Waste Stream Study
&
Waste Conversion Technologies Review

FINAL DRAFT

Presented to

City of Fort Collins

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1.0 INTRODUCTION

1.1 BACKGROUND

The City of Fort Collins (City) engaged the services of Sloan Vazquez and Clements Environmental (Project Team) to conduct a Waste Stream Study and a Waste Conversion Technologies Review. The purpose of the Waste Stream Study was to determine how much more of the City's waste that is now going to a landfill can be diverted towards materials markets or to potential energy conversion systems. The purpose of the Waste Conversion Technologies Review was to identify at least two of the most feasible types of systems or technologies in which the City may wish to invest for future waste stream management.

Accordingly, this Report provides the following:

- Identification of specific discards from the residential, commercial and Construction and Demolition (C&D) sectors that are still available for recovery and quantification of their commodity value and/or energy generation capability;
- An economic analysis of how to optimize the recovery of the landfill-disposed materials and professional recommendations for "highest and best" use in current or future recovery systems;
- Quantification of the total amount of discarded or under-utilized materials that is locally available, which may provide "feedstock" for a waste-to-energy processing facility.
- Examination of options for various technologies designed to capture more value from discards.

It is important to note that any references to specific products, systems, or companies in this report are for factual purposes only and are not intended to represent an endorsement by the City of Fort Collins.

1.2 REPORT STRUCTURE

This Report is organized as follows:

1. Introduction
2. Waste Stream Study
3. Waste Conversion Technologies Review
4. Recommendations

Section 1 provides an introduction to the report with a brief background and purpose. Section 2 includes a waste stream study including an estimate of tonnage, a waste composition, and the value of materials currently discarded. Section 3 includes the identification of the most feasible waste conversion technologies. And finally, Section 4 provides a summary of the Project Team's Recommendations.

2.0 WASTE STREAM STUDY

In order to plan for the City's future municipal solid waste (MSW) management needs, it is important that the City understand both the volume and the composition of MSW that is currently being disposed in landfills.

For solid waste planning to be effective, consideration must be given to the many factors that can, and do, cause wide fluctuations in the volume and composition of MSW. During the past five years, the economic recession and the collapse of the housing and construction industries has rendered a decrease in the volume of MSW and caused extraordinary demand and price fluctuations in the recycling markets. Concurrent with the economic decline, the U.S. has seen a rising "green" ethos that has spurred the success of municipal recycling programs, changed manufacturing practices, and reduced consumption. This combination of events has made the forecasting of MSW volume and composition a tricky, albeit achievable, task.

2.1 WASTE COMPOSITION STUDY APPROACH

The Project Team developed a new, data-based waste composition (2012 Waste Composition) of the waste generated from the City that is currently landfilled. The 2012 Waste Composition is based primarily upon waste composition studies prepared for the Boulder County Resource Conservation Division and for Larimer County. In addition, the Project Team referred to tonnage data collected by the City, anecdotal information gathered from Larimer County Public Works/Solid Waste (including the observation of loads disposed at the Larimer County Landfill), local waste collection companies, and recyclers.

Our analysis and interpretation of the methods and results of the Boulder and Larimer County studies confirmed their validity as reasonable and reliable sources for the development of a new data-based waste composition for the City. In the Boulder and Larimer County studies, the Project Team determined that the sampling plans, sampling procedures, field data collection, and statistical analysis were developed and implemented to assure that the waste composition results were statistically representative of the total disposed waste stream and statistically valid.

The 2012 Waste Composition is primarily derived from the integration of the two heterogeneous data sources. The Larimer County study was completed pre-recession (in 2007) and is primarily based upon 2006 data. The Boulder County study was completed in 2010 and captures the effects of waste generation and composition wrought by changing economic and environmental conditions. Because the communities share many similar geographic, demographic, and economic characteristics, the methodical combination of results from the two studies projects a reasonable waste composition for City's planning purposes. A detailed explanation of the methodology used to develop the City's waste composition is provided in Appendix A. The Boulder and Larimer County studies are included as Appendix B.

2.2 WASTE STREAM STUDY RESULTS

The 2012 Waste Composition for the City is presented in Table 1 as well as in Chart 1. The waste is categorized into 14 material types. A percentage of total waste is provided by material type for each waste stream i.e. residential, commercial, and C&D as well as for the total waste.

Table 1 – Fort Collins 2012 Waste Composition*

Material	Residential	Commercial	C&D	Total	Tons
Paper	20.39%	26.67%	0.38%	16.66%	21,658
Plastics	12.31%	12.29%	0.45%	9.13%	11,869
Metal	3.54%	5.24%	2.17%	3.61%	4,693
Glass	2.34%	2.79%	1.18%	2.14%	2,782
Organics	40.12%	33.40%	5.08%	28.99%	37,687
Rock/Concrete/Brick	0.85%	1.26%	31.22%	9.10%	11,830
Asphalt Shingles	0.49%	0.72%	18.02%	5.25%	6,825
Wood (Painted/Stained/Treated)	0.30%	0.44%	11.06%	3.22%	4,186
Untreated Dimensional Lumber	0.15%	0.21%	5.31%	1.55%	2,015
Clean/New Drywall	0.14%	0.20%	5.06%	1.47%	1,911
Demo/Painted Drywall	0.28%	0.42%	10.34%	3.01%	3,913
Problem Waste[1]	18.84%	15.94%	4.73%	14.31%	18,603
Other	0.19%	0.28%	4.98%	1.50%	1,950
Household Hazardous Waste	0.06%	0.13%	0.00%	0.06%	78
TOTAL	**100.0%**	**100.0%**	**100.00%**	**100.00%**	**130,000**

*Please see Appendix A for details regarding the methodology used to develop the 2012 Waste Composition.

According to data collected by the City, approximately 130,000 tons of municipal solid waste generated in the City were landfill disposed. Applying the 2010 Waste Composition to the City's landfilled tonnage produces the weights, in tons, of the specified material types as represented in Table 1, Column entitled Tons.

