix I					
16						
17						
18	87.808 coefficient for kg CO2e/unit based on weighted average of emissions from energy generation at power plants					
19	serving NYC. To convert electricity to CO2e emissions per ton: 87.81 kg CO2e/GJ * electricity in Giga Joules					
20	(277.77GJ/kwh) = kg CO2e per day/1102.3 = tons C02e per day/tons collected per day = tons CO2e emissions per ton.					
21	To convert diesel or gasoline to CO2e/l convert gallons to liters					
22	NYC-specific emission factors for electricity and vehicle fuel from NYCPlan 2011 inventory, appendix H, I					
23	http://nytelecom.vo.llnwd.net/o15/agencies/planyc2030/pdf/greenhousegas_2011.pdf					

	A	B	C	D	E
1	**Table B-06. Pneumatic vs. Manual Potentially Achievable Waste-Generator Savings**				
2					
3	**Annual Cost to Building Managers for Refuse Handling Space, Labor & Equipment**				
4		Space	Labor	Equipment	**Total**
5	Manual (No AVAC) (Refuse & Recycling Staging)	$1,134,231	$837,096	$295,524	**$2,266,851**
6	No-Action or Upgrade-Only ""	$343,142	$711,971	$125,488	**$1,180,601**
7	Upgrade +Rec (4)	$104,452	$711,971	$0	**$816,423**
8	*Savings, Upgrade v. Manual (N0-AVAC)*	$791,089	$125,125	$170,036	**$1,086,250**
9	*Savings, Upgrade v. Manual (labor & equipment only)*		$125,125	$170,036	**$295,161**
15	*Additional Savings, Upgrade + Rec v. No-Action or Upgra*	$238,691	$0	$125,488	**$364,178**
16					
17	**Annual Cost to RIOC of AVAC Terminal Space**				
18		As Land Lease(1)	#Parking Spaces(2)	Rent as Parking Lot(3)	
19	No-Action	$63,425	120	$338,231	
20	No-AVAC	$36,591	69	$195,128	
21	Upgrade-only	$40,368	76	$215,271	
22	Upgrade +Rec	$25,413	48	$135,521	
23	Upgrade+Comm+Litter	$30,852	58	$164,527	
24					
25	(1) Using land lease/sf/year cost for Manhattan Park. See Rent worksheet.				
26	(2) 200sf per space, 150 for aisles, see planning for shopping center parking,				
27	http://www.planning.org/pas/at60/report59.htm).				
28	(3) Using current $235 monthly rate for reserved parking spot at Motorgate garage on Roosevelt Island,				
29	http://www.rioc.com/parking.htm				
30	(4) SF in waste rooms and labor to collect recyclables, but no SF for central storage and staging areas. On RI it is				
31	assumed that porters would continue to collect recyclables from each floor and deposit them in exterior AVAC inlets.				
32	NOTE: Current space in existing Roosevelt Island residential buildings is unlikely to be converted to rentable space. For				
33	example, refuse and recyclables tend to be staged in basement spaces rather than on the ground floor. The space savings				
34	calculations here are meant to illustrate the savings that could be achieved. Although existing spaces for recyclables were				
35	inventoried in the Reconaissance Report (Appendix A-1), the projected SF required were based on Local Law 60 of 2012				
36	and the Planning Department's "Quality Housing Program" (which currently only applies to certain districts).				

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	**Table B-06. Pneumatic vs. Manual Potentially Achievable Waste-Generator Savings**								**(continued)**				
2	**Space**												
3	**Location**	Residential Units(17)	Manual Central Refuse Staging SF (9)	Central Recycl'g Staging SF (2)	Recycl'g storage in Waste Rooms SF (2)	Value In Annual Rent for Manual Recycling Staging(18)	Value In Annual Rent for Manual Refuse Staging(18)	Public space required 1x week for recyclables staging (DSNY collection) SF	Public Space Req. 4x Week for Refuse Staging (DSNY Collection) SF	# Existing Resident Waste Rooms	# Existing Central Int. Recycling Staging Areas(17)	Existing Waste Valves AVAC (5)	Existing Exterior Recycling Staging Areas SF (6)
4	**Residential Buildings**												
5	Octagon	501	1452.9	438.375	130	$26,563	$67,901	365	202	26	0	2	0
6	Manhattan Park	1107	3210.3	968.625	560	$71,440	$150,032	806	446	112	0	4	2241
7	Westview	371	1075.9	324.625	140	$21,714	$50,282	270	150	28	1	2	0
8	Roosevelt Landings (1)	1003	2908.7	877.625	275	$53,867	$135,937	730	404	55	2	6	0
9	Island House	400	1160	350	205	$25,938	$54,212	291	161	41	1	1	0
10	Rivercross	377	1093.3	329.875	250	$27,100	$51,095	275	152	50	1	6	0
11	South Town Buildings	1278	3706.2	1118.25	450	$73,291	$173,207	931	515	90	6	6	0
12	Planned Future South Town Buildings	800	2320	700	225	$43,229	$108,424	583	322	45	0	3	0
13	**Total Residential**	**5837**	**16927.3**	**5107.375**	**2235**	**$343,142**	**$ 791,089**	**4251**	**2352**	**447**	**11**	**30**	**2241**
14	**Businesses (6)**	NA								NA	NA	NA	400
15	SF sidewalk required for staging recyclable and refuse bags (16)						4						
16	Annual cost of compactor including maintenance (15)						$3,193						
17	Labor minutes/bag of refuse staging (14)						9						
18	Labor minutes/bag of recycling staged for weekly collection (13)						11.5						
19	Pounds of recycling per day per unit (17)						1.0						
20	Pounds of refuse per day per unit (17)						2.3						
21	Annual Ext Lease Value/SF (18)						$2						
22	Annual Residential Rent/SF (18)						$47						
23	Total Imputed Annual Labor hours (10)						19,188						
24	Imputed annual labor hours recycling staging/unit (10)						3.81						
25	SF Central Recyclables Staging/Unit(2)						0.88						
26	SF Recylables/Waste Room(2)						5						
27	SF Central Refuse Staging/Unit (9)						2.9						
28	SF Existing Terminal Total(3)						41,979						
29	SF Existing Terminal Truck Access, bulk & recyclables staging (4)						24,218						
30	SF Terminal **U** (3)(4)						26,718						
31	SF Terminal **UR** (3)(4)						16,820						
32	SF Terminal **URCL** (3) (4)						20,420						
33	Labor $/Employee/Yr(8)						$60,000						
34	Labor $/hour						$29						
35	Annual imputed recycling equipment cost/unit (bins only) (11)						$0.20						

	O	P	Q	R	S	T	U	V
1	**Table B-06. Pneumatic vs. Manual Potentially Achievable Waste-Generator Savings**							**(continued)**
2	**Labor**							
3	**Location**	Residential Units(17)	Current Imputed Annual Hours Recyclables Handling (10)	Current Imputed Annual Cost Manual Recyclables Handling (8)	Annual Hours for Recycling Staging (DSNY Collection) (12)	Annual Cost for Recycling Staging (DSNY Collection) (13)	Annual Hours for Manual Refuse Handling	Annual Cost for Refuse Staging (DSNY Collection) (14)
4	**Residential Buildings**							
5	Octagon	501	1909	$55,053	912	$26,294	1,579	$45,555
6	Manhattan Park	1107	4217	$121,645	2,014	$58,100	3,489	$100,657
7	Westview	371	1413	$40,768	675	$19,472	1,169	$33,734
8	Roosevelt Landings (1)	1003	3821	$110,216	1,825	$52,641	3,162	$91,201
9	Island House	400	1524	$43,955	728	$20,994	1,261	$36,371
10	Rivercross	377	1436	$41,427	686	$19,786	1,188	$34,280
11	South Town Buildings	1278	4868	$140,435	2,325	$67,075	4,028	$116,206
12	Planned Future South Town Buildings	800	3048	$158,471	1,456	$41,987	2,522	$72,742
13	**Total Residential**	**5,837**	**22,236**	**$711,971**	**10,620**	**$306,349**	**18,399**	**$530,747**
14	**Businesses (6)**	NA						

	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH
1	**Table B-06. Pneumatic vs. Manual Potentially Achievable Waste-Generator Savings (continued)**									
2	**Equipment**									
3	**Location**	Residential Units(17)	Current Estimated Annual Bin & Bag Cost, Recyclables Handling(7)	Projected Ann. Cost Compactor Incl. Maint. (DSNY collection) (15)	60 Gal Bags Refuse/Day (12)	60 Gal Bags Refuse/Y	Annual Cost Refuse Bags (12)	60 Gal Bags Recycling/Day (13)	60 Gal Bags Recycling/Y	Annual Cost Recycling Bags (12)
4	**Residential Buildings**									
5	Octagon	501	$5,437	$6,387	29	10,528	$11,808	13	4,756	$5,334
6	Manhattan Park	1107	$12,013	$12,773	64	23,263	$26,092	29	10,508	$11,786
7	Westview	371	$4,026	$6,387	21	7,796	$8,744	10	3,522	$3,950
8	Roosevelt Landings (1)	1003	$10,884	$19,160	58	21,078	$23,641	26	9,521	$10,679
9	Island House	400	$4,341	$3,193	23	8,406	$9,428	10	3,797	$4,259
10	Rivercross	377	$4,091	$19,160	22	7,922	$8,886	10	3,579	$4,014
11	South Town Buildings	1278	$13,868	$19,160	74	26,857	$30,122	33	12,132	$13,607
12	Planned Future South Town Buildings	800	$8,681	$9,580	46	16,812	$18,856	21	7,594	$8,518
13	**Total Residential**	**5837**	**$63,341**	**$95,800**	**336**	**122,662**	**$137,577**	**152**	**55,409**	**$62,147**
14	**Businesses (6)**	NA								

Notes

(1) Roosevelt Landings is very complicated and number of waste rooms wasn't calculated during the building survey. There are 4 wings with corridors every 3rd floor, or 7 corridors. Each has at least 1 waste room. According to the building survey, there are no waste rooms in the 3 rear wings; residents walk their waste accross via corridor. There seems to be at least 1 waste room at each of the 3 corridors of the 3 wings facing main street. This would account for 7 valves, or 37 waste rooms. Not including floor mounted valves in the basement, there are 3 other chutes shown on the network map. Assume that these are located on 3-floor buildings.

(2) Resident waste room refers to the space where residents deposit their trash. Local Law 60 of 2012 amends the building code so that new multifamily buildings must provide 5 sf of space in each waste room for recyclables and up to 350 sf for staging. Estimated 350 sf per 400 units (beginning in 2014). http://www.crainsnewyork.com/article/20121211/REAL_ESTATE/121219978

(3)) All scenarios considered assumed that a new terminal facility will be built. The current terminal building occupies 17,760 sf and the truck access and bulk and recyclables material staging area occupies 24,218 sf, for a total occupied area of 41,979 sf. The new terminal building will require between 3,000 and 10,000 sf, depending on the complexity of the system, while the truck-maneuvering and bulk-staging area will require about 12,120 sf. Thus approximately 20,000 sf (half an acre) could be available for new use if the existing building were demolished or repurposed (rather than simply putting the new equipment inside the existing building), a new terminal building were constructed, and recyclables were handled by the pneumatic system. If recyclables continued to be handled manually, approximately the same amount of space would be available for re-purposing, since the additional outdoor area required for staging these materials would be roughly offset by the decreased space required for the terminal building.

(4) Footprint sf Upgrade-Only terminal: 2500; sf Upgrade+Rec terminal: 4700; sf Upgrade+Rec.+Comm+Litter terminal: 8300. Terminal areas calculated from floor plans Envac Resum new scenarios 2012 06 06.ppt.

(5) Existing network map NY-002-000C_existent_js.pdf; 40 valves in use, 30 at the bottom of vertical chute rooms in residential buildings, 1 in school, Jerry Sorgente to Juliette Spertus 10/28/11

(6) For existing residential building data, see Ref 5 Impact Calcs and Ref 6 bldg survey in Appendix A-1. For existing business data, see Ref 4-business calcs-redacted. For businesses refuse and recycling, space requirements are combined. SF for containers is doubled to account for access and maneuvering.

