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Introduction

In 2001 the Pennsylvania Department of Environmental Protection (DEP) retained R.W. Beck to perform a State-wide municipal solid waste (MSW) characterization study to better understand the composition of solid waste being disposed in Pennsylvania. The study was designed to estimate the composition of disposed MSW generated in the Commonwealth's six regions, as well as the State-wide aggregate composition. Understanding the quantity of recoverable materials remaining in the municipal waste stream will enable the Commonwealth to develop programs to target the diversion or recovery of these materials.

Project Objectives

Successful completion of the Pennsylvania Municipal Waste Composition Study has provided extensive solid waste and recycling planning data for use across the Commonwealth. Specifically, the project helps the Commonwealth meet the following objectives:

- Evaluate and validate County-level MSW disposal estimates currently compiled by DEP on an annual basis;
- Determine the aggregate composition of the Commonwealth's disposed MSW stream, as well as the composition of MSW in each of its six regions,
- For each region and for the Commonwealth as a whole, differentiate MSW composition from the residential and commercial generating sectors;
- For each region and for the Commonwealth as a whole, differentiate MSW composition from urban, suburban and rural areas;
- Provide additional insight into the composition of self-haul waste across the Commonwealth;
- Provide additional insight into the composition of roll-off box MSW across the Commonwealth; and
- Estimate the amount and composition of packaging versus non-packaging material in the Commonwealth's disposed MSW stream.

By meeting the objectives listed above, the 2001 Study provides data for use by solid waste and recycling planners in DEP and each of the Commonwealth's 67 counties and over 2,500 incorporated municipalities. Solid waste planners are better able to measure the effectiveness of current solid waste diversion programs, identify specific sub-sectors of the municipal solid waste stream that may be targeted for future recycling or diversion programs, and, if necessary, design future solid waste management facilities to process the solid waste stream. Each of these outcomes is

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beneficial as the Commonwealth seeks additional municipal solid waste diversion opportunities that may be needed to maintain and exceed a 35 percent recycling rate.

Demographic Overview

Pennsylvania, the nation's 6th most populous state, spans a land area of almost 45,000 square miles. In 2000, Pennsylvania was home to 12.3 million people living in 5.2 million housing units with a mean annual household income of \$51,100. Pennsylvania is comprised of 67 counties that are subdivided into six DEP planning regions based on geographical location. The communities within Pennsylvania vary from urban metropolitan areas such as Philadelphia and industrial centers such as Pittsburgh, through suburban regions outlying cities across the Commonwealth, down to thousands of small rural boroughs and townships that make up the majority of the Commonwealth's land area.

Table 1 presents the breakdown of Pennsylvania's 2,579 communities by region and by demographic origin (urban, suburban and rural). As shown, the majority of municipalities in the Commonwealth—almost 75 percent—are rural communities.

Table 1 Community Demographic Summary

Region	Number of Communities				Percent of Total
	Urban	Suburban	Rural	Total	
Northeast	6	94	293	393	15.2%
Northcentral	2	15	408	425	16.5%
Northwest	2	26	363	391	15.2%
Southeast	2	165	72	239	9.3%
Southcentral	5	108	437	550	21.3%
Southwest	4	254	323	581	22.5%
State Totals	21	662	1,896	2,579	100.0%
Pct. of total	0.8%	25.7%	73.5%	100.0%	

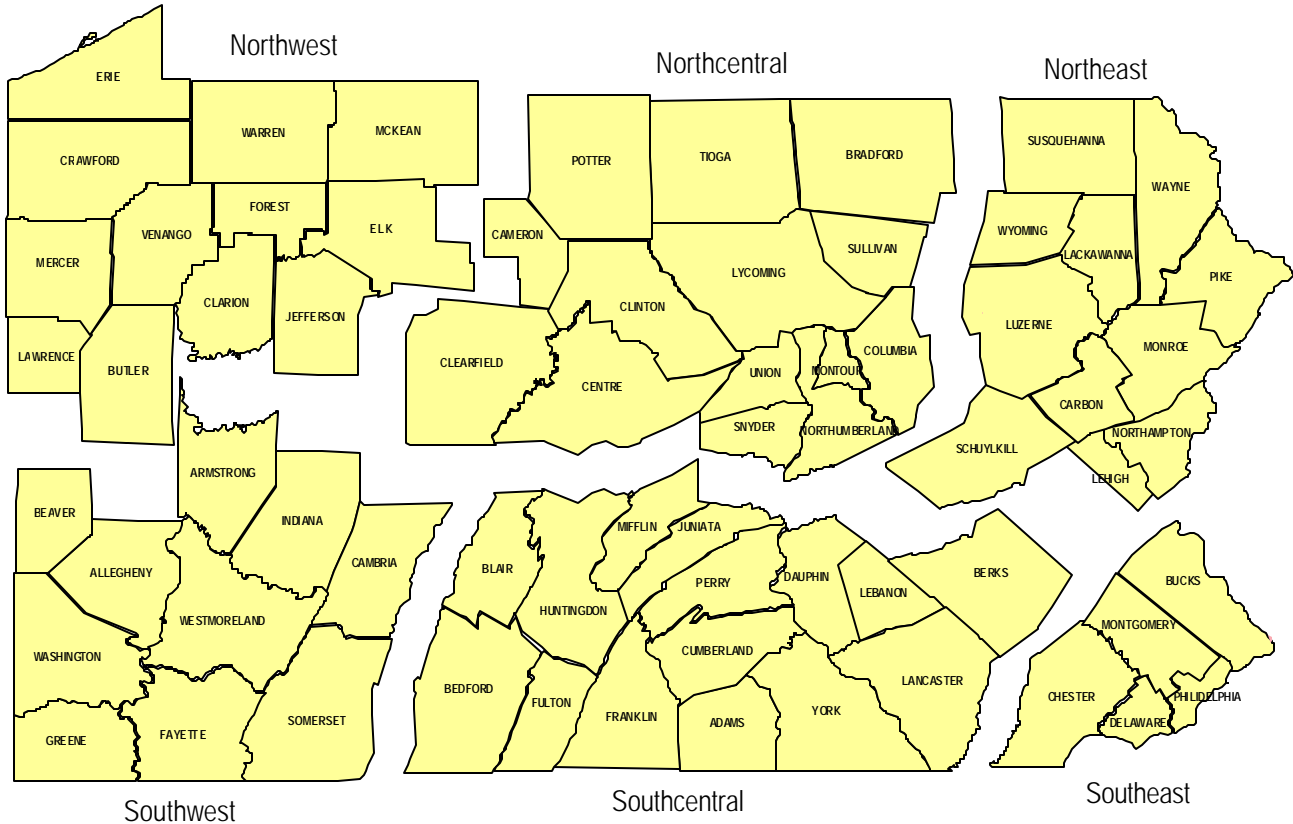
Table 2 presents a breakdown by population. Although most of the communities are rural, Pennsylvania’s population is more evenly divided across urban, suburban and rural areas. By population, almost 45 percent of Pennsylvania residents reside in suburban areas, followed by rural areas and urban areas. It is of interest to note that although there are only 21 urban municipalities in the Commonwealth, 22 percent of Pennsylvania’s population resides in these communities.