For the City's planning purposes, the Project Team chose to base recovery and recycling projections upon the treatment/processing of the commingled waste stream. That is, the direct processing and separation of mixed commercial, residential and industrial materials.

[1] Problem Waste includes Carpet/Padding, Batteries, Rubber, Tires, Diapers/Sanitary Products, Electronics, Furniture/Bulky Items, and Other Inorganics.

Chart 1 – Fort Collins 2012 Waste Composition

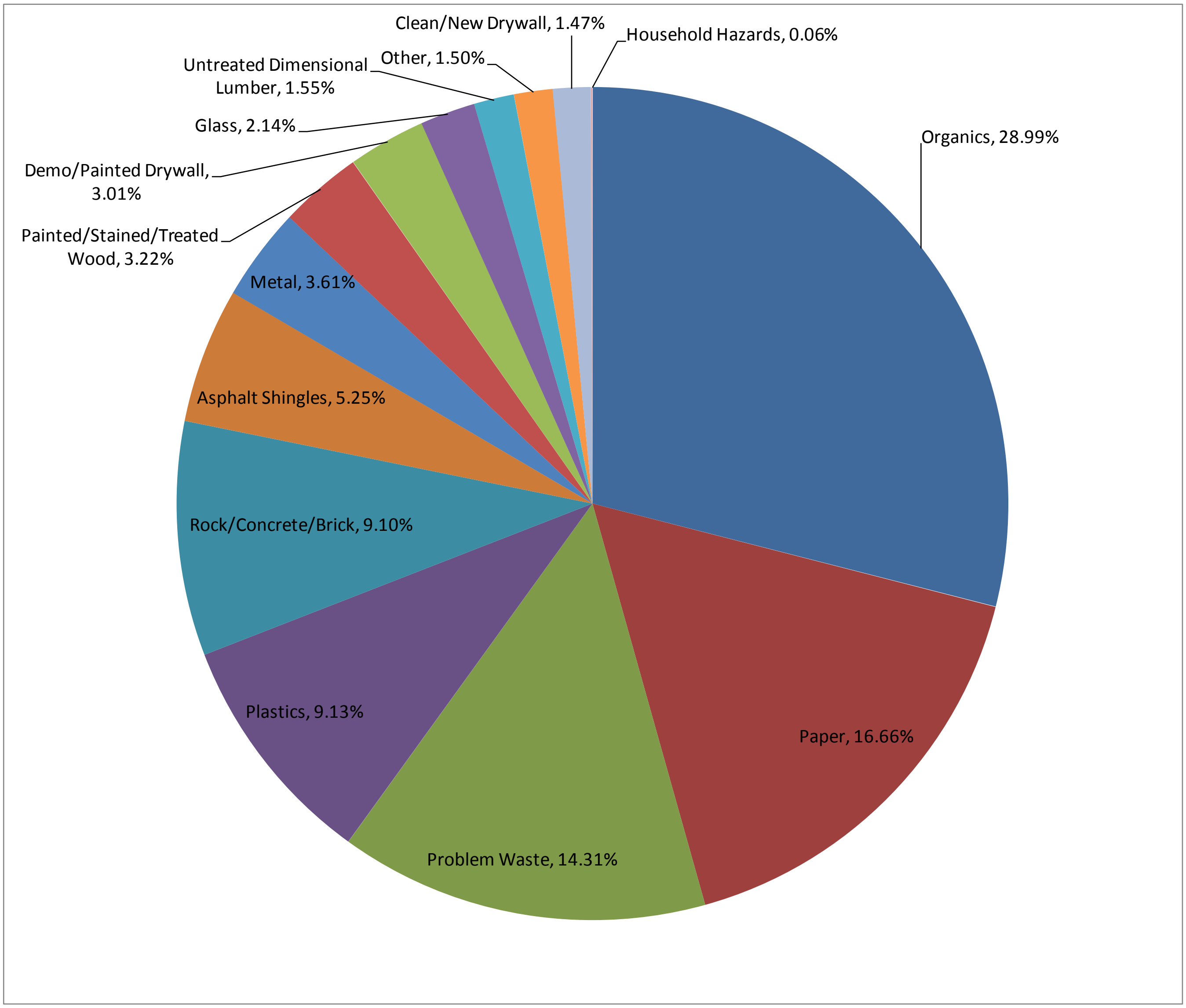
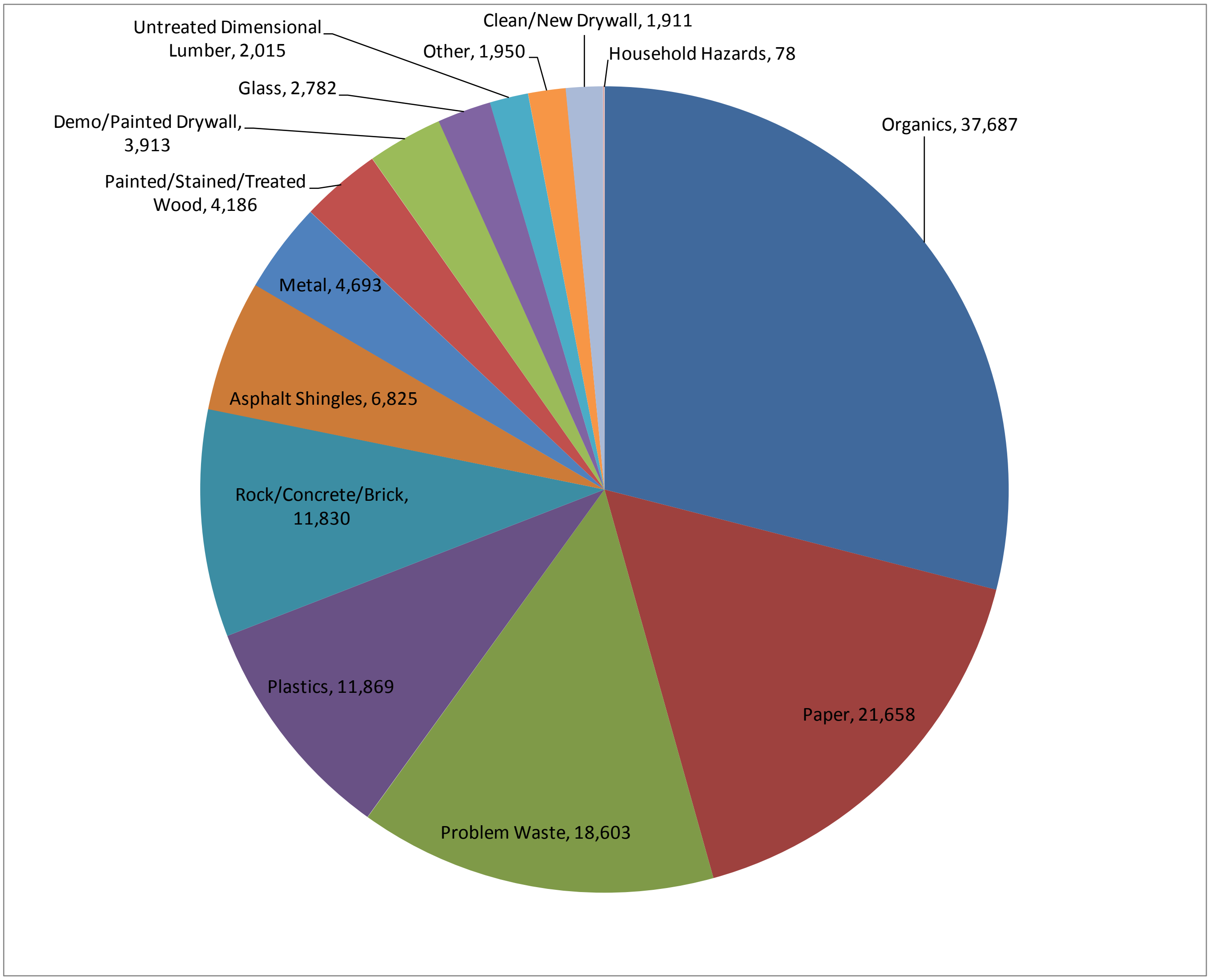