(7) Total cost in Ref5, number of bins per building and cost per bin calculated in Ref6, Appendix A-2.

(8) Assumes an annual salary of $60,000 (with fringe) for property manager based on average listed on http://www.indeed.com/salary?q1=property+manager&l1=New+York%2C+NY

(9) "storage and removal locations shall be provided at the rate of 2.9 cubic feet per #dwelling unit#" NYC Dept. of City Planning, Article II: Residence District Regulations Chapter 8 - The Quality Housing Program, 28-23 Refuse Storage and Disposal, (2/2/11)

(10) Total imputed labor hours for residential recycling 53 hours per week or 2756 hours per year, residential survey in Ref5 Appendix A-1. Current Imputed hours generated by dividing 2756 by total units and multiplying each buildings units by hours per unit.

(11) Recycling bins only. Assume equipment will be replaced every 10 years, or 10% of total cost of bins for residential recycling. See Ref 5 Appendix A-1, for current equipment cost including vehicles and carts but not including bags.

(12) Equipment cost based on High Line supplies: Trash bags 225 cases per year @ $56.08 per case of 50 (actual 2011 count). (Meeting with Mike Lampariello and Judith Simon of Friends of the High Line, 3-22-12.)

(13) DSNY recyclables collection scenario: Taking bags of recyclables dropped off by tenants in their waste rooms to storage rooms, average 5 minutes per floor (assume .5 bag per floor) or 2.5 minutes, including elevator wait, putting them into 60-gal clear or blue bags, bringing to curb 1x week, guesstimating 60-gal clear and blue bags, 40 lbs/bag, 2 minutes to fill and tie each bag, 2 minutes for each bag, round-trip, to ferry to storage room, 1 minute for each bag to place and remove from storage room, 4 minutes for each bag to place on cart to take to curb, round-trip, =11.5 minutes/bag.

(14) DSNY refuse collection scenario: Assume each existing gravity-fed chutes is retrofitted with stationary compactors. Assume 30 minutes per month or 6 hours per year maintenance at $60/hour (machinist rate), and 1 hour per week cleaning by building managers. Waste is collected in 60 gal bags, 40 lbs/bag, 2 minutes to fill and tie each bag, 2 minutes for each bag, round-trip, to ferry to storage room, 1 minute for each bag to place and remove from storage room, 4 minutes for each bag to place on cart to take to curb, round-trip, =9 minutes/bag.

(15) Assume small compactors are half cost of NYCHA 8 cubic yard exterior compactors or $20,000, with same monthly maintenance and cleaning requirements and same 15-year life. Ceasare Gentile, NYCHA to Miller 01/02/13

(16) Assume each bag occupies same area as one 64 gallon tote, or 29" x 23" or approx 4 sf. See: http://www.usplastic.com/catalog/item.aspx?itemid=27384

(17) See current operations col B for tons/day.

(18) See Rent Table

	A	B	C	D	E	F	G	H	I
1	**Table B-06. Pneumatic vs. Manual Potentially Achievable Waste-Generator Savings (continued)**								
2	Manhattan Park(1)						**Normalizing to**		
3	**Apartments**	**Rent**	**Details**	**Floorplan**	**SF**	**$/SF/Mo**	**Unfurnished**	**$/SF/Y**	**Land Rent/SF/Y(3)**
4	1 BEDROOM	$2,225	River / City View	Plan F floors 2-11	584.58	$3.81	$3.81		$1.51
5	1 BEDROOM W/ DEN	$2,595		Plan C & D floors 2-11	648	$4.00	$4.00		
6	2 BEDROOMS	$2,995	River / City View	Plan J floors 3-22	660	$4.54	$4.54		
7	2 BEDROOM W/ DEN	$3,695	Balcony	Plan H floors 3-22	864	$4.28	$4.28		
8	3 BEDROOMS W/ DEN	$4,795	Balcony		1457	$3.29	$3.29		
9	(2)	$2,950	Furnished		950	$3.11			
10		$3,200	Furn or Unfurn	Avg/SF/Furnishd	1200	$2.67	$3.45		
11		$3,600	Furnished	4.023447508	700	$5.14			
12		$3,600	Unfurnished	Avg/SF/Unfurnishd	850	$4.24			
13		$3,440	Furnished	3.450980392	900	$3.82			
14						AVG	$3.89	**$47**	
15									
16	(1)http://www.manhattanpark.com/availabilities, accessed 12-31-12								
17	(2)http://www.sublet.com/spider/supplydetails.asp?supplyid=2176321								
18	(3) "On the First Ground Rent Adjustment Date, the Ground Rent shall								
19	increase to $236,000 per annum. The Ground Rent shall thereafter								
20	cumulatively increase by 10% on each 5th anniversary until the 30th								
21	anniversary of the First Ground Rent Adjustment Date (the “Affordability								
22	Expiration Date”), as provided in Exhibit B attached hereto. Commencing								
23	on the first day following the Affordability Expiration Date, if the Master								
24	Cooperative Closing (or other conversion to some form of								
25	cooperative/condominium ownership) has occurred, the Ground Rent shall								
26	be payable as provided in Exhibit C-1 attached hereto, if, however, the								
27	Master Cooperative Closing (or other conversion to some form of								
28	cooperative/condominium ownership) has not occurred as of the								
29	Affordability Expiration Date, the Ground rent shall be payable as								
30	provided in Exhibit C-2."								
31	http://rooseveltislander.blogspot.com/2012/06/unprecedented-plan-for-roosevelt.html								
32	https://docs.google.com/file/d/1E-eOXwvNJ55T4S1HHmTcuxzir5fHMmH1TpcWGyPcS2SjEoxNZrWLWWzd75mJ/edit?pli=1								
34	Area of Island House, land and property, approx 355'x440' (Google maps)								

	A	B	C	D	E	F	G	H	I	J	K	L
1	Table B-7. Analysis of Recent Findings in Pneumatic Collection Literature											
2												
3	(1)'	**Cost (Euros/tonne)**	Conventional	Pneumatic	**Multiplier**							
4		Helsinki Capex	33	343	**10.4**							
5		Helsinki Opex	40	71	**1.8**							
6		Helsinki Enviro Cost (mainly CO2eq)	0.51	1.29	**2.5**							
7		**Total, Helsinki Base Case (5.3 tonnes/d)**	74	415	**5.6**							
8		**Total, Helsinki Max Case (21.2 tonnes/d) Total**	60	155	**2.6**							
9												
10	(20)	**Cost ($/ton): Opex Including Debt Service and Dray**										
11		**(w/o Env Cost)**										
12		High Line (11 tpd)	188	290	**1.5**							
13		Second Avenue Subway (19 tpd)	134	178	**1.3**							
14												
15		Roosevelt Island Upgrade Only	223	371	**1.7**							
16		Roosevelt Island Upgrade + Recycling	223	456	**2.0**							
17		Roosevelt Island Upgrade + Recycling + Commercial + Litt	223	468	**2.1**							
18												
19	(17,18)	**Cost Including Space Savings**										
20												
21												
22		*Hammarby Sjostad*	Manual	Pneumatic	**Ratio, P/M**							
23		Capex	€ 2,949,835	€ 4,728,408	**1.6**							
24		Opex	€ 271,696	€ 87,904	**0.3**							
25		Total/Y	€ 486,031	€ 431,415	**0.89**							
26	(21)	Capex	SEK 27,619,988	SEK 44,275,000	**1.60**							
27	(21)	Opex	SEK 2,544,468	SEK 823,099	**0.32**							
28	(21)	**Total Annual @6% interest**	SEK 4,551,030	SEK 4,039,630	**0.89**							
29		*Sodra Station, Stockholm*										
30		Capex Per Apartment	€ 1,259	€ 1,479	**1.17**							
31		Opex Per Apartment	€ 64	€ 52	**0.81**							
32		Space Cost/Y	€ 104	€ 18	**0.17**							
33		**Total/Y (Including Space Costs)**	€ 207	€ 152	**0.73**							
34												
35		**CO2eq (kg/tonne) (2)**										
36		manufacture(7)	1.86	20.74	**11.2**							
37		collection + transport	16	35.66	**2.2**							
38		**Total**	17.86	56.4	**3.2**							
39				pneu stationary	pneu mobile	mult stationary	mult mobile					
40		**Total(4,13,14,15)**	7.9	47.3	44.3	6.0	5.6					
41												
42												
43		**CO2 Equiv Units (3,8,9)**	door-to-door	kiosks	pneumatic	**multiplier v d-d**	**multiplier v kiosks**					
44		fixed infrastructure	580	3245	10062	**17.3**	**3.1**					
45		mobile equipment, 0.01km	5220	2655	2938	**0.6**	**1.1**					
46		mobile equipment, 5km	9420	6928	7993	**0.8**	**1.2**					
47		mobile equipment, 10km	13229	11507	15038	**1.1**	**1.3**					
48		mobile equipment, 20km	20134	17828	24148	**1.2**	**1.4**					
49		mobile equipment, 30km	5220	24854	30563	**5.9**	**1.2**					
50		total(10)	5800	5900	13000	**2.2**	**2.2**					
51		**Cumulative Energy Demand(11)**	470000	300000	340000	**0.7**	**1.1**					
52		Collection % of total CO2eq(12)	10	55	78	**7.8**	**1.4**					
53		Collection % of Cum. E Demand(12)	6	50	74	**12.3**	**1.5**					
54												
55		**CO2equiv% from(3)**				% of Infrastructure CO2 From Pipes Alone						
56		Fixed Infrastructure			77.4	0.68						
57		Pneumatic Transport			13.1							
58		Truck Transport			9.5							
59												
60		**Electricity Use (kwh/ metric ton)**	m tons/year	m tons/day	length of pipe (	High reported	Low reported	Baseline used	Baseline kwh/y	Sensitivity high	Sensitivity low	
61		hypothetical system, Punkkinen et al. (22) (24)	2,000	5.5	1626	356	50	95	190,000	120	70	
62		hypothetical modeled system, Jackson (23)	35,849	98.2	2000	NA	NA	**0.7**		**NA**	NA	
63												
64		Short tons per metric ton:	1.10231						203			
65												
66			manual, hrs/wk	manual, dba	pneu hrs/wk	pneu, dba	multiple hrs	multiple dba				
67		**noise reduction (19)**	10.8	81.5	4	63.5	0.37	0.78				
68												