Table 2 Population Summary

Region	Population				Percent of Total
	Urban	Suburban	Rural	Total	
Northeast	323,762	589,788	710,318	1,623,868	13.2%
Northcentral	69,126	107,815	591,014	767,955	6.3%
Northwest	120,045	251,667	663,635	1,035,347	8.4%
Southeast	1,539,409	2,042,782	267,456	3,849,647	31.3%
Southcentral	276,890	926,053	1,181,392	2,384,335	19.4%
Southwest	391,178	1,540,325	688,399	2,619,902	21.3%
State Totals	2,720,410	5,458,430	4,102,214	12,281,054	100.0%
Pct. of total	22.2%	44.4%	33.4%	100.0%	

Figure 1 illustrates the geographic breakdown of the Commonwealth's six regions.

Figure 1 Pennsylvania Regions



Waste Generating Sectors and Disposal Quantities

This study sought to independently estimate the composition of disposed MSW from the following two generating sectors:

- **Residential Waste** – Solid waste collected by public or private haulers from single-family or multi-family residential dwellings; and
- **Commercial Waste** – Solid waste collected by public or private haulers from any non-residential source, such as offices, restaurants, retail establishments, malls, institutions, warehouses, hotels, etc.

For the purposes of this study, we have relied on landfilled and processed/incinerated material quantities that have been reported by the State's landfills and waste-to-energy facilities (Facility Reports). All Pennsylvania facilities permitted to handle MSW report landfilled/processed material receipts to the Division of Reporting and Fee

Collection on a quarterly basis. Materials are reported by county of origin. The Facility Reports database captured 9.3 million tons of MSW reported to be disposed in 2001.

Table 3 Summarizes the MSW reported to be disposed by region of origin in 2001.

Table 3 Regional MSW Disposal Quantities (Tons)

Region	MSW Tons
Northeast	1,281,588
Northcentral	469,179
Northwest	537,144
Southeast	3,572,730
Southcentral	1,636,192
Southwest	1,872,249
State Totals	9,369,082

Waste composition data has been collected for this study by region, by demographic origin, and by generating sector. For the purpose of aggregating waste composition data from these substreams into regional and state-wide averages, we relied on waste generation indicators. Waste generation indicators—such as population, employment, and number of households—combined with average municipal waste disposal rates collected from communities delivering their waste to facilities that hosted sorting events for this study were used to allocate the Commonwealth’s total disposed waste stream into region, demographic area, and generating sector of origin. Table 4 summarizes this breakdown.

Table 4 Origin of Disposed MSW in Pennsylvania

Measure	Demographic Origin	Generating Sector Origin		
		Residential	Commercial	Total
Percentage	Urban	10.4%	16.7%	27.1%
	Suburban	26.2%	19.1%	45.3%
	Rural	17.6%	10.0%	27.6%
	Total	54.3%	45.7%	100.0%
Absolute Quantities [1]	Urban	976,187	1,564,279	2,540,466
	Suburban	2,459,299	1,785,064	4,244,363
	Rural	1,647,857	936,396	2,584,253
	Total	5,083,343	4,285,739	9,369,082

[1] Based on 2001 disposed MSW quantities as reported in Facility Reports.

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The following observations can be made about the analysis shown in Table 4.

- **Generating Sector Origin:** Based on the methodology used to allocate State-wide disposed MSW totals, we estimate that approximately 54 percent of the Commonwealth's disposed municipal waste comes from residential generators, with 46 percent from commercial generators. This breakdown is in line with other composition and generation studies across the country that have attempted to evaluate the split between residential and commercial waste. Note that these numbers are estimates only, and that there are sources of both statistical and data-source error inherent in the estimates.
- **Demographic Origin:** Almost one half of the Commonwealth's disposed municipal waste stream comes from regions within the Commonwealth that are classified as suburban. Interestingly, almost equal quantities of waste come from urban areas and rural areas.
- **Residential Waste Origin:** Within the residential generating sector, the majority of waste again comes from suburban demographic areas. However, a significantly greater fraction of residential waste comes from the Commonwealth's rural areas as compared to urban areas.
- **Commercial Waste Origin:** Within the commercial generating sector, there is almost as much waste originating in urban areas as from suburban areas, with rural commercial waste trailing behind.

Based on available data from other regions of the country, we believe the 54/46 percent residential/commercial split is within ranges reported in other generation and composition studies across the country that have evaluated such a split.

Methodology

This section discusses the representativeness and breadth of sampling that took place for this study. A total of 1,634 samples were ultimately taken. These samples, collected over a twelve-month period, were intended to be representative of all of the waste disposed in the Commonwealth. Sample distribution and representativeness are discussed below.

Seasonality

It was important that the annual aggregate results reflected seasonal distribution of samples. Sampling was therefore distributed across all four seasons over a one-year time-frame. Table 5 summarizes the sort dates and samples taken by season.

