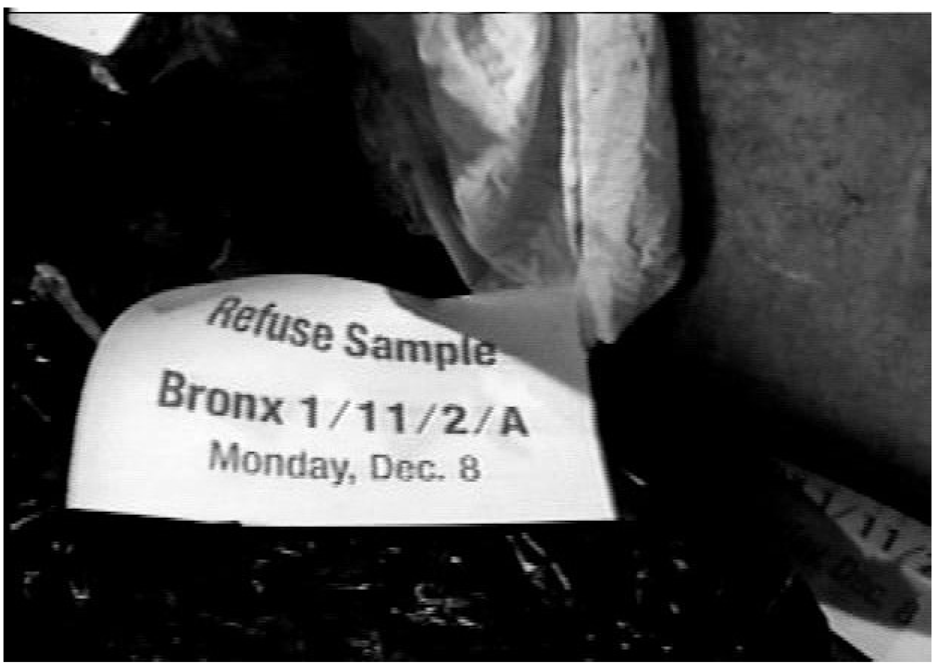
New York City Department of Sanitation

Kevin P. Farrell
Commissioner

Martha K. Hirst
Deputy Commissioner, Solid Waste

MIXED WASTE PROCESSING IN NEW YORK CITY

A Pilot Test Evaluation



Prepared by:
The New York City Department of Sanitation
Bureau of Waste Prevention, Reuse and Recycling
Robert Lange, Director

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Glossary

BCC	New York City Department of Sanitation Bureau of Cleaning and Collection
BPB	New York City Department of Sanitation Bureau of Planning and Budget
BQE	Waste Management facility at 75 Thomas St., Brooklyn, used for 2ndary sort.
BWD	New York City Department of Sanitation Bureau of Waste Disposal
Capture Rate	Total material recycled as a percent of that material in the waste generated based on a prior analysis of waste composition.
City	New York City
Composition Rate	A material or group of materials as a percent of total waste generated, inclusive of Recyclables.
Compost Test	Study of composting the Processing Test organic residual stream (Chapter 4 of this report)
Curbside Program	The Department's collection program, which provides separate curbside (certain sites are containerized) collection of Recyclables to every household in the City.
Degrees of Freedom	The number of samples minus one.
Department	Department of Sanitation
Diversion Rate	Material collected as Recyclables, as a percent of total material generated and set out at curbside. Diversion rate is measured as: Recyclables) (waste and Recyclables).
FY	Fiscal Year
HDPE	High Density Polyethylene
HDR	Department of Sanitation consultant Henningson, Durham & Richardson Architecture & Engineering, P.C. in Association with HDR Engineering, Inc.
HI/LD	High Income/Low Density Strata as defined in the 1990 Waste Composition Study. The 1990 Study used three strata (high, medium and low) for both housing density and income levels and presented waste composition analyses for nine combinations of these strata.
lb/hh/day	Pounds per household per day
LDPE	Low Density Polyethylene
Low Diversion District	As reported in the BPB Diversion Report summary for FY '97, those collection districts with Diversion Rates below 10.5% were classified as Low Diversion Districts. Twenty collection districts were in this group, or approximately one-third of the City's collection districts.
M-3	Zoning classification for heaviest industrial use
MGP	Specific materials in the categories of metal, glass and plastic which are designated Recyclables by the Department: ferrous metal and aluminum, including cans, aluminum foil and household bulk metal, such as used appliances consisting of approximately 50% ferrous metal; glass beverage and food containers; and plastic bottles and jugs.
MMR	Mayor's Management Report
MRF	Material Recovery Facility

MSW	Municipal solid waste: non-hazardous solid wastes generated from households, commercial and business establishments, institutions, and nonmanufacturing activities in industry. Excludes waste from industrial processes, agriculture, mining, sludges, regulated medical facilities, etc.
Net Diversion Rate	Material collected by the Curbside Program as Recyclables less contaminated and non-targeted materials included in the Recyclables collection as a percent of the total waste collected.
NYSDEC	New York State Department of Environmental Conservation
1990 Study	Citywide 1990 Waste Composition Study
1997 Study	Waste composition study of sampled routes in Low Diversion Districts, 12/97 (Chapter 2 of this report)
Non-Recyclables	Garbage and materials not designated recyclable for collection by the Curbside program.
O&M	Operations and maintenance
OAU	The New York City Department of Sanitation Operations Assistance Unit
OCC	Old Corrugated Cardboard
PCBs	Polychlorinated Biphenyls
PET	Polyethylene Terpephthalate
Potentially Recyclable	Classification of products that might be recyclable, based on the material content of the product, rather than the condition of the particular product.
Processing Test	12/97 study of mixed waste processing in Bk8 (Chapter 3 of this report)
PVC	Polyvinyl Chloride
Recyclable Paper	Paper components of the residential waste stream that are designated Recyclables by the Department and include newspaper, corrugated cardboard, other cardboard (cereal boxes, linerboard), paper beverage containers, junk mail, and paperback books.
Recyclables	Paper and MGP materials that are designated recyclable material for collection by the Curbside Program.
Standard Deviation	The square root of the Variation.
Standard Error	Standard Deviation divided by the square root of the number of samples.
Student t	A continuous random variable whose probability distribution is completely specified by a single parameter referred to as the number of degrees of freedom.
Variation	The sum of the data squared minus the sum of the squared data divided by the number of samples all divided by the Degrees of Freedom.

CHAPTER 1: OVERVIEW

1.0 INTRODUCTION

In December 1997, the New York City Department of Sanitation, as part of its ongoing assessment of strategies to gauge and improve the performance of New York City's Curbside Recycling Program (Curbside Program), conducted a short-term, three-part pilot program to measure the effectiveness of mixed waste processing in recovering Recyclables from City collection districts with historically low recycling diversion rates. (1) The first part of the pilot was a waste composition sampling program; it was conducted in low recycling diversion districts and was designed to ascertain current baseline waste composition values. It is referred to below as the 1997 Study. (2) The second part was the actual processing, using a mixed waste processing facility to mechanically and manually recover Recyclables from the waste of one of the districts. It is referred to as the Processing Test. (3) Finally, a Compost Test addressed questions of the suitability of composting the organic residue from mixed waste processing.

Mixed waste processing involves some degree of sorting and processing *waste* to remove items that should have been put in the recycling bin, and is a term used to describe many different collection and processing variations. (See Chapter 3.) Periodically, as the City's Recycling Program has evolved, some form of mixed waste processing has been suggested as a possible way to improve recycling Diversion Rates[1] in collection districts where those rates were the lowest. For the year ending June 30, 1997, four years after the full implementation of the City's Curbside Recycling Program that required residents to set out newspapers/magazines/corrugated and metal/glass/plastic (MGP), 20 of the New York City's 59 Sanitation collection districts (Low Diversion Districts) still had Diversion Rates of 10% or less. Overall, those districts had a Diversion Rate of 8.1% (the straight average of the 20 districts' rates was 7.7%; see Tables 1A

[1]The Diversion Rate is that portion of total material generated (waste and recyclables) that is diverted from the waste stream through recycling. Generators are NYC residents, and institutions that receive DOS collection. The Diversion Rate is measured by dividing the weight of DOS-collected recyclables by the weight of waste and DOS-collected recyclables. *That is,* $D = R \div (R + W)$, *where*

D is Diversion Rate,
R is weight of all Recyclables (paper and metal/glass/plastic [including bulk metal])
W is weight of Waste

and 1B), while the Diversion Rate for the City's other 39 districts was 18.7%, more than twice as large; the overall City Diversion Rate was 14.4%.

Thus, at the beginning of FY98 (June 1997) the Department began to consider a pilot test for Low Diversion Districts. At that time, the final expansion of the Curbside Recycling Program was partially phased in, with three of the City's five boroughs also recycling mixed paper and household/bulk metal in addition to the original materials. In September (1997), the addition of Brooklyn and Queens completed the expansion. By October, the Diversion Rate *for those same 20 Low Diversion Districts*[2] was 10.4%, and 21.0% for the other 39 districts, and rose somewhat

Table 1A: Diversion Rates +

Districts	FY97 (7/96-6/97)	Oct. 1997	Dec. 1997	Feb.1998
20 Low Diversion Districts, as originally designated	8.1%	10.4%	11.1%	10.7%
Straight average of 20 district Diversion Rates	*7.7%*	*9.7%*	*10.1%*	*10.1%*
Other 39 districts	18.7%	21.0%	21.5%	
Citywide, for district-based collection*	14.4%	17.9%	18.4%	18.5%
Citywide, for all collection (including all containerized) **	n.a.	16.7%	17.2%	17.5%

+ Diversion Rate based on total weights of recyclables and waste for each of the relevant groups, except where noted.
* The citywide Diversion Rate *excluding* material generated by apartment complexes with full containerization (where both waste and recyclables are containerized, collection trucks cross districts lines, and cannot record weight by district).
** The citywide Diversion Rate *including* the material generated by containerized apartment complexes. DOS began to calculate this rate beginning in 1998, following the final expansion of the Curbside Recycling Program. Historically, these sites recycle at somewhat lower rates than the rest of the City, and thus reduce the district-specific average Diversion Rate somewhat. (This is characteristic of a national pattern documented in "Multi-Family Recycling," a study conducted for the U.S. Conference of Mayors with funding from EPA [Barbara Stevens, Ecodata; 1999].)
n.a.: not available

Note: Beginning in Fall 1997, the NYC Council funded community outreach in low diversion collection districts through the Department's Bureau of Waste Prevention, Reuse and Recycling. Efforts were directed to the 23 districts whose Diversion Rates were 12% or less. These were the 20 districts listed in Table 1B, as well as Bk14, Q3, and Q4.

Source: DOS (Operations Management Division, Bureau of Planning & Budget).

[2] See footnote 4.

in December (to 11.1% and 21.5%, respectively) at the time of the sampling for this study. (See Table 1A.) Thus, even with the program expansion, it was presumed that in some districts much that should have been recycled was being thrown away with the garbage. It was hoped that this brief pilot would indicate the general degree to which mixed waste processing might improve the recovery of Recyclables in targeted districts, and at what possible cost.

1.1 SUMMARY

Each part of the pilot is treated in a chapter of this report. Each chapter defines relevant terms, explains the test protocols, and sets forth the results. The balance of this first chapter summarizes results described in Chapter 2, 3 and 4; further defines the Low Diversion Districts; and acknowledges those who helped.

Chapter 2 covers the findings of the 1997 Study, and compares them to waste composition results from the Department's 1990 Waste Composition Study (1990 Study) for similar districts. As stated above, the original purpose of this part of the pilot was to establish a baseline for evaluating the material to be processed in the Processing Test, and in particular to determine the Composition Rate for Recyclables, that is, the portion of all material set out by households that is designated Recyclable in the Citywide Curbside Recycling Program. But since the areas sampled covered one of the nine income/density strata used in the 1990 Study, it was possible to go beyond the initial purpose and make some comparisons with the past. Insights into the current applicability of the 1990 Study are important in assessing the success of the Curbside Recycling Program. For the districts sampled, the 1997 Study found a Recyclables Composition Rate of 23.2%, based on identifiable, program-designated materials sorted under real-life operating conditions to a current market standard. Adding estimates of broken glass and contaminated paper brought the composition to 30.2%. This Recyclables Composition was found to be (statistically) significantly smaller than that found in the 1990 Study. Figure 1A highlights the findings and their implications.

Chapter 3 covers the findings of the Processing Test. Since processing solid waste to remove Recyclables before landfilling adds to material handling, the feasibility assessment required both measuring how much this additional step might increase Diversion Rates, and estimating how much it would cost. The pilot framework also allowed for a first-round assessment of two potential program elements. The first was using mixed waste processing to sort Waste and Recyclables collected together to reduce collection costs. In sorting through Waste for materials designated Recyclable for collection by the Curbside Program, the Processing Test increased the base Diversion Rate for the district studied (7.3% on a net basis) by 11.4 points to 18.7%. Alternatively, it showed that a combined sort of Waste and Recyclables collected together yielded a total Diversion Rate of 16.0%. An economic model showed that the first result could be done under scenarios that follow the current Curbside Program structure at a cost per additional ton recycled ranging from $87 to $215, depending on cost and location assumptions. Under the same assumptions, but alternative program scenarios that allowed for co-collection of Waste and Recyclables in the same vehicle, costs might increase as much as $89 per-incremental-ton or actually fall by $51 per-incremental-ton. Figure 1B highlights these findings.

The second program element that the pilot allowed for was the composting of a sample of the residual "mixed waste" stream after the Recyclables had been removed. Chapter 4 covers a preliminary evaluation of the suitability of composting this organic residue from the Processing Test. The compost produced from a limited sample had nickel levels that exceeded New York State standards for the top quality of compost, and high levels of inert matter (mostly glass). Thus, quality and cost estimates do not justify making compost from this kind of mixed waste processing residue. Figure 1B highlights these findings.

Figure 1A

Summary, 1997 Waste Composition component of Low Diversion Collection District Pilot

The Department conducted a waste composition study as a baseline for measuring the effectiveness of mixed waste processing of Recyclables from districts with low recycling diversion rates. Material was collected from randomly selected sample routes in low income/high density districts (40 routes from 15 districts in Brooklyn and Bronx), during one week in December 1997.

RESULTS of Waste Composition Measurements

- Waste Composition: "Actual" Recyclables were 23.2% of all material.

  Measure was based on identifiable recyclable material, from both Recyclables and disposed Waste set out at curbside and sorted under regular conditions to a current market standard. [Section 2.4.2; Tables 2C and 2D]

- Adjusted Waste Composition: "Potential" Recyclables were 30.2% of all material; the paper portion was 20.6%.

  Actual Recyclables were adjusted to include (1) broken glass that could not be counted under test conditions but normally are recycled, and (2) paper residue, including contaminated paper, so that comparisons could be made with 1990 waste composition measures. [Section 2.5.2; Table 2H]

- Capture Rate: Households correctly recycled 32.2% – about one third – of the material they were supposed to recycle; the rest was incorrectly put out with garbage.

  The Capture Rate was measured by dividing the weight of correctly-separated Recyclables by the actual Recyclables, as determined by the waste composition study. [Section 2.4.4; Table 2E]

COMPARISON of 1997 Composition Study to 1990 Study

- The current potential recyclables composition is significantly less than the recyclables composition found in 1990 baseline studies, both overall (30.2% compared to 43.4%) and for paper (20.6% compared to 28.4%).

  The comparison was made between this study and the City's 1990 Waste Composition Study, for similar districts in a similar season (low income/high density; winter).
  The differences were found to be statistically significant, so that differences remain even taking sampling variation into account. [Section 2.5; Table 2H]

IMPLICATIONS of Results

- These collection districts seem to be doing a better job of recycling than had been assumed.

  Fewer Recyclables than expected were set out at curbside because there is less recyclable material in households, rather than because of lower program participation. The Capture Rates based on the 1990 Composition rates are as low as 20% to 25% for some of these districts, as opposed to the 1997 Study measure of 32.2%.

- The lower composition of Recyclables in these districts means that the Department will have greater-than-anticipated difficulty in achieving a 25% Citywide average diversion rate.

  If the rates found in the 1997 Study are representative of all low diversion districts, and assuming the City's other 39 districts have a Recyclable composition unchanged from 1990, these 39 districts would have to have the effectively unattainable Capture Rate of 87.7% – for a citywide average Capture Rate of 75.6% – to reach a 25% diversion rate. If Recyclable composition has dropped to under 25% *everywhere*, the 25% rate is unattainable by definition. [Table 2A]

Figure 1B

Summary, 1997 Mixed Waste Processing & Composting components of Low Diversion Collection District Pilot

The Department conducted a study to assess the effectiveness of using mixed waste processing to retrieve Recyclables and thus raise diversion rates in areas where rates are relatively low. All Waste and Recyclables from a single district were collected over one week in December 1997; portions of Waste alone, and portions of Waste with Recyclables, were sorted for the removal of Recyclables. Costs of processing facilities were estimated using an engineering model, and incremental costs of mixed waste processing were estimated under different collection/processing scenarios. A portion of the residual from mixed waste processing was composted.

RESULTS of Mixed Waste Processing Test *(results apply to waste stream from district and time period studied)*

- Using mixed waste processing to sort Waste alone yielded Recyclables in the amount of 11.4% of total household material. That is, for this waste stream, mixed waste processing (of Waste alone) would add 11.4 percentage points to whatever the diversion rate from Recyclables had been. For this district, the gross diversion rate became 22.5%; the net diversion rate became 18.7%.

  GROSS DIVERSION: At the time, residents in this district were setting out Recyclables at an average rate of 11.1% of all materials. Thus, by combining r*ecyclables* incorrectly thrown into Waste with correctly separated *Recyclables*, mixed waste processing here effectively doubled the "gross" diversion rate, bringing it from 11.1% to 22.5.% This is a gross measure because regular curbside diversion rates are based on the weight of Recyclables collected; thus they include residue.
  NET DIVERSION: Estimating to account for residue, mixed waste processing here contributed to a "net" diversion rate of 18.7% (11.4% from mwp of Waste, plus 7.3% net diversion from curbside collection of Recyclables). [Section 3.6; Table 3F]

- Using mixed waste processing to sort *co-collected* Waste and Recyclables yielded a net diversion rate of 16.0%.

  On two of the five test days when collection took place, residents set out Waste and separated Recyclables (paper, and metal/glass/plastic). The Waste and all Recyclables were collected together in one truck for processing, yielding the 16.0% net diversion rate. [Section 3.6; Table 3F]

COST ESTIMATES

- An economic model with a range of scenarios indicates that mixed waste processing increases recycling at considerable increases in cost, compared to the current program, for each case where Recyclables are collected separately. Cost savings for the additional recycling, compared to the current program, result under certain co-collection scenarios, as the number of collections are reduced by picking up Recyclables with Waste.

  The costs per incremental ton range from $87 to over $200, for Recyclables collected separately. Under the co-collection scenarios, the highest cost per incremental ton is $89; the lowest is a savings of $51 per ton. [Section 3.7; Tables 3I and 3J] The model assumes that current program participation rates stay the same no matter what the collection scenarios.

RESULTS of Residual Composting Test *(results apply to particular residual waste stream studied)*

- Using drum digestion on mixed waste processing residue that passed through a 4" screen yielded finished compost with a high portion of finely broken glass and other inert material, and nickel concentrations that exceeded published standards.

  This residue stream is an inappropriate target for composting. [Chap. 4] While the concentration of broken glass here may have been unique, the data obtained from this pilot suggest that the residue from mixed waste processing is inherently unsuitable for composting, despite its high organic content.

  An economic model for this process and residue stream suggests net costs of over $90 per incremental ton diverted. The results in this case do not justify using this technology as an adjunct to mixed waste processing.

This report takes appropriate care to qualify the various findings of this pilot, since they are based on the waste and recycling stream from one demographic strata during one season. We believe, however, that the general orders of magnitude are correct. It should be pointed out that a recent Boston study found remarkably similar waste composition measurement results. Excluding yard waste, the recyclable portion of the waste stream in East Boston, sampled during two one-week periods in 1997, averaged 23.3%. A similar study in West Roxbury/Roslindale, over a few weeks in 1998, measured 23%.[3] The comparable rate for the New York districts sampled in the 1997 Study, mentioned above and detailed in Chapter 2, is 23.2%.

Throughout, it may help the reader to keep in mind three major considerations. First, mixed waste processing that succeeds in increasing recycling (Diversion) means processing more material (in order to get out more Recyclables). That requires processing facilities of some threshold size and quality to process enough material to marketable standards. Second, transportation costs are a large part of the costs of New York City's waste system (as they are in many places); and as the subsequent chapters of this report show, it is generally the additional transportation costs or savings, rather than additional processing costs, that will have the biggest effect in determining program viability. Finally, it remains unknown what is the long-term interaction between how materials – waste and Recyclables – are collected and how they are processed. In particular, since transportation costs are so important, it is not a surprise that, on a modeled basis, *co-collection* can make any kind of processing cost effective. Co-collection means that black garbage bags, blue bags with metal/glass/plastic, cardboard, and clear bags with paper, all go on one truck. In this Processing Test, materials were co-collected for only two days. If co-collection were actually instituted, it would require a longer term of observation to determine whether people whose waste and Recyclables are co-collected become less careful about what and how they separate at home. If they do, there could be quality and cost impacts as material is processed, and diversion rates could drop.

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[3] The Boston studies were conducted by DSM Environmental Services for the Boston Public Works Department. (Reports from DSM to PWD are dated 9/12/97 ["Initial East Boston recovery rate analysis"], 12/18/97 ["East Boston Recovery Rate Analysis - Results of Second Survey"], and 1/99 ["West Roxbury / Roslindale Recovery Rate Analysis"].) Both recyclables composition and program participation rates were similar to those found in the (New York) 1997 Study. For East Boston, an urban neighborhood comprised primarily of 2- to 6 unit multi-family dwellings with little yard waste, the recyclables composition rates for a program similar to New York City's (including mixed paper) were 18.7% and 27.9% during 2 sampling periods, an average of 23.3%. As in NYC's 1997 Study, about 1 in 3 pounds of recyclables was correctly put in the recycling bin; the rest were found in the garbage. In West Roxbury / Roslindale, where the recyclables composition was 23% (plus 10% yard waste), people correctly recycled about 1 of every 2 pounds.

1.2 Low Diversion Districts

In June 1997, approximately 30% of the City's residential waste was generated in those 20 collection districts with Diversion Rates 10% or less. Table 1B presents the average tons per day of Recyclables and waste collected in these districts. In addition, Table 1B lists the housing density and income strata for these districts as reported in the 1990 Study. A map showing the districts follows Table 1B.

In the interval between the selection of these districts in the late summer of 1997 for the test program (districts were selected based on their reported Diversion Rates for FY '97) and the performance of the composition sampling test in December 1997, the Department completed the Citywide expansion of the Curbside Program to include mixed paper and bulk metal. That expansion, and a related public information campaign, improved diversion in these districts. But since diversion rates improved in the rest of the City, too, the gap remained, and the continued study of Low Diversion Districts was appropriate.

Table 1C shows the district-by-district Diversion Rates for the Low Diversion Districts. It includes Diversion Rates for: FY97, before the completion of program expansion; December 1997, when the tests were actually conducted; and February 1998, when analysis was begun on the Processing Test. As the notes to the table indicate, the improvement was such that two of these districts [Q12 and Q14] were no longer among the lowest 20 in the City.[4] However, data for all 20 of the original districts were used in the analysis in Chapter 3, in the level of overall waste generation for Low Diversion Districts (derived from Table 1B), and in the weighted average Diversion Rate for these districts after program expansion (10.7%, shown in Table 1C).

[4] By the time of the actual study, the ranking of the 20 lowest diversion districts had changed from the FY97 data, with two Manhattan collection districts (M9 and M3) replacing two Queens districts (QE12 and QE14). Districts M9 and M3 are similar to the other low Diversion Rate collection districts in their classification as low income/high density. In contrast, the two Queens collection districts are demographically characterized as high or medium income and medium density. The Manhattan districts are slightly smaller; had they been included from the beginning instead of the Queens districts, the portion of total City waste and recyclables accounted for by the 20 lowest districts would have been 30%, instead of 32%.

Table 1B

Collection Districts with the Lowest Recycling Diversion Rates, FY97

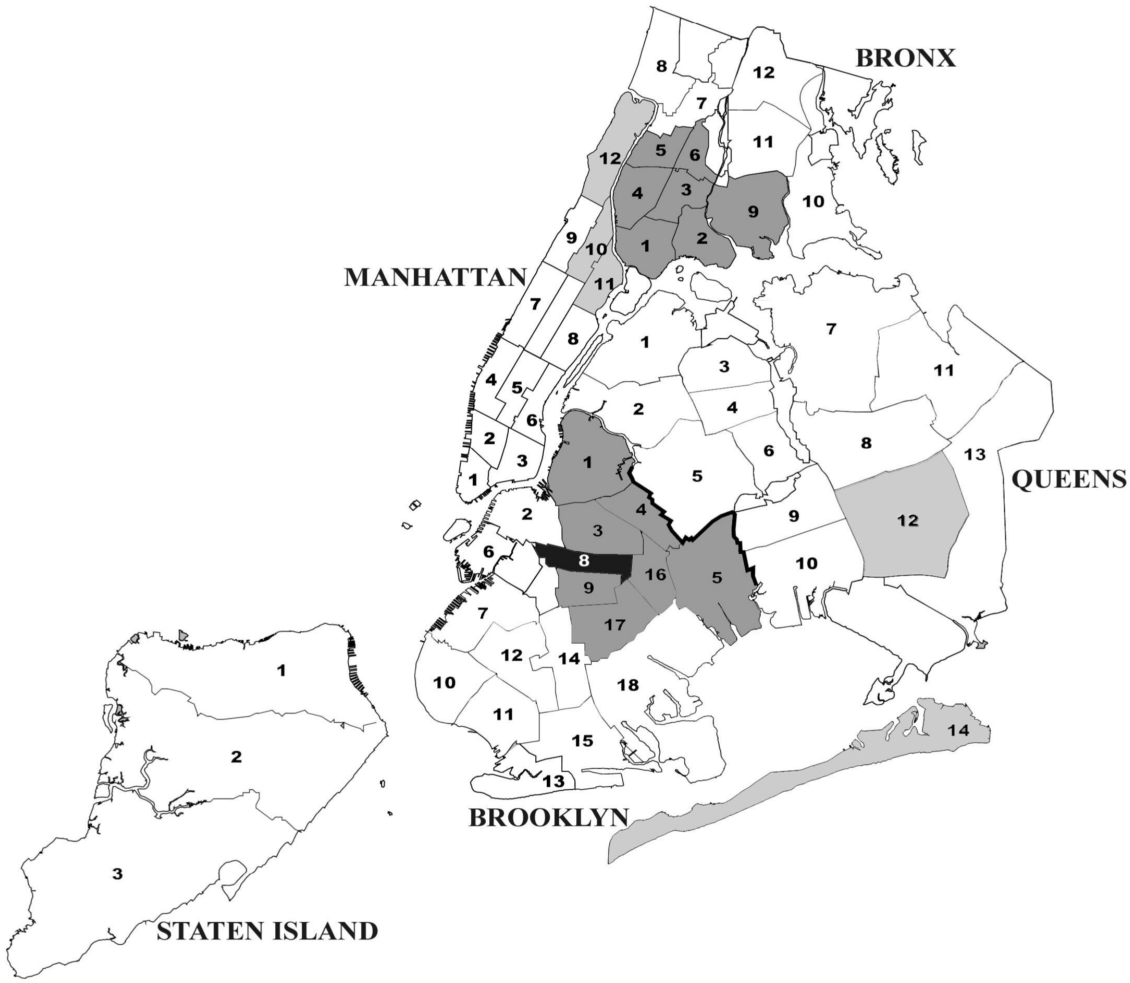
Case Number	Collection District [1]	Collection Frequency (days/week)	Diversion Rate [2] (tons recyclables collected/total tons collected)	Average Tons per Day [3]			Average Tons per Week	Housing Density[6]	Income[6]
				Recyclables	Waste	Total			
1	BX3	3	5.2	4.2	76.6	80.8	484.8	H	L
2	M10	3	5.5	7.1	121.1	128.2	769.2	H	L
3	BX1	3	5.9	5.0	80.0	85.0	510.0	H	L
4	BX2	3	6.6	4.6	64.8	69.4	416.4	H	L
5	BX6	3	6.7	5.6	77.7	83.3	499.8	H	L
6	BKS16	3	6.7	6.3	88.2	94.5	567.0	H	L
7	BX4	3	6.8	11.5	157.7	169.3	1015.8	H	L
8	BX5	3	7.5	11.3	138.8	150.1	900.6	H	L
9	M11	3	7.6	10.0	122.0	132.0	792.0	H	L
10	BKN3	3	7.6	14.4	176.2	190.6	1143.6	H	L
11	BKN5	2	7.6	15.2	185.4	200.6	1203.6	M	L
12	BKN4	3	7.9	10.1	118.5	128.6	771.6	H	L
13	M12	3	8.2	20.8	234.3	255.1	1530.6	H	L
14	BKN8	3	8.2	10.3	116.3	126.9	761.4	M	L
15	BKS9	3	8.5	11.5	124.1	135.6	813.6	M	M
16	BKS17	3/2	8.8	18.8	193.6	212.4	1274.4	M	M
17	BX9	2/3	9.1	18.1	180.8	198.9	1193.4	M	L
18	QE14	2	9.8	12.4	113.5	125.9	755.4	M	M
19	BKN1	3	10.2	20.9	183.7	204.6	1227.6	H	L
20	QE12	2	10.5	34.1	289.4	323.5	1941.0	M	H
Total [4]				252.2	2842.7	**3,095.3**	**18,571.8**		
Total All Districts [5]						**11,788**			

Notes:

[1] BX = Bronx, M = Manhattan, BK = Brooklyn North or South, QE = Queens.
[2] From Department of Sanitation Diversion Report for FY97.
[3] Tons per day are annualized using a 312-day year.
[4] Recyclable totals and Diversion Rate do not reflect the addition of mixed paper and bulk metal in Brooklyn and Queens which occurred in the first quarter of FY98.
[5] From Department of Sanitation Monthly Trend Analysis Report and Loads and Tonnage Report.
[6] H = high, M = medium, L = low.

For information purposes: FY97 total waste and recyclables (in tons per day) for the two districts that were in the bottom 20 in December 1997, replacing Q14 and Q12: M9 = 136.8; M3 = 158.4.

Pilot Study
Low Diversion Collection Districts



The total shaded area above comprises the 20 districts with the lowest recycling Diversion Rates in FY97.

The darker shaded districts contain the 15 collection routes sampled for waste and Recyclables composition analysis (1997 study).

Brooklyn District 8 is where the waste and Recyclables were collected for mixed waste processing (Processing Test; Compost Test).

Table 1C

Comparison of Diversion Rates in Low Diversion Collection Districts

FY97 Ranking	Collection District	Diversion Rate FY97	Diversion Rate December 1997	Diversion Rate February 1998	% Increase, 2/98 over FY97
1	BX3	5.2	4.7	5.9	13.5
2	M10	5.5	6.6	7.3	32.7
3	BX1	5.9	6.3	7.3	23.7
4	BX2	6.6	9.5	8.5	28.8
5	BX6	6.7	7.4	7.9	17.9
6	BKS16	6.7	8.6	8.5	26.9
7	BX4	6.8	7.9	7.8	14.7
8	BX5	7.5	9	8.5	13.3
9	M11	7.6	8.9	8.9	17.1
10	BKN3	7.6	8.7	***9.2***	21.1
11	BKN5	7.6	10.8	10.3	35.5
12	BKN4	7.9	10.2	10.4	31.6
13	M12	8.2	11.5	11.7	42.7
14	BKN8	8.2	11.1	11.0	34.1
15	BKS9	8.5	11.5	11.9	40.0
16	BKS17	8.8	11.8	12.1	37.5
17	BX9	9.1	10.8	10.5	15.4
18	QE14	9.8	17.6	15.7	60.2
19	BKN1	10.2	13.7	13.3	30.4
20	QE12	10.5	15	14.9	41.9
Average[1]		*8.1*	*11.1*	*10.7*	*30.1*
n.a.	M3[2]	n.a.	13.9	14.2	n.a.
n.a.	M9[3]	n.a.	12.7	12.9	n.a.

Notes:
n.a. – not applicable
[1]Weighted average percent based on tonnage by District.
[2]Based on both December 1997 and February 1998 Diversion, M3 is ranked #20.
[3]Based on December 1997 Diversion, M9 is ranked #18; and is #19 based on February 1998.

It should be noted that the term ‘Low Diversion’ Districts was used to characterize targeted outreach and public educational efforts funded by the New York City Council beginning in Fall 1997, through the Department’s Bureau of Waste Prevention, Reuse and Recycling. The campaign covered the same districts that were the starting point for this pilot, and a few more: With the Council’s help, the Department focused efforts on the 23 districts whose Diversion

Rates were 12% or less in the fall of 1997. This meant the original 20 districts listed in Table 1B, as well as Bk14, Q3, and Q4. (The average Diversion Rates for these 23 districts are included in Table 1A.) The 'Low Diversion' outreach efforts included the production and distribution of English and Spanish instructional videos to homes and institutions, including private and parochial schools; targeted advertising; and large-scale bi-lingual instructional seminars for building superintendents in these districts.

1.3 ACKNOWLEDGEMENTS

Important contributors to this Report include:

- The Department's Bureau of Cleaning and Collection (BCC), which made significant changes in its routine collection operations to accommodate the requirement of the test protocol;

- The Department's Operations Assistance Unit (OAU), which monitored the Department's test participation and recorded test data;

- The Department's Bureau of Planning and Budget, which assisted in transportation cost analysis included in the economic evaluation; and

- Waste Management of New York (Waste Management), the local subsidiary of one of the nation's largest waste management firms. Waste Management provided facilities, sorting personnel, services and the equipment necessary to conduct the sorting operation over a two-week period. Waste Management was compensated for their services based on the rates in their existing Recyclables processing contract with the Department. However, Waste Management's contribution substantially exceeded the amount of compensation they received. Particular appreciation goes to the Waste Management staff of Will Flower, Bill Brennan, and Steve Soucy, who participated in the planning and management of the Processing Test.

The Department's solid waste consultant, Henningson, Durham & Richardson Architecture & Engineering, P.C., in Association with HDR Engineering, Inc. (HDR), under the direction of the Department's Bureau of Waste Prevention, Reuse and Recycling, developed the test protocol, monitored the performance of the waste composition sampling and mixed waste processing activity pursuant to the protocol, collected waste sampling and mixed waste processing data,

prepared the statistical analysis of waste composition, and evaluated the Processing Test results. The organic waste stream sampling, sorting analysis, and Compost Test activities conducted following the Processing Test were performed by or under the direction of Waste Energy Technologies, Inc. (WasteTech), a consultant to the Department. Composting test runs of the organic samples were performed at the Bedminster composting facility in Sevierville, Tennessee under arrangements made by the Department. Laboratory analysis of composted end-product to evaluate compliance with NYSDEC Class I compost standards was performed by Woods End Research Laboratory, Inc. (Woods End). HDR used the results of the Compost Test, along with Departmental information, to establish assumptions and perform an economic analysis of composting organics derived from mixed waste.

I would also like to thank the following members of my staff: Robert LaValva for his assistance in managing this pilot, and Venetia Lannon, Pamela Caird and Samantha MacBride for their input during the drafting of this report. Finally, I would like to thank Susan Cohen for her efforts in editing and preparing this report, and Lise Eisenberg for layout.

Robert Lange
Director, Bureau of Waste Prevention, Reuse and Recycling

CHAPTER 2: LOW DIVERSION DISTRICT WASTE COMPOSITION ANALYSIS (THE 1997 STUDY)

2.0 PURPOSE

The 1997 Low Diversion District Composition Study (1997 Study) was conducted in December 1997. It used sampling from waste and Recyclables collection routes in Low Diversion Districts to ascertain current waste composition values. As explained in the Introduction, it was intended to provide a baseline for measuring the effectiveness of mixed waste processing in recovering Recyclables in the Low Diversion Districts (see Chapter 3).