	A	B	C	D	E	F	G	H	I	J	K	L
69		**Transfer/Baling**	transfer stations	baling								
70		CO2-eq kg/tonne(4)	2.248	0.086								
71												
72			unit-price hsehold kg	flat-fee hseh kg/yr	reduction							
73		**SAYT Reduction Effect(16)**	592	876	0.32							
74												
75												
76		(1) Teerioja										
77		(2) Punkkinen										
78		(3) Iriarte										
79		(4) Eisted										
80		(5) 5.3 tonnes/day										
81		(6) 21.2 tonnes/day										
82		(7) conventional includes only "manufacture of waste containers"; pneumatic includes waste terminal, equipment, main pipe, feeder pipe, inlets										
83		(8) Units are per 1500 "tons" (assumed to be long tons), and vary by category (kg/1500t for fixed infrastructure, GJ for mobile equipment)										
84		(9) Kms for mobile equipment refer to distance from the end of the collection route to the first dump										
85		(10) "kg CO2 equiv. 100 years/FU [1500 tons]"										
86		(11) MJ/1500 tons										
87												
88		(12) % of the CO2 Equiv. or Cumulative Energy Demand produced by a system in the collection phase (i.e., excluding transport from the end of the collection route to the first dump site)										
89		(13) Avg refuse from city center	9.6									
90		(14) Avg refuse from apt blocks	5.2									
91		(15) Avg for paper from apt blocks	9									
92		(16)Kogler, p. 61 (European averages)										
93		(17)Kogler, 2,095 apartments, 3 fractions, 52 collection locations, 6% cost of capital, 30-yr lifespan, space savings of 1,366 sq meters, with annual rental income for ground floor space of 160 eur/sq m/yr, p. 104 (from SWECO										
94		VIAK AB, 2004, "Hammarby Sjostad--Vastra Sjostaden--comparison of manual waste handling and stationary vacuum suction for three fractions")										
96		(18)Kogler, Sodra Station, Stockholm, p. 106, from BoDAB, "City planning with and without vacuum waste handling," 1999										
97		(19)Kogler, Hammarby Sjostad, p. 111, from S. Axelsson, "Economic Analysis and Environmental Assessment--Hammarby Sjostad--Summary," 2004										
98		(20) 4.75% interest, 34-year bond										
99		(21) SWECO VIAK AB, 3-23-05, Hammarby Sjostad										
100		57.76636705	cubic meters of nyc container, 20'x12'x8.5'; dsny calls 62cy, http://www.nyc.gov/html/dsny/downloads/pdf/swmp/swmp/Final360App/NShore360/vol1/04.pdf, accessed 1-8-13									
101												
102												
103		(22) "Transfer of waste from the waste inlets to the waste terminal would take place by means of air flow. Since no measured values for electricity consumption due to suction were available, we used an average value 95										
104		kWh/waste tonne in our baseline calculations. This value was determined from the variable estimates given by system suppliers (50–356 kWh/waste tonne)." p.4."As mentioned earlier in Section 2.3.2, the electricity consumption										
105		estimates provided by different system suppliers varied widely. These took no cognisance of how the properties of waste										
106		affect energy consumption. Furthermore, the compiled average value did not indicate the system's assumed operating mode: whether the suctions would be scheduled or sensors would indicate the filling rate. For the baseline										
107		calculations (results given in Section 3.1), we used an energy consumption estimate of 95 kWh/waste tonne. To test the robustness of the results with varying levels of electricity consumption, we use the estimates 70 kWh/waste										
108		tonne and 120 kWh/waste tonne in the sensitivity analysis for CO2-equivalent emissions." Punkkinen 2012, p. 5.										
109		(23) Jackson generates a kwh per day rate by modeling energy used based on a 178,200 pounds (100m tons/day), p. 26. This waste volume is highly unrealistic.										
110		(24) Teerioja 2012, p. 5.										

	A	B	C	D	E	F	G	H
1	**Table B-08. Pneumatic vs Manual Cost Calculation**							
2		*Cost of Managed Portion of Each Pneumatic Scenario*				*Manual*	*Cost of Managed Portion of Each*	
3		**No-Action: Existing AVAC**	**Upgrade**	**Upgrade+ Recycling**	**Upgrade+ Recycl'g+ Comm'l+ Litter**	**Manual (f)**	**Upgrade + Waste Metering (j)**	**Upgrade + Recycling w Waste Metering (j)**
4	Total TPY (a)	2,675	2,675	3,854	5,672	3,891	2,675	3,854
5	Capex (c)(i)	NA	$6,459,331	$16,987,777	$26,265,050	$1,381,319	$7,403,331	$17,931,777
6	Capex/T	NA	$2,414	$4,407	$4,631	$355	$2,767	$4,652
7	**Opex/Yr w/Replacement But W/O Debt Service or Dray (b)(k)**	**$2,461,548**	**$381,051**	**$566,573**	**$871,732**	**$817,089**	**$381,051**	**$566,573**
8	**Delta Opex w/o DS v. Manual**	**($1,644,459)**	**$436,038**	**$250,516**	**($54,643)**		**$436,038**	**$250,516**
9	**Normalized Delta Opex w/oDS v Manual**	**($1,899,703)**	**($180,794)**	**($242,851)**	**($319,409)**		**($180,794)**	**($242,851)**
10	Opex/Ton W/O Debt Service(d)	$920	$142	$147	$154	$210	$142	$147
11	Multiple Opex/Ton W/O Debt Service v. Manual	4.38	0.68	0.70	0.73	NA	0.68	0.70
12	Debt Service/Year	NA	$382,088	$1,004,876	$1,553,653	$97,117	$437,928	$1,060,716
13	Debt Service/Ton	NA	$143	$261	$274	$25	$164	$275
14	**Opex/Year WITH Debt Service**	**$2,461,548**	**$763,139**	**$1,571,449**	**$2,425,385**	**$914,206**	**$818,979**	**$1,627,289**
15	Opex/Ton WITH Debt Service	NA	$285	$408	$428	$235	$306	$422
16	Multiple, Opex/Ton WITH Debt Service, v. Manual(n)	3.9	1.2	1.7	1.82	NA	1.30	1.8
17	Dray Costs (e)	$134,708	$120,454	$38,024	$50,074		$120,454	$38,024
18	Total Opex w/ DS and Dray (o)	$2,596,256	$883,593	$1,609,473	$2,475,459		$939,433	$1,665,314
19	Opex w/ Dray w/o DS	**$2,596,256**	**$501,505**	**$604,597**	**$921,805**	**$817,089**	**$501,505**	**$604,597**
20	Normalized Opex Savings w/Dray w/oDS v Manual		**$60,340**	**$204,827**	**$269,336**		**$60,340**	**$204,827**
21	Multiple, Net Present Value v Manual	NA	4.8	8.3	9.1	1.0	5.7	8.9
22	Ann. Externality Benefits Req. to Eq. NPV Costs v Manual (Normalized Tons)	NA	$255,000	$700,000	$1,140,000	NA	$310,000	$755,000
23	Multiple, NPV AVAC Sensitivity v. AVAC							
24			$330					
25	**Debt Service Calculation**							
26	Monthly debt service calculated using http://bretwhissel.net/cgi-bin/amortize							
27		**No-Action**	**U**	**UR**	**URCL**	**Manual revised**	**U+metering**	**UR+metering**
28	capex	NA	$6,459,331	$16,987,777	$26,265,050	$1,381,319	$7,403,331	$17,931,777
29	Monthly DS	NA	$31,841	$83,740	$129,471	$8,093.07	$36,494	$88,393
30	Payments/Yr	NA	12	12	12	12	12	12
31	Annual DS	NA	$382,088	$1,004,876	$1,553,653	$97,117	$437,928	$1,060,716

32 Notes

33 (a) The No-AVAC cost factor ($210/t) does not include the presumed separate cost of RIOC's collection of litter-bin waste, which would be in excess of $210/y, litter is 0.2 tpd. (Appendix A-1 Ref4). See note o for current RIOC litter collection cost. Also, in real life, the absence of an AVAC system would not automatically mean that DSNY would also collect commercial waste; the total tons used for calculating DSNY costs would therefore be
34 reduced by this commercial tonnage (4.68 tpd).

35 (b) Operating and maintenance, including ongoing replacement of components to maintain an indefinite operating life. NB: this pertains only to system upgrades. For detailed calculation see worksheets U, UR and URCL. In the Manual (No-AVAC) case, opex includes amortization of capital costs (garages and trucks), see conventional cost worksheet. In No-Action alternative, system components do NOT have an indefinite life. To reflect
36 equipment replacement in the current annual opex cost maintenance costs for FY 2009, 2010 and 2011 were averaged and annualized, see note k below.

37 (c) No-AVAC capex from mortgage calculator link above based on per ton debt service * 3891 t/year. For calculation see note f below.

38 (d) AVAC Opex based on Envac calculation 1/30/13, as revised by UTRC for NYC actual personnel and electricity rates, see worksheets U, UR, URCL. No-AVAC Opex is based on RI wtd avg collection costs w/o debt service
39 2013. For calculation of conventional costs, see conventional cost worksheet.

40 (e) RI RORO.xlsx

41 (f) Manual (No-AVAC) Opex/ton and Debt service/ton is based on RI wtd avg collection costs 2005 elevated to 2013, for calculation see conventional cost worksheet.

42 (g)This is a hypothetical exercise to compare relative costs for all wastes generated on the Island (with the exception of the Cornell Campus and the hospital), assuming that conventional (DSNY) collection were used for the
43 non-AVACed portions (rather than that those portions were handled by the individual building managers, RIOC, and private carters, as at present).

44 (h) Pipe installation cost see Mateu to Miller, 2-15-12, 8.55 am, with attached ROI RI AM 15 feb 2012.xlsx, ROI(2), ROI (2)!D18.

	A	B	C	D	E	F	G	H
45	(i) Total equipment cost. Rello to Miller 01/14/13 and for UR see Rello to Miller 01/18/13							
46	(j) Waste metering: include a card reader in the inlet plus an inlet door with volume limit. An upgrade in the system control in the collection station of around $ 50,000 and an access control card for the inlet door ($2,000							
47	per door). Rello to Miller 01/14/13; There are roughly 447 inlet doors in existing and planned RI buildings. See SF worksheet. Or an additional capex of $944,000 to add card access to each of these inlets.							
48	Additional capex for metering:	$944,000						
49	(k) 2011 Actual annual DSNY labor, electricity and minor repair costs, Brautigam to Miller, 10-6-11, FY10:							
50					**2011 Actual**	**2013$**	**Projected tons**	
51				DSNY labor	$1,067,028	$1,101,310	$1,391,828	
52				DSNY electricity	$493,204	$509,050	$643,334	
53				Other DSNY minor repair	$12,000	$12,386	$15,653	
54				total DSNY	$1,572,232	$1,622,746	$2,050,815	
55				DSNY Opex/T	$743		$767	
56				RIOC 3-yr av:	$325,000	$325,000	$410,733	
57				RIOC Opex/2011 T:	$154		$154	
58				Total Opex/Yr w/Replacement But W/O dray:	$1,897,232	$1,947,746	2,461,548	
59				Total Opex w o dray /2011 T	$896		$920	
60				DSNY%	83%			
61				RIOC%	17%			
62	**Percentage increase in tonnage:**	126%						
63	(l) RIOC AVAC annual cost FY2009-11 for equipment maintenance, source: Singh to Miller 12/14/11; 3-yr average			FY 2009	$522,390			
64	corrected to reflect amortization of recent building improvements, source Chironis to Miller 06/05/13: "the average			FY 2010	$824,649			
65	capital repairs for AVAC come to about $325K per year. This takes into account building, machinery and piping			FY 2011	$754,875			
66	repairs.":			2011-13 Average:	$325,000			
67								
68	(m) 2011 Opex w/Dray for refuse only, not including MGP and OCC:			$1,924,888	$890.41			
69								
70	(n) For No-Action, since there is no debt service, this is simply total cost/ton							
71					2013$			
72	(o) In all scenarios except URCL and Manual, RIOC collects street litter bins with 10 cy rear-loader. Cost is not included in opex calculation. For reference cost is estimated to be 49,000 per year. Truck capex, based on Florida sale price, see http://mypompanobeach.org/pages/department_directory/general_services/purchasing_department/old_bids/2012/pdfs/t/t41/T-41-12-tab.pdf, accessed 04/16/13:			$100,000	$101,385			
73	Life assumed to be 7 yrs like DSNY rear-loaders, capex annualized:			$14,285.71	$14,484			
74	Maintenance assumed to be .25 of DSNY rear-loader maint., see Brautigam to Miller 06/30/13:			$24,763	$25,625			
75	RIOC annual maintenance:			$6,190.75	$6,406			
76	RIOC labor 2 employees*2.5 hours*7 days* Douglass to Miller 01/20/12. RIOC facilities handy							
77	person salary in 2009 is 45,000, see seethroughny.net. Assume 40 hours x 52 = 2080 hours or			$39,483	$46,798			
78	Assume 1/3 of labor hours are for parks and bins not included in pneumatic scenario. 2/3 of $39,483=			$26,322	$31,199			
79								
80	Total RIOC annual capex and maintenance:				$52,089			
81	Total RIOC litter tons collected				36.50			
82	Total RIOC Litter collection per ton:				$1,427			
83	(p)2011 estimated actual commercial waste fees paid to private carters				$50,000			

	A	B	C	D	E	F	G
1	**Table B-09. Electricity Cost Calculation**						
2							
3	AVAC Actual Electricity Use(1)(3)						
4		BTUs	kw	kwh	$		
5	FY2011	3318		972000	$499,186		
6	FY2010	3345		980000	$487,221		
7	**Avg(1)**	**3332**	**1087**	**976000**	**$493,204**		
8							
9	Cost Factors	DSNY Actual, Rate as of April, 2012(2)	2013$				
10	kwh@	$0.06	$0.06				
11	kw@	$23.12	$23.38				
12							
13	Electricity Use for Alternative Scenarios (4)				Total Annual Elec Cost, Actual Rates (5)		
14		Upgrade	Upg+Rcy	URCL	Upg	UR	URCL
15	KWH/year	193,974	548,935	837,017	$12,010	$33,988	$51,825
16	kw	331	331	662	$91,876	$91,876	$183,751
17	Total Electricity Cost				$103,886	$125,864	$235,577
18							
19	(1)NYC DCAS, "Core Report, Facility-Level Energy Cost, Usage, and CO2e Emissions," 4-2011.						
20							
21	(2) Donald Porter, DSNY Bureau of Building Management, to Steven Brautigam, DSNY Asst. Comr., Environmental Affairs, 2-11-13						
22	(3) Brautigam to Miller, 1-28-13						
23	(4) Ricardo Rello, Envac, to Spertus and Miller, 1-29-13						
24	(5) Customers whose maximum monthly demand is below 1,500 kw are not eligible for Time of Day service.						
25	http://www.coned.com/documents/PSC12-PASNY/PASNYPSC12.pdf, accessed 2-13-13.						