Table 5 Seasonal Field Data Collection Schedule

Season	Sort Dates	Number of Samples		
		Physical	Visual	Total
Summer	July 16- September 3, 2001	286	103	389
Fall	September 24- November 16, 2001	290	122	412
Winter	January 7- March 15, 2002	298	113	411
Spring	April 1- June 17, 2002	311	111	422
Totals		1,185	449	1,634

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Regional Distribution

Significant sampling was performed in all six regions of the Commonwealth. A total of 13 facilities ultimately hosted at least one week of field sampling and sorting, with the majority of the facilities hosting two weeks of sorting. Table 6 summarizes the facilities that hosted field sorting, as well as the seasons in which sorting occurred, the origin of waste, and the number of samples taken.

Table 6 Host Facility Summary

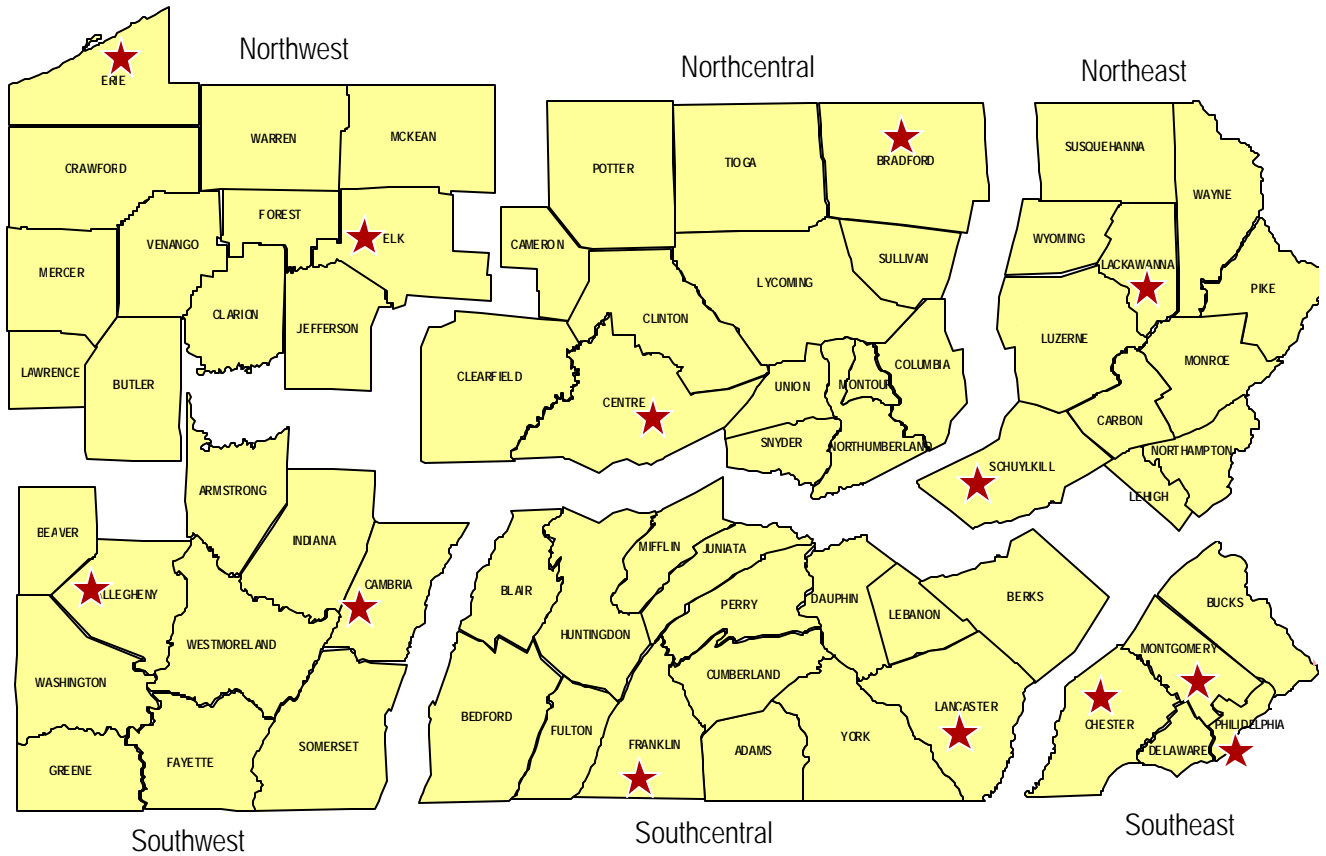
Region	Facility	Seasons of Sorting				Targeted Demographic Area(s) [1]	Samples Taken [2]
		Sum	Fall	Win	Spr		
Northeast	Keystone Landfill	✓		✓		U, S, R	129
	Commonwealth Environmental Systems (CES) Landfill		✓		✓	S, R	125
Northcentral	Centre County Solid Waste Authority Transfer Station	✓		✓	✓	U, S, R	195
	Bradford County Landfill		✓			R	57
Northwest	Superior Greentree Landfill	✓		✓		R	132
	Lake View Landfill		✓		✓	U, S, R	141
Southeast	Montgomery/Montenay RRF	✓				S	45
	TRC Transfer Station		✓		✓	U	104
	Chester County Landfill			✓	✓	S, R	123
Southcentral	Lancaster RRF	✓		✓		U, S, R	153
	Mountainview Landfill		✓		✓	S, R	153
Southwest	Laurel Highlands Landfill	✓		✓		U, S, R	139
	Imperial Landfill		✓		✓	U, S, R	138
Totals							1,634

[1] Key: U=urban, S=suburban, R=rural

[2] Includes both physical and visual samples

Figure 2 shows the locations of the 13 facilities that hosted field sorting.

Figure 2 Location of Host Facilities



Generating Sector Detail

To provide the greatest insight into the field sampling and sorting effort, the following types of incoming loads of MSW were differentiated in the study:

- Single family residential waste;
- Multifamily residential waste;
- Commercial waste;
- Self-haul waste; and
- Bulky/Roll-off waste.

These are described more fully in Section 3 of this report.

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Sampling and Sorting

Field data collection included three primary tasks:

- (1) Identifying and taking samples from targeted truckloads from the specified generating sectors and demographic areas;
- (2) Physically sorting or visually surveying each sample into the target material categories; and
- (3) Recording the weight (physical) or volume (visual) of sorted materials.