Most of the Low Diversion Districts in the 1997 Study fit the "low income/high density" stratification used in the Department's 1990 Study.[1] That Study had identified and sampled nine levels of income and housing density characteristics for waste composition. (Income and housing were each stratified as high, medium and low; thus there were nine combinations. The 1990 Study also sampled by season.) Therefore, in addition to its original baseline purpose, the 1997 Study was used for some initial comparisons with the waste composition data from the low income/high density strata in the 1990 Study. Insights into the current applicability of the 1990 Study will help in assessing household performance in the City's Curbside Program. What is the average recyclable portion – the recyclables composition – of the total waste stream today? This chapter describes the method and findings of the 1997 Study, and compares the findings to waste composition results from the Department's 1990 Study for similar districts.

2.1 BACKGROUND

It is worth recalling that the 1990 Study *preceded* the City's Curbside Recycling Program and was conducted to provide a baseline understanding of the material composition of the total waste stream. Items were classified based on their material content, irrespective of the condition or state that they were in. Thus, for example, newspaper contaminated with coffee grinds (and thus not recyclable) would have been classified as "newspaper" anyway; an aluminum cooking pan too greasy to clean nonetheless counted as "aluminum." Similarly, broken bits of glass would have been counted as glass, and even classified by color. Finally, estimates of the "potentially

[1] Four Brooklyn districts and one Bronx district were not in the low income/high density strata of the 1990 Study (in addition to the two Queens districts discussed in Chap. 1). All had lower housing density; two had higher incomes.

recyclable" portion of the waste stream were made in the context of uncertainty in emerging end-markets for post-consumer material. Newspaper, for example, was considered recyclable, so the entire 9.2% for the Citywide average composition of newspaper would be part of the (potentially) Recyclables Composition. Likewise for the contaminated aluminum. This process also resulted in counting as recyclable products that by definition of use would not be recyclable: paper napkins and paper plates are an example. They were classified as paper and thus later assumed to be recyclable. However, these are products that cannot be recycled when used as intended, unless as part of a mixed waste composting program. There was less certainty about designating other categories – for example, other paper categories and various plastics – as end markets emerged and, in some cases, faded. The result of this process was an estimate of Recyclables Composition for a Curbside Program, excluding organic material, ranging from approximately 42% to 45%, depending on what categories or portions of categories were included. In effect this optimistic measure was a 'maximum theoretic' Recyclables Composition rate. A 42% potential Recyclables Composition Rate, coupled with an assumption that people would recycle 60% of what they were supposed to (i.e., a Capture Rate of 60%), would support a planned Citywide Diversion Rate of 25%.[2]

2.2 FINDINGS

The 1997 Study documents an actual Recyclables Composition of 23.2% in the waste stream of Low Diversion Districts, based on *identifiable* Recyclable material sorted from Recyclables and waste set-outs. A post-Study adjustment to account for glass residuals in the Recyclables,[3] not sorted under this Study's protocols, would add 1% to Recyclables composition. Based on other adjusted material categories that enable comparison with the 1990 "Potentially Recyclable" definition, the report finds, for similar types of districts, a statistically significant difference between the 1997 potentially Recyclable Composition of 30.2% and the 1990 rate of 43.4%. Comparing component material categories, the 1997 Study found a statistically significant difference between the 1997 mean Paper composition of 20.6% and the 1990 mean of 28.4%. This difference may indicate a general change in waste composition. Alternately, or in addition, it

[2] The Diversion Rate is the product of the Recyclables Composition Rate and the Capture Rate.
That is, 42% x 60% = 25.2%.

[3] This and other adjustments are described in footnotes 5 and 6 in Section 2.4.4.

may show the difference between a current market-based measure and the optimistic, theoretical measure from 1990. But whatever the reasons, the difference clearly means that there is less paper available for recycling. Lesser, but nevertheless statistically significant, differences in amounts of metal and glass were also found.

These findings have two important implications for the City's Curbside Program:

First, low income collection districts seem to be doing a better job of recycling than had been assumed based on the 1990 Study data. That is, fewer Recyclables than expected are set out at curbside because there is less Recyclable material available in households, rather than because of lower-than-expected program participation. Program participation is reflected in the Capture Rate.[4] The current derived Capture Rates, based on the 1990 Study Composition Rates, are as low as 20% to 25% for some of these districts, as opposed to the 1997 Study measure of 32.2%. Yet even 32.2% is low in light of program assumptions (see next finding).

Second, the lower composition of Recyclables in the waste stream of these districts means that the Department may have greater-than-anticipated difficulty in achieving the Citywide average Diversion Rate of 25%, the FY '01 goal established in the Draft 1998 Solid Waste Management Plan Modification (1998 SWMP). For example, assuming that the rates found in the 1997 Study are representative of all Low Diversion Districts (allowing for the post-Study adjustment for glass), and the remaining 39 collection districts have a Recyclable waste composition unchanged from 1990, these 39 districts would have to achieve the practically unattainable Capture Rate of *87.7%* – for a Citywide average Capture Rate of 75.6% – to reach the 25% diversion goal (see Table 2A, Scenario 1). Alternatively, if all New Yorkers can achieve the 68.5% Capture Rate assumed in the 1998 SWMP, but the Low Diversion District Composition Rate found in the 1997 Study is correct (and the 1990 Study Composition Rate holds for the rest of the City), then we will only achieve a Citywide Diversion Rate of 22.7% (see Table 2A, Scenario 2).

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[4] *A priori* – this applies to Local Law 19 of 1989 (LL19) and the 1992 Solid Waste Management Plan – a Capture Rate is assumed, based on informed estimates of how people might participate; then the Diversion Rate is simply the result of multiplying the Capture Rate by the Composition Rate (as determined by the composition studies). But once a program is in place, diversion is a fact based on what households put out on the street; then the Capture Rate is simply the result of dividing the Diversion Rate by the Composition Rate. So for any given Diversion Rate, the lower the Composition Rate, the higher the Capture Rate.

Table 2A

Citywide Diversion Rates
(Based on Varying Assumptions about Capture and Composition Rates)

Scenario 1: "If the rates found in the 1997 Study are representative of all Low Diversion Districts (allowing for the post-Study adjustment for glass), and if the remaining 39 collection districts have a Recyclable waste composition unchanged from 1990, these 39 districts would have to have the practically unattainable Capture Rate of 87.7% – for a Citywide average Capture Rate of 75.6% – to achieve the 25% diversion goal."

Assumptions
For Low Diversion Districts, Capture Rate = 32.2%, adjusted recycling composition* = 24.2%. [1997 Study]
For other districts, recycling Composition Rate = 36.9%. [1990 Study]
Citywide, Diversion Rate = 25%.

	Capture Rate	Recycling Composition	Diversion Rate	Weighted Div. Rate
20 Low Div. Districts	32.2%	24.2%	7.8%	2.3%
Other 39 Districts	**87.7%**	36.9%	32.4%	22.7%
Citywide Average	**75.6%**	33.1%		*25.0%*

Scenario 2: "Alternatively, if all New Yorkers can achieve the 68.5% Capture Rate assumed in the City's Solid Waste Management Plan, but the Low Diversion District Composition Rate found in the 1997 Study is correct (and the 1990 Study Composition Rate holds for the rest of the City), then we will only achieve a Diversion Rate of 22.7%."

Assumptions
For low diversion districts, adjusted recycling Composition Rate* = 24.2%.
For other districts, recycling Composition Rate = 36.9%.
Citywide, Capture Rate = 68.5%.

	Capture Rate	Recycling Composition	Diversion Rate	Weighted Div. Rate
20 Low Div. Districts	*68.5%*	24.2%	16.6%	5.0%
Other 39 Districts	*68.5%*	36.9%	25.3%	17.7%
Citywide Average	*68.5%*	33.1%		**22.7%**

Notes:
*23.2% documented in 1997 Study sort, plus 1% estimate to account for glass aggregate normally recycled.
Weights: .3 for Low Diversion Districts; .7 for other 39 districts, based on FY '97 tons of Recyclables and waste generated, from Department BPB data.
Capture Rate x recycling Composition Rate = Diversion Rate.
Entries in *shaded italics* are *desired* or *assumed* rates that drive the scenario.
Regular entries are observations or derived from observations.
Boldfaced entries are the results of the driving assumptions and observations.

Waste composition studies are difficult and expensive to undertake; results are based on sampling statistics which approximate (within a measurable confidence interval) the true, but unknown, population value. When a comparison is made between sample data gathered for different purposes, at two different points in time, and under different sorting protocols, caution is in order in making interpretations. Some of these differences reflect the need in the 1997 Study to develop an overall statistically valid waste composition sample from two separately collected waste streams, Recyclables and waste; this was not a factor in the 1990 Study because the Curbside Program did not exist then. Other important differences include the following:

- Sampling was limited to: a) only Low Diversion Districts, which is consistent with the objectives of the Processing Test, as compared to the nine-level Citywide stratification used in the 1990 Study; and b) one season, as compared to four seasons of sampling in the 1990 Study;

- The methodology in the 1997 Study was different from that used in the 1990 Study in that larger sample weights were used for sorting to reduce the variability in sample data; and

- The 1997 Study used the Department's current definition of economically marketable Recyclables (those materials that have been designated recyclable by the Department) in determining what "recyclable" material should be sorted and measured. This definition affects both the categories of materials counted and the degree to which contaminated and practically unrecoverable pieces were sorted, and it contrasts with the "potentially recoverable" definition in the 1990 Study conducted before there was a Citywide Curbside Program for recycling.

These differences in study design, objectives, and definition – particularly the latter – complicate the explanation of the differences in outcomes between the two studies, and they qualify the findings to some extent, particularly for the MGP fraction. However, these study differences do not negate the finding of a statistically significant reduction in the amount of Recyclables in the waste stream, even after taking definitional differences into account. Further studies of the composition of overall City waste should be undertaken to determine - in particular - whether composition in other districts has also changed and, additionally, to further verify the 1997 Study results and investigate the possible causes of the observed changes in composition. Obtaining an understanding of possible causes can shed light on the results. Are people reading newspapers less? Has there been a measurable reduction in packaging? Was the impact of the bottle bill not yet reflected in the 1990 Study?

Whatever the answers to these questions, the 1997 Study underscores the current challenge to our Curbside Program. To the extent that there is less material available, Capture Rates would have to be increased significantly to reach our diversion goals. To the extent that products are in the waste stream but cannot be recovered and marketed after sorting through both the Recyclables and waste under normal working conditions, source separation habits would have to change, and/or costly additional processing would have to take place. In both cases, recycling enforcement efforts would have to be increased Citywide to increase recycling Diversion Rates.

2.3 SAMPLING AND TESTING

2.3.1 Sample Route Selection Protocol

Fifteen of the originally-identified 20 Low Diversion Districts, as defined in Chapter 1, are located in the Bronx and Brooklyn (seven in the Bronx and eight in Brooklyn). Three of the remaining five are in Manhattan, and two are in Queens. (The districts are listed in Table 1B.) To simplify the composition test logistics, the sampling program was limited to the Bronx and Brooklyn. This sampling approach also enabled the Department to obtain a larger number of samples from the Bronx and Brooklyn and, therefore, derive better data for evaluating any differences in waste characteristics between the two boroughs. It should be noted that the subsequent changes in the districts that comprised the 20-lowest list, with two Manhattan replacing the Queens districts, served to further the concentration somewhat in terms of geography and demographics (see footnote 4, Chapter 1). Sampling from two boroughs also allowed for using results to further explore differences in waste and recyclables composition in Low Diversion Districts by comparing the waste composition results from Brooklyn to those from the Bronx. This test is described in Section 2.6, below, and indicates some patterns of differences that might be used with demographic characteristics for additional study.

At the time of the study, the Department operated just over 1,000 service routes for waste collection and 360 routes for Recyclables collection in the Bronx and Brooklyn Low Diversion Districts. (With two- and three-times-a-week service provision, the number of particular geographic routes for waste collection was closer to 450.) The quantities of collected waste and

Recyclables per truck shift averaged approximately 10.1 tons and 6.5 tons, respectively. The sample program was designed to obtain statistically valid results with a 95% confidence interval. To satisfy these criteria, the average weight of each sample to be sorted was set at approximately 2,000 to 3,000 pounds (which exceeds the minimum 1,000-pound sample weight discussed in Appendix C), and the number of samples was set at 40 (evenly divided between the Bronx and Brooklyn) to be drawn randomly from all waste collection routes. A technical discussion of the statistical basis for selecting this sample size appears in Appendix C.

Because the Department operates different routes for waste and Recyclables collection, it was necessary, for purposes of the test, to match waste and Recyclables collection routes. Each waste route in the Bronx and Brooklyn was assigned a unique, three-digit sequential number; then a random number table was used to select 20 sample routes from each borough. For sampling purposes, the Recyclable collection routes were then aligned to match the households served on the randomly selected waste collection routes. On each sample route, waste and Recyclables were collected in separate vehicles, and, for the test only, Paper and MGP Recyclables were collected in the same vehicle. However, Recyclables were only collected from 38 of the 40 randomly selected collection routes. Two of them (BX9/93/4A and BX9/94/7A) have historically displayed high contamination in Recyclables set outs. Therefore, for efficiency reasons, the Recyclables were collected with the waste for this study and sampled as waste. However, since the Recyclables from these two collection districts would be in the waste collected, all 40 collection districts were used to calculate the mean and variance of the total waste plus Recyclables. Table A-1, in Appendix A, lists the randomly selected collection routes. Several of those in the Bronx are two-truck routes. On these routes, the Department determined a cut-off location at which the first waste collection truck route would end. The Recyclables collection route was set to match the cut-off point determined by the Department to provide Recyclables data for the same number of households that the waste collection represented.

2.3.2 Waste Sorting Protocol

The waste sorting program was conducted with the cooperation of Waste Management of New York under the provisions of its contract with the Department for processing Recyclables at its

BQE Facility located on Thomas Street in Brooklyn. In advance of the test, the Department and Waste Management developed a detailed protocol for conducting both the 1997 Study and the Processing Test that followed. Waste Management provided personnel, labor and equipment for sample weigh-in, sample selection and sample sorting. The Department provided mobile scale equipment for weighing sample fractions; personnel for monitoring truck unloading operations; and the services of its consultant for monitoring compliance with the test protocol, data collection and data evaluation.

Forty waste collection and 38 Recyclable collection vehicles from the selected routes were directed to the BQE Facility. The vehicles were weighed-in, the contents were dumped and the vehicles were then weighed out to establish the net weight of the load (the row labeled "Total Weight of Truck Load" in Tables B-1 and B-2 of Appendix B). A front-end loader mixed the load on the tip floor and a bucket-load sample from approximately 2,000 to 3,000 pounds of material was selected (the row labeled "Total Weight of Sample" in Tables B-1 and B-2 of Appendix B). The bucket sample was weighed and delivered to the sorting facility where the material was sorted into the categories of Recyclable and non-Recyclable materials listed in Table 2B. Sorted materials were placed in bins or containers. Weights were tabulated for each material fraction as it was sorted and accumulated for the total sample.

2.4 WASTE COMPOSITION RESULTS

2.4.1 Consolidation and Standardization (Normalization) of Data

Table A-2 in Appendix A lists collection routes that delivered samples on various days during the 1997 Study. The waste set out on randomly selected sample routes was collected on the designated collection day during the first week of the test. Because waste collection occurs two or three times per week on each route, a waste sample route could represent two, three or four days of waste generation by the households on a given route. Furthermore, because Recyclable collection was scheduled on alternate weeks in this district in 1997, a Recyclable sample route represented 14 days of Recyclables generation. Therefore, the Recyclable sample routes were collected during a two-week period from the same waste collection sample routes. To develop composite statistics on the percent of waste composition for the categories of sorted

Table 2B
Planned Sampling Sort for Disposed Waste and Recycled Waste

DISPOSED WASTE SORT	RECYCLABLE SORT
Recyclable Materials	**Recyclable Materials**
1. Newspaper	1. Newspaper
2. Magazines and Glossy	2. Magazines and Glossy
3. Telephone and Paperback Books	3. Telephone and Paperback Books
4. Corrugated, Kraft and Linerboard	4. Corrugated, Kraft and Linerboard
5. Other Mixed Paper[1]	5. Other Mixed Paper[1]
6. Paper Beverage Containers[2]	6. Paper Beverage Containers[2]
7. HDPE Plastic	7. HDPE Plastic
8. PET Plastic	8. PET Plastic
9. Aluminum	9. Aluminum
10. Ferrous	10. Ferrous
11. Glass	11. Glass
12. Bulk Household Metal[3]	12. Bulk Household Metal[3]
	13. Contaminated Designated Paper[4]
Non-Recyclable Materials	**Non-Recyclable Materials**
1. Non-Recyclable Paper[5]	1. Non-Recyclable Paper[5]
2. Non-Recyclable MGP[6]	2. Non-Recyclable MGP[6]
3. Wood	
4. Textiles	
5. Non-Ferrous Metals	
6. Non-Metal Bulk Materials[7]	
7. Other Waste[8]	3. Other Waste[9]
Residue[10]	**Residue**[10]

Notes:
[1] Junk mail envelopes, white or colored paper, office and computer paper, and paper bags.
[2] Beverage containers: paper milk, juice and drink cartons not included in the MGP sort.
[3] Household metal includes pots, pans, and metal bulk -- appliances and goods with more than 50% metal.
[4] Recyclable paper that is soiled with food waste or other matter.
[5] Hardcover books, soiled paper cups and plates, napkins, paper towels, tissues, and plastic or wax coated paper.
[6] Styrofoam, food containers; plastic bags, wrap, utensils, plates, and cups; plastic toys; window glass; and ceramics.
[7] Furniture and other bulk items less than 50% metal.
[8] Organics, such as food, diapers, pet waste; inorganic fines.
[9] All other non-conforming material set out as recyclable.
[10] Residue consists of small pieces of food, paper, broken glass, plastic and yard waste.

material, it was necessary to normalize the weigh data from the waste and Recyclable sample routes to correct for waste generated over varying periods. This process involved expressing the raw weigh data for each sort category in a "pounds per household per generation day." (The number of waste generation days and household counts for each sample route were provided by the Department; they are shown in Appendix A, Table A-1. That information is also shown in Appendix B tables, which list the raw sample data in pounds of material of waste and collected Recyclables for each collection route.)

The total waste and Recyclable sample weights and the weights for each sorted material were recorded. These sorted material weights were used to determine a percent composition by dividing each sorted material weight by the total sample weight. This percent composition was then multiplied by the net weight of the truck load from which the sample was derived to determine the total weight of each sorted material contained in each truck. These weights were divided by the number of days over which the waste or Recyclables were generated and then divided by the number of households from which the waste and Recyclable truck loads were collected (assuming all households participated). These calculations normalize the data to a pound per household per generation day basis and thereby enable the evaluation of waste generation on the different sample routes on a consistent basis.

Once the Recyclables and waste data were normalized for the number of households and generation days, the two quantities were added together to represent the total waste generation rate per day. The pound per household per generation day data for each waste and Recyclables load and the composite of the two are provided as Tables B-1, B-2, and B-3 in Appendix B.

2.4.2 Waste Composition Results

Recyclables waste composition and Diversion Rates are determined by material weights. Table 2C presents the average normalized sample weights (measured in pounds per household per day; lb/hh/day) by sorted material for the collected waste, Recyclables, and waste and Recyclables together. (The data come from the last columns of Appendix B-1, B-2, and B-3.) These data provide the basis for determining the **Diversion Rate**, **Recyclables Composition**, and the **Capture Rate**. In addition, they provide a number of insights about the waste and Recyclables set out for collection in the districts sampled. The last column of Table 2C presents the mean composition value (%), which is the sample weights for each sorted material divided by the total average normalized weight of all waste and Recyclables samples collected.

On average, households set out 0.73 lb/hh/day of Recyclables and 5.70 lb/hh/day of waste, for a total of 6.43 lb/hh/day. This is a **Diversion Rate** of 11.4%, (.73) 6.43). It is comparable to the average of 11.1% diverted by *all* Low Diversion Districts, as reported in December 1997 (see Table 1C).

A waste sort allows for going beyond this measured Diversion Rate to determine the amount of waste incorrectly placed with Recyclables and the amount of Recyclables incorrectly placed with waste. Table 2C shows these components. Only 65.9% of the material found in the Recyclable samples (0.48 lb/hh/day of the 0.73 lb/hh/day average) can, in fact, be recycled. (The rest is non-recyclables and residue.) And 17.7% of the material that households put out as waste (1.01 lb/hh/day of the 5.70 lb/hh/day average) was found to be discarded Recyclable materials. The non-Recyclable components that appeared in the collected Recyclables included non-recyclable paper, non-recyclable MGP, and non-recyclable textiles. Non-recyclable paper included hardcover books, soiled paper cups and plates, napkins, paper towels, tissues, and plastic or wax coated paper. Non-recyclable MGP included: styrofoam food containers; plastic bags, wrap, utensils, plates, and cups; plastic toys; window glass; and ceramics. The residue that appeared in the collected Recyclables included, for example, food; soiled paper napkins, paper towels and tissues; small torn up pieces of junk mail; small glass shards; and yard waste. Thus, Recyclables sorted from both the Recyclables and waste collection streams totaled an average 1.49 lb/hh/day (0.48 + 1.01). Therefore, the **Recyclables Composition** – the portion of all designated Recyclables in total waste generation – is 23.2% (1.01) 6.43). *Total composition is 23.2% designated Recyclables and 76.8% non-recyclables*.

Of the 1.49 lb/hh/day of designated Recyclables, households were actually setting out an average of 0.48 lb/hh/day Recyclables, reflecting a **Capture Rate** of 32.2% (.48) 1.49). In other words, one-third of the materials that could be recycled are actually being picked up in the Curbside Program in the surveyed Low Diversion Districts.

Table 2C
Waste Composition Sampling and Analysis Study
Low Diversion Districts

	Average Normalized Recyclable Sample lb/hh/day[1]	Average Normalized Waste Sample lb/hh/day[2]	Average Normalized Recyclable and Waste Sample lb/hh/day[3]	Mean[4] Composition (%)
Recyclable Materials				
Total Paper	**0.298**	**0.648**	**0.946**	**14.72%**
Newspaper	0.104	0.234	0.338	5.26%
Magazines and Glossy	0.042	0.083	0.125	1.95%
Telephone and Paperback Books	0.007	0.025	0.032	0.50%
Corrugated, Kraft & Linerboard	0.123	0.197	0.320	4.98%
Other Mixed Paper	0.013	0.083	0.097	1.50%
Paper Beverage Containers	0.005	0.027	0.032	0.49%
Contaminated Designated Paper	0.003	0.000	0.003	0.04%
Total Plastic	**0.038**	**0.091**	**0.129**	**2.00%**
HDPE Plastic	0.026	0.051	0.077	1.20%
PET Plastic	0.013	0.039	.051	0.81%
Total Metal	**0.107**	**0.156**	**0.263**	**4.09%**
Aluminum	0.004	0.014	0.018	0.28%
Ferrous	0.041	0.076	0.117	1.82%
Bulk Household Metal	0.062	0.066	0.127	1.99%
Total Glass	**0.045**	**0.117**	**0.162**	**2.53%**
TOTAL RECYCLABLE	**0.481**	**1.012**	**1.493**	**23.23%**
Non-Recyclable				
Paper	0.006	0.029	0.035	0.55%
MGP	0.030	0.423	0.453	7.05%
Wood	0.000	0.152	0.152	2.36%
Textiles	0.000	0.260	0.260	4.05%
Non-Ferrous Metals	0.000	0.022	0.022	0.34%
Non-Metal Bulk Materials	0.000	0.096	0.096	1.49%
Other Waste	0.005	0.003	0.007	0.11%
TOTAL NON-RECYCLABLE	**0.041**	**0.982**	**1.023**	**15.91%**
Residue[5]	**0.208**	**3.705**	**3.913**	**60.87%**
TOTAL	**0.730**	**5.698**	**6.429**	**100%**
Percent Recyclables in Collection	**65.89%**	**17.76%**	**23.22%**	
Percent Non-Targeted Components in Collection	**34.11%**	**82.24%**	**76.78%**	

Notes:

1 The Average Normalized Recyclable sample weights are the average of the 40 Recyclable samples (two collection routes had zero Recyclables) normalized to a lb/hh/day basis.

2 The Average Normalized waste sample weights are the average of the 40 waste samples normalized to a lb/hh/day basis.

3 The Average Normalized waste and Recyclables sample weights are the sum of the average of the Recyclables collection loads (lb/hh/day) and the total waste collection loads (lb/hh/day).

4 The mean composition is calculated using the route averages normalized to a lb/hh/day basis. The Mean = average normalized Recyclables Loads per category (lb/hh/day)/Average waste and Recyclables Collection Loads (lb/hh/day). For paper, e.g., it is .946/6.429 = 14.72; differences are due to rounding.

5 Residue consists of small pieces of food, paper, broken glass, bulky material and yard waste.

2.4.3 Overall Waste Composition Statistics

The adjusted composite samples in pounds per household per day for each sorted material were converted to percent of sample composition for the calculation of standard deviation, standard error, and upper and lower confidence intervals (UCI and LCI).

Table B-4, in Appendix B, presents the daily composite samples of waste and Recyclables sorted by component as a percent of the total quantity of collected waste and Recyclables. These data were used to calculate the statistics in Table 2D.

Table 2D presents the mean composition, standard deviation, and the UCI and LCI for the 40 composite samples. The means were calculated for each sort category by summing the data on a lb/hh/day basis and dividing by the number of samples. The mean (still in lb/hh/day) for each sort category was converted to a mean percent composition by dividing it by the mean of the total of all sort categories in lb/hh/day. The mean percentage of Recyclable components within all the sample material sorted is 23.2%. A 95% level of confidence was used to calculate the UCI and LCI.

The band created about the mean using the UCI and LCI provides a range in which one would expect, with a 95% level of confidence, that the true population mean for the Low Diversion Districts would fall. For example, the composition of newspaper in the waste generated in all low income/high density collection districts would be expected, 95% of the time, to fall within the range of 4.73% to 5.79%. However, other factors may influence the reproducibility of results. These factors include changes in the waste stream, changes in sampling and recording methods, and comparison of the results to sample data not drawn from a similar population.

2.4.4 Capture Rates by Material

As stated above, Capture Rates measure the degree to which households actually set out designated Recyclable material for recycling pick-up, as opposed to placing it in the waste.

Table 2D
Waste Stream Composition Determination
Waste and Recyclables Loads

	Mean Composition (%)	Standard Deviation (%)	Standard Error (%)	95% UCI[1] (%)	95% LCI[1] (%)
Recyclables					
Total Paper	**14.72%**	**3.44%**	**0.54%**	**15.82%**	**13.62%**
Newspaper	5.26%	1.66%	0.26%	5.79%	4.73%
Magazines and Glossy	1.95%	1.10%	0.17%	2.30%	1.60%
Telephone and Paperback Books	0.50%	0.48%	0.08%	0.65%	0.34%
Corrugated, Kraft & Linerboard	4.98%	2.47%	0.39%	5.77%	4.19%
Other Mixed Paper	1.50%	1.25%	0.20%	1.90%	1.10%
Paper Beverage Containers	0.49%	0.27%	0.04%	0.58%	0.41%
Contaminated Designated Paper	0.04%	0.13%	0.02%	0.08%	0.00%
Total Plastic	**2.00%**	**0.50%**	**0.08%**	**2.16%**	**1.85%**
HDPE Plastic	1.20%	0.30%	0.05%	1.30%	1.10%
PET Plastic	0.81%	0.36%	0.06%	0.92%	0.69%
Total Metal	**4.09%**	**1.86%**	**0.29%**	**4.69%**	**3.50%**
Aluminum	0.28%	0.30%	0.05%	0.38%	0.18%
Ferrous	1.82%	0.59%	0.09%	2.01%	1.64%
Bulk Household Metal	1.99%	1.63%	0.26%	2.51%	1.46%
Total Glass	**2.53%**	**1.08%**	**0.17%**	**2.87%**	**2.18%**
TOTAL RECYCLABLES	**23.23%**	**4.44%**	**0.70%**	**24.64%**	**21.81%**
Non-Recyclable					
Paper	0.55%	1.05%	0.17%	0.89%	0.21%
MGP	7.05%	2.30%	0.36%	7.78%	6.31%
Wood	2.36%	2.28%	0.36%	3.09%	1.63%
Textiles	4.05%	2.76%	0.44%	4.93%	3.17%
Non-Ferrous Metals	0.34%	0.26%	0.04%	0.42%	0.26%
Non-Metal Bulk Materials	1.49%	1.24%	0.20%	1.89%	1.10%
Other Waste	0.11%	0.29%	0.05%	0.21%	0.02%
TOTAL NON-RECYCLABLE	15.91%	4.73%	0.75%	17.42%	14.40%
Residue	60.87%	7.14%	1.13%	63.15%	58.58%
TOTAL	100.00%				

Note:
[1] The student t statistic for a 95% confidence interval with 39 degrees of freedom is 2.0231.

There is no reason to expect Capture Rates to be the same for all materials. Table 2E shows the overall rate of 32.2% (from Table 2C) and detail on Capture Rates by material. The entries measure the quantity of each component set out for Recyclables collection divided by the total quantity *of that material* in the total waste and Recyclables generated. The component Capture Rates provide an indication of the average variation in household behavior in recycling materials that are designated as Recyclables by the Department. These rates ranges from 13.9% for other mixed paper to 48.7% for bulk household metals. Mixed paper and bulk household metal (large items such as appliances, and small items such as pots and pans) were components recently added to the list of Recyclable items in a Citywide expansion of the Curbside Recycling Program. The fact that mixed paper has a relatively low Capture Rate, while bulk metal has a relatively high Capture Rate, is a reminder that particular qualities of materials may have more bearing on recycling compliance than the length of time that the material has been included in the Program.

Table 2E
Waste Composition Sampling and Analysis Study
Low Diversion Rate Districts

Recyclable Materials	Capture Rate (%)
Total Paper	**31.5%**
Newspaper	30.8%
Magazines and Glossy	33.7%
Telephone and Paperback Books	22.7%
Corrugated, Kraft & Linerboard	38.5%
Other Mixed Paper	13.9%
Paper Beverage Containers	16.3%
Total Plastic	**29.8%**
HDPE Plastic	33.3%
PET Plastic	24.4%
Total Metal	**40.8%**
Aluminum	21.8%
Ferrous	35.1%
Bulk Household Metal	48.7%
Total Glass	**27.7%**
TOTAL RECYCLABLE	**32.2%**

Note:
Capture Rate = lb/hh/day of Recyclable material in the Recyclable samples / lb/hh/day of Recyclable material in waste + Recyclables samples

2.5 Comparisons to 1990

2.5.1 Category Adjustments

In order to compare the 1997 Study results to those winter season sample results of the 1990 Study for the low income/high density sectors, data categories had to be adjusted. In particular, the comparison required some consolidation of the 1990 data into larger categories to match the categories in the current study, and further adjustments where consolidation alone was insufficient. The categories that were consolidated from the 1990 Study and the categories in which they are grouped in the 1997 Study are shown in Table 2F.

Mixed paper was defined differently in the two studies and required further adjustment for comparison. In 1990, mixed paper originally had twelve components (itemized in the top left quadrant of Table 2G), but with no breakdown of the component parts. In the 1997 Study, Recyclable mixed paper had fewer market-driven categories (itemized in the top right quadrant of Table 2G), and a mean composition of 1.5% of total generation, as shown in Tables 2C and 2D. Because there was no reasonable basis on which to break out the non-recyclable components in the 1990 sort, the "Other Mixed Paper" category had to be made into a comparable combination of Recyclable and non-recyclable components. To do this, adjustments were made to both the 1990 and 1997 categories.

Office Paper, shown separately in 1990, was, for present purposes, added to the 1997 "Other Mixed Paper" because it was a non-separable part of the 1997 Study mixed paper category. Similarly, for adjustments to the 1997 Study categories, Paper Beverage Containers, Contaminated Designated Paper, and Non-Recyclable paper, shown separately on Table 2C, were added to "Other Mixed Paper" for the comparison because they were included in the 1990 Study "Other Mixed Paper" component. In addition, and more important in terms of size, an adjustment was made to estimate the paper portion of the 1997 Residue,[5] and was added to the 1997 Other Mixed Paper. This adjustment addresses, in particular, the definitional differences presented in Section 2.1. Adding the estimated paper portion of Residue – paper that as set-out was not in a condition to be marketed for recycling –

[5] Comments in field notes made during the 1997 test suggest that a maximum of 10% by weight of all residue was composed of unrecoverable small pieces of paper, such as torn up direct mail and utility bills, and plastic. To assess the 1990-1997 statistical differences on the most conservative basis, this observed 10% paper-plastic residue fraction was assumed to be all paper and was added into the (adjusted) other mixed paper category.

back to a mixed paper category converts the sorted measure of "identifiable Recyclable" paper closer to one of "potentially recyclable" paper. The bottom quadrants of Table 2G show these additions.

Table 2F
1990 Study Sort Categories with Corresponding Categories from the 1997 Study

1990 SORT CATEGORIES	1997 SORT CATEGORIES
Corrugated/Kraft Non-Corrugated Cardboard	Corrugated, Kraft & Linerboard
Mixed Paper Office/Computer Paper	Other Mixed Paper[1]
Clear HDPE Color HDPE	HDPE Plastic
Green PET Clear PET	PET Plastic
Clear Glass Containers Green Glass Containers Brown Glass Containers	Glass

[1] See Table 2G and accompanying text.

Table 2G
Adjusted Other Mixed Paper Category for Comparability in 1990 and 1997 Study Results

1990 ADJUSTED "OTHER MIXED PAPER" CATEGORY COMPONENTS	1997 ADJUSTED "OTHER MIXED PAPER" CATEGORY COMPONENTS
Original Categories	
Junk Mail Envelopes	Junk Mail Envelopes
White or Colored Paper	White or Colored Paper
Paper Bags	Paper Bags
Paper Beverage Containers	Office and Computer Paper
Contaminated Paper	
Hardcover Books	
Soiled Paper Cups and Plates	
Tissue Paper	
Napkins	
Paper Towels	
Tissues	
Plastic or Wax Coated Paper	
Categories Added for Consistency in Comparison	
Office and Computer Paper	Paper Beverage Containers
	Contaminated Designated Paper
	Non-Recyclable Paper
	10% (on weight-basis) of all Residue

The 1997 (Recyclable) Glass category was also adjusted to reflect an estimate of the broken glass found in the Residue. As explained in Section 2.1, the 1990 Study counted all pieces of glass to determine the total weight of glass in the waste stream. In contrast, the Table 2C compositional analysis of the 1997 Study shows, as Recyclable glass, the weight of whole and almost whole glass found in both the Recyclables and waste. It does not include smaller, broken pieces of glass (shards), which were found mainly in the Recyclables residue. Glass jars incorrectly thrown into garbage tend to be cushioned, remaining whole or almost whole. Most were therefore sorted as Recyclables in the 1997 Study, leaving less glass in the residue from *waste loads*. The concentration of glass jars in the Recyclables generally results in a larger amount of broken glass; shards in the *Recyclables* residue were not recoverable due to practical limitations on sorting operations during the 1997 Study. (The result is a partial undercount of the weight of actually Recyclable material, because, unlike Paper, where contaminated material in the Residue is only "potentially" Recyclable, the glass shards in the recycling residue are normally marketed and recycled as glass aggregate.) Thus, for purposes of the 1990-1997 comparison, field notes were used as the basis for estimating the glass residue,[6] and this amount was added to the original composition for an adjusted Recyclable Glass estimate.

2.5.2 Composition Rate Comparison

Table 2H shows the results of comparisons between the 1990 low income/high density sample strata with the composition values derived in the 1997 Study, after making these adjustments. Overall, the 1997 Study found an *adjusted* 30.2% Recyclables composition (i.e., inclusive of allowances for paper and glass observed in residue) compared to 43.4% in 1990. The 13.2 percentage point difference in average values (the 1997 average was just over two-thirds that of 1990) is statistically significant at a 95% confidence level. (Appendix C provides a more technical discussion of the measurement of a statistically significant difference.) This means that, for the districts sampled, there is less Recyclable material available in the total waste stream than was estimated based on 1990 waste sorts. Statistically significant and lesser amounts of Paper and MGP contribute to the overall difference.

[6] Residue from the Recyclables collections was assumed to consist of 10% paper-plastic (see preceding note), and 5% food and other, based on field observations. Field notes further indicate that seven of these 38 collections had excessive amounts of glass in the residue. Therefore, for these seven samples, 75% of the residue balance (75% of 85%, or 64% of the weight of residue) was assumed to be Recyclable glass. For the other 31 samples, 25% of the balance (21% of total residue weight) was assumed to be Recyclable glass. There was no indication about glass in the waste residue; thus, no additional adjustments were made.