	A	B	C	D	E	F	G	H
1	**Table B-10. Pneumatic System Operating Cost Calculation**							
2	Upgrade-Only			**PROJECT NAME**		ROOSVELT ISLAND (op1)		
3	**CURRENCY REF**			**PLACEMENT:**		NEW YORK		
4	**$**			**Envac DATE:**	1/30/13	UTRC Date:	2/14/13	
5								
6	**PERSONNEL:**							
7			DESCRIPTION		QUANT.	COST	**TOTAL**	
8	**DIRECT O&M PERSONNEL**							
9			OPERATOR O&M (a)		1.20	$150,039.52	**180,047.42**	
10		**UNIFORMS**						
11			UNIFORMS	Ea.	2.00	457.42	**914.83**	
12		**MOBILE PHONE**						
13			TELEPHONE	P/A	1.00	228.71	**228.71**	
14		**TOTAL:**					**181,190.97**	
15								
16	**VEHICLES**							
17			DESCRIPTION	UNIT	QUANT.	COST	**TOTAL**	
18	**MAINTENANCE CARS**							
19			OPERATOR VAN	ud	1.00	10,344.66	**10,344.66**	
20		**TOTAL:**					**10,344.66**	
21								
22	**SPARE PARTS**							
23			DESCRIPTION	UNIT	QUANT.	COST	**TOTAL**	
24		**SPARE PARTS**						
25		**TERMINAL**				1.00		
26			EXHAUSTERS	P/A	1.00	4,740.95	**4,740.95**	
27			CONTAINER	P/A	1.00	759.83	**759.83**	
28			CYCLONE	P/A	1.00	992.67	**992.67**	
29			COMPACTOR	P/A	1.00	789.76	**789.76**	
30			CONTAINERS MOVE	P/A	1.00	3,241.76	**3,241.76**	
31			CONTROL SYSTEM	P/A	2.00	335.22	**670.45**	
32			SECTION IN VALVE	P/A	1.00	151.72	**151.72**	
33			COMPRESSOR	P/A	1.00	146.53	**146.53**	
34		**FILTERS**				1.00		
35			DUST FILTERS	P/A	1.00	2,908.91	**2,908.91**	
36			CARBON	P/A	1.00	4,395.70	**4,395.70**	
37		**PIPE NETWORK**				1.00		
38			DUMP VALVES	P/A	1.00	2,746.18	**2,746.18**	
39			TRANSPORT VALVES	P/A	1.00	575.27	**575.27**	
40			SYSTEM DEVICE	P/A	1.00	453.64	**453.64**	
41		**TOTAL:**					**22,573.36**	
42								
43	**SUPPLIES**							
44			DESCRIPTION	UNIT	QUANT.	COST	**TOTAL**	
45		**MATERIAL**						

	A	B	C	D	E	F	G	H
46			CLEANING GOODS	P/A	1.00	1,268.29	**1,268.29**	
47			TOOLS	P/A	1.00	1,346.25	**1,346.25**	
48			OFICCE MATERIAL	P/A	1.00	133.73	**133.73**	
49		**TOTAL:**					**2,748.27**	
50								
51	**ELECTRIC POWER**							
52			DESCRIPTION	UNIT	QUANT.	COST	**TOTAL**	
53	**ENERGY SUPPLY (b,c,d)**							
54			CONSUMPTION (Collection+Aux)	Kwh	193,974.139552321	0.062	**12,010.23**	
55			Kw CONTRACT	Kw	331.155	$23.38	**92,908.85**	
56		**TOTAL:**					**104,919.08**	
57								
58	**MISC.**							
59			DESCRIPTION	UNIT	QUANT.	COST	**TOTAL**	
60			TELEPHONE	P/A	1.00	1,477.81	**1,477.81**	
61			WATER	P/A	1.00	2,005.60	**2,005.60**	
62		**TOTAL:**					**3,483.41**	
63								
64	**EQUIPMENT REPLACEMENT**							
65			DESCRIPTION	UNIT	QUANT.	COST	**TOTAL**	
66	**COMPONENT REPL/NT UPDATING**							
67			TERMINAL	P/A	2.00			
68			EXTERNAL NET	P/A	1.00			
69		**TOTAL:**					**55,727**	
70	**PERSONNEL**			**181,190.97**	**RATIO**	**$**	**PER DWELLING**	
71	**VEHICLES**			**10,344.66**		DWELLING EQ.		5,059
72	**SPARE PARTS**			**22,573.36**		**RATIO COST/DWE.EQ.**		**75.31**
73	SUPPLIES			**2,748.27**	**RATIO**	**$**	**PER TON**	
74	**ELECTRIC POWER**			**104,919.08**		TONS		2,675
75	**MISC**			**3,483.41**		**RATIO COST/TON**		**142.42**
76	**EQUIPMENT UPDATING**			**55,726.78**	**RATIO**	**Kwh**	**PER TON**	
77	**TOTAL**			**380,986.52**		TONS		2,675
78						KWH		193,974
79	**Energy calc.**					**RATIO KWH/TON**		**72.51**
80	Total collection time		2.19	hours				
81	Average consumption		247.50	Kwh				
82	Reduction		13%					
83	**Total consumption**		**193,974.14**	**Kwh**				
84	Notes:							

85 (a) Steven Brautigam, DSNY to Miller 10/06/11. There are currently 8 full time employees, with the titles and pay rates shown in this note. Envac lists operator positions. The
86 current DSNY titles used at AVAC are: Senior Stationary Engineer base salary $116,916, fringe @ 43% $50,274 = $167,191 total; Stationary Engineer base salary $102,356,
87 fringe $43,013= $145,369; Machinist base salary $75,940, fringe $32,655 = $108,595. We assumed "Stationary Engineer" = "Operator."
88 (b)NYC DCAS, “Core Report, Facility-Level Energy Cost, Usage, and CO2e Emissions," 4-2011.
89 (c) Donald Porter, DSNY Bureau of Building Management, to Steven Brautigam, DSNY Asst. Comr., Environmental Affairs, 2-11-13
90 (d) Brautigam to Miller, 1-28-13

	A	B	C	D	E	F	G
1	Upgrade + Recycling						
2	**PROJECT NAME**		ROOSVELT ISLAND (op3)				
3	**PLACEMENT:**		NEW YORK				
4	**Envac DATE:**	1/30/13	UTRC Date:	2/14/13		$	
5	**MANAGED SERVICE COST**						
6	**PERSONNEL:**						
7			DESCRIPTION		QUANT.	COST	**TOTAL**
8		**DIRECT O&M PERSONNEL**					
9			OPERATOR O&M		1.50	150,039.52	**225,059.28**
10		**UNIFORMS**					
11			UNIFORMS	Ea.	2.00	457.42	**914.83**
12		**MOBILE PHONE**					
13			TELEPHONE	P/A	1.00	228.71	**228.71**
14		**TOTAL:**					**226,202.82**
15	**VEHICLES**						
16			DESCRIPTION	UNIT	QUANT.	COST	**TOTAL**
17		**MAINTENANCE CARS**					
18			OPERATOR VAN	Ea.	1.00	10,344.66	**10,344.66**
19		**TOTAL:**					**10,344.66**
20	**SPARE PARTS**						
21			DESCRIPTION	UNIT	QUANT.	COST	**TOTAL**
22		**SPARE PARTS**					
23		**TERMINAL**				1.00	
24			EXHAUSTERS	P/A	1.00	5,781.50	**5,781.50**
25			CONTAINER	P/A	1.00	1,519.65	**1,519.65**
26			CYCLONE	P/A	1.00	2,978.01	**2,978.01**
27			COMPACTOR	P/A	1.00	3,319.21	**3,319.21**
28			CONTAINERS MOVE	P/A	1.00	3,241.76	**3,241.76**
29			CONTROL SYSTEM	P/A	2.00	335.22	**670.45**
30			SECTION IN VALVE	P/A	1.00	455.15	**455.15**
31			COMPRESSOR	P/A	1.00	418.20	**418.20**
32		**FILTERS**				1.00	
33			DUST FILTERS	P/A	1.00	2,908.91	**2,908.91**
34			CARBON	P/A	1.00	13,485.83	**13,485.83**
35		**PIPE NETWORK**				1.00	
36			DUMP VALVES	P/A	1.00	2,746.18	**2,746.18**
37			TRANSPORT VALVES	P/A	1.00	575.27	**575.27**
38			SYSTEM DEVICE	P/A	1.00	1,575.80	**1,575.80**
39		**TOTAL:**					**39,675.91**
40	**SUPPLIES**						
41			DESCRIPTION	UNIT	QUANT.	COST	**TOTAL**
42		**MATERIAL**					
43			CLEANING GOODS	P/A	1.00	1,268.29	**1,268.29**
44			TOOLS	P/A	1.00	1,346.25	**1,346.25**
45			OFFICE SUPPLIES	P/A	1.00	133.73	**133.73**
46		**TOTAL:**					**2,748.27**

	A	B	C	D	E	F	G
47	**ELECTRIC POWER**						
48			DESCRIPTION	UNIT	QUANT.	COST	**TOTAL**
49		**ENERGY SUPPLY**					
50			CONSUMPTION (Collection+Aux)	Kwh	548,935.240453264	0.06	**33,988.24**
51			Kw CONTRACT	Kw	331.155	23.38	**92,908.85**
52		**TOTAL:**					**126,897.09**
53	**MISC.**						
54			DESCRIPTION	UNIT	QUANT.	COST	**TOTAL**
55			TELEPHONE	P/A	1.00	1,477.81	**1,477.81**
56			WATER	P/A	1.00	2,005.60	**2,005.60**
57		**TOTAL:**					**3,483.41**
58	**EQUIPMENT REPLACEMENT**						
59			DESCRIPTION	UNIT	QUANT.	COST	**TOTAL**
60		**COMPONENT REPLACEMENT**					
61			TERMINAL	P/A	2.00		
62			EXTERNAL NET	P/A	1.00		
63		**TOTAL:**					**157,162.06**
64					**RATIO**	**$**	**PER DWELLING**
65						DWELLING EQ.	5,059
66	**PERSONNEL**			**226,202.82**		RATIO COST/DWE.EQ.	**112**
67	**VEHICLES**			**10,344.66**	**RATIO**	**$**	**PER TON**
68	**SPARE PARTS**			**39,675.91**		TONS	3,854
69	SUPPLIES			**2,748.27**		**RATIO COST/TON**	**147**
70	**ELECTRIC POWER**			**126,897.09**	**RATIO**	**Kwh**	**PER TON**
71	**OTHERS**			**3,483.41**		TONS	3,854
72	**EQUIPMENT UPDATING**			**157,162.06**		KWH	548,935
73	**TOTAL (without VAT)**			**566,514.22**		**RATIO KWH/TON**	**142**
74	**Energy calc.**						
75	Total collection time		7.23	horas			
76	Average consumption		247.50	Kwh			
77	Reduction		13%				
78	**Total consuption**		**548,935.24**	**Kwh**			