In addition to physically sorting most samples, an allowance was made to visually characterize samples that contained homogenous or primarily bulky items. A complete description of the sampling and sorting process is described more fully in Section 3 of this report.

Attainment of Targeted Samples

Overall, the original sampling plan targeted 1,224 physical samples and allowed up to 360 visual samples. Ultimately, the study obtained the targeted number of samples. However, after eliminating samples during the quality control process, 1,185 physical samples and 449 visual samples were ultimately retained for the analysis. This represents 97 percent of the targeted physical samples, and over 100 percent of the expected visual samples. As described below, these samples were distributed across the seasons, regions, generating sectors, and demographic areas targeted in the study.

Table 7 summarizes the distribution of samples compared to the study targets. As shown, 97 percent of the targeted physical samples and 125 percent of visual samples were ultimately obtained.

Table 7 Comparison of Targeted Vs Actual Samples by Demographic Area and Generating Sector

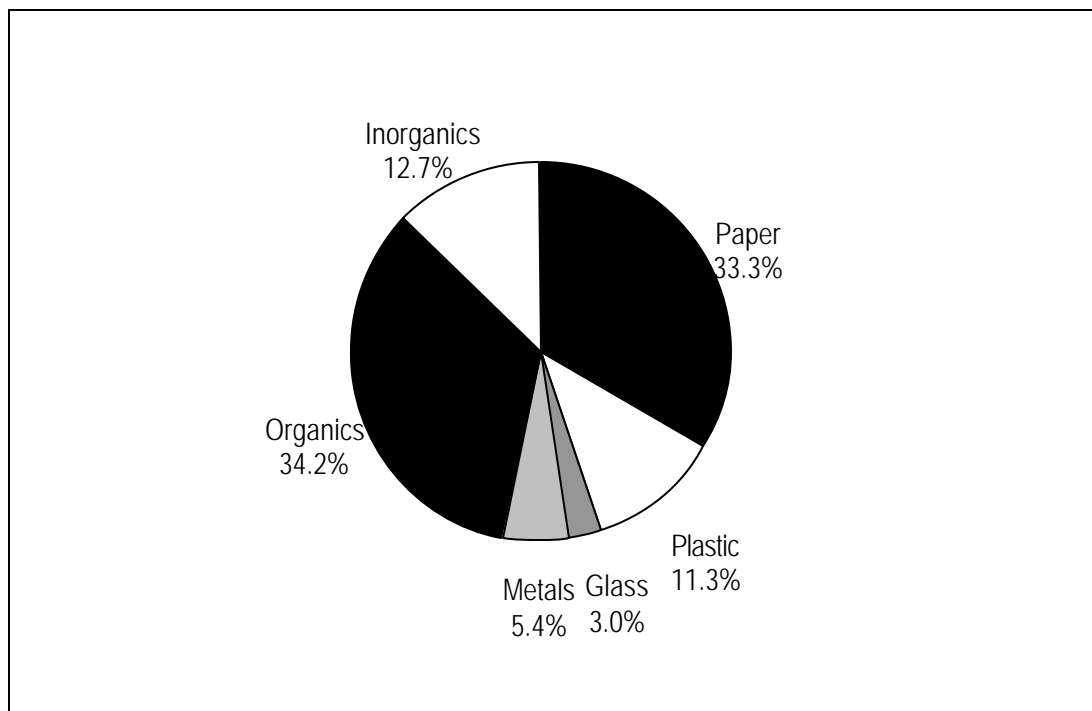
Region	Physically Sorted Samples			Visual Samples		
	Targeted	Actual	Coverage	Allotted [1]	Actual	Coverage
Urban	408	362	89%	120	136	113%
Suburban	408	386	95%	120	134	112%
Rural	408	437	107%	120	179	149%
Total	1,224	1,185	97%	360	449	125%
Residential	612	630	103%	180	131	73%
Commercial	612	555	91%	180	318	177%
Total	1,224	1,185	97%	360	449	125%

State-wide Aggregate Results

Results of the Pennsylvania Municipal Waste Composition Study were developed by aggregating individual sort results across demographic areas, generating sectors, and regions. Section 4 of this report contains detailed results about the composition of Pennsylvania's disposed MSW. Selected findings are presented below.

Figure 3 shows the breakdown of disposed MSW in Pennsylvania by major material group. As shown, Organics and Paper make up the largest fractions of the waste stream, followed by Inorganics, Plastic, Metals and Glass. This overall breakdown tracks with the composition of waste in most other areas of the country.

Figure 3 Pennsylvania State-wide Aggregate Disposed MSW Composition



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Figure 4 shows a bar graph of the actual tons of Pennsylvania MSW that are estimated to be disposed in the State's landfills (based on 2001 facility reports). In absolute terms, over 3.2 million tons of Organics and 3.1 million tons of Paper were disposed in 2001.