Table 2H
Adjusted Comparison of Waste Composition Between the 1990 Study and the 1997 Study

	1990 Study[1]		1997 Study[2]		Difference in Means	Calculated Student t-statistic	Book Student t statistic	Statistically Valid Difference?[3]
	a Mean Composition[5] (%)	b Standard Deviation (%)	c Mean Composition (%)	d Standard Deviation (%)	(column a – column c)			
***Recyclable*[4]**								
Paper	**28.39**	**8.10**	**20.59**	**4.53**	**7.80**	**10.93**	**2.0231**	**Yes**
Newspaper	7.38	5.68	5.26	1.66	2.12	5.86	2.0231	Yes
Magazines and Glossy	1.60	1.66	1.95	1.10	-0.35	2.21	2.0231	Yes
Telephone and Paperback Books	0.40	1.40	0.50	0.48	-0.10	1.01	2.0231	No
Corrugated, Kraft & Linerboard	8.85	0.69	4.98	2.47	3.87	25.19	2.0231	Yes
Other Mixed Paper, Adjusted[2]	10.17	0.79	7.91	3.10	2.25	12.21	2.0231	Yes
Plastic	**2.32**	**0.18**	**2.00**	**0.50**	**0.32**	**8.92**	**2.0231**	**Yes**
HDPE Plastic	1.60	0.12	1.20	0.30	0.40	17.61	2.0231	Yes
PET Plastic	0.72	0.06	0.81	0.36	-0.09	5.10	2.0231	Yes
Metal	**5.22**	**0.41**	**4.09**	**1.86**	**1.13**	**10.99**	**2.0231**	**Yes**
Aluminum	0.00	0.02	0.28	0.30	-0.28	30.55	2.0231	Yes
Ferrous	2.91	1.09	1.82	0.59	1.09	11.52	2.0231	Yes
Bulk Household Metal	2.31	2.39	1.99	1.63	0.32	1.39	2.0231	No
Glass, Adjusted[2]	**7.51**	**0.59**	**3.54**	**1.47**	**3.97**	**36.27**	**2.0231**	**Yes**
Total Recyclable	**43.44**	**3.39**	**30.23**	**8.36**	**13.21**	**21.07**	**2.0231**	**Yes**

Notes:
[1] The Mean Composition and Standard Deviations from the Low Income/High Density Winter Waste Composition Study conducted in 1990 were used for comparison. See Appendix C for derivation of standard deviations for the 1990 Study.
[2] Differences between Column C and Tables 2C and 2D are due to the adjustments made for comparability purposes in Other Mixed Paper, and Glass (see text for discussion).
[3] If the calculated Student t-statistic is greater than the Book Student t-statistic, then a statistically valid difference exists at a 95% confidence level.
[4] Includes some contaminated material (in Other Mixed Paper, Adjusted) that would need improved separation at the household level before it could be recycled under actual market conditions (see text for discussion).
[5] Mean Composition percentages are derived based on tons collected; numbers in this table may not add due to rounding.

For Paper, overall, the mean composition in 1997 was 20.6%, compared to 28.4% in 1990, a difference of 7.8 percentage points. The three categories of "Newspaper," "Corrugated, Kraft, & Linerboard," and "Other Mixed Paper" together account for most of the paper and were 18.2% of MSW, compared to 26.4% in 1990, an 8.2 percentage point difference. (Slightly higher 1997 amounts of magazines and telephone/paperback books, in the remaining Paper categories, reduce the overall difference for Paper by just under half a percentage point).

While determination of the causes of changes in paper waste composition is clearly beyond the scope of this Study, a consideration of plausible causes helps put the findings in perspective. It may be that the 1990s marked changes in reading patterns and packaging that result in less Recyclable material in the waste stream. The available national data on waste composition neither support nor contradict this possibility.[7] It may also be that the population of the sampled districts has changed, which could cause a change in waste composition as a result of differences in consumption patterns. While there are no year-to-year census counts of population by community district, there has been a sizable movement of people in the City, including these districts, over this period, through out-migration and in-migration.[8] Other factors that could help explain this change in measured waste composition include differences in the 1990 sorting protocols, and the cumulative impact of source reduction campaigns beyond packaging (as examples, Department's efforts to help households have names removed from unwanted direct mail lists, and double-sided printing of utility bills). Finally, it is also possible that repeated studies would result in somewhat different mean composition, although with the random sampling procedures used in this study, repeated results would be expected to yield ranges around sample means that overlap considerably.

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[7] The composition model used by the USEPA indicates a small *increase* in the Paper portion of Waste and Recyclables in the first half of the 1990s for the residential and commercial sectors combined. Since the portion of newspapers and magazines dropped somewhat, while office paper remained steady and commercial printing papers and corrugated rose, it may be that the residential paper composition did decline. See ***Solid Waste Management at the Crossroads*** (Franklin Associates, December 1997), pp. 1-10; and ***Characterization of Municipal Solid Waste in The United States: 1995 Update*** (USEPA, March 1996), pp. 61, 67.

[8] ***The Newest New Yorkers 1990-1994*** (New York City Department of City Planning, December 1996) documents an in-migration of over a half million immigrants between 1990 and 1994. Nine of the 15 districts from which the routes were randomly selected for the 1997 Study had the largest or next-to-largest numbers of immigrants (based on reported first residence) include major parts of districts 4, 5, and 6 in the Bronx and districts 1, 5, 9, 16, and 17 in Brooklyn. The overall population changed little during that period, because of people moving out of the City (***New York Times, March 18, 1998***).

Similar factors may account for a lesser amount of Recyclable Metal – that is, changes in consumption patterns, package downsizing, and differences between the two studies. An additional factor might be the combined effect of deposits on cans and scavenging, which moves cans to collection points for recycling but removes them from any accounting based on Department-managed household waste. The difference in Glass remains less certain, given the assumptions that were made in the adjustments (described above). The national data show a slight decline in the portion of food and drink glass packaging over this period (from 6.0% of total waste and recyclables to 5.8%).[9] The small (but statistically significant) Plastic increase is less certain still because of sorting protocol differences between the two studies. Consistent with the Department's current definition of Recyclables, the 1997 Study excluded wide-mouth HDPE containers (such as yogurt containers) from the Recyclables; they were included in the 1990 Study with other potentially recyclable plastics in a way that was not possible to adjust for. Thus there may be little or no difference in Plastic composition. Nationally, there has actually been a small *increase* in the portion of Plastic packaging in the waste stream (not all of which is recyclable),[10] as lighter weight materials are substituted for heavier ones.

In summary, the 1997 Study indicates that there is measurably less potentially recyclable material in the districts sampled than would have been predicted by the 1990 Study, taking into account normal sampling variations and differences in study protocols. It indicates smaller amounts of all materials, but in particular, 7.8 percentage points less of Paper – 20.6% compared to 28.4%. Moreover, since this difference is based on paper broadly defined (the Table 2H adjustments), there is even less recyclable paper under actual sorting and marketing conditions – an average of 14.7% (Table 2C) rather than the adjusted 20.6%. This is mainly because there is no market for contaminated paper; the City is restricted to recycling paper properly sorted at the household level. It is also due to the fact that no markets (currently) exist for the small amounts of non-recyclable paper found in the waste stream.

Further study is clearly called for to determine the consistency and extent of these findings and to better assess their impact on our recycling program. Additional composition studies would help

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[9] ***Characterization of Municipal Solid Waste in The United States: 1995 Update*** (USEPA, March 1996), p. 68.

[10] *Ibid.*

answer the following questions: Is there less Recyclable material in other seasons? In other districts? How much less, and which materials? How much paper is actually in the waste residuals, and what is its potential quality? That is, is it mainly non-recyclable papers, such as tissues and napkins? Or are people consistently putting potentially Recyclable Paper – unwanted mail, white or color papers, magazines, etc. – in with the garbage? Answers to these questions will help determine what kinds of educational and enforcement efforts might be needed, where they should be focused, and whether current goals and timeframes are reasonable.

2.6 Comparison Between the Bronx and Brooklyn

Table 2I contains a comparison of the waste composition of samples from the Bronx and Brooklyn found in the current study. In contrast to the 1990-1997 comparison, there were no definitional difficulties or category adjustments to be made because the sorts were from the same study. This comparison indicates that the total Recyclables portion of the waste stream (waste and Recyclables) differs between the Low Diversion Districts in Brooklyn and the Bronx. While the difference is relatively small in percentage-point terms, it is statistically significant. For the areas studied, total Recyclables set out in the waste and Recyclables were 21.9% in the Bronx, and 24.2% in Brooklyn.

The difference in composition for the total Recyclable stream is observed in the overall Paper category, HDPE plastic, metal, and glass. For Paper and Glass, the differences were statistically significant and show less Recyclable material in the Bronx. (Within Paper, the main differences were in "Other Mixed Paper" and "Beverage Containers.") For HDPE Plastic, the small difference was significant but the Bronx had slightly *more* material; for Metal, the difference was not statistically significant (the Bronx also had slightly more material).

Most of these differences are small and are unlikely to have any bearing on the operation of a recycling program. Paper is worth noting, however, since it is the largest category, and the difference in mean composition is almost 2 percentage points – 13.7% for the Bronx, compared to 15.4% for Brooklyn. Table 2J shows demographic characteristics for each of the collection districts from which the sample routes were randomly selected. The average of the Bronx districts' median income is less than 70% that of the Brooklyn districts', a difference which is statistically significant. It may be reasonable to suppose that, in general, income affects waste composition, and that, in particular, lower income reduces the portion of household Paper waste. The findings are consistent with this proposed explanation, particularly the loose paper, envelopes, and direct mail that are part of mixed paper, and perhaps cardboard and packaging. When relationships between income, or other demographic factors, and waste composition of Recyclables are better understood, the value of waste sorts for any particular district will be enhanced.

Table 2I
Comparison of Waste Composition Between the Bronx and Brooklyn Based on Sampled Routes

	Bronx 1997 Study		Brooklyn 1997 Study		Difference in Means	Calculated Student t-statistic	Book Student t-statistic	Statistically valid difference?[1]
	a Mean Composition[2] (%)	b Standard Deviation (%)	c Mean Composition (%)	d Standard Deviation (%)	(column a – column c)			
Recyclables								
Paper	**13.7**	**3.0**	**15.4**	**3.2**	**-1.8**	**3.634**	**2.093**	**Yes**
Newspaper	5.3	1.2	5.2	1.9	0.1	0.328	2.093	No
Magazines and Glossy	1.8	1.1	2.1	1.1	-0.3	1.826	2.093	No
Telephone and Paperback Books	0.4	0.5	0.5	0.5	-0.1	1.511	2.093	No
Corrugated, Kraft & Linerboard	4.6	1.6	5.2	2.6	-0.6	1.663	2.093	No
Other Mixed Paper	1.2	0.9	1.7	1.2	-0.6	2.862	2.093	Yes
Paper Beverage Containers	0.4	0.2	0.6	0.3	-0.2	4.132	2.093	Yes
Contaminated Designated Paper	0.0	0.1	0.0	0.2	0.0	1.306	2.093	No
Plastic	**2.1**	**0.6**	**1.9**	**0.5**	**0.2**	**2.416**	**2.093**	**Yes**
HDPE Plastic	1.4	0.3	1.1	0.3	0.3	5.737	2.093	Yes
PET Plastic	0.8	0.4	0.8	0.3	0.0	1.426	2.093	No
Metal	**4.3**	**1.7**	**4.0**	**2.0**	**0.3**	**0.951**	**2.093**	**No**
Aluminum	0.3	0.3	0.3	0.3	0.0	0.779	2.093	No
Ferrous	2.0	0.7	1.7	0.5	0.3	3.038	2.093	Yes
Bulk Household Metal	2.0	1.2	2.0	1.8	0.0	0.141	2.093	No
Glass	**2.1**	**1.0**	**2.8**	**1.0**	**-0.7**	**3.996**	**2.093**	**Yes**
Total Recyclable	**21.9**	**4.9**	**24.2**	**3.5**	**-2.3**	**3.224**	**2.093**	**Yes**

[1] If the Calculated Student t-statistic is greater than the Book Student t-statistic, then a statistically valid difference exists.
[2] Mean composition percentages are derived based on tons collected; numbers in this table may not add due to rounding.

Table 2J
Socioeconomic Profile of Low Diversion Districts Sampled[1]

COLLECTION DISTRICT	Education	Income		Ethnicity			Language	Housing					Facilities		
	High-School Graduates	Median Income	Receiving Support	Black	Hispanic	Other	Predominant	Multi-Family	Mixed	1 and 2 Family	NYCHA Sites	NYCHA Units	Day Care	Public Schools	Private Schools
BX1	37.4%	$9,725	60.5%	31%	67%	2%	Spanish	16.3%	10%	21.7%	11	11,189	20	28	8
BX2	36.3%	$10,165	61.1%	19%	79%	2%	Spanish	22.8%	6.2%	26.2%	0	0	6	12	1
BX3	44.5%	$10,487	60.2%	55%	43%	2%	Spanish	19.8%	6.9%	25.6%	7	4,894	18	28	4
BX4	49.3%	$15,565	54%	41%	54%	5%	Spanish	36.2%	8.4%	20.9%	2	1,543	15	18	7
BX5	48.1%	$14,605	55.8%	38%	57%	5%	Spanish	31.2%	7.2%	35%	3	1,346	18	23	5
BX6	42.0%	$12,610	53.8%	25%	59%	16%	Spanish	23.3%	6.7%	26.4%	1	531	11	26	6
BX9	59.0%	$27,550	33.7%	31%	54%	15%	Spanish	25%	3%	58%	6	7,034	18	24	13
Average Bronx	45.23%	$14,387	54.16%	34.29%	59%	6.71%		24.94%	6.91%	30.54%	4	3791	15	23	6
BK1	40.0%	$20,685	38.9%	7%	44%	49%	Spanish/Eng.	36%	14%	17%	8	6,539	30	25	36
BK3	55.1%	$17,210	44.3%	82%	16%	2%	English	32.7%	9%	37.1%	9	7,831	35	31	11
BK4	42.7%	$16,265	48.2%	25%	65%	10%	Spanish	36%	9%	30.2%	2	1,315	19	21	6
BK5	53.3%	$20,682	42%	50%	38%	12%	English	18.5%	5.9%	52.2%	7	7,168	19	34	11
BK8	60.5%	$21,265	34.5%	83%	10%	7%	English	36%	13%	32.6%	2	2,395	17	12	16
BK9	66.5%	$25,855	25.1%	78%	9%	13%	English	18.5%	10.7%	62.2%	1	230	19	15	9
BK16	49.1%	$15,042	46.5%	81%	17%	2%	English	25.3%	8%	38.9%	13	7,939	14	24	5
BK17	69.1%	$30,367	22.2%	88%	7%	5%	French Creole	20.2%	5.8%	66.2%	0	0	21	18	19
Average Brooklyn	**54.54%**	**$20,921**	**37.71%**	**61.75%**	**25.75%**	**12.5%**		**27.9%**	**9.43%**	**42.05%**	**5**	**4,177**	**22**	**23**	**14**

[1] Socioeconomic Profile of Community Districts derived from Department of City Planning Publication – 1990 U.S. Census Data.
NYCHA – New York City Housing Authority.

CHAPTER 3: TESTING MIXED WASTE PROCESSING (THE PROCESSING TEST)

3.0 PURPOSE OF PROCESSING TEST

During the week following the 1997 Study described in Chapter 2, the Department conducted the second part of the pilot, the actual Processing Test. *Trash, or refuse* – that is, black bag waste, as it is referred to in this chapter – was collected from Brooklyn 8, one of the Low Diversion Districts, and taken to a waste processing facility to mechanically and manually recover those Recyclables that residents had thrown away incorrectly. This material was added to the Recyclables that residents had separated correctly themselves. The main purpose of the test was to assess the effectiveness of this form of 'mixed waste processing,' that is, to learn how much Recyclable material could be recovered from residential trash generated in a Low Diversion District, and at what cost. The performance of the pilot program was measured in terms of the Diversion Rate (i.e., material recovered as Recyclables as a percent of the total waste generated, inclusive of Recyclables) achieved with the Processing Test compared to what the Diversion Rate had been in the test district before the Processing Test.

The test included two additional elements: the co-collection of waste and Recyclables together during part of the test period (described in this chapter), and the composting of a portion of the organic residual material left after the mixed waste processing (described in Chapter 4). The purpose of the former was to assess possible savings in transportation costs against offsets in other parameters. The purpose of the latter was to assess whether composting would be an appropriate extension to this kind of processing, and at what cost.

3.1 MIXED WASTE PROCESSING IN GENERAL

Originally, mixed waste processing meant the delivery of total waste, unsorted, to a facility equipped to sort out recyclables, using, for example, conveyors, hand-sorting stations, magnets, etc. "Garbage" went in to such a facility, and, to the degree that they could be sorted, separated waste and recyclables went out. Most communities chose not to use mixed waste processing when they began to institute recycling, preferring programs in which the separation of recyclables began at home, because source separation helps preserve the quality of secondary materials. Under these recycling programs, communities took the waste portion of the total waste stream directly for disposal, and used sorting facilities – called material recovery facilities, or MRFs – to refine and grade the recyclable portion (Scenario 1 in Table 3A).

More recently, however, a few communities have begun trying some kind of mixed waste processing to address the dual problems of too many recyclables left in household waste and the high collection costs of separate recyclables and waste pick-ups. Circumstances in particular communities result in different combinations of separation, collection, and processing. Local conditions determine which factors become variables – how much separation of materials, how materials should be set out, the number of collections, etc. In terms of set-out and collection, different forms of Scenario 1, 2, or 3 (Table 3A) might be chosen. In the latter two cases, the set-out is not "mixed," but the collection, or the processing, or both are. In one variation of Scenario 3, for example, households are supposed to separate garbage from recyclables, and continue to set out paper recyclables separately from metal, glass, and plastic.

In any of these cases, mixed waste processing is a *substitute* for a source separation program. Chicago and Omaha, for example, have tried mixed waste processing to sort through waste that has been co-collected with two "streams" of bagged recyclables (Scenario 3, single collection); Chicago's program is on-going, while Omaha's is not.[1] In Greensboro, NC, and Phoenix, residents mix together all recyclables into one "stream," which are then co-collected for mixed processing (Scenario 2, single collection).[2] No community is using the Scenario 2 variation that brings the waste portion of trash to a MRF to extract recyclables that households improperly "put in the garbage," *as a separate addition to* its recyclables program. Thus, this report puts New York City in the unique position of exploring this scenario as a supplement to source separation.

With so many variables subject to local conditions, it is not possible to know beforehand what kind of impact mixed waste processing will have on a city's recycling system. But a few things can be said to generalize about the *direction* of changes. As compared to a typical curbside

[1] "Variations on a mixed waste processing theme," by Steve Apotheker, ***Resource Recycling***, December 1997, pp. 14-20.
[2] "MRF designs around single stream recycling," by David Biddle, ***Biocycle***, August 1998, pp. 45-49.

recycling program in which there have been at least two collections – one for recyclables, one for waste – and only the recyclables go to a MRF, mixed waste processing is expected to:

- increase the quantity of recyclables diverted (and diversion rates), to the extent that households have been throwing too many recyclables away with their garbage. This will bring (a) revenue from recyclables marketed, and (b) savings from avoided disposal costs;
- reduce transportation costs, to the extent that it enables some consolidation of collection;
- raise processing costs, because it sends more material for processing, and may require more sophisticated sorting equipment; and
- reduce recyclables quality and hence market revenue, to the extent that recyclables and waste get mixed together, and depending on current market conditions.

Whether or not mixed waste processing is an improvement for any given city clearly depends on the particular net outcome of these general tendencies in specific circumstances.

Table 3A: Mixed Waste Processing Scenarios, with Set-Out, Collection, and Processing Variables

Scenario	Set out	Collection	Processing for Recyclables*	Comments *[Applicability to NYC]*
1	Households don't separate anything. All refuse is kept together and set out together.	1 single collection.	Everything is brought to a single mixed waste processing facility and put on a sorting line. Recyclables are removed.	This system characterized some early recycling programs (including some commercial programs). The sorting facilities were called "dirty MRFs" because what went in was unsorted waste – in other words, garbage. *[Not applicable. Households already source separate.]*
2	Households separate waste (e.g., "black" bags) from commingled recyclables (e.g., "blue" bags – all recyclables together).	1 collection: black bags and blue bags in one truck or 2 collections: waste in one collection, commingled recyclables in the other.	Waste taken for mixed waste processing; recyclables may be sorted separately. (See comments.)	The type of facility/ies is likely to depend on local circumstances. If a city already has a MRF for recyclables, it might add capacity with sorting equipment for mixed waste processing. In general, more varied processing means higher costs, but enables refinements to enhance the market value of recyclables. *[Full scenario does not apply because household separation rules are not to be changed. But (a) collecting all recyclables together and (b) processing waste to pull out recyclables would be reasonable program variations to study. See Scenario 3.]*
3	Households separate waste from recyclables. Recyclables, in turn, are separated into 2 (or more) commodity groups (e.g., Paper in "clear" bags and MGP in "blue bags").	1 single collection: black bags and blue/clear bags are put on the same truck or 2 (or more) collections: waste in one collection, recyclables in the other(s).	Waste taken for mixed waste processing; recyclables may or may not be sorted separately, depending on existing facility/ies. In general, black bags and blue/clear bags that are still intact are pulled out from the broken bag material; then the process proceeds as above.	Chicago uses single-collection system. Tends to discourage household separation, as people see blue/clear and black bags going onto the same truck. [Applicable. Short-term pilot did not leave enough days to try all collection combinations. Waste collected and processed separately on 3 days, and with recyclables on another.]

* In all cases, "residuals" – the remainder of the mixed waste after recyclables have been removed – could be disposed of directly, or composted for further recovery before disposal.

3.2 Mixed Waste Processing Pilot For NYC

3.2.1 Local Conditions

The main purpose of the Department's mixed waste Processing Test was to assess the impact of removing Recyclables from improperly sorted waste – the black bags set out at curbside – in districts where low Diversion Rates indicated the possibility that such sorting might yield relatively large amounts of Recyclables. As explained in Chapters 1 and 2, to assess the effectiveness of mixed waste processing, the Department needed a current measure of waste composition – that is, of the portion of the overall waste stream that is material designated Recyclable. By the time the mixed waste pilot was planned, the City's measures of waste composition – which were pre-program measures at best – were close to a decade old. If the designated recyclable composition of the City's total residential waste stream was close to the 42% indicated by the 1990 Waste Composition Study, the FY97 Diversion Rate of 8.5% or less for Low Diversion districts (Table 1A) meant that an additional 33.5% or more of designated material (8.5% + 33.5% = 42%) was escaping the recycling program.[3] On the other hand, if waste composition changed since 1990, because of changing consumer patterns and/or evolving definitions of recyclable categories, then the portion of the waste stream escaping recycling was really unknown.

There were three necessary limitations to this pilot. The first two were cost and operational limitations (including sorting-facility space limitations and the need to limit collection route changes), which made the test short term. The third had to do with the general integrity of the Curbside Program: participating households were not to be asked to make any changes in their usual recycling practices – they would continue to set out black bags and blue/clear bags. This is Scenario 3 as summarized in Table 3A for implementation in New York City.

Taking into account the main purpose and these constraints, it became clear that this pilot framework would also allow for assessing the use of mixed waste processing to sort waste and Recyclables collected together, to reduce collection costs. That was done on the two days during the Test week that black bags and blue/clear bags were both put out for collection. (As stated

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[3]Equivalently, the capture rate (of recyclables) would be only 20% (8.5% ÷ 42%), and mixed waste processing might be a way to collect the other 80% of recyclables.

above, the pilot also allowed for the testing of composting a sample of the residual "mixed waste" stream after the Recyclables had been removed, to assess the possibility of avoiding landfilling the organics part of the waste stream. Chapter 4 presents the Compost Test.)

3.2.2 Processing Test Components

In sum, the full Processing Test, including the Composting Test, involved:

- collecting waste and Recyclables, both separately and together, from normal set-outs;
- sorting through both the waste and Recyclables to extract Recyclables;
- modeling the costs of co-collection and the sorting process, taking into account material value;
- composting a sampled portion of the residual of the Processing Test; and
- modeling the costs of a hypothetical scaled-up composting plant that might handle post mixed-waste-processing material.

3.2.3 Processing Test Objectives

Stated in terms of objectives, the Processing Test was designed to do the following:

1. Measure the extent to which mixed waste processing of waste-only loads generated in the test district achieved a significant improvement in the district's overall Diversion Rate, in combination with the Diversion Rate achieved in the Curbside Program.

2. Compare the Diversion Rate achieved with the mixed waste processing of co-collected loads of waste and Recyclable setouts to the Diversion Rate achieved with the combination of the Curbside Program and processing of waste-only loads.

3. Based on the Diversion Rate results measured in the test under each of the above collection scenarios and based on conceptual engineering assessments of several alternative mixed waste processing scenarios, evaluate the incremental cost of implementing a program to recover Recyclables through mixed waste processing. That is, under a given collection scenario, compare the Department's total cost of solid waste management with and without mixed processing.

4. Measure the potential during mixed waste processing to extract a significant fraction of compostable organic material from the mixed waste stream, conduct a test of composting at an existing facility and evaluate the compliance of the composted product with regulatory standards by performing laboratory analysis.

Test results, presented in Sections 3.5 and 3.6 (and Chapter 4 for composting) and summarized in Figure 1B, must be viewed in the light of the short-term, one-time only nature of the study.

3.3 SUMMARY DESCRIPTION OF PROCESSING TEST

3.3.1 Processing Facilities

During the week of December 15 through 19, 1997, the Department tested the recovery of recyclable materials from all waste collections in Brooklyn Collection District 8 (Bk8). This was done with the ongoing cooperation of Waste Management of New York, following the prior week's waste sorts. The Processing Test used two Waste Management facilities: 1) a 3,500-ton per day (tpd) mixed waste recovery facility in Brooklyn at 123 Varick Avenue (Varick Avenue), and 2) an 800-tpd material recovery facility at 75 Thomas Street in Brooklyn (BQE). At the time of the test, Waste Management operated Varick Avenue to recover Recyclables from mixed commercial waste; certain of the intermediate products recovered at Varick Avenue were further processed into marketable materials at BQE. BQE processed various material, including Recyclables under a contract with the Department.

The use of both of these facilities was intended to evaluate the effectiveness of a two-stage processing approach, modeling the processes that would have to be in place in a single MSW mixed waste processing facility. The object of the first stage is to achieve a high throughput while maximizing recovery of certain "gross" fractions of recyclable commodities. The object of the second stage is to provide some refinement into more marketable products. In the Test, Varick Avenue was operated to recover two gross fractions: 1) a "fiber pack" of all types of recyclable paper, and 2) a commingled fraction, referred to as 'MGP,' but comprised principally of mixed plastic and some glass containers. Most of the metal was separated right there at Varick Avenue, using magnets, and recovered directly as a marketable ferrous product. In addition, clean wood was recovered at Varick through hand-sorting, for manufacture into a marketable end product at Waste Management's contiguous commercial and demolition waste processing facility. The fiber pack and commingled fractions were shipped to BQE for further refinement.

It should be noted that all Recyclable items separated for marketing are materials currently designated in the City's Curbside Program, *except* wood. Wood was included to cover all of the basic materials that would normally be part of recycling through mixed waste processing.

3.3.2 Collection Schedules

At the time of the Processing Test, Recyclables in Bk8 were collected on alternate weeks (i.e., every two weeks), with the District divided into "A" and "B" week recycling collection routes. The test was performed in a "B" week, so it was limited to one week of waste collections throughout the District, but Recyclables collection on only the B Week routes. The quantities of the A Week and B Week Recyclables collections in District 8 were approximately equal, and there was a roughly even division of households on Recyclable collection routes between both A and B week collections. As with any alternate-week collection, the B Collection Week of Recyclables represents the Recyclables generated over two weeks. In this case, it represented two weeks of Recyclables generated by approximately one-half of the District's households, or, equivalently, one week of Recyclables generated by all of the District's households. Thus, the total of Bk8 waste and the B Week Recyclables approximated the total of waste and Recyclables generated during one week by the entire District.

During the test week in Bk8, waste was collected on Monday through Saturday, and source-separated Recyclables on Wednesday and Thursday. On those two days (the district's normal collection days for the B Week Recyclables), all Recyclables were co-collected along with waste on the same route in the same Department trucks performing waste pick-ups. All collections in Bk8 from Monday through Friday were delivered to Varick Avenue for processing to recover Recyclables. The Saturday waste-only collections were not processed at Varick Avenue due to operating constraints; they were estimated based on total weight, as discussed below.

3.3.3 Processing

The intermediate fiber pack and commingled product recovered at Varick Avenue were further refined through the Recyclables recovery process at BQE to produce marketable material. The Processing Test was monitored for compliance with pre-agreed upon test protocol and the test data were collected and evaluated by the Department's consultant.

3.4 PROCESSING TEST PROTOCOL

The Department, HDR, and Waste Management developed a protocol defining the operating procedures followed during the Processing Test over the week of December 15, 1997 (Test

Week). The protocol also defined the respective responsibilities of the Department and Waste Management for specific activities during the Processing Test. Under the protocol, the Department would perform the following:

- Co-collect waste and Recyclables set out for collection in Bk8 in the same vehicles during the Test Week.
- Direct all collection vehicles operating in Bk8 during the Test Week to Waste Management's mixed waste processing facility at Varick Avenue.
- Provide personnel from OAU to monitor collection vehicles deliveries to Varick Avenue and outbound loads of processed material and revenue.
- Provided support through its consultants to: monitor Processing Test runs for compliance with the protocol; record, compile and analyze test data; and prepare a report.

The protocol specified that Waste Management would:

- Provide facilities, labor, materials and equipment to receive and process test waste at Varick Avenue and measure the recovery of Recyclables including secondary sorting and weighing at BQE.
- Market Recyclables recovered during the Processing Test.
- Comply with the operating procedures defined in the protocol for the Processing Test.
- Provide for the shipment of two loads of compost samples to the facilities designated by the Department for composting tests of organic material.

The following describe the results of key operating procedures defined in the Processing Test protocols:

- Waste deliveries in Department collection vehicles were segregated from other waste deliveries to Varick Avenue and temporarily stored (under DOS supervision) until the start of test operations each day.
- At the end of the first shift, at approximately 4:00 p.m. each day, processing of other waste stopped and all processing lines and storage bins were cleaned out in preparation for the day's test run.
- At the start of the 6:30 p.m. evening shift, processing of the test waste began with monitoring staff in-place at the facility.

- Waste Management operated the Varick Avenue and BQE process lines at pre-agreed throughput rates of 125 tons per hour (tph) and 35 tph, respectively, and staffing levels of 50 persons and 28 persons, respectively. These levels approximate normal operating conditions at these facilities.

- Processing of test waste, exclusive of other waste, continued until all Department deliveries had been sorted. Upon completion of sorting, all processing operations stopped until the processing lines were cleared of all material and bins of recovered materials and residue were weighed out.

- During each day of the test, weights of all incoming waste, sorted material and outbound residue were tabulated by HDR and OAU.

3.5 THE PROCESSING TEST

Based on historical waste generation data for Bk8, it was anticipated that approximately 750 tons of waste and Recyclables would be generated during the test period and would be collected or co-collected in 81 vehicle loads. During the week of December 15, 78 truck loads carrying 665 tons were delivered to Varick Avenue. Saturday collections, with a total of 71.7 tons of waste, were not processed. The total waste and Recyclables generation in Bk8 during the Test Week was 737 tons, which can be considered representative of a typical week.

Sorting operations at Varick Avenue and BQE were done to select materials in the pre-agreed categories listed in Table 3B. Under the column headed Varick – Primary Sort Categories, items 1 through 5 list gross fractions of Paper and MGP materials that required further sorting at BQE to yield marketable end products. Items 6 and 7, mechanically recovered Ferrous and Wood, respectively, were recovered in marketable product form at Varick Avenue. The Secondary Sort Categories materials, Commingled MGP and various types of Mixed Paper, were containerized for shipment to BQE and held there until the accumulated quantities were sufficient to support a dedicated processing run.

Table 3B

Sorting Sequence for Mixed Waste Processing Test

Varick Avenue – Primary Sort Categories	BQE – Secondary Sort Categories
1. Commingled MGP retrieved from MSW	HDPE Clear
	HDPE Mixed (1)
	PET
	Plastic Buckets/Crates
	Glass
	Ferrous
	Aluminum
	Non-Recyclable Residue
2. Retrieved Blue Bags (2)	HDPE Clear
	HDPE Mixed(1)
	PET
	Plastic Buckets/Crates
	Glass
	Ferrous
	Aluminum
	Non-Recyclable Residue
3. Bundled News	
4. Mixed Fiber	Newspaper
	Corrugated
	Other Mixed Paper
5. Mixed Paper (recovered via air-vey)	
6. Mechanically Recovered Ferrous Metal	
7. Wood(3)	
8. Residue (<4-inch size, organic-rich) (4)	
9. Other Residue	

Notes:

[1]"Wide-mouth" HDPE containers, such as certain food containers (as opposed to narrow neck containers, such as detergent bottles), will be categorized as residue on the basis that the containers are not considered recyclable by vendors who process the City's curbside Recyclables.

[2]During test operations, retrieval of intact "blue bag" material proved impractical because most bags were broken either through in-vehicle compaction or at the beginning of the waste feed operation at Varick Avenue before reaching the hand sorting stations.

[3]Wood was included as a material that would normally be part of recycling through mixed waste processing. Beside organic residue, it is the only recovered material not currently part of the Curbside Program.

[4]This residue fraction was mechanically processed by size to provide an indication of the quantity of small, organic-rich residue that could be recovered for composting. A 40-ton sample of organic-rich material from the December 15 Processing Test at Varick Avenue was shipped to two composting facilities for the composting test discussed in Chapter 4.

The Processing Test runs at Varick Avenue and BQE were independently monitored by the Department's consultant for compliance with test protocols. To correlate recovery rates with processing time, outages during test runs were recorded and excluded in calculating a net ton per hour throughput. On average, Varick Avenue processed waste at a rate of 106 tph, which was below its expected throughput rate of 125 tph. Observations during the test identified at least two contributing factors. First, the Varick Avenue process line was specifically designed for commercial waste processing, the material it normally handles. Commercial waste has a higher paper fraction, particularly corrugated cardboard, than does residential waste. Second, residential waste tends to be wetter and thus heavier, due to a higher content of organic material. There were occasional choke points in the Varick Avenue process line where steeply sloped conveyors combined with undersized motors in relation to the heavier weight of residential waste caused stoppages that had to be cleared manually. A facility specifically designed to process residential waste would avoid this problem.

Some changes in the protocol were made on-site during the Processing Test to correct procedures that inadvertently reduced recovery rates of certain materials from what they should have been. On Monday, December 15, the first day of the Processing Test, an adjustment to the normal processing line at Varick Avenue prevented the recovery of small ferrous material with a magnet. This was corrected during the remaining days of the Processing Test and the average rate of ferrous recovery on the following day, Tuesday, the next waste-only collection day, was used to adjust Monday's actual total of recovered ferrous at Varick Avenue. On Wednesday, December 17, the first day on which loads of co-collected waste and Recyclables were delivered, the protocol provided that the sorters would retrieve "blue bags" (separately bagged MGP) of commingled Recyclables and bundled news (tied newspaper). However, practically none of the "blue bag" and the bundled news were intact, and the sorters were out of position to recover loose Recyclables on the conveyor lines. This problem could not be corrected during the Wednesday test run. The situation was corrected on Thursday, the other co-collected delivery day. Thursday's recovery rate for fiber pack (paper) and commingled product (MGP) was used to calculate what recovery would have been on Wednesday, had the sorters been correctly positioned.

From Monday, December 15 through Friday, December 19, 665.3 tons of waste and co-collected Recyclables were delivered to Varick Avenue. As stated above, they were processed at a net average rate of 106 tph over a total of 5.86 hours, for an average daily processing time of 1.17 hours per day. Recovered fiber and commingled MGP totaling 87.3 tons were delivered from Varick Avenue to BQE and processed during two runs on December 17 and December 20. At BQE, the Wednesday, December 17 processing run was fiber pack and MGP recovered from the waste-only loads; the Saturday, December 20 processing run was fiber pack and MGP recovered from the Wednesday and Thursday co-collected waste and Recyclable loads and the Friday waste-only loads. The average processing rate at BQE was 16.5 tph.