Chart 2 – Fort Collins Waste Tonnage by Material Category



2.3 MATERIAL STREAMS AND LANDFILL ALTERNATIVES

The 2012 Waste Composition identifies fourteen (14) material categories. At the onset of the study, only eight (8) categories were selected, with C&D material listed as a single-segment of the eight. Subsequently, because of the number of significant C&D subsets, the C&D segment was divided into six (6) separate categories which were included as separate components in the 2012 Waste Composition.

To accomplish the City's goal of reducing the amount of landfilled MSW, the Project Team developed an operating proforma for a conceptual waste/recycling management facility where the targeted materials and waste streams could be delivered, processed, and diverted from landfill disposal.

As conceived for the purpose of this study, the facility will process the mixed waste stream (see Table 2), into four categories, as follows:

1. Feedstock for waste conversion technology,
2. Marketable fiber, plastics, glass, and metals,
3. Compostable organic materials,
4. Items recovered for reuse.

The conceptual facility was designed for the practicable, economically feasible recovery, reuse, and recycling of the City's currently landfilled MSW. As conceived, the use of the facility, as applied to the 2012 Waste Composition, will reduce the City's landfilled waste from 130,000 tons per year to 52,600 tons per year and send 77,400 tons that is currently landfilled into productive uses, as shown in Table 2.

Table 2 –Recycling Facility Outputs

Landfill Alternatives	Tons	%
Waste/Energy Conversion	27,500	21.2%
Recycling Markets	27,850	21.4%
Compost/Organic Processes	12,000	9.2%
Reuse/Re-purpose	10,500	7.7%
TOTAL	**77,400**	**59.5%**

In summary, of the 130,000 annual tons disposed in landfills, 77,400 tons or 59.5% may be recovered, recycled or reused. The remaining 52,600 or 40.5% will be landfilled.

2.4 Market Value of Recyclable Materials that are Currently Landfilled

Of the fourteen (14) material categories identified in the 2012 Waste Composition, only four demonstrate a continuously positive market value. These four material types represented approximately 44% of the currently landfilled materials.

Table 3 – Landfilled Materials with Positive Market Value

Materials	%
Paper (cardboard, news, mixed paper, etc.)	16.66%
Plastics (soda, juice, water, milk bottles & film)	9.13%
Metals (aluminum & tin cans, ferrous & non-ferrous)	3.61%
Problem Wastes (including large appliances, metals)	14.31%
TOTAL	**43.71%**

Of the 130,000 tons that are currently disposed, the annualized market value of these four categories is $4,025,476[2].

Table 4 –
Annualized Estimate of Value for Positive Value Materials in Fort Collins' Waste Stream

Materials	Tons	Price/Ton	Value
Paper	16.66%	$100	$866,320
Plastics	9.13%	$300	$2,136,420
Metals	3.61%	$300	$985,530
Problem Waste	14.31%	$5	$37,206
TOTAL	**43.71%**		**$4,025,476**

Though these identified categories, percentages, and tonnage are realistic projections of the MSW content, the recovery and sale of 100% of these materials is improbable. Practicable recovery rates and values for all material categories are included in the financial proforma as described in Section 2.5.

2.5 Environmental and Economic Impacts of Landfill Disposal Reduction

In order to project the local economic impact of recycling and reusing the recoverable portion of the City's currently landfilled MSW, the Project Team developed a cost proforma to capture the capital and operating costs of a multiple-process system capable of processing the City's entire waste stream.

[2] The value of these commodities is a conservative estimate of market prices in January 2012 obtained by contacting local buyers whenever possible and from consulting Waste & Recycling News indices for the region.

Significant reduction in landfill disposal is not likely without significant investment in MSW management infrastructure, e.g. conversion technology, waste/recycling processing, etc.

2.5.1 MATERIAL RECOVERY FACILITY (MRF) PROCESS TO REDUCE LANDFILLED WASTE

As conceived in the cost proforma, the recycling processing plant will receive and process all of the City's 130,000 tons per year of MSW. The plant will process approximately 35 tons per hour, working two, eight-hour shifts in a five-day work-week, and processing about 500 tons per day. With the addition of a third shift, the facility has sufficient capacity to process tonnage currently going to other MRFs.