Figure 4 Pennsylvania State-wide Aggregate MSW Tons Disposed

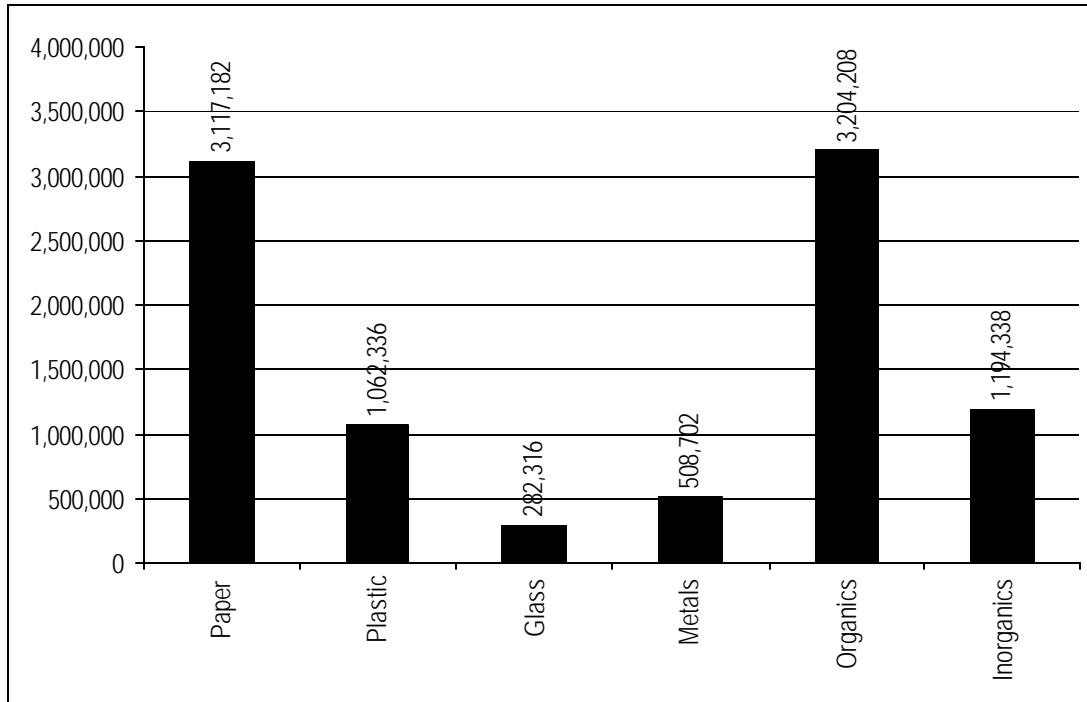
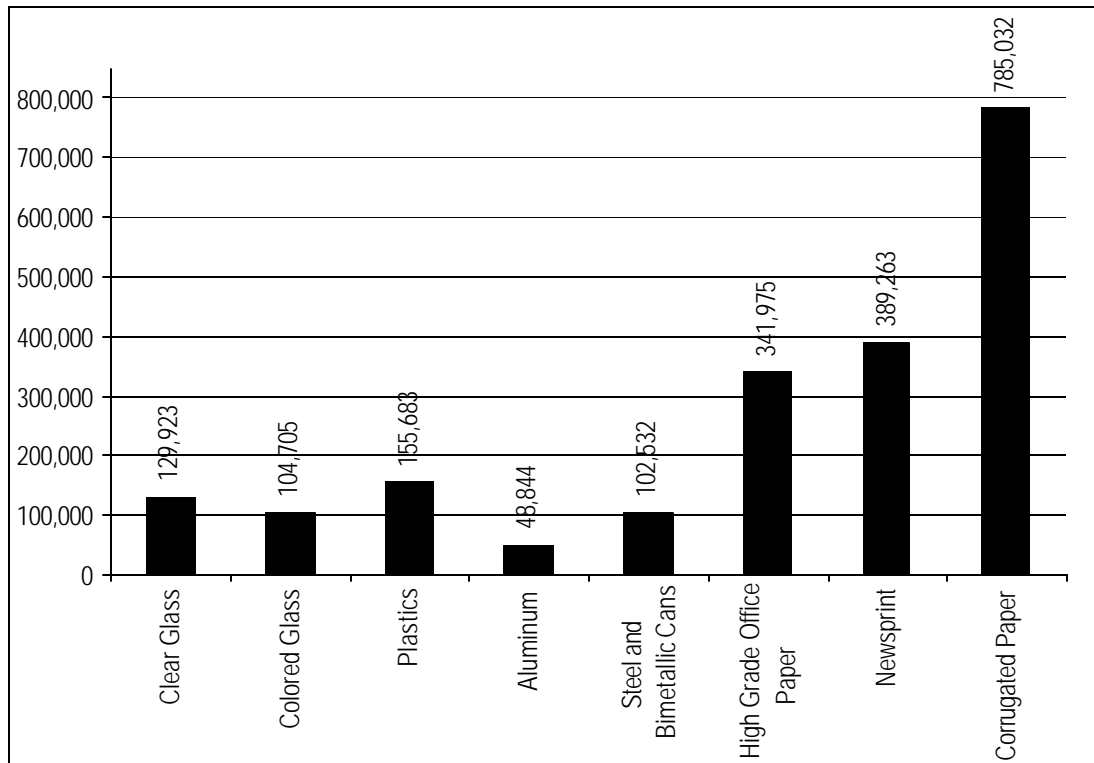


Figure 5 focuses on the quantity of Act 101-specified materials that were disposed. As shown, Corrugated Cardboard, Newspaper, and even High Grade Office Paper were found to be disposed in significant quantities in Pennsylvania, with recyclable containers at relatively lower disposal rates. This suggests that the residential recycling programs that target containers and some paper grades have been successful in recycling many of these materials prior to disposal. However, Corrugated Cardboard and High Grade Paper, which are predominantly generated in the commercial generating sector, appear to remain in the disposed municipal waste stream and could be targeted for future diversion.

Figure 5 Act 101 Recyclables in Disposed MSW



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Figure 6 lists the top ten individual materials that were most prevalent in the State-wide disposed municipal waste stream. State-wide, Food Waste makes up the largest fraction of disposed waste at 12.0 percent, followed closely by Non-recyclable Paper (9.3 percent), Corrugated Cardboard (8.4 percent), Unpainted Wood (5.8 percent) and Film Plastic (5.0 percent). No other materials make up more than 4.8 percent of the State-wide waste stream. The top ten most prevalent materials make up 61.7 percent of the disposed municipal waste stream.