Detailed weigh records of all inbound and outbound materials were recorded during the test runs. Table 3C presents daily records of Processing Test runs at Varick Avenue over the test period. They reflect the adjustments for changes in the protocol discussed above, that is:

1. The ferrous recovery rate for Monday, December 15 was adjusted to reflect the correction in the ferrous recovery process made on Tuesday, December 16.

2. The recovery rate for Wednesday, December 17 was based on Thursday, December 18 data, following a change in the test protocol to correct for the inability to retrieve intact “blue bags” on Wednesday.

3. The Saturday, December 20 rates were estimated based on Monday, December 15 and Tuesday, December 16, days on which waste-only loads were processed.

The wood and ferrous material categories noted on Table 3C were recovered in marketable form at Varick Avenue. The balance of fiber and MGP materials recovered at Varick were shipped in bulk containers to BQE for the additional processing. Table 3C also shows a total residue for the week (587.3 tons), part of which (220.4 tons) passed through a 4-inch screen. As the table notes indicate, moisture and small material losses in processing account for a small difference between the total amount received or estimated for processing (737 tons) and the sum of the gross recovered material and residue (138.0 + 587.3, or 725.3 tons).

Table 3D summarizes the results of secondary processing operations at BQE. Of the total of 87.3 tons of material shipped to BQE, 96% was recovered as marketable products.

Table 3C
Varick Avenue Processing Summary

Test Material	Test Processing Runs						Total	
Date Day Material collected	12/15/97 Monday Waste	12/16/97 Tuesday Waste	12/17/97 Wednesday Waste & Rec.	12/18/97 Thursday Waste & Rec.	12/19/97 Friday Waste	12/20/97[3] Saturday Waste	Tons	Average Tons
Total Tonnage for Processing	152.55	126.64	148.1	137.07	100.93	*71.7*	737	133.1
Net Processing Time (minutes)	65	50	91	88.73	57	*N/A*	N/A	N/A
Total Interruptions (minutes)	34	14	20.95	0	0	*N/A*	N/A	0
Net Processing Rate (tph)	140.8	152.0	103.0	92.4	106.2	*N/A*	N/A	113.4
Recovered Material (Tons)								
Fiber Pack	10.01	6.7	*33.61*[2]	31.11	5.82	*4.2*	91.50	
MGP	2.73	1.28	*4.33*[2]	4.01	2.74	*1.0*	16.10	
Ferrous	*7.71*[1]	6.4	*3.56*[2]	3.74	1.63	*3.6*	26.66	
Wood	0.5	0.35	*0.93*[2]	0.67	1.03	*0.2*	3.70	
Total Gross Recovered Tonnage	20.95	14.73	*42.44*[2]	39.53	11.22	*9.1*	137.96	
Residue Tonnage								Percentage
Residue <4" (Compostable)	45.1	42.4	*43.6*[2]	33.7	32.8	*22.8*	220.4	29.9%
Total Residue Tonnage [4]							587.3	

Notes:

N/A = not applicable. *Italicized numbers indicate adjusted data.*

[1]The value is adjusted to correct for the blinding of a front-end screen on the processing line which affected ferrous recovery by magnet. The adjusted number is based on the ferrous recovery rate for December 16, 1997 processing.

[2]The value is adjusted to correct for the inability to recover intact "blue bags" and bundled paper during the first day of processing co-collected waste and Recyclable loads. The adjusted number is based on the recovery rates for December 18, 1997.

[3] Saturday values are estimated using the actual refuse delivered from Bk8 to the Greenpoint MTS on December 20, 1997 and the percent recovery rates for the appropriate material fractions from Monday and Tuesday loads.

[4] Residue quantities other than the <4" portion were not measured daily (residue from refuse processed one day may have been disposed the next day). The total residue is adjusted for the assumed residue from Saturday tonnage using the average percent of other residue calculated over the five-day period (Monday through Friday). Total tons recovered and residue do not equal tons processed because of significant moisture losses and small material losses during processing operations.

Table 3D
BQE Processing Summary

Test Variables	**Processing Test Runs**	
Date	December 17	December 20[1]
Fiber Processing		
Total Tonnage for Processing	16.71[2]	70.61[3]
Processing Time (minutes)	148	170
Processing Rate (tph)	6.77	24.92
Recovered Fiber Materials	**Tons**	**Tons**
Newspaper	13.09	*50.98*
OCC/Kraft/Linerboard	1.92	*12.57*
Magazines/Glossy	0.55	*0.85*
Beverage Containers	0.05	*0.00*
Books	0	*0.00*
Mixed Paper	0.27	*0.28*
Subtotal Recovered Fiber Product	**15.87**	***64.68***
Residue from Fiber Processing[4]	0.55	*0.85*
Commingled Processing (MGP)		
Total Tonnage for Processing	4.01[2]	*11.09*[3]
Processing Time (minutes)	47	91
Processing Rate (tph)	5.12	*7.31*
Recovered Materials	**Tons**	**Tons**
HDPE Clear	0.12	*0.24*
HDPE Mixed	0.16	*0.38*
PET	0.24	*0.37*
Plastic Buckets/Crates	0.18	*0.44*
Glass	0.07	*0.52*
Ferrous	0.09	*0.30*
Aluminum	0.01	*0.13*
Subtotal Recovered Commingled Product	**0.87**	***2.38***
Residue from MGP Processing[4]	2.35	*1.65*

Notes:
[1]The value is adjusted to correct for the inability to recover intact "blue bags" and bundled paper on Wednesday (12/17) by using the Thursday Varick Avenue data.
[2]Monday-Tuesday amounts from Varick. [3]Wednesday-Friday amounts from Varick.
[4]Residue is due to incomplete sorting at Varick, and from material not in marketable condition. Total tons recovered plus residue do not equal total tons processed because of small losses in processing.

Container loads from Monday and Tuesday (December 15 and 16) operations at Varick Avenue were processed at BQE on Wednesday, December 17. The net yield of recovered marketable product from the BQE run of fiber pack and commingled recovered from the Monday and Tuesday waste-only loads at Varick Avenue plus the wood and ferrous recovered at Varick Avenue on Monday and Tuesday were used to calculate the recovery rate for waste-only loads, as shown on Table 3E. This information was used later in the economic evaluation in assessing the incremental cost of mixed waste processing in Low Diversion Districts.

Table 3E also consolidates the results of Varick Avenue and BQE processing operations, including the estimate of recovered material from Saturday collections. This yields a recovery rate for the entire week. (Absent Saturday's collections, the average recovery rate based on Table 3D would have accounted for only three days of waste-only collections and two days of co-collected waste and Recyclables.)

3.6 FINDINGS AND IMPLICATIONS

As Table 3E indicates, in the week studied under the Processing Test in Bk8, the total recovered marketable product for waste-only loads was 11.4% of all material, while the total recovered marketable product for the total waste and co-collected Recyclables was 16%. These are the consolidated results of both processing operations, and, with the adjustments described above, cover the full week. This section discusses these findings and their implications; the recovery rates discussed here are shown in Table 3F.

In processing waste-only loads, the Department was able to separate and market, as regularly designated recyclable material, 11.4% of that week's total material collected, net of any residue. That is, under similar conditions, the recovery of Recyclables from waste would raise the Diversion Rate 11.4 percentage points. This means that if the Curbside Program continued regular operations, and were supplemented by having the District's waste collections processed in a mixed waste processing facility, the total gross Diversion Rate in the District could be 22.5% – the sum of the 11.4% Recyclables found in the waste during the Processing Test and Bk8's

11.1% Diversion from household setouts of source-separated Recyclables (for December 1997, the period under study; see Table 1C).

It should be noted that this gross Diversion Rate is a kind of hybrid because it combines the one-week Processing Test results with regular monthly measurements. The former (the 11.4% portion) is a post-sort measure, net of residue, while the latter (the 11.1% portion) is a pre-sort measure, gross of residue. The 1997 Study (Chapter 2) provides a basis for removing the residue to yield a consistent net Diversion Rate. The 1997 Study found that the mean value of the non-designated paper, non-designated MGP and other residue in household setouts for Recyclables collections in Low Diversion Districts was 34.1% of the total material collected by the Curbside Program. Thus, adjusting Bk8's 11.1% Diversion Rate to account for residue and non-designated material results in a Curbside Program net Diversion Rate of 7.3%. Adding the district net rate of 7.3% for Curbside Recyclables to the 11.4% Recyclables from waste identified in the Processing Test yields a combined net Diversion Rate of 18.7%. Again, this rate is a combination of the (net) Curbside Program rate with Processing Test results. Table 3F shows these rates, and Capture Rates. Based on the mean reported Recyclables Composition Rate in the 1997 Study of 23.2% (Table 2D), the combined Diversion Rate implies a Recyclables Capture Rate of 81%. Based on the 1997 Study adjusted Recyclables Composition of 30.2% (Table 2H), the Capture Rate would be 62%.

The Processing Test also gave an alternative measure of a net Diversion Rate of 16%. This represents total Processing Test Recyclables recovery, and is based on the processing of all material – both waste-only loads and loads of waste and Recyclable setouts co-collected in the same collection vehicle – in the district during the test week, with adjustments for missing data. It is a net measure; that is, residues have been removed; it is the portion of material actually marketed. It suggests that if household source separation and setout of Recyclables continued, but both waste and Recyclable setouts were co-collected in one vehicle and processed through a mixed waste facility, the net Diversion Rate (16% as measured here) would be higher than under the Curbside Program alone (11.1%), but lower than under separate collection and processing of Recyclables and waste (18.7% as measured here). In conjunction with the Recyclables composition reported in the 1997 Study, a 16% Diversion Rate implies a Capture Rate of 69%.

The Capture Rate based on the 1997 Study adjusted Recyclables Composition is 53%. (See Table 3F.)

In sum, the combined results of the 1997 Study and the Processing Test indicate that mixed waste processing could yield an incremental improvement in the Diversion Rates of similar Low Diversion Districts.[4] What are the requirements and costs for achieving these incremental improvements? The recovery rates for the waste-only and co-collection loads shown in Table 3E provided a basis for assessing the incremental costs/savings for various program alternatives, presented in the economic analysis that follows. They are a first approximation and a necessary starting point to assess the order of magnitude of possible program changes. But the Diversion Rate results reported here cannot yet be generalized to collection districts with different characteristics; to do so would require composition and processing tests on waste elsewhere. In addition, the findings should be interpreted with the caveat that a one-week test does not reflect seasonal variations in the waste stream.

[4] Strictly speaking, the full increment comes from mixed waste processing with the additional designation of wood as a material to be recycled. Wood added a half a percentage point of the incremental increase in diversion rate (Table 3C).

Table 3E
Summary of Consolidated Results, Varick Avenue and BQE

Material Category	Waste Only[1]	Waste and Co-Collected Recyclables[2]
Tonnage Processed	**279.19**	**737.0**
Fiber Material (tons)		
Newspaper	13.09	67.44
OCC/Kraft/Linerboard	1.92	14.98
Magazines/Glossy	0.55	1.55
Beverage Containers	0.05	0.06
Books	0.00	0.00
Mixed Paper	0.27	0.62
Subtotal Recovered Fiber Product (tons)	**15.87**	**84.65**
Recovered Fiber Product % of Tons Processed	**5.7%**	**11.5%**
Commingled Material (tons)		
HDPE Clear	0.12	0.39
HDPE Mixed	0.16	0.59
PET	0.24	0.66
Plastic Buckets/Crates	0.18	0.66
Glass	0.07	0.60
Ferrous	14.19	27.07
Aluminum	0.01	0.14
Wood	0.85	3.7
Subtotal Recovered Commingled Product (tons)	**15.81**	**33.81**
Recovered Commingled Product % of Tons Processed	**5.7%**	**4.6%**
Total Recovered Marketable Product (tons)	**31.68**	**118.46**
Recovered Marketable Product % of Tons Processed	**11.4%**	**16.0%**
Residue < 4-inch fraction	87.5	220.1
< 4-inch fraction of residue as a % of tons processed	31.3%	29.9%

[1]12/16 and 12/17 (Mon. & Tues.) recovery from Varick, with detail on Fiber and MGP from 12/17 recovery at BQE.
[2]Results from 12/16 through 12/20 (Mon. – Sat.) recovery from Varick, with detail on Fiber and MGP from 12/17 and 12/20 recovery at BQE, plus allocation of Sat. recovered material based on 12/17 recovery at BQE. See Tables 3C and 3D.

Table 3F
Summary of District 8 Processing Test Diversion Rates

Collection Modes	Net Diversion Rate [1] (%)	Capture Rate of Test, [2] based on 23.2% recyclables[3]	Capture Rate of Test,[2] based on adjusted recyclables[4]
Waste-only	11.4	49.1	37.7
Curbside Program	7.3[1]	31.4	24.2
Waste-only Plus Curbside Program	18.7	80.5	61.9
Co-Collected Waste and Recyclables	16.0	68.8	53.0

Notes:
[1]The net diversion rate for the Curbside Program reduces the curbside diversion rate of 11.1% (for December 1997, the month that includes the actual Processing Test period; see Table 1C) to account for an estimated 34.1% residue found in the routes sampled in the 1997 Study.
[2]The Capture Rate is defined as the material recycled as a percent of that material in the waste as measured by an analysis of waste composition. Generally it is used to indicate the degree of residential participation in a recycling program, because for a curbside program it shows the portion of total Recyclables that people put in their recycling bins. Here it is a measure of how much each program component, or the program as a whole, contributes to the overall removal of Recyclables from the total waste stream.
[3]23.2% Recyclables composition, as reported in the 1997 Study of Low Diversion Districts (Chap. 2).
[4]30.2% Recyclables composition, as reported in the 1997 Study after test results were adjusted to account for estimates of recyclables in the residual material (Chap. 2).

3.7 ECONOMIC EVALUATION OF MIXED WASTE PROCESSING CASES

This analysis of the economics of mixed waste processing assumes that the net recovery rates demonstrated in the Processing Test can be achieved in the mixed waste processing of waste from all Low Diversion Districts. The analysis is based on estimates of facility capital costs, operations and maintenance (O&M) costs, and facility performance characteristics that reflect conceptual designs prepared for two alternative sizes of mixed waste processing facilities, and on the Department's transportation costs. Six potential cost cases are evaluated, covering all combinations of three plant capacity/location scenarios with two collection scenarios. The tonnages of material involved in the different scenarios are derived from applying diversion rates from the Processing Test to actual data from Low Diversion Districts. The plant-size/location variations allow for an evaluation of the trade-off between the economies of scale in capital and O&M costs offered by the one large plant, versus the lower incremental transportation costs due to a shorter total distance traveled under the two smaller plant scenarios. Similarly, using two collection scenarios – for separate and for co-collection of Recyclables and waste – allows for an evaluation of the trade-off between separate collection's higher diversion rates/higher transportation costs and co-collection's lower diversion rates/lower collection costs. As the results below will show, collection costs are generally large relative to other costs.

3.7.1 Facility Processing/Location and Collection Scenarios Evaluated

For both the large and small hypothetical plant facilities, the conceptual designs reflect the two-stage processing approach used at Varick Avenue and BQE but incorporate this process into a single facility. This two-stage process is designed to maximize the recovery of gross fractions of fiber and MGP material in the first stage and refine these gross fractions into marketable products in the second stage. The smaller facility is sized at a throughput of 100 tph, or 1600 tpd on a two-shift, 16-hour day basis. The larger plant is sized at 150 tph throughput and processes all the Low Diversion Districts on a two-shift, 20-hour day basis. It is important to note that both facility sizes entail substantial facility site requirements, as indicated in Table 3G.

Table 3G
Siting Requirements for Mixed Waste Processing Facilities

Facility Component	100 tph Design (square feet)	150 tph Design (square feet)
Processing building footprint (includes tip floors, processing equipment, residue transfer area and product storage)	123,000	160,000
Scales, truck queuing and outdoor vehicle maneuvering space	70,000	97,000
Parking for rolling stock	147,000	248,000
Employee parking	25,000	32,000
Site buffer allowance	121,000	147,000
Total site requirements Square feet/(acres)	486,000/(11.2)	684,000/(15.7)

The plant capacity/location scenarios were as follows:

1. Two smaller facilities, 100 tph – one located in the Bronx and one in Brooklyn. The Bronx facility would process waste from Low Diversion Districts in the Bronx and Manhattan; the Brooklyn facility would process waste from Brooklyn and Queens Low Diversion Districts. (The Bronx and Brooklyn were assumed as sites because 75% of the Low Diversion Districts are in these two boroughs.); or

2. A larger plant, 150 tph facility, located in the Bronx and processing all Low Diversion Districts; or

3. A larger plant, 150 tph facility, located in Brooklyn and processing all Low Diversion Districts.

The combinations of plant capacity/location allow for the following impacts: 1) the economies of scale obtainable in one larger plant versus two smaller plants; and 2) the difference in waste collection costs attributable to directing Low Diversion waste to a single processing plant located in the Bronx or Brooklyn versus directing it to smaller plants located in each of these boroughs.

Collection costs here, as affected by location, are critical in the analysis because collection vehicles under either the two smaller or one larger plant scenarios would, in aggregate, travel longer distances from the end of their collection routes to their modeled disposal destinations than they did at the time of the study using the Department's marine transfer stations. However, particular districts could have shorter travels. In the two smaller plants scenario, the overall travel distances are shorter than in the one large plant scenario.

"Collection" scenarios refer to how Recyclables and waste are handled from the curb, and are the actual program variations. The alternatives evaluated were:

1. Mixed waste processing with separate collection of Recyclables from the curb (i.e., no change in existing Curbside Program collection).
2. Mixed waste processing with the combined collection of waste and Recyclables in the same collection vehicles from the curb (i.e., a change in the existing Curbside Program, which is defined as a *separate* collection for Recyclables).

These collection scenarios also allow for competing impacts of: 1) the benefit of a somewhat higher Diversion Rate under the first alternative, because waste and Recyclables are collected separately and go separately through a mixed waste processing line, versus 2) the benefit of lower costs under the second alternative, because collection is combined, but without the extra gain in Diversion Rate from the complete processing of two separate streams.

Table 3H shows the six possible combinations of the facility/location and collection scenarios, identified "A" through "F" as they are reported in the results below.

Table 3H
Facility and Collection Scenarios

		Collection Scenarios [Program variations]	
		Separate Curbside Collection of Recyclables (no change in current collection system)	Co-collection of waste and Recyclables in same vehicle (change from current collection system)
Facility/Location Scenarios	2 facilities (100 tph each), Brooklyn & Bronx	Case A	Case D
	1 facility (150 tph), Bronx	Case B	Case E
	1 facility (150 tph), Brooklyn	Case C	Case F

In sum, modeling all six cases allows for the evaluation of the net impact of:

- some economies of scale offered by a single larger plant;
- certain lower incremental transportation cost components incurred by the Department's collection operations under the two smaller plant scenarios;
- additional lower incremental transportation costs under combined collection of waste and Recyclables; and
- higher diversion rates under separate collection of waste and Recyclables.

3.7.2 Economic Analysis Using Incremental Costs

The economic analysis evaluated the incremental cost of mixed waste processing. An incremental cost analysis evaluates the change in the total cost of the City's waste management system as a function of the addition or deletion of a specific program. For each of the six cases, the evaluation of incremental costs considers 1) the direct costs attributed to the addition of the mixed waste processing program, and 2) the avoided costs in other existing Department programs resulting from the addition of the mixed waste program. The resulting total program incremental costs are then shown as a cost per incremental ton.

3.7.2a Cost Categories: Direct and Avoided Costs

The direct costs of mixed waste processing include the following:

- The estimated capital and O&M costs for mixed waste processing facilities under two different facility size scenarios.
- The difference (positive or negative) in collection costs attributed to redirecting collection vehicles in each of the Low Diversion Districts from their current disposal destinations to the assumed locations of the mixed waste processing facilities under each of the plant capacity/location scenarios.
- The direct costs of the additional refuse truck-shifts required to co-collect the tons which otherwise would be diverted annually by the Curbside Program.
- A revenue credit from the sale of the increased Recyclables recovered under the two different collection scenarios.

The avoided costs of mixed waste processing include the following:

- Savings in separate Recyclables collection and processing costs in the co-collection scenario.
- The avoided cost of export for the incremental tons of Recyclables recovered in excess of what would have been recycled through the existing Curbside Program.

3.7.2b Cost Assumptions

Assumptions about various elements of direct and avoided costs are based on the following:

- Capital and O&M costs are based on conceptual designs developed for the alternative facilities by the Department's consultant. (See Appendix D for details.) All costs are estimated in 1998 dollars.
- Facility construction costs include a 20% contingency allowance on the building structure and a 5% contingency allowance on building equipment. Allowances for design, permitting and construction management are calculated on base construction costs and are, respectively, 8%, 5% and 8%. Total capital costs are amortized over 15 years, assuming that the Department would be willing to enter into a 15-year service agreement with the facility operator. The capital recovery factor used to calculate annual capital costs reflects an assumed weighted cost of capital for debt and equity financing of 10%. A longer or shorter amortization period will significantly affect economics.
- Operating costs were estimated by the Department's consultant and are inclusive of labor, maintenance and other O&M expenses. An allowance of 20% was applied to base O&M expenses for the facility operator's general and administrative expense and contingency. Labor costs assume two 10-hour shifts per six-day work week for the 150 tph facilities and two 8-hour shifts for the 100 tph facilities.
- Available capacity at a facility in excess of that required to process Low Diversion District waste is assumed to be sold to other private customers by the facility operator. That is, the costs of excess, unutilized capacity are not reflected in the economics.
- Site lease costs are assumed to be $3 per square foot, all borne by the Department.
- Collection cost increases and decreases were evaluated by the BPB using its model for evaluating the differentials in transportation costs of collection operations between alternative disposal destinations.

- Revenues from the sale of Recyclables were assumed to be shared 50-50 with the facility operator, and were based on average market prices during 1996 and 1997. Average prices were used to incorporate the effects of a normal range of price fluctuations, instead of selecting a single low and high point. Section 3.7.3 considers the impact of a hypothetical increase in market prices.

- Weighted per-ton revenue for all material was assumed to be $22.90 (rounded) for the mixed waste processing with regular Recyclables collection/processing (Cases A, B, and C), and $20.40 for mixed waste processing of co-collected waste and Recyclables (Cases D, E, and F). The fiber pack that the latter produces is only a mixed paper grade, the lowest paper grade, while New York's Curbside Program also produces (at least) higher-valued newspaper grades.

- A low range sensitivity case was evaluated for a -7.5% change in both capital and O&M costs and a $90 per ton avoided waste export cost. A high range sensitivity case evaluated a +7.5% change in both capital and O&M costs and a $70 per ton avoided waste export cost.

3.7.2c Review of tonnage and rate assumptions

The costs of mixed waste processing as a program increment are reported in total, and per incremental ton. In general, incremental tons are the tonnage change attributed to a particular program. As shown above, the six cases studied here are the result of two program variations (and three location variations) – mixed waste processing of waste as an add-on to the regular Recyclables collection and processing (Cases A, B, and C), and mixed waste processing of co-collected waste and Recyclables (Cases D, E, and F). Thus, incremental tonnages were calculated by applying the change in diversion rate attributable to each program (derived, in turn, from Processing Test results) to annual tonnages for the initial 20 Low Diversion districts. In particular:

- Low Diversion Districts were assumed to generate a total of 965,600 tons of waste and Recyclables annually. This is based on the annualized total of the Average Tons per Day generated in these districts in FY97; see Table 1B.

- For Cases A, B, and C, identifying the program increment is straightforward, since mixed waste processing of waste is a separate *addition* to the Curbside Program. The increment is the increase in the recycling rate resulting from the additional processing – or 11.4 percentage points, based on Processing Test experience as reported in

Sections 3.5 and 3.6. This is 110,100 incremental tons recycled (11.4% x 965,600, with rounding) per year for the Low Diversion Districts. For these scenarios, the overall net Diversion Rate is 18.5%. This is derived in the same way as the 18.7% reported in Table 3F, but using somewhat later data for the 20-district Curbside Program Diversion Rate.[5]

- For Cases E, F, and G, identifying the program increment is somewhat less straightforward, since nothing discrete has been *added*; the change is really the creation of one integrated program combining collection and processing of Recyclables and waste. Therefore, the increment is calculated as the difference between the pre-program net Diversion Rate and the post-program rate. The latter is 16.0%, as demonstrated in the Processing Test (see Sections 3.5 and 3.6, and Table 3F). Since this is net of residue, the pre-program rate also has to be expressed on a net basis. This was 7.1%, or 7.05% before rounding (see footnote 3). Thus, the difference – the program increment – is an 8.95 percentage-point addition to the Diversion Rate. This is 86,400 incremental tons recycled (8.95% x 965,600, with rounding) per year for the Low Diversion Districts.

[5] The net diversion rate is derived as follows:

"Gross" diversion, Curbside Program, 20 Low Diversion Districts, 2/98	10.7%*
"Net" diversion, Curbside Program, 20 Low Diversion Districts, 2/98	7.1%**
"Net" diversion from Waste only:	11.4%
"Net" diversion total, Waste-only plus Curbside	18.5%

* From Table 1C: Weighted average of the regular district diversion rates as reported by the Department for all Low Diversion Districts, February 1998, the latest data available when the analysis was begun.

** Gross rate reduced by 34.1% , the portion of residuals found in 1998 Waste Composition study (Section 2.4.2 and Table 2C). (The rate is actually reduced to 7.05%, before rounding.)

Note that the 18.7% net diversion rate shown in Table 3F is similarly derived; it applies to District 8, for December 1997, with a gross diversion rate that was the starting point for that month of 11.1%.

3.7.3 Results of Economic Model

The economic model shows that over most of the range of processing scenarios and economic assumptions, mixed waste processing has a significant cost per additional ton of Recyclables recovered. There are two cases in which, under favorable, lower-cost assumptions, there are savings per additional ton recycled. Results are presented in a series of tables: Table 3I summarizes the economic analysis and presents results in total annual dollars and dollars per ton for the high- and low-range sensitivity cases. The six Tables 3I-Cases A through F provide detail for each case, itemizing the direct and avoided costs for the high- and low-cost assumptions. Finally, Table 3J presents costs for each case rounded and together for comparison, with the worst and best cases highlighted. Itemized costs have been grouped somewhat: facility costs include both capital and O&M; the net transportation impact is the combined effect of a waste collection cost differential, a Recyclables co-collection cost, and a change in costs of Recyclables collection.

The three plant capacity/locations combined with the no-change in curbside collection of Recyclables – that is, Cases A, B and C – had positive incremental costs. This was so under less favorable, higher-cost assumptions, and even under more favorable, lower-cost assumptions. In these cases, the cost per ton for each incremental ton diverted (tons in excess of what the Curbside Program alone would have diverted) ranges from $87 to $215. These are the scenarios for which mixed waste processing of waste collections would divert an additional 110,100 tons of Recyclables (see Section 3.7.2c above). But while Recyclables tonnages and thus the Diversion Rate would increase for Low Diversion Districts, the City's total solid waste management cost would increase more than proportionately, as Table 3J makes clear. The higher diversion has reduced overall costs because of the export cost savings, but there are either small (Case A) or large (Cases B and C) additional transportation costs, because of the separate collection and processing of waste. Added to facility costs, they more than overwhelm any savings. It should be re-emphasized that these are the per-ton costs *after* accounting for savings from the avoided cost of not exporting, as the detailed tables show.

Results differ somewhat for combined collection and processing of Recyclables and waste – Cases D, E, and F. These are the scenarios for which mixed waste processing of co-collected waste and Recyclables in Low Diversion Districts would result in 86,400 tons more recycled than currently. Under high-cost assumptions, such a system would have positive incremental costs (Cases E and F) or be cost neutral (Case D). Under low-cost assumptions, one case still has positive incremental costs (Case E), but two (Cases E and F) have negative incremental costs – in other words, hypothetical savings compared to the current Curbside Program. Overall, the cases range from a per-ton savings of $51 to a per-ton cost of $89. As Tables 3I-D through F and Table 3J show, transportation cost savings from co-collection are significant; and there are additional savings from avoided export cost and from combined processing (Recyclables are processed with waste; those costs are included in the category of facility costs). The low-cost assumptions result in total program savings per incremental ton recycled, for co-collected waste and Recyclables brought for processing to two hypothetical facilities in the Bronx and Brooklyn, or to one larger hypothetical facility in the Bronx.

Table 3J highlights a particular reality of recycling – the fact that revenue offsets from secondary materials are small relative to many other costs, particularly facility (both capital and operating) and transportation costs. In general, the Department's experience suggests that assumed increases in commodity prices are not a good basis for program implementation, and that revenue assumptions should be zero. However, in the model, revenue from the sale of Recyclables was assumed to be approximately $20/ton, of which the City would receive half. Thus, for example, a doubling of market prices would reduce program incremental costs for any particular case by approximately $10/ton. That would make Case D (co-collection to two facilities), the "best case" scenario, more cost-effective under low-cost assumptions, and marginally cost effective under even high-cost assumptions. But it still leaves all of the separate-collection scenarios with high incremental costs.

Table 3I
Results of Economic Analysis[1]

CASES	Tonnage (tpy)	Incremental Program Cost (1998$)		Cost per Incremental Ton of Diverted Recyclables[2] ($/Ton)	
		Low End of Range	High End of Range	Low End of Range	High End of Range
A. Two 100 tph facilities (Bronx & Brooklyn) – *Separate collection of Recyclables* (i.e., no change in curbside collection of Recyclables)	110,100	$9,622,456	$14,572,313	$87	$132
B. One 150 tph processing facility (Bronx) – *Separate collection of Recyclables*	110,100	$19,234,487	$23,697,649	$175	$215
C. One 150 tph processing facility (Brooklyn) - *Separate collection of Recyclables*	110,100	$14,078,610	$18,541,773	$128	$168
D. Two 100 tph processing facilities (Bronx & Brooklyn) – *Combined collection of waste and Recyclables in same vehicle* (i.e., a change in curbside collection)	86,400	($4,398,325)	($514,565)	($51)	($6)
E. One 150 tph processing facility (Bronx) – *Combined collection of waste and Recyclables in same vehicle*	86,400	$4,403,644	$7,688,763	$51	$89
F. One 150 tph processing facility (Brooklyn) – *Combined collection of waste and Recyclables in same vehicle*	86,400	($752,232)	$2,532,887	($9)	$29

Notes:
1. The total tons processed per week are: (i) with separate Recyclables collection - 16,682 tons; and (ii) with combined Recyclables & waste collection – 17,056 tons. The costs of exporting the non-recycled residue portion of the waste processed were not considered in the analysis. That is, it was assumed that the export costs for these tons would be the same as those for the balance of waste exported by the City. However, an avoided cost credit equivalent to the per ton cost of export was assumed for each additional ton of diverted Recyclables in excess of the quantity that would have been diverted by the Curbside Program only.
2. The incremental – additional – tons of Recyclables recovered from mixed waste processing in excess of what the Curbside Program only would recover, expressed as an annualized tonnage based on extrapolation from the test results, are 110,100 tpy and 86,400 tpy, for the waste only processing (separate collection of Recyclables) and the waste and co-collected Recyclables processing scenarios, respectively.

Table 3I – Case A
Mixed Waste Processing – with Separate Curbside Collection
(Two 100 tph Facilities)

DIRECT COSTS	Low	High
Site Lease Costs	$2,871,000	$2,871,000
Capital Costs	5,748,991	6,681,259
O&M Costs	11,196,000	13,012,000
Waste Collection Costs Differential	975,568	975,568
Recyclables Co-Collection Cost	0	0
Subtotal Direct Costs	20,791,558	23,539,827
Revenue from Sale of Recovered Recyclables	(1,261,956)	(1,261,956)
Total Direct Costs (1998$)	19,529,602	22,277,871
Direct Cost per Incremental Ton Diverted ($/Ton)	177	202
AVOIDED COSTS		
Recycling Collection Costs	0	0
Export Costs Differential	(9,907,146)	(7,705,558)
Recycling Processing Cost	0	0
Total Avoided Cost	(9,907,146)	(7,705,558)
Avoided Cost per Incremental Ton Diverted	(90)	(70)
INCREMENTAL COST		
Program Incremental Cost (Annual Cost 1998$)	9,622,456	14,572,313
Cost per Incremental Ton Diverted ($/Ton)	87	132
Incremental Tons Diverted [1]	**110,100 tpy**	

Note:
[1] The Incremental Tons Diverted is calculated using the total waste generated in the Low Diversion Rate Districts multiplied by the potential increase in Diversion Rate (11.4%) determined by the Mixed Waste Processing test conducted in December 1997. See Section 3.7.2c.

Table 3I – Case B
Mixed Waste Processing - with Separate Curbside Collection
(One 150 tph Facility in the Bronx)

DIRECT COSTS	Low	High
Site Lease Costs	$2,088,000	$2,088,000
Capital Costs	5,553,542	6,454,116
O&M Costs	8,388,000	9,749,000
Waste Collection Costs Differential	14,374,047	14,374,047
Recyclables Co-Collection Cost	0	0
Subtotal Direct Costs	30,403,589	32,665,163
Revenue from Sale of Recovered Recyclables	(1,261,956)	(1,261,956)
Total Direct Costs (1998$)	29,141,633	31,403,207
Direct Cost per Incremental Ton Diverted ($/Ton)	265	285
AVOIDED COSTS		
Recycling Collection Costs	0	0
Export Costs Differential	(9,907,146)	(7,705,558)
Recycling Processing Cost	0	0
Total Avoided Cost	(9,907,146)	(7,705,558)
Avoided Cost per Incremental Ton Diverted	(90)	(70)
INCREMENTAL COST		
Program Incremental Cost (Annual Cost 1998$)	19,234,487	23,697,649
Cost per Incremental Ton Diverted ($/Ton)	175	215
Incremental Tons Diverted [1]	**110,100**	**tpy**

Note:
[1] The Incremental Tons Diverted is calculated using the total waste generated in the Low Diversion Rate Districts multiplied by the potential increase in Diversion Rate (11.4%) determined by the Mixed Waste Processing test conducted in December 1997. See Section 3.7.2c.

Table 3I – Case C

Mixed Waste Processing – with Separate Curbside Collection

(One 150 tph Facility in Brooklyn)

DIRECT COSTS	Low	High
Site Lease Costs	$2,088,000	$2,088,000
Capital Costs	5,553,542	6,454,116
O&M Costs	8,388,000	9,749,000
Waste Collection Costs Differential	9,218,171	9,218,171
Recyclables Co-Collection Cost	0	0
Subtotal Direct Costs	25,247,713	27,509,287
Revenue from Sale of Recovered Recyclables	(1,261,956)	(1,261,956)
Total Direct Costs (1998$)	23,985,757	26,247,331
Direct Cost per Incremental Ton Diverted ($/Ton)	218	238
AVOIDED COSTS		
Recycling Collection Costs	0	0
Export Costs Differential	(9,907,146)	(7,705,558)
Recycling Processing Cost	0	0
Total Avoided Cost	(9,907,146)	(7,705,558)
Avoided Cost per Incremental Ton Diverted	(90)	(70)
INCREMENTAL COST		
Program Incremental Cost (Annual Cost 1998$)	14,078,610	18,541,773
Cost per Incremental Ton Diverted ($/Ton)	128	168
Incremental Tons Diverted [1]	**110,100 tpy**	

Note:

[1] The Incremental Tons Diverted is calculated using the total waste generated in the Low Diversion Rate Districts multiplied by the potential increase in Diversion Rate (11.4%) determined by the Mixed Waste Processing test conducted in December 1997. See Section 3.7.2c.

Table 3I – Case D
Mixed Waste Processing – without Separate Curbside Collection

(Two 100 tph Facilities)

DIRECT COSTS	Low	High
Site Lease Costs	$2,871,000	$2,871,000
Capital Costs	6,439,325	7,483,540
O&M Costs	11,196,000	13,012,000
Waste Collection Costs Differential	1,095,294	1,095,294
Recyclables Co-Collection Cost	7,607,735	7,607,735
Subtotal Direct Costs	29,209,355	32,069,570
Revenue from Sale of Recovered Recyclables	(882,287)	(882,287)
Total Direct Costs (1998$)	28,327,067	31,187,282
Direct Cost per Incremental Ton Diverted ($/Ton)	328	361
AVOIDED COSTS		
Recycling Collection Costs	(24,771,542)	(24,771,542)
Export Costs Differential	(4,605,954)	(3,582,409)
Recycling Processing Cost	(3,347,896)	(3,347,896)
Total Avoided Cost	(32,725,393)	(31,701,847)
Avoided Cost per Incremental Ton Diverted	(379)	(367)
INCREMENTAL COST		
Program Incremental Cost (Annual Cost 1998$)	(4,398,325)	514,565
Cost per Incremental Ton Diverted ($/Ton)	(51)	(6)
Incremental Tons Diverted [1]	**86,400 tpy**	

Note:
[1] The Incremental Tons Diverted is calculated using the total waste generated in the Low Diversion Rate Districts multiplied by the potential increase in Diversion Rate determined by the Mixed Waste Processing test conducted in December 1997. See Section 3.7.2c for derivation of incremental tons.