As presented in Table 5, the MRF will generate four primary outputs.

Table 5 – Volume Allocation of Recycling Facility Outputs

Material	Tons	CT(*)	Recycle(**)	Organics(+)	Reuse(++)	Recovered	Disposed
Paper	21,658	8,663	8,663	0	0	17,326	4,332
Plastics	11,869	0	7,121	0	0	7,121	4,748
Metal	4,693	0	3,285	0	0	3,285	1,408
Glass	2,782	0	835	0	566	1,391	1,391
Organics	37,687	18,844	0	9,422	0	28,265	9,422
Rock/Concrete/Brick	11,830	0	0	0	5,915	5,915	5,915
Asphalt Shingles	6,825	0	0	0	1,706	1,706	5,119
Wood (Painted/Stained/Treated)	4,186	0	0	0	0	0	4,186
Untreated Dimensional Lumber	2,015	0	0	1,612	0	1,612	403
Clean/New Drywall	1,911	0	0	956	0	956	956
Demo/Painted Drywall	3,913	0	0	0	0	0	3,913
Problem Waste[1]	18,603	0	7,441	0	1,860	9,302	9,302
Other	1,950	0	0	0	0	0	1,950
Household Hazardous Waste	78	0	0	0	0	0	78
TOTAL	130,000	27,507	27,833	11,989	10,038	77,367	52,633

NOTES:

- * CT – Conversion Technology
- ** Recycle – Traditional recyclables; paper, plastics, metals, etc.
- \+ Organics – Yard waste, tree trimmings, food waste, etc.
- ++ Reuse – Inert materials, appliances, etc.

Considering the current capabilities of solid waste recycling technology and mechanical systems, the following allocation of materials (as listed in Table 5) into value-added streams can be reasonably expected. Please note that these material had been destined to disposal at a landfill and therefore do not include materials that are currently being recycled.

Table 6 – % of Material Type Allocated to Landfill Alternative

Material	% Diverted to Landfill Alternative
Paper	40% into Energy production
	40% into secondary recycling markets
Plastics	60% into secondary recycling markets
Glass	30% into secondary recycling markets
	20% into reuse (e.g. pipe-bedding, trench drains, etc.
Organics	50% into Energy conversion technology
	25% into soil amendments and composting
Rock/Concrete	50% into reuse
Asphalt	25% into reuse
Treated Wood	Disposed
Lumber	80% into soil amendment and composting
Clean Drywall	50% into soil amendment and composting
Demo Drywall	Disposed
Problem Waste[1]	40% into secondary recycling markets
	10% into reuse
HHW	Disposed

2.5.2 Green House Gas Reduction from Landfill Disposal Reduction

According to the WARM Model Greenhouse Gas (GHG) Emission Analysis, the implementation of the processes to reduce landfill disposal will reduce total GHG emission.

The total GHG emission reductions are equivalent to the following:

- Removing annual emissions from **16,124** passenger vehicles
- Conserving **9,992,222** gallons of gasoline
- Conserving **36,679,783** cylinders of propane used for home barbeques
- Conserving **460** railway cars of coal

Please see Appendix C for the WARM Model Greenhouse Gas (GHG) Analysis.

2.5.3 Local Economic Impacts of Landfill Disposal Reduction

The development of local infrastructure to process the City's MSW, reduce landfill disposal, and create value-added recyclable outputs will produce the following:

a) $29,000,000 Capital Investment in local infrastructure
   - $7.5M Land & Buildings
   - $12.0M Recycling Processing Equipment
   - $6.0M Energy Conversion Equipment
   - $2.25M Ancillary Processing Equipment
   - $1.1M Loaders, Lifts, Sweepers, Trucks, Etc.

b) Direct creation of 74 "green" jobs for the operation of recycling processing and energy conversion process:
   - Material Processors 50
   - Equipment Operators 12
   - Mechanics 4
   - Supervisors 2
   - Administration 3
   - Managers 3

   74

Indirectly, additional jobs will be created as a result of the economic activity generated by the recycling and energy conversion plants, including; truck drivers to transport plant outputs, industrial service jobs to meet the operational requirements of the plant, and retail service jobs to meet the consumer needs of the new workforce.

During the first year of operation, the plant will have a local payroll of $4,500,000. Additionally, the plant will spend over $1,600,000 during the first year for local goods and services. Expecting a minimum of 2% annual growth in payroll and operating expenses, the 20 year projection of local economic contribution from the landfill reduction project is set forth in Table 7.

Table 7 – Contribution to Local Economy

	1st Year	20 Year
Jobs/Wages	$4,500,000	$109,000,000
Goods & Services	$1,600,000	$45,000,000
TOTAL	**$6,100,000**	**$154,000,000**

2.5.4 The Cost of Landfill Disposal Reduction

In order to implement the conceptual landfill disposal reduction, solid waste service fees will require adjustment to reflect the described capital and operating costs. Assuming that landfill disposal costs constitute twenty-five percent (25%) of the total cost of solid waste service fees paid by the City's residents and businesses, it is estimated that service costs will increase by approximately forty percent (40%). For example, a resident that currently pays $15 per month for solid waste service will pay $21 per month after the described landfill disposal reduction plan is implemented.

3.0 WASTE CONVERSION TECHNOLOGIES REVIEW

The purpose of the this portion of the study is to evaluate the feasibility of new technologies to reduce solid waste currently being disposed at the Larimer County Landfill, and to assist in achieving the City's mission to meet the solid waste disposal needs of its residents and businesses through strategic planning, efficient, operations, sound environmental practices, innovation, and technology.