Figure 6 Top Ten Most Prevalent Materials Disposed in Pennsylvania

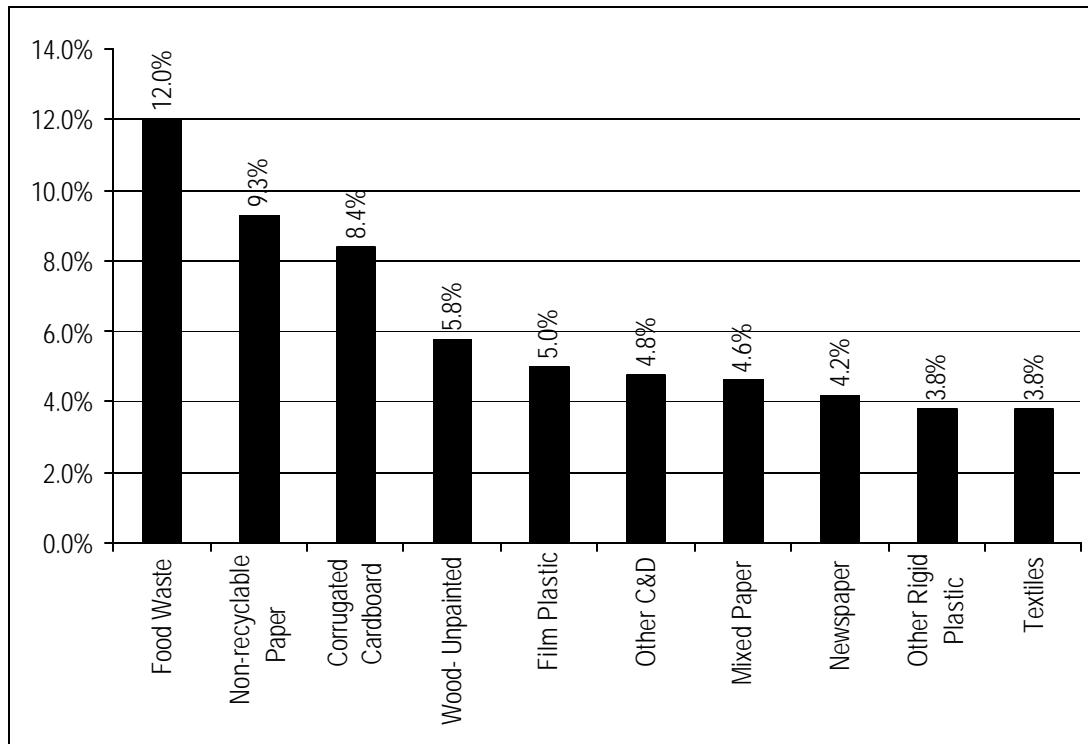
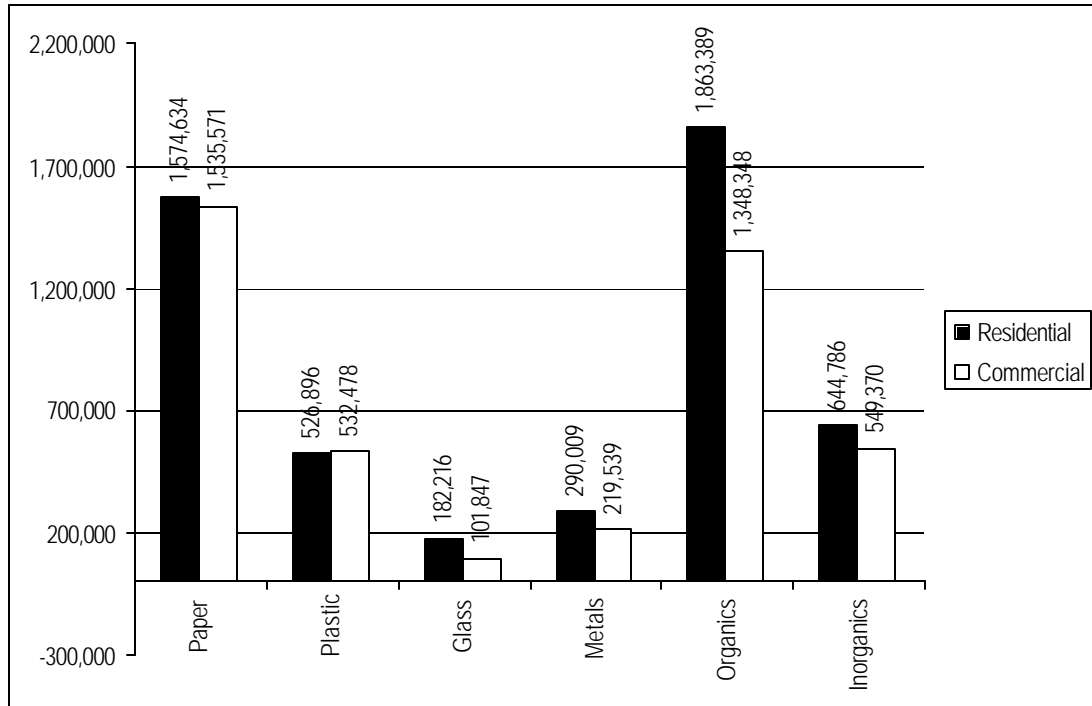


Figure 7 compares the actual tons disposed from each generating sector (based on an allocation of 2001 facility reports). Note that some of the difference between residential and commercial waste quantities is due to there being more residential waste in the disposed municipal waste stream State-wide.