Table 3I – Case E
Mixed Waste Processing – without Separate Curbside Collection

(One 150 tph Facility in the Bronx)

DIRECT COSTS	Low	High
Site Lease Costs	$2,088,000	$2,088,000
Capital Costs	5,553,542	6,454,116
O&M Costs	8,388,000	9,749,000
Waste Collection Costs Differential	14,374,047	14,374,047
Recyclables Co-Collection Cost	7,607,735	7,607,735
Subtotal Direct Costs	38,011,324	40,272,898
Revenue from Sale of Recovered Recyclables	(882,287)	(882,287)
Total Direct Costs (1998$)	37,129,037	39,390,611
Direct Cost per Incremental Ton Diverted ($/Ton)	430	456
AVOIDED COSTS		
Recycling Collection Costs	(24,771,542)	(24,771,542)
Export Costs Differential	(4,605,954)	(3,582,409)
Recycling Processing Cost	(3,347,896)	(3,347,896)
Total Avoided Cost	(32,725,393)	(31,701,847)
Avoided Cost per Incremental Ton Diverted	(379)	(367)
INCREMENTAL COST		
Program Incremental Cost (Annual Cost 1998$)	4,403,644	7,688,763
Cost per Incremental Ton Diverted ($/Ton)	51	89
Incremental Tons Diverted [1]	**86,400 tpy**	

Note:
[1] The Incremental Tons Diverted is calculated using the total waste generated in the Low Diversion Rate Districts multiplied by the potential increase in Diversion Rate determined by the Mixed Waste Processing test conducted in December 1997. See Section 3.7.2c for derivation of incremental tons.

Table 3I – Case F
Mixed Waste Processing – without Separate Curbside Collection

(One 150 tph Facility in Brooklyn)

DIRECT COSTS	**Low**	**High**
Site Lease Costs	$2,088,000	$2,088,000
Capital Costs	5,553,542	6,454,116
O&M Costs	8,388,000	9,749,000
Waste Collection Costs Differential	9,218,171	9,218,171
Recyclables Co-Collection Cost	7,607,735	7,607,735
Subtotal Direct Costs	32,855,448	35,117,022
Revenue from Sale of Recovered Recyclables	(882,287)	(882,287)
Total Direct Costs (1998$)	31,973,160	34,234,735
Direct Cost per Incremental Ton Diverted ($/Ton)	370	396
AVOIDED COSTS		
Recycling Collection Costs	(24,771,542)	(24,771,542)
Export Costs Differential	(4,605,954)	(3,582,409)
Recycling Processing Cost	(3,347,896)	(3,347,896)
Total Avoided Cost	(32,725,393)	(31,701,847)
Avoided Cost per Incremental Ton Diverted	(379)	(367)
INCREMENTAL COST		
Program Incremental Cost (Annual Cost 1998$)	(752,232)	2,532,887
Cost per Incremental Ton Diverted ($/Ton)	(9)	29
Incremental Tons Diverted [1]	**86,400**	**tpy**

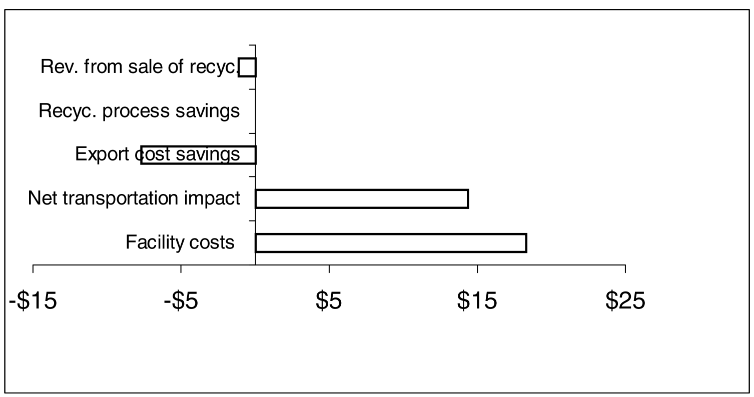
Note:
[1] The Incremental Tons Diverted is calculated using the total waste generated in the Low Diversion Rate Districts multiplied by the potential increase in Diversion Rate determined by the Mixed Waste Processing test conducted in December 1997. See Section 3.7.2c for derivation of incremental tons.

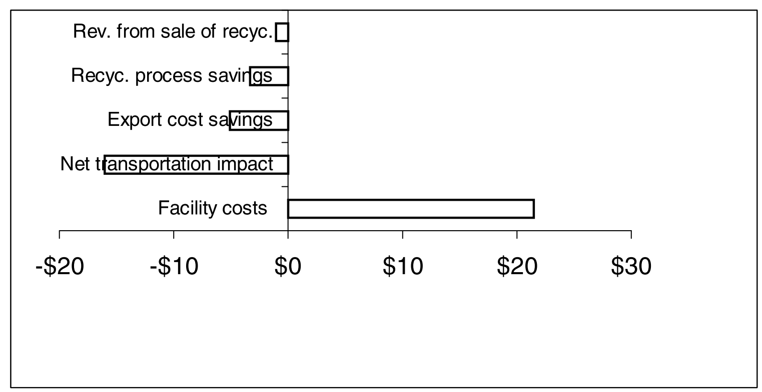
Table 3J

INCREMENTAL COSTS ($m), RESTATED	Separate Curbside Collection of Recyclables						Combined Collection of Recyclables w/ Garbage					
	2 Facilities Table A		1 Facility: Bronx Table B		1 Facility: Brooklyn Table C		2 Facilities Table D		1 Facility: Bronx Table E		1 Facility: Brooklyn Table F	
	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
Facility costs	19.8	22.6	16.0	18.3	16.0	18.3	21.5	24.5	16.0	18.3	16.0	18.3
Net transportation impact	1.0	1.0	14.4	14.4	9.2	9.2	-16.1	-16.1	-2.8	-2.8	-7.9	-7.9
Export cost savings	-9.9	-7.7	-9.9	-7.7	-9.9	-7.7	-5.1	-4.0	-5.1	-4.0	-5.1	-4.0
Recyc. process savings	0.0	0.0	0.0	0.0	0.0	0.0	-3.3	-3.3	-3.3	-3.3	-3.3	-3.3
Rev. from sale of recyc.	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1
TOTAL	9.8	14.7	19.4	23.8	14.2	18.7	-4.1	0.0	3.7	7.1	-1.4	2.0
Incremental tons diverted	110,100	110,100	110,100	110,100	110,100	110,100	86,400	86,400	86,400	86,400	86,400	86,400
Inc. cost per ton diverted	87	132	175	215	128	168	-51	-6	51	89	-9	29
	Collection advantage: relatively higher diversion rate; Collection disadvantage: relatively higher transportation costs						Collection advantage: relatively lower transportation costs; Collection disadvantage: relatively lower diversion rate					
	Facility Advantage: lower transportation costs		Facility Advantage: economies of scale due to 1 larger plant				Facility Advantage: lower transportation costs		Facility Advantage: economies of scale due to 1 larger plant			

WORST CASE SCENARIO: Cost/ton = $215
Higher transportation and facility costs overwhelm smaller savings from recycling.

BEST CASE SCENARIO: Savings/ton = $51
Transportation savings offset most facility costs. Additional savings due to added recycling contribute to a net savings overall.





Source: Tables 3I-A through 3I-F. + dollars are costs; - dollars are savings

CHAPTER 4: COMPOSTING THE RESIDUAL – A PRELIMINARY EVALUATION

4.0 INTRODUCTION

In addition to the recovery of Recyclables, the mixed waste Processing Test provided an opportunity to evaluate, on a preliminary basis, the suitability of composting the organic residue from such a test. In general, such an evaluation is warranted because a relatively large fraction of mixed waste has a high organic content and can be mechanically separated from the other waste material by using screens in a mixed waste processing line. If it could be composted to produce a quality compost at an acceptable cost, it represents a significant potential to increase waste diversion. Furthermore, producing this material as an extension of mixed waste processing to recover Recyclables would avoid the cost of separate curbside collection of residentially generated organic waste, which has posed a major economic barrier to composting this waste stream. Given the short-term nature of the Processing Test as a starting point, and cost limitations of extending the study to include composting a part of the residual, it was understood from the outset that any results from this composting evaluation would not be a sufficient basis for program implementation. Rather, they would be an indication of whether such a process merited further study.

It is important to note that in the United States experience with composting mixed waste on a large scale has been limited. Miami, Florida (Agripost) and Portland, Oregon (Ridell) are examples of mixed waste composting facilities that were unable to operate successfully and are now closed. For this test, the Department had initial compost processing done in a facility in Sevierville, Tennessee, and final compost processing done at its own compost facility on Rikers Island. The Sevierville plant, owned by Bedminster Bioconversion Corporation, has composted mixed municipal solid waste for six years. It was selected because it had a stable operating history over a period of six years in composting mixed municipal waste, and at the time was the only operating U.S. facility capable of accepting the mixed waste residue from the Processing Test. Sevierville processes about 300 tpd of municipal waste a day, primarily for agricultural applications.

As detailed in Chapter 3, mixed waste was collected from Brooklyn 8, one of 20 Low Diversion Districts, and delivered to Varick Avenue the week of December 15, 1997, for a Processing Test. A fraction of that waste stream, < 4–inch size, was mechanically separated from the processed material at the beginning and the end of the mixed waste processing line at Varick Avenue, and its quantity recorded; the total (based on adjusted data) over the week of the Processing Test was 220 tons, or 29.9% by weight of the Test District waste and Recyclables processed at Varick Avenue (Table 3C). A one-day portion of the < 4-inch material was composted in the two-stage process, and tested at various stages. The overall process and analysis are the Compost Test.

The Compost Test had three objectives. They were:

- to assess the quality of compost produced from the Test District's waste stream <u>residue</u>, for compliance with regulatory standards and potential marketability;
- to evaluate the potential effect of composting on increasing the net diversion of waste from disposal; and
- to conduct a *preliminary* analysis of the economics of large scale composting of organics from a mixed waste processing system residue.

The findings, described in this chapter, are:

- compost quality complies with regulatory limits for pathogen contamination but not for trace metal contamination (nickel). Glass levels were too high for product marketability;
- composting has the potential to increase the diversion rate *only if* glass levels could be radically reduced. Since <u>half</u> of the test compost product was inert material (mainly glass), processes would have to be developed that could effect a radical reduction in the content of glass shards.[1] If, for example, glass levels could be reduced by 90% of Test levels, results suggest that composting would have the potential to raise diversion rates by 16 percentage points or more.
- costs are over $90 per ton diverted through composting, even after taking into account avoided waste disposal charges.

It must be kept in mind that the objectives were measured only with respect to the particular residue stream from this one test.

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[1] Without a new, as-yet-undeveloped processing technology, or a significant change in collection, there will continue to be broken glass in a mixed waste processing residual. And any collection change that separates glass to prevent contamination would add to the already high incremental cost.

4.1 PROCESS OVERVIEW

On the first day of the mixed waste Processing Test (Monday, December 15, 1997), the screening generated approximately 45 tons of < 4-inch residue. That organic fraction screened on Monday was developed into compost through a two-stage process:

- First, the material was sent to the Bedminster Bioconversion Corporation's composting facility, a mixed waste composting plant in Sevierville, Tennessee. There it was placed in a drum and mixed with biosolids for three days. *The Sevierville plant composts as-received municipal waste; that is, there has not been prior separation of organics from other waste. The municipal waste is combined in an enclosed drum with wastewater sludge (from sewage treatment plants; also referred to as biosolids) to attain the particular mix of carbon and nitrogen that accelerates microbial growth early in the composting process. Biosolid sludge is a homogenous, nitrogen rich feedstock, typically processed with the addition of wood chips to add a source of carbon. The mix stays in a rotating drum for an initial three days of processing. The material is then discharged and composted in aerated rows called windrows.*
- After the three-day digestion process in drums in Sevierville, the material was tested and transported back to the Department's Rikers Island composting facility for further composting and curing.

4.2 MEETING STANDARDS AND REQUIREMENTS

New York State, through the Department of Environmental Conservation (NYSDEC), sets compost quality requirements and regulates the facilities that produce compost. The regulations for producing compost from mixed waste – i.e., compostable organic material recovered from loads of refuse – are much more stringent than those regulations applicable to source separated yard waste, both with respect to compost quality and facility design. Meeting these standards as well as general market standards present significant challenges to making compost successfully from a mixed waste residue, challenges that are more fully discussed in this section.

4.2.1 Compost Quality Standards

4.2.1a Trace metals, chemical and bacterial contaminants

At a minimum, a Departmental composting program would have to produce a composted material that conforms to NYSDEC's stringent limits on the maximum levels of trace metal, chemical and bacterial contaminants. Section 6 NYCRR Part 360 Subpart 360-5 of the NYSDEC regulations classify compost material as either a Class I or Class II compost product. Class I and Class II compost products must meet trace metal, chemical and bacterial contaminant requirements. In addition, Class I compost products must not exceed 10 millimeters in particle size and must not be used on crops grown directly for human consumption (for example, tomatoes). However, Class I compost products can be distributed to the public for use on food chain crops (for example, soybeans grown for animal feed) and for other agricultural and horticultural uses. Class II compost must not exceed 25 millimeters in particle size and must be restricted to use on non-food chain crops. In 1995, NYSDEC proposed revisions to the regulations for classifying compost material which would eliminate the two quality classes and relax the Class I requirements, but has not yet adopted them. Therefore, this report compares the test results of the composted product to the promulgated 1993 compost quality standards.

Requirements to attain these quality standards, in order to minimize the potential for bacterial and trace metal contamination in a compost end product that may be used in food chain or horticultural applications, include: minimum processing times; maintenance of the process temperature within a minimum-maximum range for a minimum period of time to destroy pathogens; and testing of the end product to establish that threshold limits for trace metal contamination are not exceeded.

The potential for trace metal contamination of a compost product derived from mixed waste is a focus of regulatory concern. Trace metal contamination can be introduced into an organic stream derived from municipal solid waste (MSW) from such products as batteries, light bulbs, household electronic devices, and painted wood. If trace metals are present in the organic waste, the concentration of these trace metals will increase (as a percent of the total mass) as the decomposition process during composting reduces the amount of organic matter and moisture.

The laboratory tests performed during the Compost Test on the cured compost product indicate that the compost complies with regulatory limits for pathogen contamination but not for trace metal contamination. Nickel levels exceeded regulatory standards for Class I compost but were within the limits for Class II. The sources of this nickel contamination could not be identified during the Compost Test, and are often difficult to identify. (While problems with the magnet on the day of sampling were noted in Chapter 3, tin cans are generally considered a less likely contaminant than nickel-cadmium batteries, which do respond to magnetic separation; in some circumstances nickel may be introduced through biosolids.) Any future evaluations of the feasibility of composting MSW should include identifying these sources and evaluating the feasibility of removing them.

4.2.1b Glass, plastic, and other inert materials

The ability to minimize the quantity of small glass and plastic inert material in the finished product is very important to the aesthetics, quality and marketability of the compost product, and to the efficiency of the process. Laboratory testing of the finished compost established that the organic fraction recovered in the test had a high concentration of glass: The final compost product, analyzed after four months of curing, was 51% inert material (on a dry weight basis).

Glass in excess of even 1% can be noticed in compost, and is thus an aesthetic problem that reduces marketability. The importance of product quality to marketability is of particular concern because the supply of higher-quality compost product in the New York metropolitan area is increasing. This includes production of compost from biosolids (i.e., wastewater sludge from treatment plants), which has no glass particles and is homogenous and nitrogen rich. Because of the Compost Test results, the economic analysis assumes that the compost product yields economic benefits in terms of avoided disposal cost but generates zero revenue. The other fundamental concern is that high glass content wastes resources, and therefore increases costs: glass (mixed with waste) is transported to a composting facility and uses space in the digester and compost piles, without enough of it breaking down into sand in the compost. And it then must be disposed of, just as if it had not gone through these processes.

In this particular Compost Test, the mixed waste separation system concentrated small glass particles in the compostable residue. The high glass percentage is at least partly attributable to the test process itself. The Varick facility, where the organic fraction was separated, was not specifically designed to recover a high quality, organic rich fraction. Varick's processing system does not focus on glass removal because it is a low value product compared to paper, metal and plastic. Thus, glass is broken into smaller fragments as it moves through the processing line and is entrained in the heavy organic fraction.

But other factors also contribute to the glass problem. Households fail to separate sufficiently, which results in a larger fraction of glass appearing in the disposed waste. It should be recalled that Brooklyn District 8, from which the waste was collected, was part of the Low Diversion Districts for which the Capture Rate for recyclable glass recovery was just demonstrated to be 28% (Table 2E); this means that almost three-quarters of the glass that should have been recycled was in the garbage, where it was more likely to be ground into the organic refuse.[2] Furthermore, the Low Diversion districts are high density. That is, most residents live in apartment buildings, where waste and Recyclables undergo more handling between household and curbside, as each apartment's material is consolidated, compared to single-family homes. The additional handling and movement mean more glass breakage. Final contributing factors are the compaction in collection vehicles, the dumping onto the tipping floor of a MRF, and the use of front-end loading vehicles for moving material at the MRF.

It must be noted here that the Bedminster technology is designed to compost all municipal solid waste (MSW), including glass, so in principal the presence of glass should not be described as a problem. But "all MSW" is different from a post-sort residue from which highly compostable paper has been removed, and glass has been broken before it can be sufficiently screened away from other material. The Department is not in a position to know the extent to which glass may be a problem in general in compost produced at Sevierville, or whether paper kept with mixed waste – not sorted out for higher-valued recycling – mitigates the glass problem by diluting it, in effect, with more compostables. Study beyond the scope of this report would be needed to assess the suitability of this technology for other waste streams.

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[2] The adjustments described in Section 2.5 suggest that the capture rate may be even lower, once the glass portion of residual waste is taken into account.

4.2.2 Facility Standards

NYSDEC's rigorous requirements for the design and operation of facilities that compost mixed waste establish a high cost threshold for processing facilities. Part 360 Subpart 360-5.3 (a) 1 – 3 gives three options for facility design, in part to minimize the impacts of a compost facility and its processing operations on the surrounding environment. One option is for the use of an enclosed processing system, and collection and treatment of process odors and effluent. These require significant capital investment. At a minimum, incoming mixed waste residue is processed, during the active composting phase, in an enclosed facility with a sophisticated temperature, moisture and odor control system; then there must be substantial on-site storage capacity for a minimum 50-day time period. It is assumed that this most complex and costly of the three design options is a *de facto* requirement for a facility in or around New York City, or one that composts NYC mixed waste. Thus, the economic evaluation in this section assumes a generic compost facility design that incorporates these elements.

It should be noted here that the Department's Rikers Island composting facility is an example of this type of design. It is totally enclosed, has automated process and odor control systems, and produces a high quality compost product. But it should also be noted that the Rikers Island composting facility, in contrast to a mixed waste composting facility, uses a feedstock of approximately 15 tons per day of *source separated* organic material principally comprised of cafeteria food waste from the Department of Correction jails on Rikers Island. Thus, it does not have the problems with contamination from glass, metal, and plastic that come from compost made from household mixed waste.

4.2.3 Facility Siting

The development of composting facilities in the City presents significant siting issues because of the limited availability of large parcels of available land with the requisite M-3 zoning. The acreage requirements for facilities to process the < 4-inch residue fraction of the MSW stream are substantial (see Table 4B) because of areas needed for compost curing and for a buffer around the site. The economic analysis assumes that while the mixed waste recovery facility must be located in the City to keep the Department's route collection costs within acceptable bounds, the compost facilities would be in locations remote from the City. The economic analysis builds in the cost of transporting the < 4-inch compostable fraction to these remote sites.

4.3 COMPOSTING TEST

4.3.1 Processing at Sevierville and Rikers Island

The 45 tons (90,280 pounds) of < 4-inch screened material sorted on the first day of the Processing Test at Varick Avenue (Table 3C) were shipped to the Sevierville facility for that stage of the Compost Test. The < 4–inch fraction was comprised of: food waste and other organics, such as small pieces of paper; plastic and glass; and dirt and grit. On arrival at the Sevierville facility, this test material was dumped on a pad along with two types of biosolid sludge used in the Bedminster process, dewatered plant sludge and final screen sludge. Approximately 54,000 pounds of the sludge were added to the 90,280 pounds of < 4-inch organic MSW, in a ratio of 37% sludge to 63% mixed waste. This mixture was introduced into a digester drum and mixed over a three-day period, the normal time period for mixing MSW and biosolids in the Bedminster process. During residence time in the drum, the heat produced by the biological activity caused an estimated 6.9% by weight of the material in the drum to evaporate into the atmosphere as moisture.

After three days residence in the drum, the material was discharged onto the floor and then screened to separate material greater than (>) 1.5 inches from the remainder. The > 1.5 inch material was approximately 16% of the total, and it was discarded as residue. It should be noted that the organic fraction delivered to the Sevierville facility had a significantly higher moisture content (approximately 70%) than MSW normally seen in the Bedminster process. The high moisture content of the material discharged from the drum reduced the efficiency of the screening process and also affected the composting process. In retrospect, using smaller quantities of biosolids would have corrected this problem.

The remaining compostable fraction was deposited on the curing floor and dried for a two-day period. This step may not have been necessary if a smaller quantity of biosolids had been introduced. The material was then loaded into covered vehicles and transported back to the Department's Rikers Island composting facility for further composting and curing. The weight of this material was estimated at 110,280 pounds. The material returned to Rikers Island was cured over a 50-day period, as required under NYSDEC sludge and solid waste composting facility operating requirements. Table 4B (below) summarizes these tonnage flows as they pertain to tracking the mass balance of the materials tested.

4.3.2 Laboratory Testing

Laboratory tests of materials were performed on multiple samples at various stages during the Compost Test program to: verify that the integrity of the sample material was maintained; evaluate the presence of trace metals, bacteria, PCBs, and inerts; and measure moisture content and carbon loss. The final tests were performed after full curing at Rikers Island, and therefore served to assess the quality of the finished compost. Appendix E identifies the tests performed, and summarizes the general results.

For the finished product, laboratory test results outside of normal ranges were discussed in Section 4.2.1. To recap, the finished compost product failed Class I standards for nickel contamination but complied with Class II standards, making it suitable for horticultural but not food-based applications. The compost was also found to have a high level – 51% on a dry weight basis – of glass and other inert material. The inability to meet Class I standards and the high inert content would affect marketability, were the end product to be sold.

4.3.3 Implications

The Compost Test indicates that the mechanical separation used to increase Recyclables diversion is incompatible with the desire to divert the organic fraction of the mixed waste for composting for this waste stream. While the presence of some glass in the < 1.5-inch organic fraction is unavoidable, a 50% inert fraction is far too high, for reasons indicated above. Further study would be required to understand whether various process changes could reduce glass content to acceptable levels, or whether removing paper for recycling leaves the residual unsuitable for composting. The sources of metal contamination would also have to be addressed.

4.4 HYPOTHETICAL CONTRIBUTION TO DIVERSION RATE

Since mechanical separation for mixed waste processing did not yield a <4-inch organic residue fraction suitable for composting from the Low Diversion Rate collection district, there was no "add on" contribution to the Diversion Rate from the Compost Test. More generally, it is not known whether any front-end mixed waste processing system designed to recover recyclables from high-density urban neighborhoods can produce an organic fraction for composting that keeps the entrapment of small glass particles in the compostable fraction to within acceptable levels. Therefore, to evaluate any *potential* increase in diversion rate in general from composting an organic residue fraction, it was necessary to make the assumption that the glass and other inert content of the feedstock produced by a mixed waste processing system would be reduced significantly compared to the Compost Test. In particular, it was assumed – for the purpose of deriving a theoretical diversion rate increase through composting the mixed waste processing residual – that the organic-rich fraction that comes out of an improved-design mixed waste processing facility and goes into a compost facility would have, proportionately, no more than 10% of the actual level of inert material that came out of the Varick facility during the Compost Test. *This is a 90% reduction from test levels.* At present, there is no established basis to support such an assumption, nor does the Compost Test demonstrate the ability to achieve this quality level. However, readers should note that compost industry experts consulted by the Department have indicated that greater than 10% inert material in the finished compost product would yield an unmarketable product.

The hypothetical range of contribution to diversion from composting was derived based on this purely theoretical assumption of a 90% reduction in inerts, and is shown in Table 4A. Since glass and inerts in the final compost are introduced from the mixed waste organic residue, not the sludge, and pass through the compost process unchanged, there is a direct relation between reduced inerts in the finished product and in the feedstock. The calculations in the table are based on this relation. A lower bound estimate of 16% is derived by multiplying the overall organic residue portion by the dry-weight portion of finished product remaining after accounting for the 90% of inerts. An upper bound estimate of 26% is derived by subtracting from a full-program organic residue tonnage level the estimated tons of inerts in the finished compost product. As the table note explains, the difference between the two measures depends on where

Table 4A
Derivation of Hypothetical Diversion Rate from Composting Mixed Waste Processing Residue [Assuming as-yet-unidentified mixed waste technologies that when adopted would result in inert levels 90% less than Compost Test levels]

	Given:	
1	Total waste stream from low diversion districts *[Table 1B]*	3,095 tpd
2	Organic residue portion (< 4-inch fraction from mixed waste processing line) *[Table 3C]*	29.9%
3	Organic residue tonnage that is potential for composting from hypothetical, 20-district mixed waste processing program (Note: this residue from mixed waste processing is the input to composting) [*Line 1 x Line 2]*	925 tpd
4	Moisture content of organic residue (calculated from sample results) *[Appendix E, Table E-2]*	70.5%
5	Organic residue stated on dry weight basis [*(100% - line 4) x line 3]*	273 tpd
6	Inert portion of finished compost product, from sampled results) *[Section 4.3.2 and Appendix E]*	51%
	*Lower bound estimate of compostable fraction:**	
a	Reduction in final product *[90% x Line 6]*	46%
b	Portion of full waste stream that would end as compost *[(100% - Line a) x Line 2]*	16%; lower bound est.
	*Upper bound estimate of compostable fraction:**	
A	(Calculated) Inert tonnage of finished product *[line 5 x line 6]*	139 tpd
B	Amount of final compost product that would have to be removed, through as-yet-unidentified technology, to reduce final inert levels to 10% of Compost Test results *[Line A x 90%]*	125 tpd
C	Potential amount of organic residue from mixed waste processing that would be input for composting, if inert levels could be reduced *[Line 3 – Line C]*	800 tpd
D	Portion of full waste stream that would end as compost, assuming inert levels could be reduced *[Line D ÷ Line 1]*	26%; upper bound est.

*Note: The test samples showing the portion of inerts, and therefore the basis for how much would have to be removed, were made on a dry-weight basis. Moisture is lost through the entire process from waste collection through composting, and inerts might start with moisture embedded or attached. Sampling results do not allow for estimating moisture portion of inerts alone. The lower-bound estimates implicitly assume inerts start with the same moisture content as the rest of the organic residue; the upper-bound estimates implicitly assume inerts begin completely dry. Therefore the estimates are simply boundaries.

moisture is allocated. Since the <4-inch organic residue is estimated to be about 70% moisture, the apparent portion available for composting, 29.9% by weight before adjustments, includes a considerable amount of moisture that will be lost through evaporation before the compost is produced.

Finally, the diversion rate bounds here are, in a sense, bounds on a "net" rate; they represent the organic portion with inert levels reduced – in effect, with most glass removed. However, this is a hypothetical reduction based on the assumption of changes in the mixed waste processing system. From this perspective, the initial portion diverted for composting is the "gross" rate. A net rate would take into account any of the organic portion that has to be discarded as compost is produced. During the Compost Test, biosolids were added to the recovered < 4-inch organic fraction; the composting process itself generated various losses. Some were material losses from the evaporation of moisture into the atmosphere and the decomposition of carbonaceous material in the organic feedstock; but there was also residual material that had to be landfilled. The material balance information collected from various stages of the Compost Test was used to estimate material flows and to allocate the losses. For estimating a net diversion rate, only the landfilled losses have to be allocated. (The overall mass balance estimates, including allocating moisture and other losses, were used for the economic analysis [Section 4.5], and are shown in Appendix E.) As Table 4B shows, given the Processing and Compost Test results together with the purely theoretical assumption that most inerts could be kept out of the compost input stream, other losses are such that composting the residue of mixed waste processing would yield a net contribution to diversion somewhere between 13% and 21%.

It is important to recognize that much of information in Tables 4A and 4B was derived from extrapolation of laboratory test data (see Appendix E) on small samples, because weigh data on total material in the process could not be collected at every stage of the test. And again, *it must be emphasized that the potential contribution to the Diversion Rate is only achievable if a higher quality organic feedstock can be separated by a mixed waste processing system to produce a marketable compost product.*

Table 4B
Derivation of Hypothetical Net Diversion Rate from Composting Mixed Waste Processing Residue

CATEGORY	Wt. in lbs. / %
Inputs to Bedminster facility:	
Less than 4-inch fraction of mixed waste processing residue, screened at Varick Avenue and shipped to the Bedminster facility	**90,280** / 62.6%
Wastewater biosolids added to waste	**54,000** / 37.4%
Total: < 4-inch organics (mixed waste residual) & biosolids	**144,280** / 100 %
Outputs from Bedminster (totaling 144,280 lbs.):	
Moisture loss from drying post-drum processed material prior to screening[1]	**10,000** / 6.9%
Greater than 1.5-inch material screened as residue ('residual') at the Sevierville facility,[2] and subsequently landfilled	**24,000** / 16.6%
Material shipped to Rikers Island for composting and curing NOTE: glass/inerts are part of this segment	**110,280** / 76.4%
Derivation of "net" diversion rate:	
Estimated glass/inerts in finished compost[3]	**18,335**
90% of glass/inerts (.9 x 18,335)	**16,500**
Mixed waste inputs, reduced by 90% of glass/inerts (90,280 – 16,500)	**73,780**
Mixed waste's allocated share of the 24,000 residual landfilled from Sevierville (62.6% x 24,000)	**15,024**
Portion of reduced mixed waste input that is landfilled (15,024 / 73,780)	20%
"Gross" Diversion Rate range, from Table 4A	16% - 26%
"Net" Diversion Rate range, after accounting for landfilled portion (80% of gross rate)	13% - 21%

Notes:
1 After processing in the drum, the material was dried over a two-day period. The moisture loss during the drying period is based on sample analysis from the interior of the compost pile.
2 Quantities as provided in the Compostable Test Report.
3 Based on measured inert material by weight in eight samples tested by Woods End Laboratory.

4.5 ECONOMIC ANALYSIS

This section presents an economic evaluation of the incremental cost of composting organic material that is assumed to be mechanically separated from mixed waste. Cost estimates are based on a model of a 300-tpd generic composting facility located outside of New York City. Given the open question of whether an organic fraction with an acceptably low level of inerts can be successfully produced from the mixed waste stream and waste processing system evaluated in Chapter 3, the economics reviewed in this section should be viewed as purely hypothetical. If an acceptable organic stream can be recovered, the economics of composting this material would approximate those presented here, given the assumptions set forth below.

The incremental costs of composting presented in this chapter are incremental to the costs of mixed waste processing presented in Chapter 3. That is, the analysis assumes a mixed waste processing facility is available to receive waste collection vehicles at a location in the City and to separate out an organic fraction which is then transported to an out-of-City location for composting. Thus, the total incremental costs of mixed waste processing combined with composting are the sum of the Total Program Incremental Costs for the appropriate mixed waste processing scenario in Chapter 3 added to the Total Program Incremental Cost for Composting in this Chapter 4. However, the per ton incremental costs are not additive because these are average numbers calculated on different tonnage bases, either 110,100 tpy or 86,400 tpy for the mixed waste Processing Test depending upon the scenario (with or without separate curbside collection) and 109,500 tpy for the Compost Test. Appendix E provides details on the facility conceptual design, capital and O&M used in the analysis of compost economics.

4.5.1. Economic Analysis – Assumptions and Methodology

The evaluation of incremental costs considers: 1) the direct costs attributed to the addition of the composting program, and 2) the avoided costs in other existing Department programs resulting from the addition of the composting program.

1. The direct costs of composting include the following:
   - The estimated capital and O&M costs for a facility that composts 300 tpd of < 4-inch organics from mixed waste.
   - The costs of transporting 300 tpd of < 4-inch organic material from the mixed waste processing facility to the composting facility, which is assumed to be located 75 miles from the City.

- The costs of transporting residue from the compost facility to a landfill. Approximately 16.6% of the input material was assumed to be screened out after mixing in the drum. The material screened out included biosolids adhering to the > 1.5-inch fraction. However, since the biosolids would not have been processed but for the contribution to accelerating the composting process, all the residue costs for an estimated 68 tons (16.6% of 300 tpd of < 4-inch organics plus 111 tpd of sludge) of > 1.5-inch residue are allocated as a direct cost of organic composting.

2. The avoided costs of composting include:

   - The waste export costs that the City would otherwise incur in disposing of the volume of recovered organic material < 4 inches initially diverted to composting.

The assumptions used are in part based on the estimated material balance, shown in Table 4B and Appendix E. Information from these tables includes: the proportions of material initially recovered as a < 4-inch organic fraction; the residues from the composting process that must be landfilled; and the quantity of compost product produced, inclusive of the losses (evaporation of moisture to the atmosphere and the decomposition of carbonaceous material to carbon dioxide) that are part of the composting process.

HDR developed a generic conceptual design for a 300 tpd compost facility which is the basis for estimating capital and O&M costs. A 300 tpd facility size was assumed because that is the size of the facility that has been demonstrated at Sevierville. In addition, given the site size requirements for this type of waste processing facility, it was reasonable to assume that facilities would be sited in 300 tpd increments rather than a single large plant. All costs are estimated in 1998 dollars. The contingency allowances on capital and O&M costs reflect the generic nature of the design. Appendix E contains tables with detailed estimates of the capital and O&M costs for such a facility, including associated transportation and disposal costs. These costs were used to calculate annualized facility tip fees under the economic assumptions discussed below.

The acreage requirements for siting a composting facility are substantial, as indicated in Table 4C. The remote likelihood of finding and permitting one or more M-3 zoned parcels of this size within the City resulted in an assumption that the modeled compost facility would be located 75 miles away from the City.

The estimated facility construction costs include a 20% contingency allowance on the building structure and a 5% contingency allowance on processing and material handling equipment. Estimates include allowances for building design at 8% of construction costs, for equipment design at 2% of equipment costs, for permitting at 5% of construction costs, and for construction monitoring at 2% of construction costs. Total capital costs are amortized over 15 years, assuming that the Department would be willing to enter into a 15-year service agreement with the facility operator. The capital recovery factor used to calculate annual capital costs reflects an assumed weighted cost of capital for debt and equity financing of 8% for rolling stock and 10% for facility capital costs. A longer or shorter amortization period will change costs.

Operating costs were estimated inclusive of labor, maintenance and other O&M expenses. An allowance of 20% was applied to base O&M expenses for the facility operator's general and administrative expense and contingency. The economic evaluation also included the following assumptions:

- The City's waste export costs are $80 per ton (an average of the low and high estimates used for the mixed waste processing facility).
- Site lease costs are $2.54 per square foot, based on a downward adjustment of the assumed site lease of $3.00 per square foot for the in-City mixed waste processing facility, to reflect lower land costs outside of the City.
- The costs of recovering the input organic fraction are incorporated in the cost of the mixed waste processing facility and are therefore not included as a direct cost of the composting facility. This is based on the assumption that the economics of Recyclables recovery from mixed waste are more favorable and, therefore, a compost facility would not be developed independently of a mixed waste processing facility.
- The distance from the compost facility to the landfill is assumed to be 50 miles. Landfill disposal costs for residue from the compost facility are assumed to be $35.40 per ton.
- The compost facility will receive and load mixed waste eight hours per day, five days per week and four hours on Saturdays.
- The compost facility design assumes a facility capacity of 300 tpd of organics processed seven days per week.
- Approximately 1/3 of biosolid material will be added to 2/3s of mixed waste.
- The compost end product will have a moisture content of approximately 21%.
- The compost curing time is 50 days.