	A	B	C	D	E	F	G
1	Upgrade, Recycling, Commercial & Litter						
2	**PROJECT NAME**		ROOSVELT ISLAND (op4) c1				
3	**PLACEMENT:**		NEW YORK				
4	**Envac DATE:**	1/30/13	UTRC Date:	2/14/13		**$**	
5							
6	**PERSONNEL:**						
7			DESCRIPTION		QUANT.	COST	**TOTAL**
8		**DIRECT O&M PERSONNEL**					
9			OPERATOR O&M		2.00	150,039.52	**300,079.04**
10		**UNIFORMS**					
11			UNIFORMS	Ea.	4.00	457.42	**1,829.67**
12		**MOBILE PHONE**					
13			TELEPHONE	P/A	2.00	228.71	**457.42**
14		**TOTAL:**					**302,366.12**
15	**VEHICLES**						
16			DESCRIPTION	UNIT	QUANT.	COST	**TOTAL**
17		**MAINTENANCE CARS**					
18			OPERATOR VAN	Ea.	1.00	10,344.66	**10,344.66**
19		**TOTAL:**					**10,344.66**
20	**SPARE PARTS**						
21			DESCRIPTION	UNIT	QUANT.	COST	**TOTAL**
22		**SPARE PARTS**					
23		**TERMINAL**				2.00	
24			EXHAUSTERS	P/A	2.00	5,238.31	**10,476.62**
25			CONTAINER	P/A	2.00	1,519.65	**3,039.30**
26			CYCLONE	P/A	2.00	2,978.01	**5,956.03**
27			COMPACTOR	P/A	2.00	2,830.36	**5,660.72**
28			CONTAINER MOVER	P/A	2.00	3,241.76	**6,483.51**
29			CONTROL SYSTEM	P/A	4.00	335.22	**1,340.89**
30			SECTION IN VALVE	P/A	2.00	455.15	**910.30**
31			COMPRESSOR	P/A	2.00	279.16	**558.31**
32		**FILTERS**				1.00	
33			DUST FILTERS	P/A	4.00	2,908.91	**11,635.62**
34			CARBON	P/A	2.00	8,842.64	**17,685.27**
35		**NET**				1.00	
36			DUMP VALVES	P/A	2.00	2,746.18	**5,492.36**
37			TRANSPORT VALVES	P/A	2.00	575.27	**1,150.54**
38			SYSTEM DEVICE	P/A	2.00	978.90	**1,957.81**
39		**TOTAL:**					**72,347.30**
40	**SUPPLIES**						
41			DESCRIPTION	UNIT	QUANT.	COST	**TOTAL**
42		**MATERIAL**					
43			CLEANING GOODS	P/A	1.00	1,594.20	**1,594.20**

	A	B	C	D	E	F	G
44			TOOLS	P/A	1.00	1,445.36	**1,445.36**
45			OFFICE SUPPLIES	P/A	1.00	168.09	**168.09**
46		**TOTAL:**					**3,207.66**
47	**ELECTRIC POWER**						
48			DESCRIPTION	UNIT	QUANT.	COST	**TOTAL**
49		**ENERGY SUPPLY**					
50			CONSUMPTION (Collection+Aux)	Kwh	837,017.040000000	0.06	**51,825.31**
51			Kw CONTRACT	Kw	662.315	23.38	**185,819.10**
52		**TOTAL:**					**237,644.40**
53	**MISC.**						
54			DESCRIPTION	UNIT	QUANT.	COST	**TOTAL**
55			TELEPHONE	P/A	1.00	1,477.81	**1,477.81**
56			WATER	P/A	1.00	2,005.60	**2,005.60**
57		**TOTAL:**					**3,483.41**
58	**EQUIPMENT REPLACEMENT**						
59			DESCRIPTION	UNIT	QUANT.	COST	**TOTAL**
60	**COMPONENT REPLACEMENT**						
61			TERMINAL	P/A	2.00		
62			EXTERNAL NETWORK	P/A	1.00		
63		**TOTAL:**					**242,322.66**
64							
65	**PERSONNEL**	**302,366.12**	**RATIO**	**$**	**PER DWELLING**		
66	**VEHICLES**	**10,344.66**		DWELLING EQ.		6,359	
67	**SPARE PARTS**	**72,347.30**		**RATIO COST/DWE.EQ.**		**137.08**	
68	SUPPLIES	3,207.66	**RATIO**	**$**	**PER TON**		
69	**ELECTRIC POWER**	**237,644.40**		TONS		5,672	
70	**OTHERS**	**3,483.41**		**RATIO COST/TON**		**153.69**	
71	**EQUIPMENT UPDATING**	**242,322.66**	**RATIO**	**Kwh**	**PER TON**		
72	**TOTAL (without VAT)**	**871,716.21**		TONS		5,672	
73				KWH		837,017	
74				**RATIO KWH/TON**		**147.57**	
75	**Energy comsuption Terminal 1**			**Energy comsuption Terminal 2**			
76	Total collection time	4.66	horas	Total collection time		4.76	horas
77	Average consumption	247.50	Kwh	Average consumption		247.50	Kwh
78	Reduction	13%		Reduction		13%	
79	Total consumption	410,138		Total consumption		426,879	

	I	J	K	L	M	N	O	P	Q
5	**Table B-10A Sensitivity Analysis: Effect of Labor & Electricity on Operating Cost Calculation, Upgrade Only**								
6									
7	**Labor (personnel requirements x3)**								
8			quantity	COST	TOTAL				
9	OPERATOR O&M (a)		3.6	$150,039.52	540,142.27				
10									
11	UNIFORMS		6.0	457.42	2,744.50				
12									
13	TELEPHONE		3.0	228.71	686.13				
14	TOTAL:				543,572.90				
15	Cost Increase v. projected:				362,381.93				
16	Total Opex w Replacement at 3x labor:				**743,368.46**				
17	Total Opex/t:				**278**				
18									
19	**Electricity**								
20				120% kwh	150% kwh				
21			kwh/t	87	109				
22			kwh/y	232,768.97	290,961.21				
23			Cost per kwh	0.062	0.062				
24			Total cost kwh	14,412.28	18,015.35				
25			Total Cost KW (	92,908.85	92,908.85				
26			Total	**107,321.13**	**110,924.20**				
27			Total Opex w/ replacement	**488,307.65**	**491,910.72**				
28			**Total Opex/t**	**183**	**184**				
29									
30									
31	3x labor 150% kwh Total Opex w/ replacement				**749,373.57**				
32					**280**				

	I	J	K	L	M	N
4	**Table B-10B Sensitivity Analysis: Effect of Labor & Electricity on Operating**					
5	**Cost Calculation, Upgrade, Recycling, Commercial & Litter**					
6	**Labor (personnel requirements x3)**					
7		QUANT.	COST	TOTAL		
8						
9	OPERATOR O&M	6	150,039.52	900,237.12		
10						
11	UNIFORMS	12	457.42	5,489.00		
12						
13	TELEPHONE	6	228.71	1,372.25		
14	TOTAL:			**907,098.37**		
15	Cost Increase v. projected:			604,732.25		
16	Total Opex w Replacement at 3x labor:			**$1,476,448**		
17	Total Opex/t:			**$260**		
18						
19	**Electricity**					
20			120% KWH	150% KWH		
21	Kwh/y		1,004,420	1,255,526		
22	Cost per kwh		$0.06	$0.06		
23	Total cost of kwh		$62,190	$77,738		
24	Cost of KW (constant)		$185,819	$185,819		
25	Total		**$248,009**	**$263,557**		
26	Cost Increase v. projected:		$10,365	$25,913		
27	Total Opex w/ replacement		**$882,081**	**$897,629**		
28	Total Opex/t:		**$156**	**$158**		
29						
30	3x labor 150% kwh Total Opex w/ replacement			$1,502,361		
31				**$265**		

	A	B	C	D	E	F
1	**Table B-11. Pneumatic v. Manual Net Present Value of Debt Service Calculation**					
2	3% Discount Rate					
3	No-AVAC v U	U	No-AVAC v UR	UR	No-AVAC v URCL	URCL
4	3.000%	3.000%	3.000%	3.000%	3.000%	3.000%
5	(949,818)	(6,459,331)	(1,368,361)	(16,987,777)	(2,013,667)	(26,265,050)
6	(66,779)	$ (321,748)	(96,206)	$ (800,049)	(141,576)	-1,284,318
7	(66,779)	$ (321,748)	(96,206)	$ (800,049)	(141,576)	-1,284,318
8	(66,779)	$ (321,748)	(96,206)	$ (800,049)	(141,576)	-1,284,318
9	(66,779)	$ (321,748)	(96,206)	$ (800,049)	(141,576)	-1,284,318
10	(66,779)	$ (321,748)	(96,206)	$ (800,049)	(141,576)	-1,284,318
11	(66,779)	$ (321,748)	(96,206)	$ (800,049)	(141,576)	-1,284,318
12	(66,779)	$ (321,748)	(96,206)	$ (800,049)	(141,576)	-1,284,318
13	(66,779)	$ (321,748)	(96,206)	$ (800,049)	(141,576)	-1,284,318
14	(66,779)	$ (321,748)	(96,206)	$ (800,049)	(141,576)	-1,284,318
15	(66,779)	$ (321,748)	(96,206)	$ (800,049)	(141,576)	-1,284,318
16	(66,779)	$ (321,748)	(96,206)	$ (800,049)	(141,576)	-1,284,318
17	(66,779)	$ (321,748)	(96,206)	$ (800,049)	(141,576)	-1,284,318
18	(66,779)	$ (321,748)	(96,206)	$ (800,049)	(141,576)	-1,284,318
19	(66,779)	$ (321,748)	(96,206)	$ (800,049)	(141,576)	-1,284,318
20	(66,779)	$ (321,748)	(96,206)	$ (800,049)	(141,576)	-1,284,318
21	(66,779)	$ (321,748)	(96,206)	$ (800,049)	(141,576)	-1,284,318
22	(66,779)	$ (321,748)	(96,206)	$ (800,049)	(141,576)	-1,284,318
23	(66,779)	$ (321,748)	(96,206)	$ (800,049)	(141,576)	-1,284,318
24	(66,779)	$ (321,748)	(96,206)	$ (800,049)	(141,576)	-1,284,318
25	(66,779)	$ (321,748)	(96,206)	$ (800,049)	(141,576)	-1,284,318
26	(66,779)	$ (321,748)	(96,206)	$ (800,049)	(141,576)	-1,284,318
27	(66,779)	$ (321,748)	(96,206)	$ (800,049)	(141,576)	-1,284,318
28	(66,779)	$ (321,748)	(96,206)	$ (800,049)	(141,576)	-1,284,318
29	(66,779)	$ (321,748)	(96,206)	$ (800,049)	(141,576)	-1,284,318
30	(66,779)	$ (321,748)	(96,206)	$ (800,049)	(141,576)	-1,284,318
31	(66,779)	$ (321,748)	(96,206)	$ (800,049)	(141,576)	-1,284,318
32	(66,779)	$ (321,748)	(96,206)	$ (800,049)	(141,576)	-1,284,318
33	(66,779)	$ (321,748)	(96,206)	$ (800,049)	(141,576)	-1,284,318
34	(66,779)	$ (321,748)	(96,206)	$ (800,049)	(141,576)	-1,284,318
35	(66,779)	$ (321,748)	(96,206)	$ (800,049)	(141,576)	-1,284,318
36	(66,779)	$ (321,748)	(96,206)	$ (800,049)	(141,576)	-1,284,318
37	(66,779)	$ (321,748)	(96,206)	$ (800,049)	(141,576)	-1,284,318
38	(66,779)	$ (321,748)	(96,206)	$ (800,049)	(141,576)	-1,284,318
39	(66,779)	$ (321,748)	(96,206)	$ (800,049)	(141,576)	-1,284,318
40	(1,411,168)	(6,799,128)	(2,033,006)	(16,906,510)	(2,991,753)	-27,139,989
41	Differential	(5,387,960)		(15,495,342)		-25,728,821
42	Multiplier	4.8		8.3		9.1
43	Manual capex and opex costs normalized by P-option tons.					
44	NPV of annual debt service for pneumatic scenarios includes normalized delta Opex w/o debt service v manual					
45	Bond term and interest rate assumptions based on NYC Water Authority actuals:					
46	http://nycbonds.org/NYW/pdf/2013/NYW_2013_AA_Adj_Rate.pdf, accessed 12-19-12					
47	p1: term, latest nyc water authority bonds: 34 yrs					
48	pp181-2, interest rates for latest 3 years long-term fixed bonds (24 issues) (see "avg interest" worksheet for raw numbers					
49	Discount rate is 3% and 7%, as per current US DOT guidance for benefit-cost analyses required for transportation investm					
50	1-2012, http://www.dot.gov/sites/dot.dev/files/docs/TIGER_BCA_RESOURCE_GUIDE.pdf, accessed 3-19-13.					