Specifically, the Project Team determined the most feasible types of energy-conversion systems and/or technologies in which the City may wish to invest for future waste stream management. The following factors were considered in the evaluation:

- CT throughput capacities and residuals management
- Quantification of energy generation
- Scalability of the system
- Environmental and health impacts and mitigations
- Permitting procedures and issues
- Diversion credits
- CT tipping fees compared to projected landfill fees
- Capitol and operational costs
- Financing options including private/public partnership potential

It important to reiterate that any references to specific products, systems, or companies in this report are for factual purposes only and are not intended to represent an endorsement by the City of Fort Collins.

3.1 OVERVIEW

3.1.1 WHAT ARE CONVERSION TECHNOLOGIES?

Conversion technologies include a wide array of thermal, biological, chemical, and mechanical technologies capable of converting municipal solid waste (MSW) into energy such as steam and electricity; fuels such as hydrogen, natural gas, ethanol and synthetic diesel; and other useful products and chemicals.

Most conversion technologies can be described as having three separate and distinct components:

1. front-end MSW preprocessing or feedstock preparation
2. the conversion unit itself, and
3. the energy/chemicals production system

Front-end preprocessing is used to prepare the solid waste for treatment by helping to separate out any recyclables. The level of preprocessing varies depending on technology. Shredding, grinding, and/or drying the MSW may be required to create a more homogeneous feedstock. The energy production module can be a gas turbine, boiler, or reciprocating engine for power production or a system that converts the biogas or syngas into fuels such as ethanol and Compressed Natural Gas (CNG).

These technologies not only create beneficial products, but have the potential to reduce greenhouse gas emissions and other air pollutants, from disposal and transportation avoidance as well as fuel/electricity offsets.

3.1.2 Why Are Conversion Technologies of Interest Now?

There are several driving factors contributing to the proliferation of CT projects across the US and Canada:

1. Decreasing capacity and increasing tipping fees for landfill disposal of MSW
2. Desire to reduce dependence on landfills and waste exporting, maintaining local control over disposal
3. Ability to recover materials not feasibly recyclable for beneficial use
4. Demand for increased level of recycling and diversion from landfills to reach "Zero Waste"
5. Ability to manage excess biomass and organic wastes (including biosolids, agricultural residue, etc.)
6. Demand for renewable energy, especially local, and higher values for this energy due to renewable energy credits and other mechanisms
7. Demand for low-carbon, renewable fuels such as: CNG, ethanol, and synthetic diesel and gasoline
8. Demand for reduction in GHG emissions to combat Global Warming
9. Desire for energy independence from foreign oil, especially from troubled and dangerous areas of the world
10. Availability of grants and low-interest loans for CT projects
11. Strong interest from entrepreneurs and the investment community in renewable energy as a major growth industry of the future
12. Diversification of mid-level and major waste management companies into the energy field
13. Public and political perception that this is the "right" thing to do
14. Desire to reduce pollution and environmental impacts from landfill disposal
15. Creation of "green collar" jobs

3.1.3 What is the Status of Conversion Technologies in the United States?

There are scores of commercial-scale conversion technology facilities operating worldwide. To date, growth in this industry has primarily been in Europe and Japan, where hundreds of plants are in operation. However, in recent years, several commercial projects have made significant progress in North America. Below are several examples of projects that have recently been completed or are currently under construction:

- Enerkem (Edmonton, Alberta, Canada): The Enerkem Edmonton Facility is designed to convert municipal solid waste to biofuels (ethanol). Construction began in 2010 and is expected to be completed with the start of operations in 2012. The Advanced Energy Research Facility at the same location had its grand opening in June of 2011. The picture below shows the progress of construction as of August 2011.

Picture 1 – Enerkem (Edmonton, Alberta, Canada)

- Plasco Energy Group (Ottawa, Ontario, Canada and Salinas, California): Plasco Energy Group is in the process of developing a 400 tpd plasma-arc gasification plant in Salinas, CA. The Salinas Valley Solid Waste Authority chose a CEQA consultant in the summer of 2011 and recently gave approval to begin the preparation of an Environmental Impact Report (EIR).

  This picture below shows Plasco's demonstration plant in Ottawa. This facility began operating in 2007 and has recently been reconfigured to demonstrate continuous commercial performance. The Ottawa City Council also approved a long-term contract with Plasco in December 2011.

Picture 2 – Plasco's Demonstration Plant, Ottawa

- BIOFerm™ Energy Systems (University of Wisconsin - Oshkosh): Construction on the first dry fermentation system in the United States began in September of 2010. The facility accepts food, agriculture, and yard waste, primarily from the University. Biogas from the anaerobic digestion of organic wastes is collected and used to generate electricity for use on campus. The facility began operations in the fall of 2011. The picture below shows the completed facility in Oshkosh, Wisconsin.

Picture 3 – BIOFerm™ Energy Systems (University of Wisconsin)

- Zero Waste Energy (San Jose, California): The first Kompoferm facility to be constructed in the United States will be located in San Jose, CA. Eventually, the City of San Jose plans to process all of its commercial organic waste at the site, over 270,000 tons per year. In June, the city adopted the Mitigated Negative Declaration for the project and authorized the City Manager to execute a ground lease with Zero Waste Energy Development Company for the construction and operation of the facility on Water Pollution Control Plant land. Groundbreaking for this project was in September 2011. The picture below shows a rendering of the facility.

Picture 4 – Zero Waste Energy (San Jose, California)

- Fulcrum BioEnergy (McCarran, Nevada): Construction on a municipal solid waste to biofuels plant was set to begin by the end of 2011. Located in the Tahoe-Reno Industrial Center, in the City of McCarran, Storey County, Nevada, the Plant will produce up to 10.5 million gallons of ethanol per year.

  Fulcrum has already obtained the necessary local and state regulatory permits necessary to begin site preparation. They have also begun detailed engineering of the plant design, contracted for feedstock and have entered into an off-take agreement for the full output of the plant. The projected completion date of the plant is the second half of 2013. The photo below shows a rendering of the plant.

Picture 5 – Fulcrum BioEnergy (McCarran, Nevada)

- INEOS New Planet BioEnergy (Vero Beach, Florida): INEOS will convert organic material into a syngas, which will then be converted to ethanol through fermentation. The project construction was 30% complete as of October 2011. The project is currently on schedule to be mechanically complete by April 2012 and operating in the second half of the year. The photo below shows the status of construction in October 2011.