- There is zero revenue realized from the processing of sludge and the sale of the compost product.

4.5.2 Conclusions

Table 4D summarizes the economic analysis, showing the total and per-incremental-ton costs of composting an organic fraction derived from mixed waste. As stated above, costs are based on a 300 tpd facility; the annualized incremental tons are thus 109,500 (365 x 300). The table shows that the additional cost of composting organics produced by a mixed waste processing system, *after taking into account the savings from not having to export the material composted,* is over $90/ton. Costs are almost twice as large before accounting for export savings; site requirements and capital equipment, including expensive environmental controls, are among the factors contributing to high per-ton costs.

The model shows the costs for a single facility, operating at full capacity. Since the Low Diversion collection districts together would have a residual organic waste stream of more than 600 tpd, even assuming the ability to reduce the glass and inert content (see Table 4A), more than two facilities would be needed. Cost implications of the need to site more than one facility, and of unutilized capacity in a 3rd facility, are not reflected in the economics.

Table 4C
Siting Requirements for Residue Composting Facilities[1]

Facility Component	Design (Square Feet)
Process building footprint (includes tip floors, processing equipment, residue transfer area and product storage)	165,000
Scales, truck queuing and outdoor vehicle maneuvering space	400
Administration building	1,600
Curing area	50,000
Biofilter	65,000
Site buffer allowance (150-foot perimeter)	582,000
Total site requirements	20 acres

[1]The siting requirements are based on a feedstock of 300 tpd of mixed waste, 365 days per year. Approximately 111 tons per day of biosolids are added to the mixed waste for composting.

Table 4D
Cost for Modeled Compost Facility, 1998$

Cost Categories	Annual Cost, 300 tpd [109,500 tpy][1]
Direct Costs	
Site Lease	$1,879,000
Capital Amortization Cost	$7,145,000
O&M Cost	$7,147,000
Transportation and Disposal Costs	$2,838,000
Revenue from Sale of Compost	0
Revenue from Disposal of Sludge	0
Total Direct Costs	$19,009,000
Avoided Costs	
Avoided Export Cost	$8,760,000
Incremental Cost	
Total Annual Program Incremental Cost per Facility	$10,249,000
Annual Tonnage	109,500
Per Ton Program Incremental Cost	$93.60

Note
[1]Assumes facility operates 365 days per year.

Assumptions are set forth in Section 4.5.1. In particular, costs are developed for a 300 tpd composting facility, of which approximately two-thirds of the tonnage is mixed waste and one-third (111 tpd) is biosolids. Costs have not been scaled for a larger waste stream that would require multiple facilities.

Sanitation collection truck, identified for mixed waste processing pilot test.

A sample waiting to be sorted.

Sorters stationed at sorting line to separate waste for waste composition test (1997 Test).

Sorting conveyor used in waste composition test, before receiving waste and Recyclables.

APPENDIX A

COLLECTION ROUTES, HOUSEHOLDS

AND GENERATION DAYS

Table A-1
Collection Routes, Households, and Generation Days

Collection District	Collection Route	Number of Households		Waste
		Waste	Recyclables	Generation Days
BX1	11/2A	2755	1060	3
BX1	11/2A	2943	2943	2
BX1	12/2B	3872	2497	2
BX2	21/2A	2044	2044	3
BX3	31/4B	1699	1699	3
BX4	43/4B	1821	1821	3
BX4	42/1A	2362	2362	2
BX5	51/2A	1483	1483	2
BX5	51/6A	1766	1766	3
BX5	53/3B	2211	2211	2
BX6	62/1B	1032	1032	2
BX6	62/5B	1777	1777	3
BX9	92/2B	1348	1348	2
BX9	92/4B	872	872	2
BX9	93/3B	1401	1401	2
BX9	93/4A	3968	0	2
BX9	94/2A	843	843	3
BX9	94/3A	2575	2378	4
BX9	94/6A	716	716	4
BX9	94/7A	2352	0	4
BK1	12/2A	1188	988	2
BK1	14/4A	1114	502	2
BK1	15/2B	1107	1014	2
BK3	34/1B	1980	1651	2
BK3	31/4A	1374	702	3
BK4	43/1B	1330	1330	2
BK4	43/4B	1529	1529	2
BK4	41/2B	1178	1178	2
BK5	54/1A	849	595	2
BK5	52/5B	298	298	2
BK5	54/3A	636	636	2
BK8	83/2B	2025	1533	2

Table A-1 Continued
Collection Routes, Households, and Generation Days

Collection District	Collection Route	Number of Households		Waste
		Waste	Recyclables	Generation Days
BK9	93/4B	2086	2086	2
BK9	93/1B	1640	1640	3
BK9	91/2A	2451	2451	2
BK16	161/1A	1148	1148	3
BK17	171/5A	1303	1303	3
BK17	173/2B	772	772	4
BK17	171/2A	1325	1325	2
BK17	173/2B	781	781	4

Table A-2
Composition Sort
Randomly Selected Truck Shifts by Delivery Days

Day	Date	Waste Samples District/Section/Route/A or B	Recyclables Samples District/Section/Route
Week of December 8: Waste Samples and B Route Recyclables Samples			
Monday	Dec. 8	(1) Bronx 1/11/2A	
		(2) Bronx 3/31/4B	
		(3) Bronx 6/62/5B	
		(4) Bronx 9/94/3A	
		(5) Brooklyn 8/83/3B	
		(6) Brooklyn 9/93/1B	
		(7) Brooklyn 16/161/1A	
		(8) Brooklyn 17/173/2B	(1) Brooklyn 17/173/2B
		(9) Brooklyn 17/171/5A	
Tuesday	Dec. 9	(10) Bronx 2/21/2A	
		(11) Bronx 4/43/4B	
		(12) Bronx 5/51/6A	
		(13) Bronx 9/92/4B	
		(14) Bronx 9/94/6A	
		(15) Bronx 9/94/7A	
		(16) Brooklyn 17/173/2B	(2) Brooklyn 173/2B
			(3) Brooklyn 5/52/5B
Wednesday	Dec. 10	(17) Bronx 6/62/1B	
		(18) Bronx 9/92/2B	(4) Bronx 9/92/2B
		(19) Bronx 9/93/4B	
		(20) Bronx 9/93/3B	
			(5) Bronx 5/53/3B
		(21) Brooklyn 1/15/2B	
		(22) Brooklyn 1/12/2A	
		(23) Brooklyn 5/54/1A	
		(24) Brooklyn 9/93/4B	(6) Brooklyn 9/93/1B
			(7) Brooklyn 9/93/4B
		(25) Brooklyn 17/171/2A	
Thursday	Dec. 11	(26) Bronx 1/11/2A	
		(27) Bronx 1/12/2B	(8) Bronx 1/12/2B
		(28) Bronx 4/42/1A	
			(9) Bronx 9/92/4B
		(29) Brooklyn 3/34/1B	(10) Brooklyn 3/34/1B
		(30) Brooklyn 4/43/4B	(11) Brooklyn 4/43/4B
			(12) Brooklyn 4/41/2B
Friday	Dec. 12	(31) Bronx 5/53/3B	
	Dec. 12		(13) Bronx 3/31/4B
			(14) Bronx 6/62/5B
			(15) Bronx 6/62/1B
		(32) Brooklyn 5/52/5B	

Table A-2 (Continued)
Composition Sort
Randomly Selected Truck Shifts by Delivery Days

Day	Date	Waste Samples District/Section/Route/A or B	Recyclables Samples District/Section/Route
Week of December 8: Waste Samples and B Route Recyclables Samples			
Friday (continued)		(33) Brooklyn 5/54/3A	
			(16) Brooklyn 1/15/2B
		(34) Brooklyn 8/83/2B	(17) Brooklyn 8/83/3B
			(18) Brooklyn 8/83/2B
		(35) Brooklyn 9/91/2A	
Saturday	Dec. 13	(36) Bronx 5/51/2A	
		(37) Bronx 9/94/2A	
			(19) Bronx 4/43/4B
			(20) Bronx 9/93/3B
		(38) Brooklyn 1/14/4A	
		(39) Brooklyn 4/41/2B	
		(40) Brooklyn 4/43/1B	(21) Brooklyn 4/43/1B
Week of December 15: A Route Recyclables Samples			
Monday		None	None
Tuesday		None	None
Wednesday	Dec. 17	None	(1) Brooklyn 1/12/2A
			(2) Brooklyn 16/161/1A
			(3) Brooklyn 17/171/5A
			(4) Brooklyn 17/171/2A
Thursday	Dec. 18	None	(5) Bronx 2/21/2A
			(6) Bronx 9/94/3A
Friday	Dec. 19	None	(7) Bronx 1/11/2A
			(8) Bronx 9/94/6A
			(9) Brooklyn 5/54/3A
			(10) Brooklyn 9/91/2A
Saturday	Dec. 20		(11) Bronx 1/11/2A
			(12) Bronx 4/42/1A
			(13) Bronx 55/51/6A
			(14) Bronx 5/51/2A
			(15) Bronx 9/94/2A
			(16) Brooklyn 1/14/4A
			(17) Brooklyn 5/54/1A

APPENDIX B

WASTE AND RECYCLABLES LOADS

Table B-1
Waste Stream Composition Determination
Waste Loads

District/Section/Route	BK/9/93/1B	BK/17/173/2B	BX9/94/3A	BK17/173/2B	BX3/31/4B
Total Weight of Truck Load	23980	16920	22240	16600	16780
Total Weight of Sample	2740	2650	3620	3020	3120
Days	3	4	4	4	3
Households	1640	781	2575	772	1699
Sorted materials in lb/hh/day					
Recyclable					
Newspaper	0.26	0.14	0.15	0.19	0.22
Magazines and Glossy	0.10	0.11	0.04	0.02	0.03
Telephone and Paperbacks	0.13	0.01	0.01	0.01	0.00
Corrugated, Kraft & Linerboard	0.22	0.19	0.06	0.12	0.22
Other Mixed Paper	0.14	0.08	0.04	0.24	0.06
Paper Beverage Containers	0.03	0.03	0.02	0.03	0.01
HDPE Plastic	0.05	0.03	0.02	0.02	0.05
PET Plastic	0.04	0.04	0.02	0.03	0.03
Aluminum	0.01	0.00	0.00	0.00	0.03
Ferrous	0.08	0.05	0.05	0.06	0.07
Glass	0.14	0.06	0.02	0.10	0.15
Bulk Household Metal	0.24	0.04	0.01	0.10	0.01
Total Recyclable	1.45	0.77	0.41	0.94	0.87
Non Recyclable					
Paper	0.05	0.04	0.01	0.07	0.02
MGP	0.43	0.71	0.17	0.40	0.26
Wood	0.06	0.22	0.02	0.03	0.05
Textiles	0.30	0.12	0.07	0.36	0.14
Non-Ferrous Metals	0.04	0.03	0.01	0.02	0.00
Non-Metal Bulk Materials	0.03	0.05	0.00	0.08	0.08
Other Waste	0.00	0.00	0.00	0.00	0.00
Total Non-Recyclable*	0.92	1.18	0.29	0.95	0.55
Residue	2.51	3.46	1.46	3.48	1.87
TOTAL	4.87	5.42	2.16	5.38	3.29

Table B-1 (Cont'd)
Waste Stream Composition Determination
Waste Loads

District/Section/Route	BX2/21/2A	BX6/62/5B	BX1/11/2A	BX4/43/4B	BK16/161/1A
Total Weight of Truck Load	20480	18280	17460	15540	15880
Total Weight of Sample	2980	2480	2820	2720	2980
Days	3	3	3	3	3
Households	2044	1777	2755	1821	1148
Sorted materials in lb/hh/day					
Recyclable					
Newspaper	0.16	0.17	0.10	0.14	0.22
Magazines and Glossy	0.06	0.02	0.03	0.03	0.13
Telephone and Paperbacks	0.05	0.02	0.01	0.01	0.02
Corrugated, Kraft & Linerboard	0.19	0.17	0.05	0.06	0.13
Other Mixed Paper	0.14	0.06	0.07	0.02	0.07
Paper Beverage Containers	0.02	0.02	0.01	0.01	0.02
HDPE Plastic	0.04	0.04	0.02	0.03	0.04
PET Plastic	0.04	0.02	0.01	0.01	0.02
Aluminum	0.00	0.01	0.00	0.00	0.01
Ferrous	0.13	0.07	0.03	0.04	0.04
Glass	0.12	0.10	0.05	0.07	0.11
Bulk Household Metal	0.22	0.08	0.04	0.04	0.03
Total Recyclable	1.18	0.77	0.41	0.47	0.82
Non Recyclable					
Paper	0.06	0.01	0.00	0.08	0.02
MGP	0.23	0.27	0.20	0.20	0.20
Wood	0.05	0.02	0.06	0.11	0.09
Textiles	0.31	0.16	0.07	0.12	0.12
Non-Ferrous Metals	0.03	0.02	0.01	0.01	0.04
Non-Metal Bulk Materials	0.06	0.06	0.04	0.06	0.05
Other Waste	0.00	0.00	0.00	0.00	0.00
Total Non-Recyclable ***	0.74	0.54	0.39	0.59	0.52
Residue	1.42	2.13	1.31	1.79	3.27
TOTAL	3.34	3.43	2.11	2.84	4.61

Table B-1 (Cont'd)
Waste Stream Composition Determination
Waste Loads

District/Section/Route	BK17/171/5A	BK3/31/4A	BX9/94/6A	BX9/94/7A	BK17/171/2A
Total Weight of Truck Load	17460	15720	19460	20080	14760
Total Weight of Sample	2760	2320	3200	2620	3320
Days	3	3	4	4	2
Households	1303	1374	716	2352	1325
Sorted materials in lb/hh/day					
Recyclable					
Newspaper	0.10	0.23	0.30	0.12	0.18
Magazines and Glossy	0.08	0.05	0.15	0.03	0.20
Telephone and Paperbacks	0.00	0.05	0.00	0.02	0.04
Corrugated, Kraft & Linerboard	0.13	0.16	0.17	0.08	0.11
Other Mixed Paper	0.07	0.09	0.03	0.02	0.10
Paper Beverage Containers	0.01	0.01	0.01	0.01	0.04
HDPE Plastic	0.06	0.04	0.07	0.05	0.04
PET Plastic	0.03	0.03	0.03	0.02	0.02
Aluminum	0.01	0.01	0.02	0.01	0.01
Ferrous	0.07	0.04	0.10	0.04	0.05
Glass	0.18	0.14	0.04	0.01	0.10
Bulk Household Metal	0.09	0.03	0.00	0.01	0.04
Total Recyclable	0.83	0.88	0.93	0.42	0.91
Non Recyclable					
Paper	0.06	0.01	0.04	0.00	0.03
MGP	0.29	0.27	0.38	0.13	0.39
Wood	0.10	0.05	0.07	0.02	0.42
Textiles	0.25	0.20	0.10	0.07	0.20
Non-Ferrous Metals	0.02	0.03	0.02	0.01	0.00
Non-Metal Bulk Materials	0.22	0.03	0.15	0.05	0.22
Other Waste	0.00	0.00	0.00	0.00	0.00
Total Non-Recyclable*	0.93	0.59	0.76	0.29	1.26
Residue	2.71	2.35	5.10	1.43	3.40
TOTAL	4.47	3.81	6.79	2.13	5.57

Table B-1 (Cont'd)
Waste Stream Composition Determination
Waste Loads

District/Section/Route	BX9/92/4B	BX5/51/6A	BK1/15/2B	BK5/54/1A	BX9/92/2B
Total Weight of Truck Load	21660	17540	15060	19280	23360
Total Weight of Sample	2680	2920	3420	3400	1940
Days	2	3	2	2	2
Households	872	1766	1107	849	1348
Sorted materials in lb/hh/day					
Recyclable					
Newspaper	0.38	0.13	0.13	0.66	0.50
Magazines and Glossy	0.20	0.04	0.05	0.09	0.16
Telephone and Paperbacks	0.03	0.00	0.05	0.07	0.08
Corrugated, Kraft & Linerboard	0.39	0.07	0.16	0.55	0.37
Other Mixed Paper	0.03	0.02	0.09	0.23	0.22
Paper Beverage Containers	0.03	0.01	0.01	0.13	0.03
HDPE Plastic	0.11	0.05	0.07	0.10	0.12
PET Plastic	0.05	0.02	0.02	0.10	0.12
Aluminum	0.01	0.00	0.01	0.00	0.06
Ferrous	0.12	0.06	0.06	0.10	0.18
Glass	0.32	0.03	0.10	0.19	0.21
Bulk Household Metal	0.09	0.04	0.06	0.04	0.00
Total Recyclable	1.77	0.46	0.82	2.27	2.05
Non Recyclable					
Paper	0.04	0.00	0.02	0.40	0.05
MGP	0.68	0.21	0.58	1.29	1.06
Wood	0.06	0.06	0.08	0.48	0.16
Textiles	0.41	0.14	0.36	0.66	0.30
Non-Ferrous Metals	0.06	0.02	0.03	0.00	0.00
Non-Metal Bulk Materials	0.20	0.15	0.09	0.24	0.21
Other Waste	0.00	0.00	0.00	0.12	0.00
Total Non-Recyclable**	1.45	0.58	1.17	3.07	1.77
Residue	9.21	2.27	4.82	6.02	4.84
TOTAL	12.42	3.31	6.80	11.35	8.66

Table B-1 (Cont'd)
Waste Stream Composition Determination
Waste Loads

District/Section/Route	BX9/93/4B	BX9/93/3B	BK5/52/5B	BX4/42/1A	BX1/12/2B
Total Weight of Truck Load	17420	24000	11200	17180	17720
Total Weight of Sample	2620	2840	3120	3020	2480
Days	2	2	2	2	2
Households	3968	1401	298	2362	3872
Sorted materials in lb/hh/day					
Recyclable					
Newspaper	0.18	0.35	0.60	0.15	0.09
Magazines and Glossy	0.02	0.12	0.27	0.06	0.03
Telephone and Paperbacks	0.00	0.09	0.04	0.00	0.00
Corrugated, Kraft & Linerboard	0.05	0.22	0.75	0.12	0.07
Other Mixed Paper	0.03	0.07	0.60	0.02	0.01
Paper Beverage Containers	0.01	0.06	0.08	0.01	0.01
HDPE Plastic	0.02	0.12	0.13	0.05	0.03
PET Plastic	0.02	0.04	0.20	0.02	0.01
Aluminum	0.00	0.01	0.10	0.02	0.00
Ferrous	0.04	0.20	0.25	0.05	0.03
Glass	0.03	0.09	0.52	0.07	0.04
Bulk Household Metal	0.01	0.07	0.00	0.05	0.03
Total Recyclable	0.42	1.43	3.53	0.62	0.34
Non Recyclable					
Paper	0.00	0.01	0.12	0.00	0.00
MGP	0.15	0.60	1.37	0.26	0.13
Wood	0.02	0.51	0.30	0.00	0.11
Textiles	0.07	0.37	0.45	0.11	0.12
Non-Ferrous Metals	0.00	0.04	0.08	0.00	0.00
Non-Metal Bulk Materials	0.01	0.07	0.23	0.04	0.04
Other Waste	0.00	0.00	0.00	0.00	0.00
Total Non-Recyclable**	0.26	1.60	2.56	0.42	0.40
Residue	1.51	5.54	12.70	2.60	1.54
TOTAL	2.20	8.57	18.79	3.64	2.29

Table B-1 (Cont'd)
Waste Stream Composition Determination
Waste Loads

District/Section/Route	BX1/11/2A	BX6/62/1B	BK9/93/4B	BK4/43/4B	BK3/34/1B
Total Weight of Truck Load	16160	22480	23200	14360	13560
Total Weight of Sample	2680	2680	2660	2400	2420
Days	2	2	2	2	2
Households	2943	1032	2086	1529	1980
Sorted materials in lb/hh/day					
Recyclable					
Newspaper	0.09	0.51	0.28	0.14	0.12
Magazines and Glossy	0.05	0.06	0.17	0.04	0.12
Telephone and Paperbacks	0.01	0.00	0.02	0.01	0.02
Corrugated, Kraft & Linerboard	0.04	0.30	0.15	0.01	0.17
Other Mixed Paper	0.02	0.14	0.06	0.03	0.03
Paper Beverage Containers	0.00	0.05	0.02	0.01	0.01
HDPE Plastic	0.03	0.10	0.03	0.03	0.01
PET Plastic	0.02	0.10	0.02	0.02	0.04
Aluminum	0.01	0.02	0.04	0.00	0.00
Ferrous	0.05	0.14	0.00	0.04	0.04
Glass	0.05	0.18	0.03	0.07	0.04
Bulk Household Metal	0.00	0.04	0.04	0.17	0.01
Total Recyclable	0.37	1.63	0.86	0.56	0.60
Non Recyclable					
Paper	0.00	0.01	0.00	0.00	0.00
MGP	0.16	0.59	0.30	0.19	0.22
Wood	0.00	0.12	0.27	0.20	0.08
Textiles	0.08	0.31	0.15	0.19	0.07
Non-Ferrous Metals	0.00	0.07	0.03	0.01	0.00
Non-Metal Bulk Materials	0.04	0.53	0.07	0.03	0.01
Other Waste	0.00	0.00	0.00	0.00	0.00
Total Non-Recyclable**	0.28	1.63	0.82	0.63	0.39
Residue	2.10	7.64	3.88	3.51	2.43
TOTAL	2.75	10.89	5.56	4.70	3.42

Table B-1 (Cont'd)
Waste Stream Composition Determination
Waste Loads

District/Section/Route	BK1/12/2A	BK9/91/2A	BK4/41/2B	BX5/53/3B	BK5/54/3A
Total Weight of Truck Load	18000	21340	13600	13040	16520
Total Weight of Sample	2620	2700	2500	2640	3140
Days	2	2	2	2	2
Households	1188	2451	1178	2211	636
Sorted materials in lb/hh/day					
Recyclable					
Newspaper	0.23	0.17	0.13	0.14	0.66
Magazines and Glossy	0.12	0.12	0.08	0.02	0.07
Telephone and Paperbacks	0.05	0.02	0.05	0.00	0.00
Corrugated, Kraft & Linerboard	0.27	0.17	0.23	0.16	0.52
Other Mixed Paper	0.03	0.04	0.06	0.04	0.15
Paper Beverage Containers	0.07	0.03	0.02	0.01	0.07
HDPE Plastic	0.08	0.03	0.05	0.04	0.04
PET Plastic	0.09	0.02	0.04	0.02	0.05
Aluminum	0.07	0.03	0.01	0.01	0.01
Ferrous	0.08	0.04	0.10	0.06	0.12
Glass	0.20	0.06	0.19	0.11	0.22
Bulk Household Metal	0.08	0.02	0.05	0.02	0.46
Total Recyclable	1.36	0.73	1.00	0.63	2.37
Non Recyclable					
Paper	0.00	0.00	0.00	0.00	0.00
MGP	0.36	0.38	0.53	0.21	0.72
Wood	0.07	0.24	0.27	0.08	0.93
Textiles	0.23	0.40	0.49	0.24	0.37
Non-Ferrous Metals	0.02	0.07	0.03	0.01	0.03
Non-Metal Bulk Materials	0.16	0.00	0.01	0.09	0.21
Other Waste	0.00	0.00	0.00	0.00	0.00
Total Non-Recyclable*	0.84	1.09	1.32	0.63	2.27
Residue	5.38	2.54	3.45	1.69	8.35
TOTAL	7.58	4.35	5.77	2.95	12.99

Table B-1 (Cont'd)
Waste Stream Composition Determination
Waste Loads

District/Section/Route	BK1/14/4A	BX5/51/2A	BX9/94/2A	BK4/43/1B	BK8/83/2B	Average of Normalized Waste Sample Weights
Total Weight of Truck Load	16760	19600	12740	15420	15180	
Total Weight of Sample	2620	2680	2440	2740	2960	
Days	2	2	3	2	2	
Households	1114	1483	843	1330	2025	
Sorted materials in lb/hh/day						
Recyclable						
Newspaper	0.24	0.31	0.27	0.08	0.13	0.234
Magazines and Glossy	0.02	0.12	0.04	0.03	0.13	0.833
Telephone and Paperbacks	0.00	0.04	0.00	0.03	0.01	0.025
Corrugated, Kraft & Linerboard	0.35	0.25	0.14	0.19	0.09	0.197
Other Mixed Paper	0.09	0.04	0.04	0.01	0.03	0.083
Paper Beverage Containers	0.04	0.01	0.02	0.01	0.05	0.027
HDPE Plastic	0.06	0.07	0.05	0.06	0.03	0.051
PET Plastic	0.04	0.03	0.02	0.03	0.03	0.039
Aluminum	0.00	0.01	0.00	0.01	0.01	0.014
Ferrous	0.06	0.08	0.07	0.11	0.06	0.076
Glass	0.15	0.08	0.06	0.14	0.11	0.117
Bulk Household Metal	0.01	0.06	0.02	0.25	0.06	0.066
Total Recyclable	1.05	1.10	0.72	0.96	0.75	1.01
Non Recyclable						
Paper	0.00	0.00	0.00	0.00	0.00	0.029
MGP	0.93	0.49	0.38	0.35	0.27	0.423
Wood	0.08	0.11	0.18	0.21	0.08	0.152
Textiles	0.22	0.98	0.62	0.31	0.15	0.260
Non-Ferrous Metals	0.03	0.01	0.01	0.01	0.02	0.022
Non-Metal Bulk Materials	0.09	0.12	0.00	0.00	0.00	0.096
Other Waste	0.00	0.00	0.00	0.00	0.00	0.003
Total Non-Recyclable*	1.34	1.71	1.18	0.87	0.52	0.982
Residue	5.13	3.80	3.13	3.96	2.48	3.71
TOTAL	7.52	6.61	5.04	5.80	3.75	5.70

Table B-2
Waste Stream Composition Determination
Recyclables Loads

District/Section/Route	BK9/93/1B	BK17/173/2B	BX09/94/3A	BK/17/173/2B	BX3/31/4B
Total Weight of Truck Load	10480	12240	12120	12760	9000
Total Weight of Sample	1480	2680	1520	4280	3000
Days	14	14	14	14	14
Households	1640	781	2378	772	1699
Sorted materials in lb/hh/day					
Recyclable					
Newspaper	0.00	0.31	0.06	0.21	0.03
Magazines and Glossy	0.00	0.01	0.03	0.08	0.01
Telephone and Paperbacks	0.00	0.01	0.01	0.02	0.00
Corrugated, Kraft & Linerboard	0.06	0.07	0.04	0.16	0.05
Other Mixed Paper	0.00	0.06	0.02	0.02	0.00
Paper Beverage Containers	0.00	0.01	0.00	0.01	0.00
HDPE Plastic	0.02	0.03	0.01	0.04	0.01
PET Plastic	0.00	0.02	0.01	0.03	0.00
Aluminum	0.00	0.01	0.00	0.00	0.00
Ferrous	0.02	0.06	0.02	0.09	0.02
Glass	0.01	0.06	0.03	0.06	0.01
Bulk Household Metal	0.20	0.03	0.02	0.05	0.05
Contaminated Designated Paper	0.00	0.00	0.00	0.00	0.00
Total Recyclable	0.33	0.67	0.26	0.78	0.20
Non Recyclable					
Paper	0.00	0.01	0.00	0.00	0.00
MGP	0.04	0.03	0.02	0.04	0.01
Other Waste	0.04	0.00	0.00	0.00	0.00
Total *Non-Recyclable*	0.08	0.04	0.03	0.05	0.01
Residue	0.05	0.41	0.08	0.35	0.17
TOTAL	0.46	1.12	0.36	1.18	0.38

Table B-2 (Cont'd)
Waste Stream Composition Determination
Recyclables Loads

District/Section/Route	BX2/21/2A	BX6/62/5B	BX1/11/2A	BX4/43/4B	BK16/161/1A
Total Weight of Truck Load	8140	13280	8660	6820	8080
Total Weight of Sample	1480	1540	2980	1320	1300
Days	14	14	14	14	14
Households	2044	1777	1060	1821	1148
Sorted materials in lb/hh/day					
Recyclable					
Newspaper	0.03	0.00	0.03	0.01	0.08
Magazines and Glossy	0.01	0.00	0.01	0.01	0.03
Telephone and Paperbacks	0.00	0.00	0.00	0.00	0.01
Corrugated, Kraft & Linerboard	0.00	0.24	0.09	0.07	0.08
Other Mixed Paper	0.00	0.00	0.00	0.00	0.00
Paper Beverage Containers	0.00	0.00	0.00	0.00	0.01
HDPE Plastic	0.01	0.02	0.02	0.02	0.02
PET Plastic	0.00	0.01	0.01	0.01	0.01
Aluminum	0.00	0.00	0.01	0.00	0.00
Ferrous	0.02	0.02	0.03	0.02	0.03
Glass	0.02	0.01	0.01	0.03	0.07
Bulk Household Metal	0.04	0.05	0.06	0.03	0.00
Contaminated Designated Paper	0.00	0.01	0.00	0.00	0.00
Total Recyclable	0.15	0.37	0.26	0.19	0.36
Non Recyclable					
Paper	0.00	0.00	0.00	0.00	0.00
MGP	0.01	0.02	0.02	0.01	0.02
Other Waste	0.00	0.00	0.00	0.00	0.01
Total *Non-Recyclable*	0.01	0.02	0.02	0.01	0.03
Residue	0.12	0.14	0.30	0.06	0.12
TOTAL	0.28	0.53	0.58	0.27	0.50

Table B-2 (Cont'd)
Waste Stream Composition Determination
Recyclables Loads

District/Section/Route	BK17/171/5A	BK3/31/4A	BX9/94/6A	BK17/171/2A	BX9/92/4B
Total Weight of Truck Load	7060	8580	10640	14120	16880
Total Weight of Sample	1640	1580	2620	840	1840
Days	14	14	14	14	14
Households	1303	702	716	1325	872
Sorted materials in lb/hh/day					
Recyclable					
Newspaper	0.08	0.16	0.20	0.17	0.21
Magazines and Glossy	0.05	0.07	0.15	0.10	0.09
Telephone and Paperbacks	0.01	0.02	0.01	0.01	0.02
Corrugated, Kraft & Linerboard	0.09	0.09	0.10	0.10	0.15
Other Mixed Paper	0.01	0.01	0.01	0.01	0.02
Paper Beverage Containers	0.00	0.01	0.01	0.00	0.01
HDPE Plastic	0.02	0.03	0.04	0.02	0.03
PET Plastic	0.01	0.02	0.02	0.01	0.02
Aluminum	0.00	0.00	0.00	0.00	0.01
Ferrous	0.02	0.04	0.06	0.04	0.04
Glass	0.06	0.13	0.03	0.07	0.04
Bulk Household Metal	0.01	0.07	0.16	0.01	0.10
Contaminated Designated Paper	0.00	0.00	0.00	0.00	0.00
Total Recyclable	0.36	0.66	0.78	0.56	0.75
Non Recyclable					
Paper	0.00	0.00	0.00	0.00	0.00
MGP	0.01	0.03	0.04	0.03	0.04
Other Waste	0.00	0.00	0.00	0.00	0.00
Total *Non-Recyclable*	0.02	0.04	0.04	0.04	0.05
Residue	0.01	0.18	0.24	0.17	0.59
TOTAL	0.39	0.87	1.06	0.76	1.38

Table B-2 (Cont'd)
Waste Stream Composition Determination
Recyclables Loads

District/Section/Route	BX5/51/6A	BK1/15/2B	BK5/54/1A	BX9/92/2B	BK9/93/4B
Total Weight of Truck Load	10100	14560	11520	14100	18000
Total Weight of Sample	1440	2480	2420	1650	1600
Days	14	14	14	14	14
Households	1766	1014	595	1348	2086
Sorted materials in lb/hh/day					
Recyclable					
Newspaper	0.03	0.27	0.32	0.10	0.20
Magazines and Glossy	0.01	0.02	0.19	0.04	0.01
Telephone and Paperbacks	0.01	0.01	0.00	0.01	0.01
Corrugated, Kraft & Linerboard	0.16	0.11	0.10	0.06	0.12
Other Mixed Paper	0.01	0.03	0.08	0.01	0.04
Paper Beverage Containers	0.00	0.01	0.00	0.02	0.00
HDPE Plastic	0.01	0.02	0.03	0.02	0.01
PET Plastic	0.01	0.01	0.02	0.01	0.01
Aluminum	0.00	0.00	0.00	0.01	0.00
Ferrous	0.02	0.06	0.05	0.04	0.03
Glass	0.01	0.04	0.08	0.05	0.05
Bulk Household Metal	0.04	0.00	0.02	0.07	0.01
Contaminated Designated Paper	0.00	0.00	0.00	0.00	0.00
Total Recyclable	0.00	0.58	0.91	0.43	0.49
Non Recyclable					
Paper	0.00	0.01	0.00	0.00	0.02
MGP	0.00	0.04	0.02	0.03	0.03
Other Waste	0.02	0.00	0.00	0.00	0.01
Total *Non-Recyclable*	0.01	0.05	0.02	0.03	0.06
Residue	0.01	0.40	0.45	0.28	0.07
TOTAL	0.02	1.03	1.38	0.75	0.62

Table B-2 (Cont'd)
Waste Stream Composition Determination
Recyclables Loads

District/Section/Route	BX9/93/3B	BK5/52/5B	BX4/42/1A	BX1/12/2B	BX1/11/2A
Total Weight of Truck Load	18520	10220	15320	10980	8060
Total Weight of Sample	1580	1740	2460	2040	1410
Days	14	14	14	14	14
Households	1401	298	2362	2497	2943
Sorted materials in lb/hh/day					
Recyclable					
Newspaper	0.21	0.30	0.05	0.02	0.00
Magazines and Glossy	0.09	0.24	0.02	0.01	0.00
Telephone and Paperbacks	0.00	0.03	0.00	0.00	0.00
Corrugated, Kraft & Linerboard	0.11	0.53	0.09	0.13	0.06
Other Mixed Paper	0.02	0.05	0.00	0.00	0.00
Paper Beverage Containers	0.00	0.06	0.00	0.00	0.00
HDPE Plastic	0.03	0.11	0.01	0.01	0.01
PET Plastic	0.01	0.06	0.01	0.01	0.00
Aluminum	0.00	0.04	0.00	0.00	0.00
Ferrous	0.03	0.20	0.01	0.03	0.01
Glass	0.03	0.09	0.01	0.01	0.02
Bulk Household Metal	0.14	0.34	0.04	0.03	0.02
Contaminated Designated Paper	0.00	0.01	0.00	0.00	0.00
Total Recyclable	0.67	2.06	0.26	0.26	0.14
Non Recyclable					
Paper	0.00	0.18	0.00	0.00	0.00
MGP	0.02	0.16	0.03	0.02	0.01
Other Waste	0.01	0.00	0.00	0.00	0.00
Total *Non-Recyclable*	0.04	0.34	0.03	0.02	0.01
Residue	0.24	0.05	0.18	0.04	0.05
TOTAL	0.94	2.45	0.46	0.31	0.20

Table B-2 (Cont'd)
Waste Stream Composition Determination
Recyclables Loads

District/Section/Route	BX6/62/1B	BK4/43/4B	BK3/34/1B	BK1/12/2A	BK9/91/2A
Total Weight of Truck Load	11860	17720	16840	7120	18600
Total Weight of Sample	2620	2720	2700	1220	1700
Days	14	14	14	14	14
Households	1032	1529	1651	988	2451
Sorted materials in lb/hh/day					
Recyclable					
Newspaper	0.05	0.14	0.07	0.05	0.09
Magazines and Glossy	0.01	0.03	0.04	0.03	0.04
Telephone and Paperbacks	0.00	0.02	0.01	0.00	0.00
Corrugated, Kraft & Linerboard	0.08	0.06	0.05	0.07	0.10
Other Mixed Paper	0.00	0.01	0.01	0.00	0.01
Paper Beverage Containers	0.00	0.01	0.00	0.00	0.00
HDPE Plastic	0.04	0.03	0.01	0.03	0.02
PET Plastic	0.01	0.02	0.01	0.01	0.01
Aluminum	0.00	0.01	0.00	0.00	0.01
Ferrous	0.05	0.06	0.07	0.03	0.01
Glass	0.03	0.03	0.05	0.07	0.02
Bulk Household Metal	0.16	0.05	0.01	0.02	0.01
Contaminated Designated Paper	0.01	0.00	0.05	0.00	0.00
Total Recyclable	0.46	0.45	0.38	0.31	0.32
Non Recyclable					
Paper	0.00	0.01	0.00	0.00	0.00
MGP	0.03	0.04	0.02	0.02	0.02
Other Waste	0.00	0.01	0.00	0.01	0.00
Total *Non-Recyclable*	0.03	0.06	0.02	0.03	0.02
Residue	0.32	0.31	0.33	0.18	0.20
TOTAL	0.82	0.83	0.73	0.51	0.54