	G	H	I	J	K	L
1						
2			255,000	700,000	1,140,000	310,000
3	U+metering	UR+metering	U Externality	UR Ext	URCL Ext	U+m Ext
4	3.000%	3.000%	3.000%	3.000%	3.000%	3.000%
5	(7,403,331)	(17,931,777)	(6,459,331)	(16,987,777)	(26,265,050)	(7,403,331)
6	-377,588	-855,890	-66,748	-100,049	-144,318	-67,588
7	-377,588	-855,890	-66,748	-100,049	-144,318	-67,588
8	-377,588	-855,890	-66,748	-100,049	-144,318	-67,588
9	-377,588	-855,890	-66,748	-100,049	-144,318	-67,588
10	-377,588	-855,890	-66,748	-100,049	-144,318	-67,588
11	-377,588	-855,890	-66,748	-100,049	-144,318	-67,588
12	-377,588	-855,890	-66,748	-100,049	-144,318	-67,588
13	-377,588	-855,890	-66,748	-100,049	-144,318	-67,588
14	-377,588	-855,890	-66,748	-100,049	-144,318	-67,588
15	-377,588	-855,890	-66,748	-100,049	-144,318	-67,588
16	-377,588	-855,890	-66,748	-100,049	-144,318	-67,588
17	-377,588	-855,890	-66,748	-100,049	-144,318	-67,588
18	-377,588	-855,890	-66,748	-100,049	-144,318	-67,588
19	-377,588	-855,890	-66,748	-100,049	-144,318	-67,588
20	-377,588	-855,890	-66,748	-100,049	-144,318	-67,588
21	-377,588	-855,890	-66,748	-100,049	-144,318	-67,588
22	-377,588	-855,890	-66,748	-100,049	-144,318	-67,588
23	-377,588	-855,890	-66,748	-100,049	-144,318	-67,588
24	-377,588	-855,890	-66,748	-100,049	-144,318	-67,588
25	-377,588	-855,890	-66,748	-100,049	-144,318	-67,588
26	-377,588	-855,890	-66,748	-100,049	-144,318	-67,588
27	-377,588	-855,890	-66,748	-100,049	-144,318	-67,588
28	-377,588	-855,890	-66,748	-100,049	-144,318	-67,588
29	-377,588	-855,890	-66,748	-100,049	-144,318	-67,588
30	-377,588	-855,890	-66,748	-100,049	-144,318	-67,588
31	-377,588	-855,890	-66,748	-100,049	-144,318	-67,588
32	-377,588	-855,890	-66,748	-100,049	-144,318	-67,588
33	-377,588	-855,890	-66,748	-100,049	-144,318	-67,588
34	-377,588	-855,890	-66,748	-100,049	-144,318	-67,588
35	-377,588	-855,890	-66,748	-100,049	-144,318	-67,588
36	-377,588	-855,890	-66,748	-100,049	-144,318	-67,588
37	-377,588	-855,890	-66,748	-100,049	-144,318	-67,588
38	-377,588	-855,890	-66,748	-100,049	-144,318	-67,588
39	-377,588	-855,890	-66,748	-100,049	-144,318	-67,588
40	-7,979,136	-18,086,518	-1,410,509	-2,114,224	-3,049,695	-1,428,267
41	-6,567,968	-16,053,512	658	-81,218	-57,942	-17,099
42	5.7	8.9	1.00	1.0	1.0	1.0
43						
44						
45						
46						
47						
48	): 4.725%					
49	ents pursuant to its Transportation Investment Generating Economic Recovery (TIGER) grant program (TIGER Benefit-Cos					
50						

	M	N	O	P	Q	R
1						
2	755,000	Sensitivity Analysis				
3	UR+m Ext	URCL 120%	URCL 150%	URCL labor x3	U 150%	U 3xLabor
4	3.000%	3.000%	3.000%	3.000%	3.000%	3.000%
5	(17,931,777)	(26,265,050)			(6,459,331)	
6	-100,890	-$1,294,667	-$1,310,215	-$1,889,034	-$432,608	-$684,066
7	-100,890	-$1,294,667	-$1,310,215	-$1,889,034	-$432,608	-$684,066
8	-100,890	-$1,294,667	-$1,310,215	-$1,889,034	-$432,608	-$684,066
9	-100,890	-$1,294,667	-$1,310,215	-$1,889,034	-$432,608	-$684,066
10	-100,890	-$1,294,667	-$1,310,215	-$1,889,034	-$432,608	-$684,066
11	-100,890	-$1,294,667	-$1,310,215	-$1,889,034	-$432,608	-$684,066
12	-100,890	-$1,294,667	-$1,310,215	-$1,889,034	-$432,608	-$684,066
13	-100,890	-$1,294,667	-$1,310,215	-$1,889,034	-$432,608	-$684,066
14	-100,890	-$1,294,667	-$1,310,215	-$1,889,034	-$432,608	-$684,066
15	-100,890	-$1,294,667	-$1,310,215	-$1,889,034	-$432,608	-$684,066
16	-100,890	-$1,294,667	-$1,310,215	-$1,889,034	-$432,608	-$684,066
17	-100,890	-$1,294,667	-$1,310,215	-$1,889,034	-$432,608	-$684,066
18	-100,890	-$1,294,667	-$1,310,215	-$1,889,034	-$432,608	-$684,066
19	-100,890	-$1,294,667	-$1,310,215	-$1,889,034	-$432,608	-$684,066
20	-100,890	-$1,294,667	-$1,310,215	-$1,889,034	-$432,608	-$684,066
21	-100,890	-$1,294,667	-$1,310,215	-$1,889,034	-$432,608	-$684,066
22	-100,890	-$1,294,667	-$1,310,215	-$1,889,034	-$432,608	-$684,066
23	-100,890	-$1,294,667	-$1,310,215	-$1,889,034	-$432,608	-$684,066
24	-100,890	-$1,294,667	-$1,310,215	-$1,889,034	-$432,608	-$684,066
25	-100,890	-$1,294,667	-$1,310,215	-$1,889,034	-$432,608	-$684,066
26	-100,890	-$1,294,667	-$1,310,215	-$1,889,034	-$432,608	-$684,066
27	-100,890	-$1,294,667	-$1,310,215	-$1,889,034	-$432,608	-$684,066
28	-100,890	-$1,294,667	-$1,310,215	-$1,889,034	-$432,608	-$684,066
29	-100,890	-$1,294,667	-$1,310,215	-$1,889,034	-$432,608	-$684,066
30	-100,890	-$1,294,667	-$1,310,215	-$1,889,034	-$432,608	-$684,066
31	-100,890	-$1,294,667	-$1,310,215	-$1,889,034	-$432,608	-$684,066
32	-100,890	-$1,294,667	-$1,310,215	-$1,889,034	-$432,608	-$684,066
33	-100,890	-$1,294,667	-$1,310,215	-$1,889,034	-$432,608	-$684,066
34	-100,890	-$1,294,667	-$1,310,215	-$1,889,034	-$432,608	-$684,066
35	-100,890	-$1,294,667	-$1,310,215	-$1,889,034	-$432,608	-$684,066
36	-100,890	-$1,294,667	-$1,310,215	-$1,889,034	-$432,608	-$684,066
37	-100,890	-$1,294,667	-$1,310,215	-$1,889,034	-$432,608	-$684,066
38	-100,890	-$1,294,667	-$1,310,215	-$1,889,034	-$432,608	-$684,066
39	-100,890	-$1,294,667	-$1,310,215	-$1,889,034	-$432,608	-$684,066
40	-2,131,982	-27,358,697	-27,687,246	-39,918,767	(9,141,805)	(14,455,569)
41	-98,976	-25,947,529	-24,695,493			
42	1.0	9.1	9.3	13.3	6.5	10.2
43						
44						
45						
46						
47						
48						
49	t Resource Guide, 2-					
50						

	A	B	C	D	E	F
1	**Table B-12. Cost of Transport & Disposal of Refuse Pneumatic (Applying Volume Reduction From "Save As You Throw" P**					
2		No-Action OR				
3		Manual	Upgrade(3)(4)	Upgrade(5)	Upgrade Avg(6)	
4	Residential Refuse TPD(1)	7.33	6.45	6.45	6.45	
5	Residential Paper TPD(1)	1.96	2.08	2.33	2.20	
6	Residential MGP TPD(1)	1.27	1.33	1.64	1.48	
7	Total	10.56	9.86	10.41	10.14	
8	W/ Avg 6% Source Reduction(3)				9.93	
9						
10	REFUSE					
11	Transport+Disposal Cost/Yr(12)	$382,589	$336,679	$336,679	$336,679	
12	Transport+Disposal Savings/Yr				$45,911	
13	Transport Fuel/Gals Yr(8)	6,827	6,008	6,008	6,008	
14	Transport Fuel Savings/Gals Yr				819.24	
15	Transport GHG/Yr(7)	88			78	
16	Transport GHG Savings/Yr				11	
17	Disposal GHG/Yr(9)	270			237	
18	Disposal GHG Savings/Yr				32	
19	Total Transport+Disposal GHG	358	0	0	315	
20	Total Transport+Disposal GHG Savings				42.96	
21	Transport BTUs/Yr(11)	948,271,737	834,479,128	834,479,128	834,479,128	
22	Transport BTU Savings/Yr				113,792,608	
23	Transport Truck Miles/Yr(10)	1264	1113	1113	1113	
24	Transport Truck Mile Savings/Yr				152	
25						
26	(1)Reconnaissance Report.					
27	(2)Compostables are a subset of Refuse, so these four rows cannot be summed.					
28	(3)National averages, http://www.paytnow.org/PAYT_CO_faqpaytSERA_v6.pdf, 2008, accessed 12-14-12.					
29	National average %reduction in waste-generation, not including yard waste:				0.12	
30	(4)Ibid., national avg % increase in recycling.				0.06	
31	(5)Ibid, national average recycling increase as % of waste generation.				0.05	
32	(6)Ibid, using average of (4)+(5) methods.					
33	(7)CBC, Taxes In, Garbage Out, 5-2012, p. 18, http://www.cbcny.org/sites/default/files/REPORT_SolidWaste_053312012.pdf, accessed 12-17-					
34	12. (Metric tons*1.1 to convert to US tons)					
35	(8)Ibid, p. 16, tons landfilled/yr	2,900,000				
36	(8)Ibid, pp.18-9., gals/yr	7,400,000				
38	(9)Ibid, Table 2.					
39	(10)NYC Mayor's Office of Sustainability and Long-Term Planning, Inventory of New York City Greenhouse Gas Emissions, 9-2011, pp. 21 and					
40	32, cited by CBC, op. cit.					
41	(11)Gals-to-BTUs conversion factor from Fuel-Use Comparison.xlsx, Current Operations worksheet					
42	(12)CBC op cit., p. 30: avg cost of transport and disposal				143	

Table B-13. Annual Cost of Ro-Ro Collection from Roosevelt Island

Refuse Collection

	2011 Actual	No-Action	U	UR	URCL
Fuel Gallons (1)	933	1179	770	907	1398
Fuel Cost (1)	$3,125	$3,950	$2,581	$3,039	$4,684
Cost of Ro-Ro Truck, Ann (2)	$4,709	$5,951	$3,477	$3,477	$3,123
Vehicle Maintenance (3)	$2,929	$3,701	$2,163	$2,163	$3,423
Labor:					
Total shifts per year (4)	35.75	45.18	26.40	26.25	41.78
Annual labor cost (5)	$16,894	$21,351	$12,477	$12,477	$19,745
Total annual RO RO Cost:	$27,656	$34,952	$20,698	$21,156	$30,975
Cost per ton:	$13	$13	$8	$8	$8