Picture 6 – INEOS New Planet BioEnergy (Vero Beach, Florida)

3.1.4 Identification and General Description of Conversion Technologies

Table 8 lists CT vendors that have been identified in the most recent search efforts. Although the list provided in Table 1 does not capture all possible vendors, it represents a broad spectrum of conversion technologies, including companies that are more established in the industry and that have achieved the greatest level of development (including, in several cases, commercial operation overseas and in Canada). Companies that are highlighted submitted responses to the County of Los Angeles Department of Public Works Request for Expression of Interest distributed in June 2011.

Table 8 – Conversion Technology Vendors (1)

Thermal Processing	Biological Processing
Gasification	**Anaerobic Digestion**
Bioengineering Resources, Inc./New Planet Energy/Ineos Bio	ArrowBio
CBES Global, LLC	Arrow Ecology and Engineering
Crystal Creek Energy	Bekon
Dynecology	BioFERM
Ebara Corporation	Biogas Energy, Inc.
Ecosystems Projects	Canada Composting
EcoTech Fuels, LLC	CCI BioEnergy
Enerkem	Clean World Partners
Entech Solutions	CR&R, Inc. with Organic Waste Systems (DRANCO)
Envirepel Energy, LLC	Ecocorp
Global Alternative Green Energy	Harvest Power
Global Energy Solutions	KAME/DePlano
Global Recycling Group	Mustang Renewable Power Ventures (Bekon)
Green Energy Corporation	New Bio
Holloway Environmental/Entech	Orgaworld
ILS Partners/Pyromex	Ros Roca Envirotec
Interstate Waste Technologies (Thermoselect)	Strategic Management Group w/ Entec Biogas USA
KAME/DePlano	Urbaser, Inc. (Valorga)
MaxWest Environmental Systems	Vagron
Mustang Renewable Power Ventures (Waste 2 Energy)	Waste Recovery Systems, Inc. (Urbaser/Valorga)
Primenergy	Zero Waste Energy, LLC (Kompoferm)
Princeton Environmental Group	
Taylor Biomass	**Aerobic Digestion/Composting**
Taylor Recycling Facility	Civic Environmental Systems
Thermogenics	Conporec
Urbaser, Inc. (Energos AS)	Mining Organics Management
Waste Gasification Systems / Allan Environmental	
Waste to Energy, LLC/BioEnergy Design, LLC	
World Waste Technologies	
Ze-Gen	
Zeros Technology Holding	
Zero Waste Energy Systems	

	Chemical Processing
Plasma Gasification	**Hydrolysis**
AdaptiveARC	Arkenol Fuels/Blue Fire Ethanol
Alter NRG Corporation / Westinghouse	Biofine / BioMetics
BioGold Fuels Corporation / Alter NRG	Genahol
Environmental Energy Resources/ SNC-Lavalin	Masada OxyNol
EnviroArc Technologies / Nordic American Group	RCR International
Global Environmental Technologies	
GSB Technologies	**Other**
InEnTec	Changing World Technologies
NRG Energy, Inc.	Innovative Energy Solutions, Inc.
Peat International / Menlo Int.	Terrabon, Inc. w/ Waste Management California
Plasco Energy Group	
Solena Group	**Mechanical Processing**
Startech Environmental	CES Autoclaves
Technip USA, Inc.	Cleansave Waste Corporation
	Comprehensive Resources
Pyrolysis	EnerTech Environmental
Bioconversion Technology LLC (Emerald Power)	Herhof Gmbh
Eco Waste Solutions	Recycled Refuse International
Entropic Technologies Corporation	Ros Roca Envirotec (MBT)
GEM America	Tempico
Pan-American Resources	Vorus Biopower
Pyrogenesis Canada, Inc.	WET Systems
Recycled Energy Corporation/Pyrolysis "Plus" Technology	World Waste Technologies
Renewable Energy Resources, Inc.	WSI Management, LLC
International Environmental Solutions	
Steam Reformation	
Synterra Energy	

(1) Highlighted companies submitted responses to the County of Los Angeles Department of Public Works Request for Expression of Interest, Conversion Technology Providers distributed in June 2011.

As shown in **Table 8**, conversion technologies can be grouped into several broad categories. The following sections provide brief descriptions of these categories.

THERMAL

Thermal technologies encompass a variety of processes that use or produce heat, under controlled conditions, to convert MSW to usable products. The organic fraction of MSW is converted to energy, and the inorganic fraction is recovered as products (e.g., aggregate, metal). Thermal technologies can potentially convert all organic components of MSW into energy (i.e., all carbon and hydrogen-based materials, including plastic, rubber, textiles, and other organic materials that are not converted in biological processes). Thermal processing includes such technologies as gasification, plasma gasification, and pyrolysis. Distinctions between the different thermal technologies center around the processing temperature, the means of maintaining the elevated temperatures, and the degree of decomposition of the organic fraction of the MSW. Some of these distinctions are noted in **Section 3.2**. The distinction between the different types of thermal technologies is not always clearly defined, and therefore, the sub-classification of many thermal technologies is based largely on the representations made by the technology suppliers. **Figure 1** below shows a generic flow diagram of a gasification process, including the varying products that can be made.