Table B-2 (Cont'd)
Waste Stream Composition Determination
Recyclables Loads

District/Section/Route	BK4/41/2B	BX5/53/3B	BK5/54/3A	BK1/14/4A	BX5/51/2A
Total Weight of Truck Load	21480	14560	15780	14480	7020
Total Weight of Sample	2420	2420	1500	980	1580
Days	14	14	14	14	14
Households	1178	2211	636	502	1483
Sorted materials in lb/hh/day					
Recyclable					
Newspaper	0.24	0.00	0.27	0.03	0.00
Magazines and Glossy	0.08	0.00	0.10	0.00	0.00
Telephone and Paperbacks	0.02	0.00	0.00	0.00	0.00
Corrugated, Kraft & Linerboard	0.11	0.04	0.34	0.92	0.11
Other Mixed Paper	0.02	0.00	0.03	0.02	0.00
Paper Beverage Containers	0.02	0.00	0.01	0.00	0.00
HDPE Plastic	0.06	0.01	0.08	0.06	0.00
PET Plastic	0.03	0.00	0.03	0.04	0.00
Aluminum	0.01	0.00	0.00	0.02	0.00
Ferrous	0.07	0.02	0.13	0.07	0.00
Glass	0.06	0.01	0.06	0.29	0.01
Bulk Household Metal	0.03	0.13	0.17	0.08	0.13
Contaminated Designated Paper	0.02	0.00	0.00	0.00	0.00
Total Recyclable	0.76	0.21	1.22	1.55	0.26
Non Recyclable					
Paper	0.00	0.00	0.00	0.00	0.00
MGP	0.04	0.02	0.09	0.07	0.01
Other Waste	0.00	0.02	0.00	0.00	0.00
Total *Non-Recyclable*	0.05	0.05	0.09	0.07	0.02
Residue	0.49	0.22	0.46	0.44	0.05
TOTAL	1.30	0.47	1.77	2.06	0.34

Table B-2 (Cont'd)
Waste Stream Composition Determination
Recyclables Loads

District/Section/Route	BX9/94/2A	BK4/43/1B	BK8/83/2B	Average of Normalized Waste Sample Weights
Total Weight of Truck Load	8720	5340	11140	
Total Weight of Sample	2040	1560	1720	
Days	14	14	14	
Households	843	1330	1533	
Sorted materials in lb/hh/day				
Recyclable				
Newspaper	0.09	0.01	0.04	0.104
Magazines and Glossy	0.02	0.01	0.02	0.0423
Telephone and Paperbacks	0.00	0.00	0.01	0.007
Corrugated, Kraft & Linerboard	0.07	0.02	0.08	0.123
Other Mixed Paper	0.00	0.01	0.01	0.014
Paper Beverage Containers	0.01	0.00	0.00	0.005
HDPE Plastic	0.04	0.02	0.01	0.026
PET Plastic	0.01	0.01	0.02	0.013
Aluminum	0.01	0.00	0.00	0.004
Ferrous	0.07	0.02	0.02	0.041
Glass	0.05	0.03	0.05	0.045
Bulk Household Metal	0.03	0.01	0.06	0.063
Contaminated Designated Paper	0.00	0.00	0.00	0.003
Total Recyclable	0.41	0.13	0.32	0.481
Non Recyclable				
Paper	0.00	0.00	0.00	0.007
MGP	0.05	0.01	0.02	0.032
Other Waste	0.00	0.01	0.00	0.005
Total *Non-Recyclable*	0.05	0.02	0.02	0.041
Residue	0.28	0.13	0.17	0.209
TOTAL	0.74	0.29	0.52	0.731

Table B-3
Waste Stream Composition Determination
Waste and Recyclables Loads

District/Section/Route	BK/9/93/1B	BK/17/173/2B	BX9/94/3A	BK17/173/2B	BX3/31/4B
Sorted materials in lb/hh/day					
Recyclable					
Total Paper	**0.95**	**1.06**	**0.48**	**1.09**	**0.64**
Newspaper	0.27	0.35	0.22	0.50	0.26
Magazines and Glossy	0.10	0.19	0.07	0.03	0.03
Telephone and Paperbacks	0.13	0.03	0.02	0.03	0.00
Corrugated, Kraft & Linerboard	0.28	0.35	0.10	0.19	0.27
Other Mixed Paper	0.14	0.10	0.05	0.29	0.07
Paper Beverage Containers	0.03	0.03	0.02	0.04	0.01
Contaminated Designated Paper	0.00	0.00	0.00	0.00	0.00
Total Plastic	**0.12**	**0.13**	**0.06**	**0.09**	**0.09**
HDPE Plastic	0.07	0.06	0.03	0.05	0.06
PET Plastic	0.05	0.07	0.03	0.04	0.03
Total Metal	**0.56**	**0.24**	**0.09**	**0.26**	**0.18**
Aluminum	0.01	0.01	0.00	0.01	0.03
Ferrous	0.11	0.14	0.07	0.11	0.09
Bulk Household Metal	0.44	0.09	0.02	0.14	0.06
Total Glass	**0.16**	**0.13**	**0.05**	**0.17**	**0.16**
Total Recyclable	1.78	1.56	0.67	1.62	1.07
Non Recyclable					
Paper	0.05	0.05	0.01	0.08	0.02
MGP	0.46	0.75	0.19	0.42	0.28
Wood	0.06	0.22	0.02	0.03	0.05
Textiles	0.30	0.12	0.07	0.36	0.14
Non-Ferrous Metals	0.04	0.03	0.01	0.02	0.00
Non-Metal Bulk Materials	0.03	0.05	0.00	0.08	0.08
Other Waste	0.04	0.00	0.00	0.00	0.00
Total Non-Recyclable	1.00	1.23	0.31	0.99	0.57
Residue	2.55	3.81	1.54	3.89	2.03
TOTAL	5.33	6.60	2.53	6.50	3.67

Table B-3
Waste Stream Composition Determination
Waste and Recyclables Loads

District/Section/Route	BX2/21/2A	BX6/62/5B	BX1/11/2A	BX4/43/4B	BK16/161/1A
Sorted materials in lb/hh/day					
Recyclable					
Total Paper	**0.68**	**0.71**	**0.39**	**0.36**	**0.79**
Newspaper	0.19	0.17	0.13	0.15	0.30
Magazines and Glossy	0.07	0.02	0.04	0.04	0.16
Telephone and Paperbacks	0.05	0.02	0.01	0.02	0.03
Corrugated, Kraft & Linerboard	0.20	0.41	0.13	0.13	0.21
Other Mixed Paper	0.14	0.06	0.07	0.02	0.07
Paper Beverage Containers	0.02	0.02	0.01	0.01	0.03
Contaminated Designated Paper	0.00	0.01	0.00	0.00	0.00
Total Plastic	**0.10**	**0.08**	**0.05**	**0.07**	**0.10**
HDPE Plastic	0.05	0.05	0.03	0.05	0.06
PET Plastic	0.05	0.03	0.02	0.02	0.04
Total Metal	**0.41**	**0.24**	**0.16**	**0.13**	**0.11**
Aluminum	0.00	0.01	0.01	0.00	0.01
Ferrous	0.15	0.09	0.06	0.06	0.08
Bulk Household Metal	0.25	0.14	0.10	0.07	0.03
Total Glass	**0.14**	**0.11**	**0.06**	**0.11**	**0.18**
Total Recyclable	1.33	1.14	0.67	0.66	1.18
Non Recyclable					
Paper	0.06	0.01	0.00	0.08	0.02
MGP	0.25	0.29	0.22	0.21	0.22
Wood	0.05	0.02	0.06	0.11	0.09
Textiles	0.31	0.16	0.07	0.12	0.12
Non-Ferrous Metals	0.03	0.02	0.01	0.01	0.04
Non-Metal Bulk Materials	0.06	0.06	0.04	0.06	0.05
Other Waste	0.00	0.00	0.00	0.00	0.01
Total Non-Recyclable	0.75	0.56	0.41	0.60	0.54
Residue	1.54	2.26	1.62	1.85	3.39
TOTAL	3.62	3.96	2.70	3.11	5.11

Table B-3
Waste Stream Composition Determination
Waste and Recyclables Loads

District/Section/Route	BK17/171/5A	BK3/31/4A	BX9/94/6A	BX9/94/7A	BK17/171/2A
Sorted materials in lb/hh/day					
Recyclable					
Total Paper	**0.64**	**0.96**	**1.15**	**0.28**	**1.07**
Newspaper	0.18	0.40	0.49	0.12	0.35
Magazines and Glossy	0.14	0.13	0.31	0.03	0.30
Telephone and Paperbacks	0.01	0.07	0.01	0.02	0.05
Corrugated, Kraft & Linerboard	0.22	0.26	0.27	0.08	0.22
Other Mixed Paper	0.08	0.09	0.04	0.02	0.10
Paper Beverage Containers	0.01	0.01	0.02	0.01	0.05
Contaminated Designated Paper	0.00	0.00	0.00	0.00	0.00
Total Plastic	**0.11**	**0.11**	**0.15**	**0.07**	**0.09**
HDPE Plastic	0.08	0.07	0.10	0.05	0.07
PET Plastic	0.04	0.05	0.04	0.02	0.03
Total Metal	**0.20**	**0.20**	**0.35**	**0.06**	**0.14**
Aluminum	0.01	0.01	0.02	0.01	0.01
Ferrous	0.09	0.08	0.16	0.04	0.08
Bulk Household Metal	0.09	0.10	0.17	0.01	0.05
Total Glass	**0.24**	**0.26**	**0.07**	**0.01**	**0.17**
Total Recyclable	1.19	1.54	1.71	0.42	1.47
Non Recyclable					
Paper	0.06	0.01	0.04	0.00	0.03
MGP	0.30	0.30	0.41	0.13	0.43
Wood	0.10	0.05	0.07	0.02	0.42
Textiles	0.25	0.20	0.10	0.07	0.20
Non-Ferrous Metals	0.02	0.03	0.02	0.01	0.00
Non-Metal Bulk Materials	0.22	0.03	0.15	0.05	0.22
Other Waste	0.00	0.00	0.00	0.00	0.00
Total Non-Recyclable	0.95	0.63	0.80	0.29	1.29
Residue	2.72	2.53	5.34	1.43	3.56
TOTAL	4.85	4.69	7.86	2.13	6.33

Table B-3
Waste Stream Composition Determination
Waste and Recyclables Loads

District/Section/Route	BX9/92/4B	BX5/51/6A	BK1/15/2B	BK5/54/1A	BX9/92/2B	BX9/93/4B
Sorted materials in lb/hh/day						
Recyclable						
Total Paper	**1.58**	**0.49**	**0.94**	**2.43**	**1.59**	**0.29**
Newspaper	0.60	0.16	0.40	0.98	0.60	0.18
Magazines and Glossy	0.29	0.05	0.08	0.28	0.20	0.02
Telephone and Paperbacks	0.05	0.01	0.06	0.08	0.09	0.00
Corrugated, Kraft & Linerboard	0.54	0.23	0.26	0.65	0.43	0.05
Other Mixed Paper	0.05	0.04	0.11	0.31	0.23	0.03
Paper Beverage Containers	0.04	0.01	0.02	0.13	0.05	0.01
Contaminated Designated Paper	0.00	0.00	0.00	0.00	0.00	0.00
Total Plastic	**0.21**	**0.08**	**0.12**	**0.25**	**0.27**	**0.04**
HDPE Plastic	0.14	0.06	0.09	0.13	0.14	0.02
PET Plastic	0.07	0.02	0.03	0.12	0.13	0.02
Total Metal	**0.37**	**0.16**	**0.19**	**0.22**	**0.36**	**0.06**
Aluminum	0.02	0.00	0.01	0.00	0.07	0.00
Ferrous	0.16	0.07	0.12	0.16	0.22	0.04
Bulk Household Metal	0.19	0.08	0.06	0.06	0.07	0.01
Total Glass	**0.36**	**0.04**	**0.14**	**0.28**	**0.26**	**0.03**
Total Recyclable	2.52	0.46	1.39	3.18	2.48	0.42
Non Recyclable						
Paper	0.04	0.00	0.03	0.40	0.05	0.00
MGP	0.72	0.21	0.62	1.30	1.09	0.15
Wood	0.06	0.06	0.08	0.48	0.16	0.02
Textiles	0.41	0.14	0.36	0.66	0.30	0.07
Non-Ferrous Metals	0.06	0.02	0.03	0.00	0.00	0.00
Non-Metal Bulk Materials	0.20	0.15	0.09	0.24	0.21	0.01
Other Waste	0.00	0.02	0.00	0.12	0.00	0.00
Total Non-Recyclable	1.49	0.59	1.21	3.09	1.80	0.26
Residue	9.79	2.28	5.22	6.47	5.13	1.51
TOTAL	13.80	3.33	7.83	12.74	9.41	2.20

Table B-3
Waste Stream Composition Determination
Waste and Recyclables Loads

District/Section/Route	BX9/93/3B	BK5/52/5B	BX4/42/1A	BX1/12/2B	BX1/11/2A	BX6/62/1B
Sorted materials in lb/hh/day						
Recyclable						
Total Paper	**1.34**	**3.56**	**0.55**	**0.38**	**0.28**	**1.22**
Newspaper	0.55	0.90	0.20	0.11	0.09	0.56
Magazines and Glossy	0.21	0.52	0.09	0.04	0.05	0.08
Telephone and Paperbacks	0.10	0.06	0.00	0.00	0.01	0.00
Corrugated, Kraft & Linerboard	0.33	1.28	0.21	0.20	0.10	0.38
Other Mixed Paper	0.09	0.66	0.03	0.02	0.02	0.14
Paper Beverage Containers	0.06	0.14	0.01	0.01	0.01	0.05
Contaminated Designated Paper	0.00	0.01	0.00	0.00	0.00	0.01
Total Plastic	**0.19**	**0.49**	**0.09**	**0.06**	**0.07**	**0.25**
HDPE Plastic	0.15	0.23	0.06	0.04	0.04	0.14
PET Plastic	0.05	0.25	0.03	0.02	0.02	0.11
Total Metal	**0.44**	**0.92**	**0.16**	**0.12**	**0.09**	**0.41**
Aluminum	0.01	0.14	0.02	0.00	0.01	0.02
Ferrous	0.23	0.45	0.06	0.06	0.06	0.19
Bulk Household Metal	0.20	0.34	0.08	0.06	0.02	0.20
Total Glass	**0.12**	**0.61**	**0.08**	**0.04**	**0.07**	**0.22**
Total Recyclable	2.09	5.59	0.88	0.60	0.51	2.09
Non Recyclable						
Paper	0.01	0.31	0.00	0.00	0.00	0.01
MGP	0.62	1.53	0.29	0.14	0.17	0.63
Wood	0.51	0.30	0.00	0.11	0.00	0.12
Textiles	0.37	0.45	0.11	0.12	0.08	0.31
Non-Ferrous Metals	0.04	0.08	0.00	0.00	0.00	0.07
Non-Metal Bulk Materials	0.07	0.23	0.04	0.04	0.04	0.53
Other Waste	0.01	0.00	0.00	0.00	0.00	0.00
Total Non-Recyclable	1.63	2.91	0.44	0.42	0.29	1.66
Residue	5.78	12.75	2.77	1.58	2.15	7.96
TOTAL	9.51	21.24	4.10	2.60	2.94	11.71

Table B-3
Waste Stream Composition Determination
Waste and Recyclables Loads

District/Section/Route	BK9/93/4B	BK4/43/4B	BK3/34/1B	BK1/12/2A	BK9/91/2A
Sorted materials in lb/hh/day					
Recyclable					
Total Paper	**1.09**	**0.49**	**0.69**	**0.92**	**0.78**
Newspaper	0.48	0.27	0.19	0.28	0.25
Magazines and Glossy	0.18	0.06	0.16	0.15	0.16
Telephone and Paperbacks	0.03	0.03	0.02	0.05	0.02
Corrugated, Kraft & Linerboard	0.27	0.07	0.22	0.34	0.27
Other Mixed Paper	0.10	0.04	0.04	0.03	0.05
Paper Beverage Containers	0.02	0.02	0.01	0.07	0.03
Contaminated Designated Paper	0.00	0.00	0.05	0.00	0.00
Total Plastic	**0.07**	**0.09**	**0.07**	**0.21**	**0.08**
HDPE Plastic	0.04	0.05	0.02	0.11	0.04
PET Plastic	0.03	0.04	0.05	0.10	0.03
Total Metal	**0.11**	**0.33**	**0.14**	**0.27**	**0.11**
Aluminum	0.04	0.01	0.01	0.07	0.03
Ferrous	0.03	0.10	0.11	0.10	0.05
Bulk Household Metal	0.04	0.22	0.02	0.10	0.03
Total Glass	**0.07**	**0.10**	**0.09**	**0.27**	**0.08**
Total Recyclable	1.35	1.01	0.99	1.66	1.05
Non Recyclable					
Paper	0.02	0.01	0.00	0.00	0.00
MGP	0.33	0.23	0.23	0.38	0.40
Wood	0.27	0.20	0.08	0.07	0.24
Textiles	0.15	0.19	0.07	0.23	0.40
Non-Ferrous Metals	0.03	0.01	0.00	0.02	0.07
Non-Metal Bulk Materials	0.07	0.03	0.01	0.16	0.00
Other Waste	0.01	0.01	0.00	0.01	0.00
Total Non-Recyclable	0.88	0.69	0.41	0.87	1.11
Residue	3.95	3.82	2.76	5.56	2.74
TOTAL	6.18	5.52	4.15	8.09	4.90

Table B-3
Waste Stream Composition Determination
Waste and Recyclables Loads

District/Section/Route	BK4/41/2B	BX5/53/3B	BK5/54/3A	BK1/14/4A	BX5/51/2A	BX9/94/2A
Sorted materials in lb/hh/day						
Recyclable						
Total Paper	**1.08**	**0.41**	**2.21**	**1.71**	**0.89**	**0.71**
Newspaper	0.37	0.14	0.93	0.27	0.32	0.36
Magazines and Glossy	0.16	0.02	0.17	0.02	0.13	0.07
Telephone and Paperbacks	0.07	0.00	0.00	0.00	0.04	0.00
Corrugated, Kraft & Linerboard	0.34	0.19	0.86	1.27	0.35	0.22
Other Mixed Paper	0.08	0.04	0.17	0.12	0.04	0.05
Paper Beverage Containers	0.04	0.01	0.08	0.04	0.01	0.02
Contaminated Designated Paper	0.02	0.00	0.00	0.00	0.00	0.00
Total Plastic	**0.17**	**0.08**	**0.20**	**0.20**	**0.11**	**0.12**
HDPE Plastic	0.11	0.05	0.11	0.12	0.07	0.09
PET Plastic	0.07	0.02	0.08	0.08	0.04	0.03
Total Metal	**0.26**	**0.22**	**0.89**	**0.24**	**0.28**	**0.20**
Aluminum	0.02	0.01	0.01	0.03	0.01	0.01
Ferrous	0.17	0.07	0.26	0.13	0.09	0.13
Bulk Household Metal	0.08	0.14	0.63	0.09	0.19	0.05
Total Glass	**0.25**	**0.12**	**0.28**	**0.45**	**0.08**	**0.11**
Total Recyclable	1.76	0.84	3.59	2.60	1.36	1.13
Non Recyclable						
Paper	0.00	0.00	0.00	0.00	0.00	0.00
MGP	0.57	0.23	0.81	1.00	0.50	0.43
Wood	0.27	0.08	0.93	0.08	0.11	0.18
Textiles	0.49	0.24	0.37	0.22	0.98	0.62
Non-Ferrous Metals	0.03	0.01	0.03	0.03	0.01	0.01
Non-Metal Bulk Materials	0.01	0.09	0.21	0.09	0.12	0.00
Other Waste	0.00	0.02	0.00	0.00	0.00	0.00
Total Non-Recyclable	1.37	0.68	2.36	1.42	1.73	1.24
Residue	3.94	1.91	8.81	5.57	3.85	3.41
TOTAL	7.07	3.42	14.76	9.58	6.95	5.78

Table B-3
Waste Stream Composition Determination
Waste and Recyclables Loads

District/Section/Route	BK4/43/1B	BK8/83/2B	Average of Normalized Recyclable and Waste Sample Weights
Sorted materials in lb/hh/day			
Recyclable			
Total Paper	**0.39**	**0.60**	**0.946**
Newspaper	0.09	0.17	0.338
Magazines and Glossy	0.04	0.15	0.125
Telephone and Paperbacks	0.03	0.01	0.032
Corrugated, Kraft & Linerboard	0.21	0.17	0.320
Other Mixed Paper	0.02	0.04	0.097
Paper Beverage Containers	0.01	0.05	0.032
Contaminated Designated Paper	0.00	0.00	0.003
Total Plastic	**0.12**	**0.09**	**0.129**
HDPE Plastic	0.09	0.04	0.077
PET Plastic	0.04	0.05	0.051
Total Metal	**0.41**	**0.22**	**0.0263**
Aluminum	0.01	0.01	0.018
Ferrous	0.14	0.09	0.117
Bulk Household Metal	0.26	0.12	0.127
Total Glass	**0.17**	**0.16**	**0.162**
Total Recyclable	1.10	1.07	1.49
Non Recyclable			
Paper	0.00	0.00	0.035
MGP	0.36	0.29	0.453
Wood	0.21	0.08	0.152
Textiles	0.31	0.15	0.260
Non-Ferrous Metals	0.01	0.02	0.022
Non-Metal Bulk Materials	0.00	0.00	0.096
Other Waste	0.01	0.00	0.01
Total Non-Recyclable	0.89	0.54	1.02
Residue	4.09	2.65	3.91
TOTAL	6.08	4.27	6.43

Table B-4
Waste Stream Composition Determination
Waste and Recyclables Loads

Sample Number	1	2	3	4	5
District/Section/Route	BK/9/93/1B	BK/17/173/2B	BX9/94/3A	BK17/173/2B	BX3/31/4B
Sorted materials in %					
Recyclable					
Paper	**17.76%**	**16.04%**	**18.90%**	**16.77%**	**17.47%**
Newspaper	5.02%	5.33%	8.64%	7.72%	7.01%
Magazines and Glossy	1.80%	2.89%	2.69%	0.51%	0.94%
Telephone and Paperbacks	2.42%	0.46%	0.82%	0.43%	0.03%
Corrugated, Kraft & Linerboard	5.34%	5.28%	4.02%	3.00%	7.29%
Other Mixed Paper	2.60%	1.56%	2.02%	4.52%	1.81%
Paper Beverage Containers	0.57%	0.51%	0.72%	0.59%	0.32%
Contaminated Designated Paper	0.00%	0.00%	0.00%	0.00%	0.06%
Plastic	**2.25%**	**1.97%**	**2.27%**	**1.45%**	**2.45%**
HDPE Plastic	1.33%	0.98%	1.16%	0.77%	1.62%
PET Plastic	0.92%	0.99%	1.11%	0.68%	0.84%
Metal	**10.42%**	**3.66%**	**3.61%**	**4.07%**	**4.88%**
Aluminum	0.20%	0.12%	0.03%	0.18%	0.86%
Ferrous	1.98%	2.18%	2.60%	1.77%	2.33%
Bulk Household Metal	8.24%	1.37%	0.98%	2.12%	1.69%
Glass	**2.94%**	**1.95%**	**1.81%**	**2.61%**	**4.39%**
Total Recyclable	33.37%	23.62%	26.58%	24.89%	29.19%
Non Recyclable					
Paper	0.96%	0.69%	0.53%	1.19%	0.58%
MGP	8.66%	11.41%	7.69%	6.53%	7.50%
Wood	1.19%	3.33%	0.70%	0.52%	1.37%
Textiles	5.69%	1.86%	2.95%	5.52%	3.90%
Non-Ferrous Metals	0.78%	0.52%	0.43%	0.27%	0.00%
Non-Metal Bulk Materials	0.65%	0.81%	0.06%	1.21%	2.08%
Other Waste	0.80%	0.07%	0.05%	0.02%	0.00%
Total Non-Recyclable	18.73%	18.70%	12.41%	15.26%	15.43%
Residue	47.90%	57.69%	61.01%	59.85%	55.39%
TOTAL	100.00%	100.00%	100.00%	100.00%	100.00%

Table B-4
Waste Stream Composition Determination
Waste and Recyclables Loads

Sample Number	6	7	8	9	10
District/Section/Route	BX2/21/2A	BX6/62/5B	BX1/11/2A	BX4/43/4B	BK16/161/1A
Sorted materials in %					
Recyclable					
Paper	**18.73%**	**17.80%**	**14.41%**	**11.67%**	**15.44%**
Newspaper	5.34%	4.32%	4.88%	4.82%	5.86%
Magazines and Glossy	1.99%	0.47%	1.46%	1.31%	3.14%
Telephone and Paperbacks	1.48%	0.39%	0.25%	0.49%	0.51%
Corrugated, Kraft & Linerboard	5.39%	10.46%	4.92%	4.21%	4.10%
Other Mixed Paper	3.90%	1.57%	2.65%	0.56%	1.32%
Paper Beverage Containers	0.63%	0.43%	0.25%	0.28%	0.51%
Contaminated Designated Paper	0.00%	0.16%	0.00%	0.00%	0.00%
Plastic	**2.72%**	**2.06%**	**2.02%**	**2.10%**	**1.92%**
HDPE Plastic	1.41%	1.37%	1.20%	1.54%	1.18%
PET Plastic	1.31%	0.70%	0.82%	0.56%	0.74%
Metal	**11.25%**	**6.14%**	**6.08%**	**4.11%**	**2.24%**
Aluminum	0.06%	0.28%	0.35%	0.08%	0.19%
Ferrous	4.20%	2.39%	2.17%	1.80%	1.47%
Bulk Household Metal	6.99%	3.47%	3.55%	2.23%	0.57%
Glass	**4.00%**	**2.69%**	**2.31%**	**3.38%**	**3.47%**
Total Recyclable	36.69%	28.69%	24.81%	21.26%	23.07%
Non Recyclable					
Paper	1.54%	0.35%	0.18%	2.63%	0.43%
MGP	6.81%	7.34%	8.21%	6.69%	4.23%
Wood	1.36%	0.59%	2.25%	3.66%	1.68%
Textiles	8.61%	4.03%	2.75%	3.88%	2.36%
Non-Ferrous Metals	0.79%	0.45%	0.29%	0.44%	0.78%
Non-Metal Bulk Materials	1.68%	1.42%	1.53%	1.86%	1.04%
Other Waste	0.02%	0.00%	0.07%	0.14%	0.12%
Total Non-Recyclable	20.82%	14.18%	15.28%	19.31%	10.65%
Residue	42.48%	57.13%	59.91%	59.43%	66.29%
TOTAL	100.00%	100.00%	100.00%	100.00%	100.00%

Table B-4
Waste Stream Composition Determination
Waste and Recyclables Loads

Sample Number	11	12	13	14	15
District/Section/Route	BK17/171/5A	BK3/31/4A	BX9/94/6A	BX9/94/7A	BK17/171/2A
Sorted materials in %					
Recyclable					
Paper	**13.10%**	**20.43%**	**14.59%**	**13.06%**	**16.83%**
Newspaper	3.62%	8.47%	6.30%	5.65%	5.56%
Magazines and Glossy	2.84%	2.69%	3.92%	1.21%	4.66%
Telephone and Paperbacks	0.28%	1.56%	0.17%	1.17%	0.85%
Corrugated, Kraft & Linerboard	4.51%	5.47%	3.42%	3.80%	3.41%
Other Mixed Paper	1.63%	2.00%	0.54%	0.75%	1.60%
Paper Beverage Containers	0.22%	0.25%	0.25%	0.48%	0.74%
Contaminated Designated Paper	0.00%	0.00%	0.00%	0.00%	0.00%
Plastic	**2.32%**	**2.45%**	**1.86%**	**3.47%**	**1.50%**
HDPE Plastic	1.56%	1.46%	1.32%	2.37%	1.03%
PET Plastic	0.77%	0.99%	0.53%	1.10%	0.46%
Metal	**4.02%**	**4.23%**	**4.44%**	**2.63%**	**2.28%**
Aluminum	0.20%	0.22%	0.31%	0.30%	0.12%
Ferrous	1.88%	1.79%	1.99%	1.96%	1.34%
Bulk Household Metal	1.94%	2.22%	2.13%	0.36%	0.82%
Glass	**5.05%**	**5.65%**	**0.91%**	**0.54%**	**2.66%**
Total Recyclable	24.49%	32.76%	21.80%	19.70%	23.26%
Non Recyclable					
Paper	1.17%	0.11%	0.56%	0.13%	0.43%
MGP	6.24%	6.49%	5.24%	6.24%	6.74%
Wood	2.05%	0.98%	0.89%	1.10%	6.61%
Textiles	5.09%	4.20%	1.30%	3.20%	3.17%
Non-Ferrous Metals	0.36%	0.73%	0.22%	0.54%	0.00%
Non-Metal Bulk Materials	4.49%	0.73%	1.96%	2.29%	3.49%
Other Waste	0.09%	0.09%	0.03%	0.00%	0.02%
Total Non-Recyclable	19.50%	13.34%	10.20%	13.50%	20.45%
Residue	56.01%	53.90%	68.00%	66.80%	56.30%
TOTAL	100.00%	100.00%	100.00%	100.00%	100.00%

Table B-4
Waste Stream Composition Determination
Waste and Recyclables Loads

Sample Number	16	17	18	19	20	21
District/Section/Route	BX9/92/4B	BX5/51/6A	BK1/15/2B	BK5/54/1A	BX9/92/2B	BX9/93/4B
Sorted materials in %						
Recyclable						
Paper	**11.42%**	**14.87%**	**12.00%**	**19.08%**	**16.88%**	**13.19%**
Newspaper	4.33%	4.69%	5.08%	7.67%	6.41%	8.10%
Magazines and Glossy	2.12%	1.56%	1.01%	2.22%	2.08%	1.00%
Telephone and Paperbacks	0.36%	0.22%	0.83%	0.62%	0.90%	0.00%
Corrugated, Kraft & Linerboard	3.93%	6.95%	3.34%	5.10%	4.60%	2.34%
Other Mixed Paper	0.40%	1.09%	1.46%	2.41%	2.42%	1.22%
Paper Beverage Containers	0.29%	0.36%	0.28%	1.06%	0.48%	0.54%
Contaminated Designated Paper	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Plastic	**1.53%**	**2.26%**	**1.53%**	**2.00%**	**2.92%**	**1.87%**
HDPE Plastic	1.03%	1.66%	1.18%	1.03%	1.49%	0.79%
PET Plastic	0.50%	0.61%	0.35%	0.97%	1.43%	1.08%
Metal	**2.67%**	**4.68%**	**2.45%**	**1.74%**	**3.79%**	**2.56%**
Aluminum	0.17%	0.15%	0.11%	0.03%	0.75%	0.12%
Ferrous	1.15%	2.14%	1.52%	1.23%	2.29%	2.02%
Bulk Household Metal	1.35%	2.39%	0.83%	0.47%	0.75%	0.43%
Glass	**2.60%**	**1.16%**	**1.78%**	**2.17%**	**2.77%**	**1.53%**
Total Recyclable	18.22%	13.91%	17.77%	24.99%	26.36%	19.16%
Non Recyclable						
Paper	0.29%	0.00%	0.41%	3.12%	0.48%	0.20%
MGP	5.22%	6.27%	7.91%	10.24%	11.60%	7.02%
Wood	0.46%	1.69%	1.01%	3.77%	1.73%	0.85%
Textiles	2.95%	4.24%	4.66%	5.22%	3.13%	3.00%
Non-Ferrous Metals	0.44%	0.63%	0.33%	0.00%	0.00%	0.16%
Non-Metal Bulk Materials	1.46%	4.61%	1.19%	1.88%	2.22%	0.61%
Other Waste	0.00%	0.49%	0.00%	0.91%	0.00%	0.00%
Total Non-Recyclable	10.82%	17.75%	15.51%	24.23%	19.17%	11.84%
Residue	70.96%	68.35%	66.72%	50.78%	54.48%	69.00%
TOTAL	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Table B-4
Waste Stream Composition Determination
Waste and Recyclables Loads

Sample Number	22	23	24	25	26	27
District/Section/Route	BX9/93/3B	BK5/52/5B	BX4/42/1A	BX1/12/2B	BX1/11/2A	BX6/62/1B
Sorted materials in %						
Recyclable						
Paper	**14.11%**	**16.78%**	**13.34%**	**14.51%**	**9.57%**	**10.42%**
Newspaper	5.80%	4.24%	4.90%	4.14%	3.11%	4.75%
Magazines and Glossy	2.25%	2.44%	2.13%	1.46%	1.84%	0.66%
Telephone and Paperbacks	1.01%	0.29%	0.10%	0.02%	0.43%	0.04%
Corrugated, Kraft & Linerboard	3.46%	6.03%	5.19%	7.82%	3.28%	3.26%
Other Mixed Paper	0.95%	3.09%	0.67%	0.69%	0.71%	1.18%
Paper Beverage Containers	0.65%	0.65%	0.36%	0.37%	0.20%	0.41%
Contaminated Designated Paper	0.00%	0.04%	0.00%	0.00%	0.00%	0.13%
Plastic	**2.05%**	**2.29%**	**2.16%**	**2.22%**	**2.29%**	**2.13%**
HDPE Plastic	1.55%	1.10%	1.48%	1.54%	1.47%	1.21%
PET Plastic	0.49%	1.19%	0.68%	0.69%	0.82%	0.92%
Metal	**4.65%**	**4.35%**	**4.02%**	**4.80%**	**3.01%**	**3.47%**
Aluminum	0.10%	0.64%	0.42%	0.03%	0.42%	0.16%
Ferrous	2.42%	2.10%	1.56%	2.36%	2.07%	1.59%
Bulk Household Metal	2.13%	1.61%	2.04%	2.41%	0.52%	1.72%
Glass	**1.22%**	**2.87%**	**1.96%**	**1.59%**	**2.34%**	**1.84%**
Total Recyclable	22.03%	26.30%	21.48%	23.12%	17.22%	17.86%
Non Recyclable						
Paper	0.05%	1.44%	0.00%	0.06%	0.00%	0.10%
MGP	6.56%	7.21%	7.02%	5.48%	5.65%	5.34%
Wood	5.35%	1.41%	0.00%	4.40%	0.00%	1.04%
Textiles	3.89%	2.14%	2.75%	4.66%	2.85%	2.63%
Non-Ferrous Metals	0.42%	0.39%	0.00%	0.19%	0.00%	0.58%
Non-Metal Bulk Materials	0.77%	1.10%	1.06%	1.35%	1.25%	4.51%
Other Waste	0.14%	0.00%	0.00%	0.00%	0.00%	0.00%
Total Non-Recyclable	17.18%	13.68%	10.84%	16.14%	9.75%	14.20%
Residue	60.79%	60.02%	67.68%	60.74%	73.03%	67.95%
TOTAL	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Table B-4
Waste Stream Composition Determination
Waste and Recyclables Loads