MGP Collection

	2011 Actual	No-Action	U	UR	URCL
Fuel Gallons (1)	414	523	585	202	218
Fuel Cost (1)	$1,387	$1,753	$1,753	$677	$729
Cost of Ro-Ro Truck, Ann (2)	$4,248	$5,236	$5,236	$1,566	$1,742
Vehicle Maintenance (3)	$2,642	$3,257	$3,257	$974	$1,083
Labor:					
Total shifts per year (4)	32.25	40.76	40.76	11.89	13.22
Annual labor cost (5)	$15,240	$18,788	$18,788	$5,617	$6,249
Total annual RO RO Cost:	$23,517	$29,035	$29,035	$8,834	$9,804
Cost per ton:	$63	$63	$63	$19	$19

Paper & OCC Collection

	2011 Actual	No-Action	U	UR	URCL
Fuel Gallons (1)	1053	1330	1487	196	240
Fuel Cost (1)	$3,526	$4,456	$4,456	$658	$803
Cost of Ro-Ro Truck, Ann (2)	$10,141	$12,503	$12,503	$1,566	$1,802
Vehicle Maintenance (3)	$6,308	$7,776	$7,776	$195	$224
Labor:					
Total shifts per year (4)	77.00	97.31	97.31	11.89	13.68
Annual labor cost (5)	$36,387	$45,986	$45,986	$5,617	$6,465
Total annual RO RO Cost:	$56,362	$70,721	$70,721	$8,035	$9,295
Cost per ton:	$97	$99	$99	$11	$10

	2011 Actual	No-Action	U	UR	URCL
Total ann. cost all fractions:	**$107,536**	**$134,708**	**$120,454**	**$38,024**	**$50,074**
Total ann. Shifts all fractions:	**145.00**	**183.25**	**164.47**	**50.02**	**68.69**
Total ann. Collections all fractions:	**580.00**	**733.00**	**657.89**	**200.07**	**274.76**

Notes:

(1) (Fuel for garage-AVAC*percentage of total trips from AVAC)+(fuel for AVAC-disposal location)*52 weeks/year*cost of fuel. For mileage calculation Table B-4.

#2 ULS B5 Diesel fuel/gallon, Brautigam to Miller 10/06/11, $3.25 in 2011$, inflated to 2013$:	$3.25	$3.35

(2) 2011 DSNY Ro-Ro, 5-yr life. Brautigam to Miller 10/06/11. Cost annualized and apportioned based on number of shifts over total possible assuming 6-day work wk, 52 wks/yr.

Truck cost, $199,066 2011$, inflated to 2013$:	$205,462

(3) 2011 DSNY Roll-On/Roll-Off annual maintenance. Brautigam to Miller 6/30/11. Cost apportioned based on number of shifts over total possible assuming 6-day work wk, 52 wks/yr.

Annual maintenance cost, $24,763 in 2011$, inflated to 2013$:	$25,559

(4) Total annual shift calculation: each round trip takes 2 hours or 25% of an 8-hour shift*number of trips*52 weeks/year. For trip calculation see mileage in Table B-4.

(5) Labor cost aportioned based on number of shifts over the total 6 days a week, 52 weeks a year. 2011 DSNY Salary. Brautigam to Miller 06/30/11.

The average annual Sanworker salary plus fringe as of 6/1/2010, $109,517, inflated to 2013$:	$116,604
RO/RO Pickup Differential @ $92.82 per Day for 312 days year, inflated to 2013$:	$30,835
Maximum annual labor Cost for RO RO:	$147,438.96

Table B-14 Pneumatic Upgrade Container Calculation

	A	B	C	D	E	F	G	H	I	J
12	**FRACTIONS**								**T/day**	
13		% WEIGHT	FRACTION	REST	PACKING	ORGANIC	PAPER		dwellings	5,875
14	REST	0.30	1	0.30	0.00	0.00	0.00		kg/dwelling	3.20
15	PACKINGS	0.07	0	0.07	0.00	0.00	0.00		kg/Dwellin data	
16	ORGANIC	0.49	0	0.49	0.00	0.00	0.00		**total**	**7.33**
17	PAPER	0.14	0	0.14	0.00	0.00	0.00			
18		1.00		1.00	0.00	0.00	0.00			

	A	B	C	D	L
21	**DENSITY**				
22		KG/L	DATA	CALC	
23	REST	0.13		0.13	
24	PACKING	0.08		0.08	
25	ORGANIC	0.20		0.20	
26	PAPER	0.05		0.05	**Correc. factor(0,25-1,00)**
27					0.75

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
29	**CONTAINERS MOVE**																
30		FRAC-CONT.	TRANSP	**CONT**	% Fraction	Tons/CONT	VOLUM	COMPACT.	DENSITY	RATIO VOL	RATIO WEIGHT	MAX VALUE	€/TRIP	€/DAY	**TOTAL**	Trips/Yr	Tons/Container
31	REST C	0	1	**0**	0.00	12.00	30.00	0.29	0.13	0.00	0.00	0.00	0.00	0.00	**0.00**		
32	PACKING C	0	1	**0**	0.00	12.00	30.00	0.50	0.08	0.00	0.00	0.00	0.00	0.00	**0.00**		
33	ORGANIC C	0	1	**0**	0.00	12.00	30.00	0.77	0.20	0.00	0.00	0.00	0.00	0.00	**0.00**		
34	PAPER-CARDBOARD C	0	1	**0**	0.00	12.00	30.00	0.67	0.05	0.00	0.00	0.00	0.00	0.00	**0.00**		
35	REST C-CRANE	0	0	**0**	0.00	10.00	25.00	0.29	0.13	0.00	0.00	0.00	0.00	0.00	**0.00**		
36	PACKING C-CRANE	0	0	**0**	0.00	10.00	25.00	0.50	0.08	0.00	0.00	0.00	0.00	0.00	**0.00**		
37	ORGANIC C-CRANE	0	0	**0**	0.00	10.00	25.00	0.77	0.20	0.00	0.00	0.00	0.00	0.00	**0.00**		
38	PAPER-CARDBOARD C-CRANE	0	0	**0**	0.00	10.00	25.00	0.67	0.05	0.00	0.00	0.00	0.00	0.00	**0.00**		
39	REST G	1	1	**1**	1.00	19.00	45.60	0.29	0.13	0.35	0.39	0.29	0.00	0.00	**0.00**	105.61	25.33
40	PACKING G	1	1	**1**	0.00	19.00	45.60	0.50	0.08	0.00	0.00	0.00	0.00	0.00	**0.00**		
41	ORGANIC G	0	1	**0**	0.00	19.00	45.60	0.30	0.20	0.00	0.00	0.00	0.00	0.00	**0.00**		
42	PAPER-CARDBOARD G	1	1	**1**	0.00	19.00	45.60	0.50	0.05	0.00	0.00	0.00	0.00	0.00	**0.00**		
43	REST G-CRANE	1	0	**0**	0.00	10.00	25.00	0.29	0.13	0.00	0.00	0.00	0.00	0.00	**0.00**		
44	PACKING G-CRANE	1	0	**0**	0.00	10.00	25.00	0.50	0.08	0.00	0.00	0.00	0.00	0.00	**0.00**		
45	ORGANIC G-CRANE	0	0	**0**	0.00	10.00	25.00	0.77	0.20	0.00	0.00	0.00	0.00	0.00	**0.00**		
46	PAPER-CARDBOARD G-CRANE	1	0	**0**	0.00	10.00	25.00	0.67	0.05	0.00	0.00	0.00	0.00	0.00	**0.00**		
47	REST F	0	-	**0**	0.00	6.00	21.00	0.40	0.13	0.00	0.00	0.00	0.00	0.00	**0.00**		

	A	B	C	D	E	F	G
20	**Table B-14 Pneumatic Upgrade Container Calculation**		**(continued: Upgrade + Recycling)**				
21	**FRACTIONS**						
22		% WEIGHT	FRACTION	REST	PACKING	ORGANIC	PAPER
23	REST	0.41	1	0.41	0.00	0.00	0.00
24	PACKINGS	0.12	1	0.00	0.12	0.00	0.00
25	ORGANIC	0.28	0	0.28	0.00	0.00	0.00
26	PAPER	0.19	1	0.00	0.00	0.00	0.19
27		1.00		0.69	0.12	0.00	0.19
28							
29							

	A	B	C	D	F	G	H	I	L
30	**DENSITY**				RI 2011 Actual % Weight		Total RI 2011 t	Projected tpd	
31		KG/L	DATA	CALC	mgp	0.12	8.42	10.56	
32	REST	0.13		0.13	paper	0.19			
33	PACKING	0.08		0.08	refuse-organi	0.28			
34	ORGANIC	0.20		0.20	refuse-refuse	0.41			
35	PAPER	0.05		0.05	total refuse	0.69			**Correc. factor(0,25-1,00)**
36									0.75
37									

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
38	**CONTAINERS MOVE**																
39		FRAC-CONT.	TRANSP	**CONT**	% Fraction	Tons/CONT	VOLUM	COMPACT.	DENSITY	RATIO VOL.	RATIO WEIGHT	MAX VALUE	€/TRIP	€/DAY	**TOTAL**	Trips/Yr	Tons/Container
40	REST C	0	1	**0**	0.00	12.00	30.00	0.29	0.13	0.00	0.00	0.00	0.00	0.00	**0.00**		
41	PACKING C	0	1	**0**	0.00	12.00	30.00	0.50	0.08	0.00	0.00	0.00	0.00	0.00	**0.00**		
42	ORGANIC C	0	1	**0**	0.00	12.00	30.00	0.77	0.20	0.00	0.00	0.00	0.00	0.00	**0.00**		
43	PAPER-CARDBOARD C	0	1	**0**	0.00	12.00	30.00	0.67	0.05	0.00	0.00	0.00	0.00	0.00	**0.00**		
44	REST C-CRANE	0	0	**0**	0.00	10.00	25.00	0.29	0.13	0.00	0.00	0.00	0.00	0.00	**0.00**		
45	PACKING C-CRANE	0	0	**0**	0.00	10.00	25.00	0.50	0.08	0.00	0.00	0.00	0.00	0.00	**0.00**		
46	ORGANIC C-CRANE	0	0	**0**	0.00	10.00	25.00	0.77	0.20	0.00	0.00	0.00	0.00	0.00	**0.00**		
47	PAPER-CARDBOARD C-CRANE	0	0	**0**	0.00	10.00	25.00	0.67	0.05	0.00	0.00	0.00	0.00	0.00	**0.00**		
48	REST G	1	1	**1**	0.69	19.00	45.60	0.29	0.13	0.35	0.38	0.29	0.00	0.00	**0.00**	104.98	25.33
49	PACKING G	1	1	**1**	0.12	19.00	45.60	0.50	0.08	0.17	0.07	0.13	0.00	0.00	**0.00**	47.55	9.73
50	ORGANIC G	0	1	**0**	0.00	19.00	45.60	0.30	0.20	0.00	0.00	0.00	0.00	0.00	**0.00**		
51	PAPER-CARDBOARD G	1	1	**1**	0.19	19.00	45.60	[redacted]								43.40	16.88
52	REST G-CRANE	1	0	**0**	0.00	10.00	25.00	0.29	0.13	0.00	0.00	0.00	0.00	0.00	**0.00**		
53	PACKING G-CRANE	1	0	**0**	0.00	10.00	25.00	0.50	0.08	0.00	0.00	0.00	0.00	0.00	**0.00**		
54	ORGANIC G-CRANE	0	0	**0**	0.00	10.00	25.00	0.77	0.20	0.00	0.00	0.00	0.00	0.00	**0.00**		
55	PAPER-CARDBOARD G-CRANE	1	0	**0**	0.00	10.00	25.00	0.67	0.05	0.00	0.00	0.00	0.00	0.00	**0.00**		
56	REST F	0	-	**0**	0.00	6.00	21.00	0.40	0.13	0.00	0.00	0.00	0.00	0.00	**0.00**		
57	PACKING F	0	-	**0**	0.00	3.50	21.00	1.00	0.08	0.00	0.00	0.00	0.00	0.00	**0.00**		
58	ORGANIC F	0	-	**0**	0.00	6.00	21.00	0.91	0.20	0.00	0.00	0.00	0.00	0.00	**0.00**		
59	PAPER-CARDBOARD F	0	-	**0**	0.00	2.00	21.00	1.25	0.05	0.00	0.00	0.00	0.00	0.00	**0.00**		
60	**TOTAL**				**1.00**							**0.75**			**0.00**		
61	UTRC: assume 750 lbs compacted mixed office paper/OCC per cy																