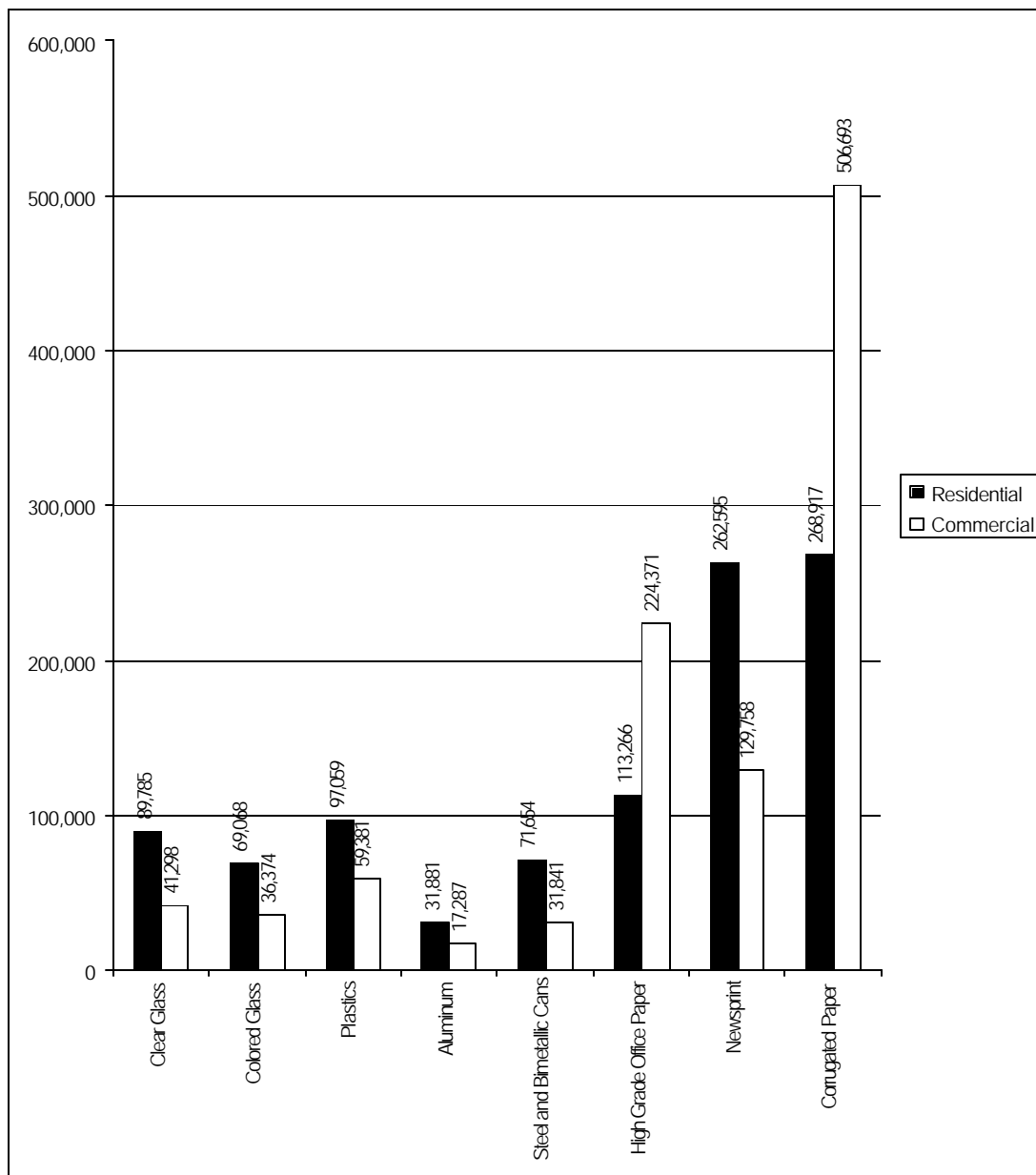
Figure 7 Residential and Commercial Aggregate Tons Disposed



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Figure 8 compares the quantity of materials defined in Act 101 that are being disposed from the residential and commercial waste streams. Note that the recyclable containers typically associated with residential recycling programs are being disposed in relatively small quantities. Only newspaper, which is also commonly collected in residential recycling programs, appears to be getting disposed in large quantities. Interestingly, the most commonly disposed material defined in Act 101—corrugated cardboard—is primarily coming from the commercial sector. This is also the case for high grade office paper. Such findings suggest that additional diversion opportunities exist for these materials in the commercial sector.

Figure 8 Act 101 Recyclables Disposed, by Generating Sector



Figures 9 and 10 divide the disposed municipal waste stream by demographic origin. Figure 9 compares the composition of urban, suburban, and rural residential waste by major material group. It is of interest to note that urban areas have the lowest percentage of paper, plastic, glass, and metals. Although beyond the scope of this study to determine the cause, it is likely that the State’s residential recycling programs—which are more extensive in urban and suburban areas—are diverting more of these wastes in urban and suburban areas compared to rural areas. Figure 10 shows an opposite trend in terms of the percentage of paper, plastic, and glass being disposed. Disposed fractions of these materials are higher in urban areas and lower in rural areas.

Figure 9 Landfilled Residential Waste Composition by Demographic Origin

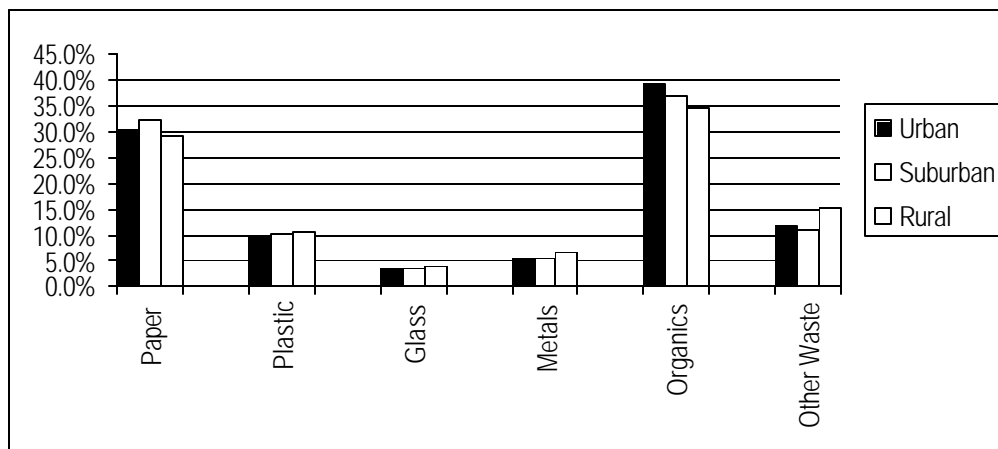
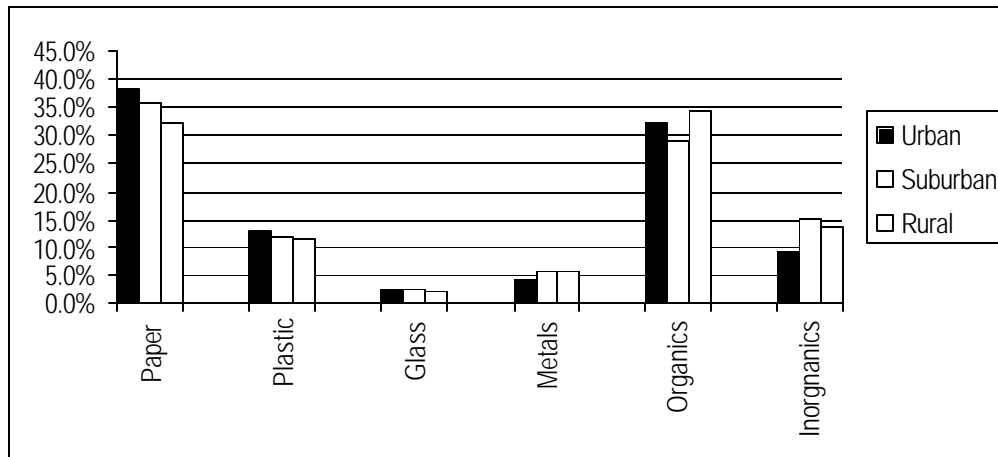


Figure 10 Landfilled Commercial Waste Composition by Demographic Origin



Complete State-wide sort results can be found in Section 4 of this report. Results by region can be found in Sections 6 through 11 if this report.