Sample Number	28	29	30	31	32
District/Section/Route	BK9/93/4B	BK4/43/4B	BK3/34/1B	BK1/12/2A	BK9/91/2A
Sorted materials in %					
Recyclable					
Paper	**17.65%**	**8.94%**	**16.55%**	**11.36%**	**15.89%**
Newspaper	7.79%	4.97%	4.51%	3.49%	5.20%
Magazines and Glossy	2.93%	1.15%	3.74%	1.83%	3.18%
Telephone and Paperbacks	0.55%	0.47%	0.56%	0.63%	0.37%
Corrugated, Kraft & Linerboard	4.40%	1.32%	5.36%	4.23%	5.61%
Other Mixed Paper	1.63%	0.73%	0.89%	0.34%	0.95%
Paper Beverage Containers	0.35%	0.30%	0.32%	0.84%	0.57%
Contaminated Designated Paper	0.00%	0.00%	1.18%	0.00%	0.00%
Plastic	**1.18%**	**1.64%**	**1.70%**	**2.54%**	**1.58%**
HDPE Plastic	0.68%	0.96%	0.54%	1.37%	0.92%
PET Plastic	0.51%	0.68%	1.16%	1.18%	0.67%
Metal	**1.79%**	**5.90%**	**3.43%**	**3.35%**	**2.35%**
Aluminum	0.66%	0.11%	0.15%	0.82%	0.68%
Ferrous	0.41%	1.85%	2.70%	1.28%	1.06%
Bulk Household Metal	0.72%	3.94%	0.57%	1.24%	0.61%
Glass	**1.21%**	**1.87%**	**2.07%**	**3.31%**	**1.56%**
Total Recyclable	21.84%	18.35%	23.75%	20.56%	21.38%
Non Recyclable					
Paper	0.36%	0.24%	0.06%	0.00%	0.00%
MGP	5.39%	4.18%	5.65%	4.70%	8.25%
Wood	4.36%	3.55%	1.94%	0.83%	4.81%
Textiles	2.35%	3.46%	1.78%	2.85%	8.22%
Non-Ferrous Metals	0.48%	0.22%	0.10%	0.23%	1.34%
Non-Metal Bulk Materials	1.15%	0.62%	0.22%	1.99%	0.00%
Other Waste	0.12%	0.17%	0.00%	0.12%	0.03%
Total Non-Recyclable	14.20%	12.44%	9.76%	10.71%	22.65%
Residue	63.95%	69.20%	66.49%	68.73%	55.97%
TOTAL	100.00%	100.00%	100.00%	100.00%	100.00%

Table B-4
Waste Stream Composition Determination
Waste and Recyclables Loads

Sample Number	33	34	35	36	37	38
District/Section/Route	BK4/41/2B	BX5/53/3B	BK5/54/3A	BK1/14/4A	BX5/51/2A	BX9/94/2A
Sorted materials in %						
Recyclable						
Paper	**15.25%**	**12.05%**	**15.00%**	**17.88%**	**12.81%**	**12.22%**
Newspaper	5.20%	4.18%	6.29%	2.82%	4.54%	6.15%
Magazines and Glossy	2.25%	0.70%	1.17%	0.16%	1.86%	1.13%
Telephone and Paperbacks	0.97%	0.03%	0.01%	0.00%	0.59%	0.00%
Corrugated, Kraft & Linerboard	4.85%	5.66%	5.84%	13.29%	5.10%	3.74%
Other Mixed Paper	1.12%	1.12%	1.18%	1.21%	0.53%	0.84%
Paper Beverage Containers	0.59%	0.34%	0.51%	0.39%	0.19%	0.37%
Contaminated Designated Paper	0.27%	0.00%	0.00%	0.00%	0.00%	0.00%
Plastic	**2.41%**	**2.27%**	**1.34%**	**2.05%**	**1.53%**	**2.06%**
HDPE Plastic	1.49%	1.58%	0.78%	1.26%	1.02%	1.56%
PET Plastic	0.92%	0.69%	0.56%	0.79%	0.51%	0.50%
Metal	**3.72%**	**6.57%**	**6.06%**	**2.52%**	**4.05%**	**3.41%**
Aluminum	0.22%	0.15%	0.07%	0.29%	0.11%	0.19%
Ferrous	2.40%	2.19%	1.73%	1.34%	1.23%	2.29%
Bulk Household Metal	1.09%	4.22%	4.25%	0.89%	2.70%	0.93%
Glass	**3.51%**	**3.60%**	**1.93%**	**4.65%**	**1.21%**	**1.85%**
Total Recyclable	24.89%	24.48%	24.33%	27.10%	19.61%	19.55%
Non Recyclable						
Paper	0.05%	0.04%	0.00%	0.00%	0.00%	0.00%
MGP	8.09%	6.83%	5.48%	10.43%	7.24%	7.43%
Wood	3.77%	2.31%	6.31%	0.84%	1.62%	3.13%
Textiles	6.90%	7.08%	2.53%	2.28%	14.16%	10.72%
Non-Ferrous Metals	0.38%	0.37%	0.22%	0.33%	0.08%	0.15%
Non-Metal Bulk Materials	0.16%	2.52%	1.42%	0.89%	1.79%	0.00%
Other Waste	0.03%	0.64%	0.02%	0.00%	0.07%	0.02%
Total Non-Recyclable	19.37%	19.80%	15.99%	14.77%	24.96%	21.45%
Residue	55.74%	55.73%	59.69%	58.12%	55.43%	59.01%
TOTAL	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Table B-4
Waste Stream Composition Determination
Waste and Recyclables Loads

Sample Number	39	40
District/Section/Route	BK4/43/1B	BK8/83/2B
Sorted materials in %		
Recyclable		
Paper	**6.46%**	**14.10%**
Newspaper	1.50%	3.96%
Magazines and Glossy	0.61%	3.63%
Telephone and Paperbacks	0.49%	0.31%
Corrugated, Kraft & Linerboard	3.38%	3.96%
Other Mixed Paper	0.27%	0.98%
Paper Beverage Containers	0.21%	1.24%
Contaminated Designated Paper	0.00%	0.00%
Plastic	**2.05%**	**2.17%**
HDPE Plastic	1.40%	0.99%
PET Plastic	0.65%	1.18%
Metal	**6.66%**	**5.13%**
Aluminum	0.19%	0.34%
Ferrous	2.26%	2.05%
Bulk Household Metal	4.21%	2.75%
Glass	**2.84%**	**3.79%**
Total Recyclable	18.01%	25.19%
Non Recyclable		
Paper	0.00%	0.00%
MGP	5.85%	6.80%
Wood	3.43%	1.92%
Textiles	5.02%	3.46%
Non-Ferrous Metals	0.17%	0.45%
Non-Metal Bulk Materials	0.00%	0.00%
Other Waste	0.23%	0.00%
Total Non-Recyclable	14.70%	12.62%
Residue	67.29%	62.19%
TOTAL	100.00%	100.00%

APPENDIX C

STATISTICAL METHODOLOGY

1 Determination of Sample Size

Two factors were considered when developing the statistical samples:

- The size of the sample, in terms of weight;
- Given a specific weight of a sample, the number of samples themselves.

Sample Weight

In developing a recommended sample weight, the analysis examined how the variance of waste proportions changed with the weight of the samples. Using the 1990 waste composition studies (sample weights of approximately 320 pounds) and a more recent Staten Island waste composition study (sample weights of approximately 3,000 pounds), a curve relating sample weight to standard deviation around the sample parameters was created. Using this curve, it was determined that the standard deviation tends to "level out" at about 1,000 pounds. Alternatively stated, it did not appear that sample weights above 1,000 pounds significantly reduced the relative variability of the samples. Therefore, 1,000 pounds was the targeted weight for each sample.

Number of Samples

The optimal sample size using a 95% confidence limit is estimated using the following equation:

(4 times S^2) divided by L^2

where S^2 is the standard deviation squared and L^2 is the square of the tolerance desired. The standard deviation from the 1990 winter composition study was used to estimate the required number of samples. Statistics texts indicate that L is generally plus or minus 10 to 20 percent of the preliminary estimate of the sample mean. At 1,000 pounds, approximately 40 to 45 random samples would need to be drawn from the Low Diversion Rate districts. If the samples were 20,000 pounds each the number of samples required would only be reduced to 25. Therefore, 40 samples at a weight of at least 1,000 pounds was assumed reasonable.

2 Statistical Analysis of Data

The data from the waste and Recyclables samples were statistically analyzed after being normalized to a lb/hh/day basis. The combined waste and Recyclables sample data on a lb/hh/day basis was used to calculate the mean. The mean was calculated by summing the individual sample data and dividing by the number of samples for each sort category. The mean was calculated as a percent composition by dividing the sort category total in lb/hh/day by the total lb/hh/day sum for all sort categories. The data were then analyzed statistically using the student t test. The student t test estimates population parameters from sample data. The student t is a continuous random variable whose probability distribution is completely specified by the number of degrees of freedom. The student t test was derived by assuming that each sample observation is selected randomly from a normally distributed population.

The UCI and LCI is calculated as follows:

UCI/LCI = (Mean) + or - (Student t) x (Standard Error)

where:
the Standard Error = Standard Deviation ÷ the square root of the number of samples;

the Standard Deviation = the square root of the Variation; and the Variation = (sum of the data)^2-(sum of the data^2/number of samples)/Degrees of Freedom.

A 95% confidence interval was calculated about the mean. The student t statistic for a 95% two tailed confidence interval with 39 degrees of freedom is 2.0231.

The comparisons between the 1997 Study and 1990 study (shown in Table 7) and between the Bronx and Brooklyn sample district data (shown in Table 8) were calculated using the student t statistic. The difference in means and joint standard error were calculated to determine the t statistic value.
The difference in means is the calculated mean for one group of data subtracted from the calculated mean for the other group of data.

The joint standard error is calculated as follows:

The square root of the standard deviation* of one data set times the standard deviation of the other data set divided by the square root of the number of samples.

The calculated student t statistic is then equal to the difference in means divided by the joint standard error.

For example, the adjusted mean composition of the paper category from the 1990 winter study was 28.4% and 20.6% from the 1997 Study. The difference in means is equal to 28.4% minus 20.6% or 7.8 percentage points. The joint standard error was calculated by taking the square root of the standard deviation of the paper category from the 1990 winter study multiplied by the standard deviation of the paper category from the 1997 Study (square root of 8.10% times 4.53%) and dividing this quantity by the square root of the number of samples (square root of 72). The joint standard error is equal to 0.00714. The student t statistic was calculated by dividing the difference in means (7.8/100 = 0.078) by the joint standard error (0.00714) which equals 10.93. Since this value exceeds the book value of the student t statistic (2.0231), a statistically valid difference exists.

This calculated student t statistic is then compared to the book student t value. If the calculated student t value exceeds the book student t value, there is statistically significant differences between the sample data sets.

* For the 1990 study, for product/material categories for which standard deviations were not available, the weighted average standard deviation from the information was calculated and used as a percent of the mean to estimate the standard deviation, that is:

Newspaper mean x Newspaper standard deviation +
Magazine & Glossy mean x Magazine & Glossy Std Dev.
+ Telephone & paperback mean x Telephone & Paperback std dev
+ … etc."
divided by the sum of the means.

This weighted Average Standard Deviation is 7.8%.
A sensitivity analysis was conducted by testing the standard deviation at 15% and 3.98% of the means. 3.98% was selected in particular because it was the weighted average standard deviation calculated from all information available from the 1990 Study (all means and respective standard deviations). The only difference when using 3.98% was a finding of no statistical difference between the means for Aluminum.

APPENDIX D

ECONOMICS OF MIXED WASTE PROCESSING FACILITIES

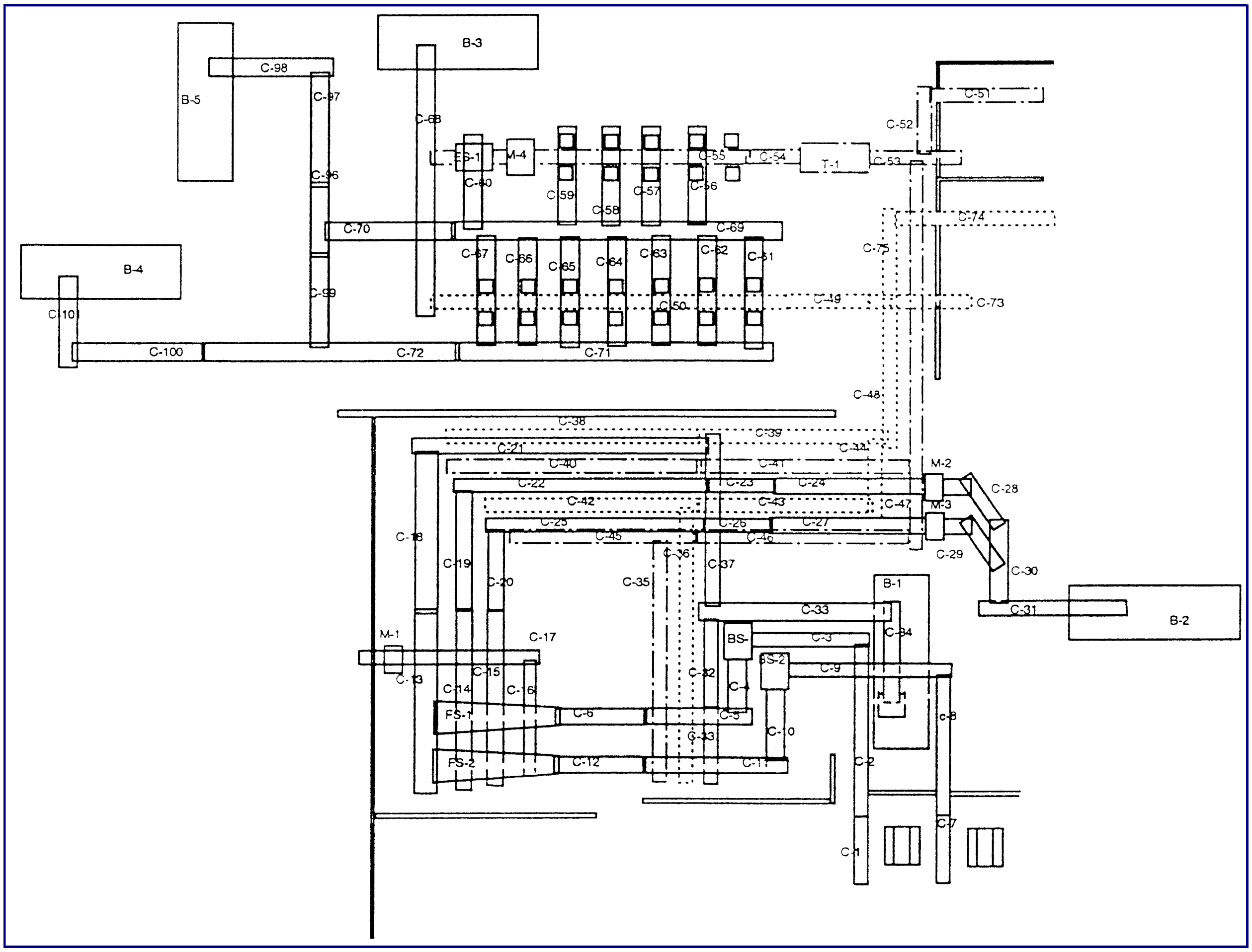
Table D-1

Capital Cost For A 100 TPH Mixed Waste MRF/Transfer Station		
	Total	**Annual**
Site Acquisition	0	0
Site Work	$ 1,660,400	$ 218,299
Mrf/Transfer Building And Maneuvering Area	12,437,400	1,635,192
Scale House And Scales	372,980	49,037
Subtotal Construction Capital Costs	**$ 14,470,780**	**$ 1,902,528**
Contingency (20% Of Construction)	2,894,156	380,506
Total Construction Capital Costs	**$ 17,364,936**	**$ 2,283,034**
Front-End Loader (Rubber Tired)	360,000	67,480
Fork Lift	105,000	27,699
Subtotal Mobile Equipment	**465,000**	**95,179**
Conveyors	3,160,610	415,537
Balers	1,500,000	244,118
Bag Splitters	250,000	32,868
Screens	280,000	36,813
Magnets	120,000	15,777
Separators	150,000	19,721
Pedestal Grapple Boom	80,000	10,518
Picking Platforms	199,500	26,229
Chutes & Misc. Sheet Metal	350,000	46,016
Electrical (Wiring & Controls)	1,445,000	189,980
Installation (20% Of Capital Cost)	1,507,022	207,515
Subtotal Recovery Equipment	**9,042,132**	**1,245,092**
Subtotal Equipment	**9,507,132**	**1,340,271**
Contingency (5% Of Equipment)	475,357	67,014
Total Equipment Capital Costs	**9,982,489**	**1,407,284**
Design/Engineering (8% Of Construction)	1,389,195	152,202
Design/Engineering (2% Of Facility Equipment)	189,885	26,805
Permitting (5% Of Construction)	868,247	95,126
Surveying And Soils Report	80,000	10,518
Construction Management (8% Of Construction)	1,389,195	152,202
Total Capital Cost (Facility Implementation)	**$ 31,263,900**	**$ 4,127,200**
Total Capital Cost (Including Capitalized Interest)	**$ 34,077,651**	**$ 4,498,648**

Table D-2

Operations And Maintenance Cost Summary, 100 TPH Mixed Waste MRF/Transfer Station		
Transfer Station Labor	$	3,571,000
Recovery Equipment Maintenance		361,700
Building And Site Maintenance		347,300
Utilities - Building And Site		539,300
Rolling Stock Fuel Costs		76,300
Rolling Stock Operation And Maintenance Costs		147,400
Subtotal Operation & Maintenance		**5,043,000**
Administration And Profit (20%)		1,009,000
Total Operation And Maintenance	**$**	**6,052,000**

Mixed Waste Processing
100 TPH



Conveyors		***Conveyors (Continued)***	
C-1, C-7	48" Apron	C-69	48" Belt Infloor
C-2 To C-6, C-8 To C-12, C-37, C-70 To C-72, C-97, C-99	48"Belt	C-73	36" Reversible Belt
C-13, C-18	60" Belt W/ Cleats	C-74	36" Apron
C-14, C-15, C-19, C-20	42" Belt W/ Cleats	C-96	48" Reversible Belt
C-16	32" Belt	***Balers***	
C-16A	32" Belt Aluminum	B-1 To B-3	Waste Baler
C-17, C-23, C-26, C-32, C-32A, C-35, C-36, C-54A, C-75	36" Belt	B-4, B-5	Recyclables Baler
C-21	42" Belt (Over 12" Sorting)	***Bag Splitters***	
C-22, C-25	36" Belt (Sorting)	BS-1, BS-2	Bag Splitter
C-24, C-27	42" Belt		
C-28 To C-31, C-33, C-34	48" Belt Baler Feed	***Screens***	
C-38, C-39, C-42 To C-44, C-48 To C-50	36" Belt Fiber	FS-1, FS-2	Finger Screen
		T-1	Trommel
C-40, C-41, C-45, C-47, C-52, C-54, C-55	36" Belt Commingled	***Magnets***	
C-51	36" Apron Commingled	M-1 To M-4	Belt Magnet
C-53	36" Belt Commingled Rev.		
C-56 To C-60	48" Belt/Wlkg Flr	***Separators***	
C-61 To C-67	48" Reversible Belt/Wlkg Flr	EC-1, EC-2	Eddy Current Separator
C-68, C-98, C-100, C-101	48" Belt Baler Feed		

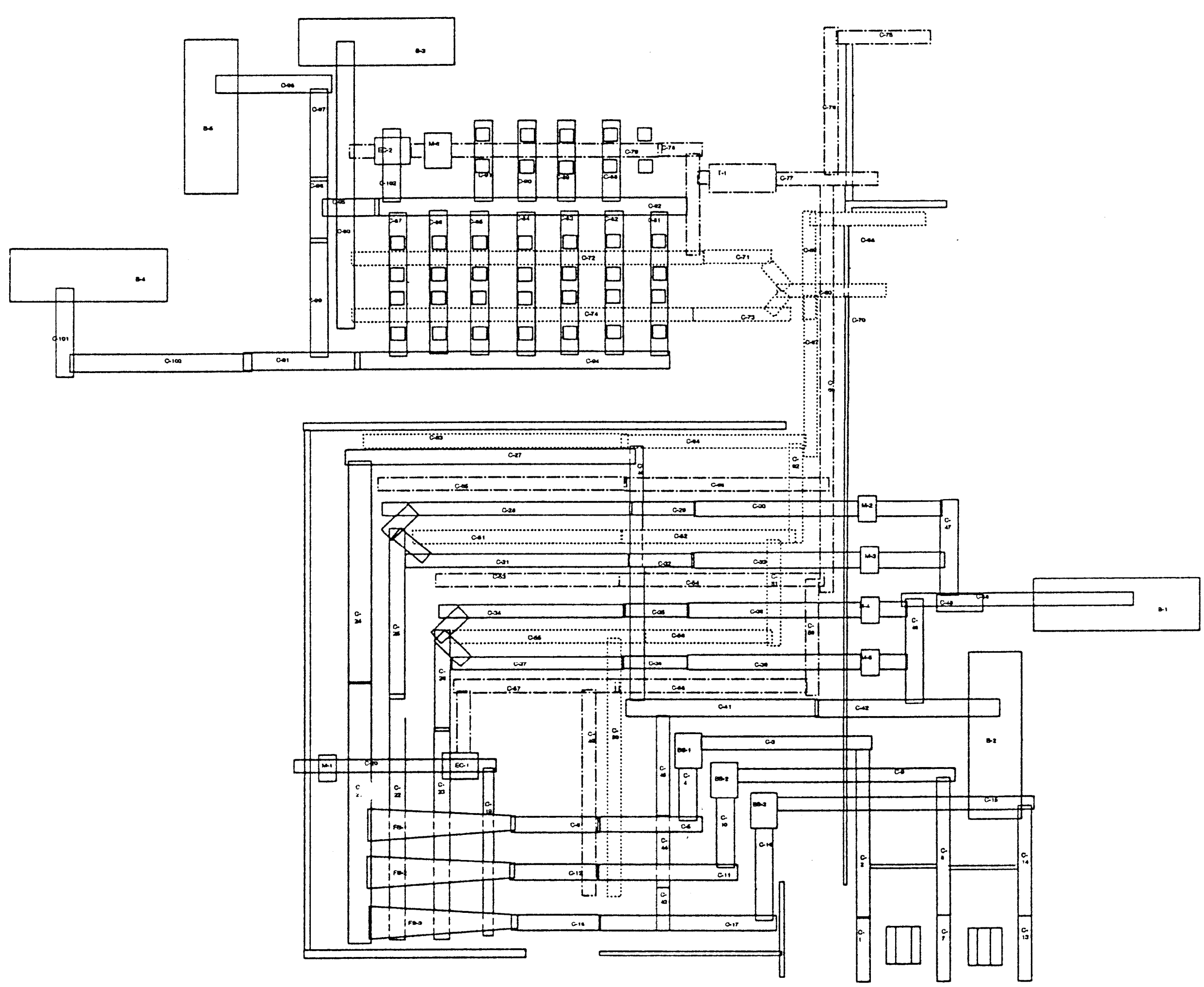
Table D-3

Capital Cost For A 150 TPH Mixed Waste MRF/Transfer Station		
	Total	**Annual**
Site Acquisition	0	0
Site Work	$ 2,340,100	$ 307,662
Mrf/Transfer Building And Maneuvering Area	16,533,800	2,173,761
Scale House And Scales	372,980	49,037
Subtotal Construction Capital Costs	**14,470,780**	**1,902,528**
Contingency (20% Of Construction)	3,849,376	506,092
Total Construction Capital Costs	**37,567,036**	**4,939,080**
Front-End Loader (Rubber Tired)	540,000	101,220
Fork Lift	140,000	36,932
Subtotal Mobile Equipment	**680,000**	**138,151**
Conveyors	3,864,540	508,086
Balers	1,865,000	303,520
Bag Splitters	375,000	49,303
Screens	380,000	49,960
Magnets	180,000	23,665
Separators	150,000	19,721
Pedestal Grapple Boom	160,000	21,036
Picking Platforms	252,000	33,131
Chutes & Misc. Sheet Metal	500,000	65,737
Electrical (Wiring & Controls)	1,745,000	229,422
Installation (20% Of Capital Cost)	1,894,300	260,700
Subtotal Recovery Equipment	**11,365,840**	**1,564,281**
Subtotal Equipment	**12,045,840**	**1,702,432**
Contingency (5% Of Equipment)	602,292	85,122
Total Equipment Capital Costs	**12,648,132**	**1,787,554**
Design/Engineering (8% Of Construction)	1,847,700	242,924
Design/Engineering (2% Of Facility Equipment)	252,963	35,751
Permitting (5% Of Construction)	1,154,813	151,828
Surveying And Soils Report	80,000	10,518
Construction Management (8% Of Construction)	1,847,700	242,924
Total Capital Cost (Facility Implementation)	**$ 40,927,600**	**$ 5,508,100**
Total Capital Cost (Including Capitalized Interest)	**$ 44,611,084**	**$ 6,003,829**

Table D-4

Operations And Maintenance Cost Summary, 150 TPH Mixed Waste MRF/Transfer Station		
Transfer Station Labor	$	5,674,000
Recovery Equipment Maintenance		454,600
Building And Site Maintenance		461,900
Utilities - Building And Site		663,000
Rolling Stock Fuel Costs		110,400
Rolling Stock Operation And Maintenance Costs		193,500
Subtotal Operation & Maintenance		**7,557,400**
Administration And Profit (20%)		1,511,000
Total Annual Operation & Maintenance	**$**	**9,068,400**

Mixed Waste Processing
150 TPH



Conveyors

C-75	36" Apron Commingled
C-68	36" Apron Fiber
C-19, C-20, C-29, C-32, C-35, C-38	36" Belt
C-28, C-31, C-34, C-37	36" Belt (Sorting)
C-44, C-45	36" Belt Bulky Waste
C-43, C-49, C-53, C-54, C-57 To C-59, C-65, C-66, C-76, C-78, C-79	36" Belt Commingled
C-60, C-77	36" Belt Commingled Rev.
C-50 To C-52, C-55, C-56, C-61 To C-64, C-67, C-69, C-71 To C-74	36" Belt Fiber
C-70	36" Belt Fiber Reversible
C-30, C-33, C-36, C-39, C-40	42" Belt

Conveyors (Continued)

C-27	42" Belt (Over 12" Sorting)
C-22, C-23, C-25, C-26	42" Belt W/ Cleats
C-1, C-7, C-13	48" Apron
C-41, C-42, C-46, C-92 To C-95, C-97 To C-101	48" Belt
C-102	48" Belt - Aluminum
C-47, C-48	48" Belt Baler Feed
C-80	48" Belt Baler Feed (Rejects)
C-96, C-103	48" Belt Reversible
C-81 To C-87	48" Belt Reversible/Wlkg Flr
C-88 To C-91	48" Belt/Wlkg Flr
C-2 To C-6, C-8 To C-12, C-14 To C-18	48"Belt
C-21, C-24	60" Belt W/ Cleats

Balers

B-1 To B-3	Waste Baler
B-4, B-5	Recyclables Baler

Bag Splitters

BS-1 To BS-3	Bag Splitter

Screens

FS-1 To FS-3	Finger Screen
T-1	Trommel

Magnets

M-1 To M-6	Belt Magnet

Separators

EC-1, EC-2	Eddy Current Separator

APPENDIX E

COMPOST TEST RESULTS AND FACILITY ECONOMICS

Table E-1
Summary of Testing Performed During Composting Test

	Test Method or Object	Test Objective
Under 4-inch screen	TCLP[1]	Determine leachate toxicity for metals in sample source fraction before Bedminster process.
Under final screen as discharged	TCLP[1]	Determine leachate toxicity for metals in sample source fraction before Bedminster process.
Final screen sludge	Salmonella Metals Fecal Coliform	Identify a potential source of heavy metal contamination in final compost.
Dewatered plant sludge	Salmonella Metals Fecal Coliform	Identify a potential source of heavy metal contamination in final compost.
Bedminster drum <1.5-inch material	Compost Composition and Metals	For comparison with test material after compost curing.
Bedminster curing floor compostable material	Compost Composition and Metals	For comparison with test material after compost curing and verification that the material shipped to Rikers Island was from the original test material.
Bedminster drum >1.5-inch material disposed as residue	TCLP[1]	Determine the leachate toxicity for metals in sample source fraction after the Bedminster process.
Rikers Island compost pile*	Composition, Metals and Pesticides	Assess compliance with NYSDEC regulations and quality for marketing.

[1]Toxicities Characteristics Leachate Properties

* Annotated Summary of Composition Analysis on Compost Pile Samples

The following is an annotated summary of the results of the composition analysis performed by Woods End Research Laboratory on the compost produced from the <4-inch residual of the Mixed Waste Processing Test. Residual material was combined with biosolids and processed through an Eweson digester in the Bedminster Bioconversion Company=s Sevierville, Tennessee plant (see Chapter 4), then sent to cure in the City=s enclosed composting facility at Rikers Island. After approximately four months, grab samples were collected from the interior and exterior of the compost pile and combined into two samples, one from the interior and one from the exterior.

Concerns:
The two major concerns when analyzing mixed-waste compost are heavy metals and polychlorinated biphenyls (PCBs). Both federal and State regulations dictate contamination levels of metals and PCBs that compost must not exceed. The US EPA Part 503 Regulations provide the federal standards while the New York State, Department of Environmental Conservation (6 NYCRR Part 360-5) goes beyond the federal guidelines and offers stringent regulations. The DEC=s Part 360-5 provides for two grades of compost, Class I and Class II. Class I compost must meet a higher standard and may be used on food chain crops (though never ones directly for human consumption), for public use and other agricultural and horticultural purposes. Class II compost is restricted to use on nonfood chain crops.

Metals:
The most recent DEC regulations are from 1993; 1995 updates that relax certain contaminant levels are still pending. By the 1993 standards, the mixed-waste pilot compost would be graded Class II as the levels of nickel are in excess of Class I allowances. If, however, the 1995 updates were passed into law, the compost would receive a Class I grade.

PCBs:
By both the 1993 and the 1995 DEC Part 360-5 update, Class I compost cannot contain more than 1.0 part per million (ppm) total of PCBs; Class II cannot exceed 10.0 ppm. The total PCB level, testing for seven Aroclors (components of PCBs), was under 1.4 ppm. NYC DEC has indicated that such a result would be acceptable as meeting Class I standards.

Compost Quality:
Moisture levels:
The inner core sample revealed a moisture level that was rather low for a high organic matter compost, whereas the exterior had a moisture level twice as high as the core. Two factors lie behind this situation. Moisture travels outward as the pile continues to compost and is trapped in the outer band of the pile. Secondly, the compost cured on the aerated floor of the Rikers Island facility. This means that air was almost continuously traveling up into the pile, drying the center and forcing moisture out.

Inerts:
More than half of the compost was composed of inerts, such as glass and other debris.

As the report notes, this is an extraordinarily high ratio. Under normal circumstances the pre-cured compost would be screened through a 3/4 inch and then 3/8 inch screen to remove inerts, and final compost would be screened multiple times. In this pilot, screening was impeded at least in part because of moisture: more biosolids had been added than was optimal given the composition of the mixed waste processing residual. The lab, however, did screen the compost after measuring the inerts and then analyzed the remainder; thus, the results for pH, VOAs, and mineral content (see below) are not affected by the inert content.

pH:
The pH was 7.5 for the exterior sample and 7.6 for the inner core sample, both of which are neutral and a positive result for the mixed waste compost.

Volatile Organic Acids:
Responsible for phytotoxicity (meaning harmful to plants), volatile organic acids (VOAs) are another important measure for compost. The presence of VOAs indicates anaerobic fermentation, which accounts for Aodor complaints@ and attracts vermin at compost facilities. The compost had 283 ppm of VOAs on a dry weight basis; the lab characterization of this level is Avery low.@

Mineral Analysis:
The amounts of mineral nutrients, and the cation exchange capacity, in the samples were assessed by a Departmental compost consultant; the qualitative rating is:

Total Nitrogen and Organic-Nitrogen	Good
Phosphorous	Good
Potassium	Good
Sodium	Fair
Calcium	Poor
Magnesium	Poor
Ammonium	Good
Chloride	Good
Sulfate	Good
Cation Exchange Capacity	Excellent

Table E-2
Summary Mass Balance on Test Process

Category	Weight in Pounds/(%)
Less than 4-inch fraction screened at Varick Avenue and shipped to the Bedminster facility[1] / (MSW share)	90,280 / (62.6%)
Wastewater biosolids added to waste[1] / (biosolids share)	54,000 / (37.4%)
Total inputs: < 4-inch organics and biosolids	144,280 / (100%)
Moisture ***loss*** from drying post-drum processed material prior to screening[2]	10,000 / (6.9%)
Greater than 1.5-inch material screened as residue at the Sevierville facility[3]	24,000 / (16.6%)
Material shipped to Rikers Island for composting and curing	110,280 / 76.4%
Estimated and rounded components of 110,280 lbs. shipped to Rikers:	
Est. ***losses*** in composting process due to moisture[4]	50,620
Est. ***losses*** in composting due to decomposition[5]	15,440
Est. inerts in finished compost[6]	18,330
Est. ***finished compost***[7]	25,890
Proportioning *all* ***losses*** and ***compost product*** based on input share:	
MSW share of losses and compost from material shipped to Rikers	57,560
MSW share of pre-shipment loss, standardized for moisture [8]	2,000
Total organic mixed waste from MSW diverted, including allocated moisture losses and decomposition	59,560

Notes:

[1] The reported moisture content of the sludge (biosolids) used in the test was 70.4%. The calculated moisture content of the < 4-inch organics was 70.5%, taking into account moisture content out of the digester drum; the organics share of total input into the drum; and moisture loss across the drum.

[2] After processing in the drum, the material was dried over a two-day period. The moisture loss during the drying period is based on sample analysis from the interior of the compost pile.

[3] Quantities as provided in the Compostable Test Report.

[4] Calculated using data provided in the Compostable Test Report. Percent moisture of material out of the digester was an average of 67.4%. The average moisture of the interior compost pile was 21.5%.

[5] Data provided in the Woods End Laboratory report. Carbon loss rate on average was 5.6 lbs./ton.

[6] Measured inert material by weight in eight samples tested by Woods End Laboratory was 51% on a dry weight basis. Moisture of the material sampled (that is, material shipped to Rikers out of the digestor) was 67.4%; therefore dry weight was 32.6%. Thus, total estimated inerts = 51% x (32.6% x 110,280), or 18,330.

[7] Estimated balance of compost material net of losses and residue.

[8] Post-drum drying loss (10,000) standardized as other losses (based on percent moisture of material out of the digester at 67.4% and average moisture of the interior compost pile at 21.5%).

Table E-3
Summary Of Composting Facility Capital Cost

	Compost Facility	Annual Costs
Site Size (acres)	17	
Construction Capital Cost	19,200,614	3,029,253
Sitework	1,138,383	149,668
Processing Building	17,614,151	2,315,799
Other Support Facilities	448,080	58,911
Equipment Capital Cost	$21,072,000	$2,864,707
Composting Facility Equipment	$19,664,000	$2,630,509
Lab. Equipment	$400,000	$82,162
Conveyors	$804,000	$105,705
Air Compressor System	$200,000	$26,295
Digesters	$17,500,000	$2,300,791
Trommel	$260,000	$34,183
Agitator	$500,000	$81,373
Rolling Stock Capital Cost	$1,408,000	$234,198
Front-End Loader 950	$208,000	$33,851
Front-End Loader 988	$1,150,000	$187,157
Sweeper	$50,000	$13,190
Contingency (20% of Construction)	$3,840,123	$596,954
Subtotal of Construction Costs	**$23,040,737**	**$3,626,207**
Contingency (5% of Equipment)	$1,053,600	$143,235
Subtotal of Equipment Costs	**$22,125,600**	**$3,007,942**
Design/Engineering (8% of Construction)	$1,843,259	$242,340
Design Engineering (2% of Equipment) (3)	$393,280	$52,610
Permitting (5% of Construction)	$1,152,037	$151,463
Construction Monitoring (2% of Construction)	$460,815	$60,585
Surveying and Soils Report	$80,000	$10,518
Subtotal Capital Costs	$49,095,727	$6,554,711
Total Capital Cost (1)	**$53,514,343**	**$7,144,635**
Notes:		
(1) Includes Capitalized Interest during Construction and Project Development Phases.		

Table E-4
Summary Of Compost Facility O&M Cost

	1998 COST
Compost Facility Labor	$990,353
Equipment Maintenance	$768,600
Building And Site Maintenance	$2,860,790
Utilities - Building And Site	$885,000
Rolling Stock Fuel Costs	$400,200
Rolling Stock Operating And Maintenance Costs	$51,000
Subtotal Operation & Maintenance	**$5,955,944**
Administration And Profit (20%)	$1,191,189
Total Operation And Maintenance	**$7,147,132**