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
29	**Table B-14 Pneumatic Upgrade Container Calculation**				**(continued: Upgrade, Recycling, Commercial & Litter)**												
30	**FRACTIONS**								**T/day**								
31		% WEIGHT	FRACTION	REST	PACKING	ORGANIC	PAPER		dwellings	5,875							
32	REST	0.54	1	0.54	0.00	0.00	0.00		kg/dwelling	3.20							
33	PACKINGS	0.09	1	0.00	0.09	0.00	0.00		kg/Dwellin data								
34	ORGANIC	0.21	0	0.21	0.00	0.00	0.00		**total**	**15.54**							
35	PAPER	0.16	1	0.00	0.00	0.00	0.16										
36		1.00		0.75	0.09	0.00	0.16										
37	**DENSITY**																
38		KG/L	DATA	CALC													
39	REST	0.13		0.13													
40	PACKING	0.08		0.08													
41	ORGANIC	0.20		0.20								**Correc. factor(0,25-1,00)**					
42	PAPER	0.05		0.05								0.75					
43																	
44	**CONTAINERS MOVE**																
45		FRAC-CONT.	TRANSP	**CONT**	% Fraction	Tons/CONT	VOLUM	COMPACT.	DENSITY	RATIO VOL.	RATIO WEIGH	MAX VALUE	€/TRIP	€/DAY	**TOTAL**	Trips/Yr	Tons/Container
46	REST C	0	1	**0**	0.00	12.00	30.00	0.29	0.13	0.00	0.00	0.00	0.00	0.00	**0.00**		
47	PACKING C	0	1	**0**	0.00	12.00	30.00	0.50	0.08	0.00	0.00	0.00	0.00	0.00	**0.00**		
48	ORGANIC C	0	1	**0**	0.00	12.00	30.00	0.77	0.20	0.00	0.00	0.00	0.00	0.00	**0.00**		
49	PAPER-CARDBOARD C	0	1	**0**	0.00	12.00	30.00	0.67	0.05	0.00	0.00	0.00	0.00	0.00	**0.00**		
50	REST C-CRANE	0	0	**0**	0.00	10.00	25.00	0.29	0.13	0.00	0.00	0.00	0.00	0.00	**0.00**		
51	PACKING C-CRANE	0	0	**0**	0.00	10.00	25.00	0.50	0.08	0.00	0.00	0.00	0.00	0.00	**0.00**		
52	ORGANIC C-CRANE	0	0	**0**	0.00	10.00	25.00	0.77	0.20	0.00	0.00	0.00	0.00	0.00	**0.00**		
53	PAPER-CARDBOARD C-CRANE	0	0	**0**	0.00	10.00	25.00	0.67	0.05	0.00	0.00	0.00	0.00	0.00	**0.00**		
54	REST G	1	1	**1**	0.75	19.00	45.60	0.29	0.13	0.56	0.61	0.46	0.00	0.00	**0.00**	167.13	25.33
55	PACKING G	1	1	**1**	0.09	19.00	45.60	0.50	0.08	0.19	0.07	0.14	0.00	0.00	**0.00**	52.90	9.73
56	ORGANIC G	0	1	**0**	0.00	19.00	45.60	0.30	0.20	0.00	0.00	0.00	0.00	0.00	**0.00**		
57	PAPER-CARDBOARD G	1	1	**1**	0.16	19.00	45.60	[redacted]					0.00	0.00	**0.00**	54.73	16.88
58	REST G-CRANE	1	0	**0**	0.00	10.00	25.00	0.29	0.13	0.00	0.00	0.00	0.00	0.00	**0.00**		
59	PACKING G-CRANE	1	0	**0**	0.00	10.00	25.00	0.50	0.08	0.00	0.00	0.00	0.00	0.00	**0.00**		
60	ORGANIC G-CRANE	0	0	**0**	0.00	10.00	25.00	0.77	0.20	0.00	0.00	0.00	0.00	0.00	**0.00**		
61	PAPER-CARDBOARD G-CRANE	1	0	**0**	0.00	10.00	25.00	0.67	0.05	0.00	0.00	0.00	0.00	0.00	**0.00**		
62	REST F	0	-	**0**	0.00	6.00	21.00	0.40	0.13	0.00	0.00	0.00	0.00	0.00	**0.00**		
63	PACKING F	0	-	**0**	0.00	3.50	21.00	1.00	0.08	0.00	0.00	0.00	0.00	0.00	**0.00**		
64	ORGANIC F	0	-	**0**	0.00	6.00	21.00	0.91	0.20	0.00	0.00	0.00	0.00	0.00	**0.00**		
65	PAPER-CARDBOARD F	0	-	**0**	0.00	2.00	21.00	1.25	0.05	0.00	0.00	0.00	0.00	0.00	**0.00**		
66	**TOTAL**				**1.00**							**1.02**			**0.00**		

67 UTRC: assume 750 lbs compacted mixed office paper/OCC per cy

68	RI 2011 Actual % Weight (2)				
69		% Weight	tpd	future tpd recycling	Projected tpd
70	mgp	0.12	1.03	0.24	1.27
71	paper	0.19	1.59	0.37	1.96
72	refuse-organic	0.28	1.60		
73	refuse-refuse	0.41	4.20		2.02
74	total refuse	0.69	5.80		5.31
75	Total	1.00	8.42		7.33
76		Total add. Future tpd recycling:		0.61	10.56

RI Commercial 2011 Actual same as proj. (1)		
	% Weight	tpd
mgp	0.03	0.14
paper	0.12	0.57
refuse-organic	0.26	1.20
refuse-refuse	0.59	2.77
total refuse	1.00	3.97
	Total proj commercial:	4.68
	RIOC & Litter refuse:	0.30

77			
78	RI 2011 Projected combined Commercial & Residential (& .3 refuse for RIOC & litterbins)		
79		tpd	%weight
80	mgp	1.41	0.09
81	paper	2.53	0.16
82	refuse-organic	3.22	0.21
83	refuse-refuse	8.38	0.54
84	total refuse	11.30	0.73
85	total	15.54	1.00

86 Notes
87 (1) See Ref 4 Summary
88 (2) See Ref3-RI_residential bldgs.xlsx

	A	B	C	D	E	F	G	H
1	**Table B-15. Current Roosevelt Island DSNY RO RO Collections**							
2		Collections(b)	Fraction Ratio	Tons(b)	Avg T/Col	Tons 2007-9(a)	Delta '07-'09 v '12©	Delta%
3	Refuse/Y	143	0.25	1770.49	12.38	2014.3		
4	Paper/Y	308	0.53	369.26	1.20	402		
5	MGP/Y	129	0.22	266.03	2.06	259.4		
6	Total	580		2405.78		2675.7	269.9	0.10
7	Tot Per/Wk	11.15						
8	Hrs/Wk	22.31						
9	Hrs/Day	3.19						
10	Refuse/Wk	2.75						
11	Refuse Hr/W	5.50						
12	Refuse Hr/D	0.79						
13								
14								
15	(a) DSNY, Roosevelt Island Costs to Convert to 25 Yard Truck Pick-Up, Braugtigam to Miller, 6-30-11, Appendix A, Reference 1.							
16	(b) DSNY Collection Route Data, FY2012 (SCAN).							
17								
18	© Delta 2007-9 v. 2012 could be due to (1) general citywide reduction in generation, (2) missing some routes because scrubbed routes that							
19	had comments or other indication that might not be valid RI routes for sampling purposes.							

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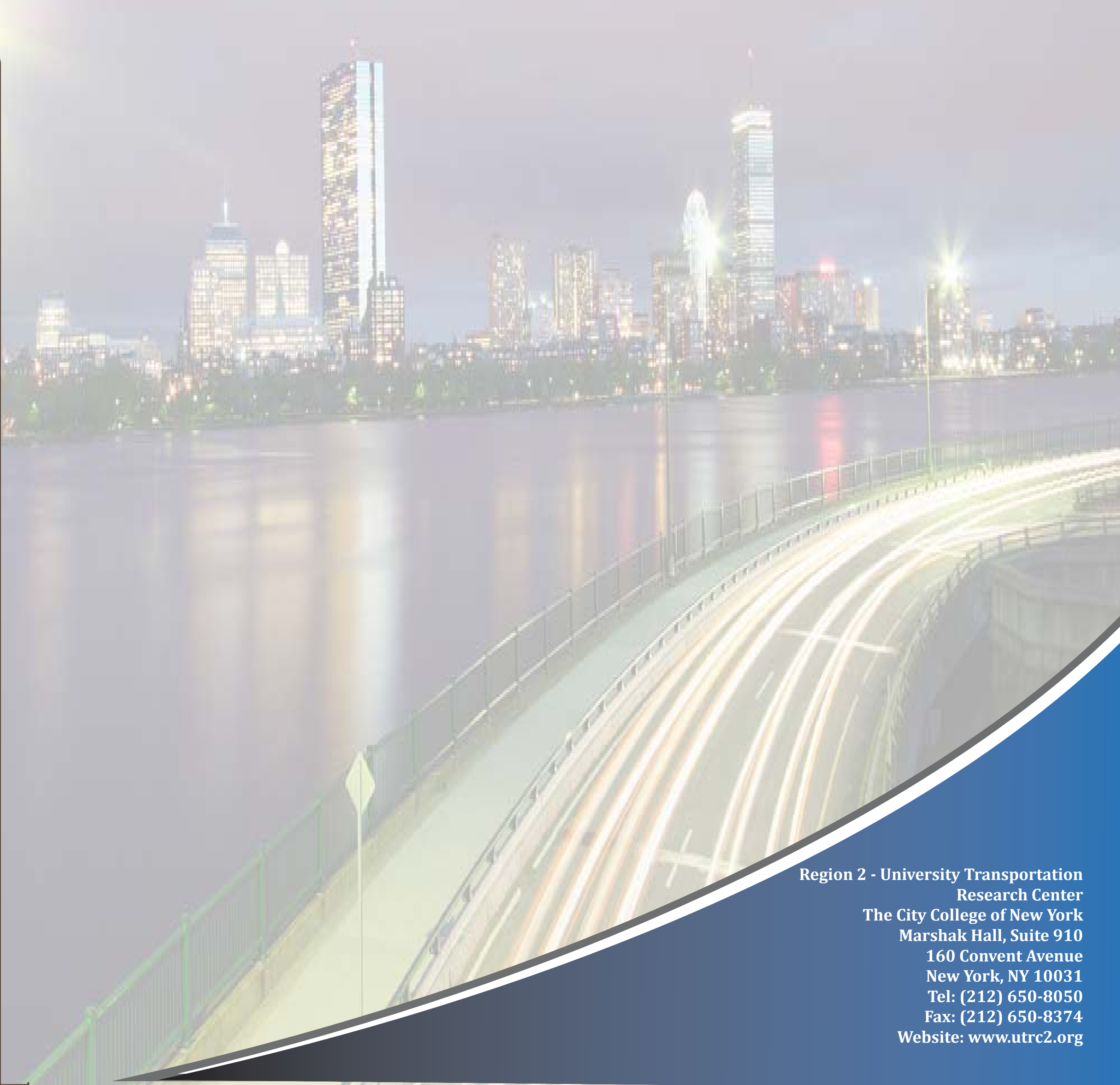

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