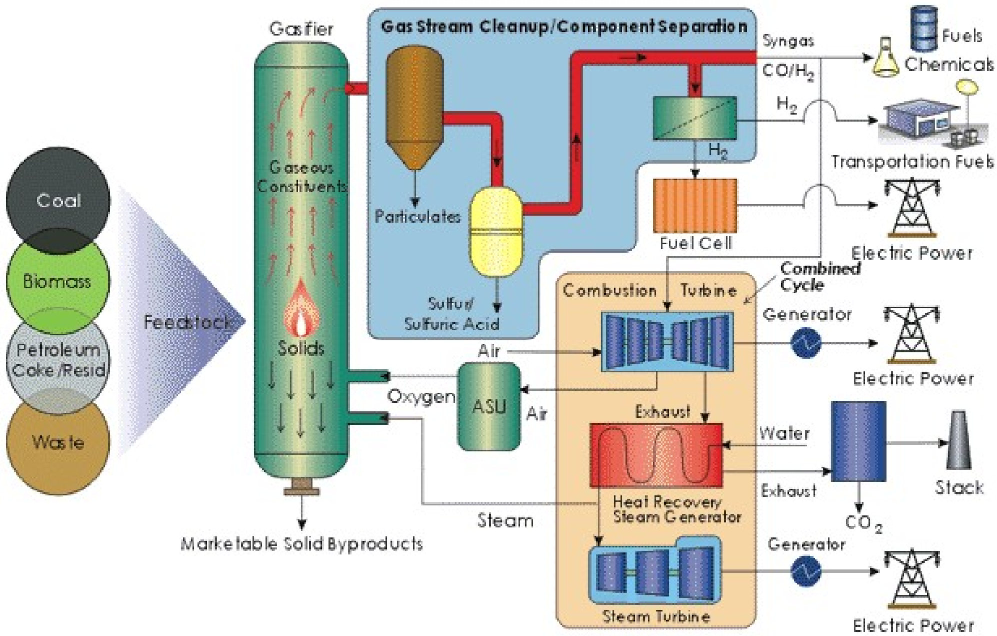


Figure 1 – Typical Gasification Flow Diagram

BIOLOGICAL

Anaerobic digestion is the reduction of carbon-based organic materials through controlled decomposition by microbes, accompanied by the generation of liquids and gases. In anaerobic digestion, the biodegradable, organic components of the waste stream are metabolized by microorganisms in the absence of oxygen, producing a biogas (primarily methane and carbon dioxide), a solid byproduct (called "digestate", which is generally used as a compost feedstock), and reclaimed water. The anaerobic digesters achieve lower but significant diversion of 60 percent to 80 percent, assuming the composted digestate can be marketed. **Figure 2** shows a typical flow diagram of the process.

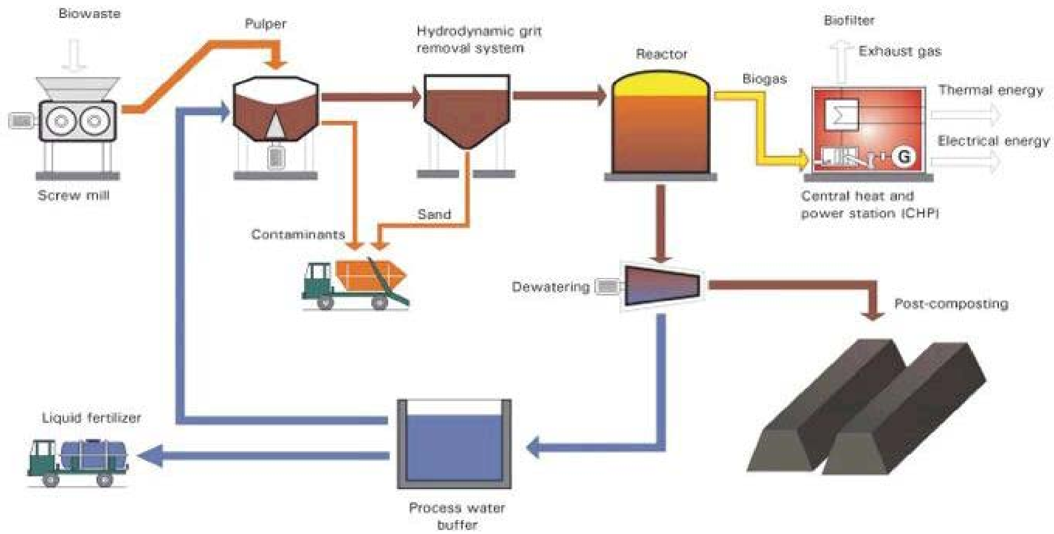


Figure 2 – Typical Anaerobic Digestion Flow Diagram

CHEMICAL

Chemical processing technologies use one or a combination of various chemical means to convert MSW into usable products, often uniquely encompassing aspects of other conversion processes such as digestion and gasification. An example of a chemical processing technology is depolymerization, which is the permanent breakdown of large molecular compounds into smaller, relatively simple compounds. Depolymerization is thermal in nature, but instead of a single thermal reaction step it involves a number of complex and interrelated processing steps, some similar to petroleum refining.

Hydrolysis is also subset of chemical processing technologies. Hydrolysis is generally a chemical reaction in which water reacts with another substance to form two or more new substances. Specifically in relation to MSW, hydrolysis refers to a chemical reaction of the cellulose fraction of the waste (e.g., paper, food waste, yard waste) with water and acid to produce sugars. The sugars are then fermented to produce an alcohol, followed by distillation to separate the water from the alcohol and recover a concentrated, fuel-grade ethanol.

Chemical conversion technologies have not gained the popularity gasification and anaerobic digestion. Although several notable companies are currently pursuing hydrolysis projects for the production of ethanol, they are focused on woodwaste as a feedstock, not MSW. Therefore, chemical conversion technologies will not be examined further for the purposes of this report.

MECHANICAL

Mechanical processing technologies employ physical processing, such as steam classification (autoclaving), primarily to recover recyclables and separate the organic and inorganic fractions of MSW. Mechanical processing technologies are typically followed by other conversion processes and can be viewed as a “pre-processing” step for conversion technologies (CT).

Autoclaving of medical waste for sterilization before disposal has long been practiced throughout the U.S. However, in recent years, a much broader, larger, and innovative application has emerged as a process for MSW. Mixed residential and commercial MSW or post-MRF residue is "pressure cooked" with steam in large, rotating drums up to 25 ft in diameter and 100 ft long. This facilitates subsequent separation of organic biomass (processed paper, cardboard, foodwaste, etc.) from inorganic (glass, metal, plastic, textiles, etc.). The initial purpose for autoclave development was the recovery and sale of paper fiber.