Packaging Analysis

Packaging and packaging materials make up a large fraction of the disposed MSW in Pennsylvania and across the country. To further evaluate the prevalence of packaging components in the disposed municipal waste stream, a packaging analysis was performed during the winter season of sorting. During all six weeks of sorting that took place during the winter season, all physical samples were divided into the 37 targeted material categories, and then split between packaging and non-packaging within each material category. Based on the 298 physically sorted samples taken in the winter season, a total of 19 material categories were found to contain at least some packaging or packaging components.

Figure 11 shows a pie chart of the composition of residential waste by major material group. As shown, roughly one-quarter (24.4 percent) of the disposed residential waste stream was found to be made up of packaging and packaging components. The top five packaging components in residential waste were found to be corrugated cardboard (5.7 percent), non-recyclable paper (2.6 percent), recyclable paper (2.3 percent), film plastic (2.2 percent), and steel cans (1.7 percent).

Figure 11 Packaging Composition of Residential Waste

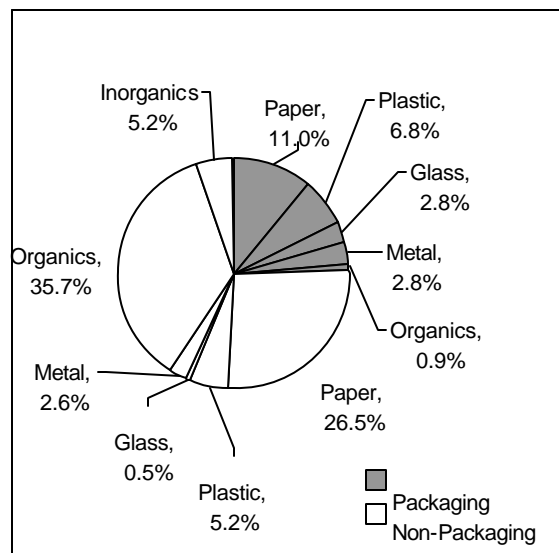
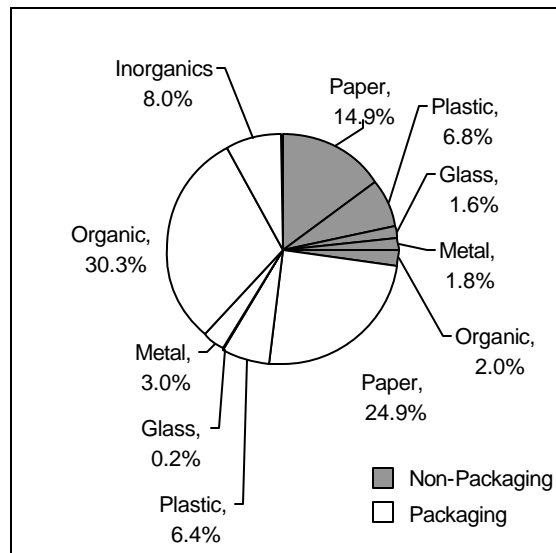


Figure 12 shows a pie chart of the composition of commercial waste by major material group. As shown, there was slightly more packaging in the commercial disposed waste stream (27.1 percent) compared to the residential stream. The top five most prevalent packaging components in the commercial waste stream were corrugated cardboard (11.2 percent), film plastic (2.1 percent), non-recyclable paper (1.9 percent), unpainted wood (1.7 percent), and other rigid plastic (1.6 percent).

Figure 12 Packaging Composition of Commercial Waste



Section 5 of this report contains additional details about the prevalence of packaging and packaging components in Pennsylvania's disposed municipal waste stream.

Availability of Data

The body of this report contains a wealth of information on the amounts and composition of disposed MSW generated in Pennsylvania. However, it is recognized that the value of this project will be optimized if the findings of the study can be made readily and electronically available to Pennsylvania's solid waste stakeholders.

Accordingly, DEP has provided additional options for interested parties to obtain and manipulate the municipal waste composition data compiled in this study. Subsequent to the delivery of this report, the following products will be generated and made available to interested parties across the Commonwealth:

- **Educational Video:** Details of the sampling and sorting process have been captured and will be published in an educational video. The video will provide an overview of the project, footage of the actual sampling and sorting, and summary state-wide aggregate results.
- **Waste Composition Computer Model:** This study captured over 1,600 samples of disposed MSW from across the Commonwealth. Although this report presents a

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wide range of composition estimates by region, by demographic origin, and by generating sector, there may be solid waste and recycling planners who desire a more local view of their waste stream. To maximize the ability of interested stakeholders to view and download composition data that is applicable to their municipality, county or region, this project will also entail development of an Internet-based computer model to provide customized composition estimates. The computer model will apply regression analysis to a range of waste disposal indicators—such as solid waste program characteristics, population and employment—to estimate local municipal waste composition anywhere in the Commonwealth.

These work products are currently under development and will be available to the Commonwealth at the conclusion of the project.

Conclusion

The 2001 Pennsylvania Municipal Waste Composition Study provides comprehensive information about the composition and quantities of the Commonwealth's disposed municipal solid waste. This study places Pennsylvania at the forefront of the nation in terms of better understanding and managing solid waste. The information contained in the remainder of this report will be useful to solid waste and recycling planners throughout the State.

Complete details of the study background, methodology, State-wide results, and region-specific results are contained in the body of the report.