To date there have been two autoclave plants build in the U.S. processing MSW (Minnesota and California), but neither sustained commercial operation. A demonstration autoclave has been operating in Salinas, CA on and off for the past three years and the Salinas Valley Solid Waste Authority is pursuing a demonstration project there. In the following sections, wherever MRFs are discussed, autoclaves could be included as well as a future refinement. To date, the CT vendors have chosen to go with standard MRF processing.

3.2 THERMAL (GASIFICATION/PYROLYSIS)

3.2.1 TECHNICAL ASPECTS

Typically gasification, plasma gasification, and pyrolysis facilities have a capacity on the order of 300 to 500 TPD and are modular in design with each module capable of processing roughly 100 to 150 TPD. There are exceptions, such as the ThermoSelect process marketed by IWT which prefers much larger facilities and can process up to 1,500 TPD. Additionally, gasification has the potential for high diversion from landfill disposal, between 85% and 100% diversion by weight.

Thermal processing occurs in a high-temperature reaction vessel. Reactor temperatures may range from approximately 800°F for a pyrolysis technology to as high as 8,000°F for a plasma gasification technology. Within the reaction vessel, the organic fraction of the MSW is converted to a gas typically composed of hydrogen, carbon monoxide and carbon dioxide gases. This gas is commonly called synthesis gas or "syngas". Some thermal technologies, such as pyrolysis, produce a gas that also consists of various low molecular weight organic compounds. Thermal technologies sometimes introduce a supplemental fuel (e.g., natural gas, coke, etc.) to improve the quality and consistency of the synthesis gas. Plasma gasification technologies use a supplemental source of energy, most commonly electricity, to produce an electric arc to elevate the temperature and enhance dissociation of the molecules in the MSW. The syngas and other products of the thermal technologies represent unoxidized or incompletely oxidized compounds, which in most cases differentiate these technologies from the more complete combustion attained in traditional waste-to-energy (WTE) projects.

With some thermal technologies, such as gasification, the inorganic fraction of MSW is commonly recovered in the form of a vitrified material (i.e., a solid, glassy, rock-like substance often used as aggregate), mixed metals, industrial salts, chemicals, and other byproducts. Some thermal technologies, such as pyrolysis, generate a char (i.e., a carbon-based solid) rather than a vitrified product. Depending upon market conditions, these byproducts of thermal processes may have beneficial uses or may require landfill disposal. The syngas produced by thermal conversion technologies can be combusted to generate electricity or converted to fuels.

In an overview fashion, thermal processing of MSW can be described in two primary steps: (1) pre-processing, if required, and (2) thermal conversion, including combustion of the syngas to generate electricity.

- **Pre-processing.** Pre-processing requirements are often very minimal for thermal technologies. Except for the common requirement to remove or size-reduce very large, over-sized materials such as furniture and large appliances, many thermal processing technologies do not require size reduction or separation of MSW by component. This is not always the case, though, as some thermal technologies (e.g., many pyrolysis technologies) shred and/or dry the waste prior to processing. While recyclables such as metals can be recovered in a pre-processing step, many of the thermal technologies recover the metal after the thermal conversion process (i.e., as a "product" rather than as **a front-end "recyclable".)**

- **Thermal Conversion and Use of Gas.** The thermal conversion process results in a syngas and other products, as described above. The gas may be processed into fuels such as hydrogen or chemicals such as methanol, but currently, most technology suppliers have been or are focusing on converting the syngas to energy by using it as a fuel in traditional boilers, reciprocating engines and combustion turbines. Some of the thermal technologies pre-clean the syngas prior to combustion using standard, commercially-available technology to remove sulfur compounds, chlorides, heavy metals and other impurities. Pre-cleaning the syngas prior to power generation can be more cost-effective than air emission controls at the back end. The extent of syngas cleaning and the type of air pollution control varies by technology.

3.2.2 ENVIRONMENTAL ASPECTS

Air emissions from thermal technologies are tightly controlled and information gathered to date shows that these facilities can meet the strictest air quality standards in the country, including all current California standards. These facilities have a low air emissions profile comparable to engine/generators running on natural gas, and cleaner than engines running on landfill gas. None the less, the evaluation of air emissions and the conducting of health risk assessments related to those emissions are critical and controversial aspects of these projects.

Some thermal technologies generate a small amount of air pollution control residue that requires disposal, and some thermal technologies incorporate pre-processing for feedstock preparation, which generates an inert residue such as dirt and other inert debris removed from the MSW. The inert residue associated with pre-processing should be suitable for disposal in an MSW landfill. Air pollution control residue may not be suitable for disposal in a Class 3 landfill, depending on the thermal CT, and may need to be disposed at a landfill permitted to receive hazardous material. Alternatively, some technologies process and recycle this material.

Thermal technologies provide reductions in GHGs in two ways:

1. Avoidance of methane emissions that would have been released if the feedstock had been landfilled, and
2. Offset of the GHG emissions that would have been generated by the local fossil fuel burning power plant for the electricity the CT project generates; or offset of the tailpipe emissions that would have resulted by burning fossil fuel instead of the ethanol or CNG produced by the CT plant

Depending on the type of fossil fueled supplanted, and the amount of methane control (or lack thereof) at the landfill, CT projects are typically awarded between 0.5 and 2.0 tons of CO2 equivalent for every ton of MSW processed. This can amount to tens or even hundreds of thousands of tons of CO2E reduced each year.

One major advantage of Thermal CTs is their ability to process mixed post-recycled MSW and provide extremely high diversion, typically over 95%. This implies that large Thermal CT projects can essentially replace landfills in the future; although landfills will always be needed for inert residues and non-processible waste.

3.2.3 INSTITUTIONAL ASPECTS

In the choice of technologies, institutional aspects can be just as important to a jurisdiction as technical ones.

POLICIES

The City has adopted several policies that encourage the development of CT projects:

1. A goal of 50% diversion from landfills; likely to be raised in the future
2. A goal of 10% renewable power generation by 2020

Furthermore, the City has a strong desire to work with local enterprises to advance the use of Renewable Energy Credits (RECs) to raise the value of renewable energy generation as enacted by the State of Colorado.

PERMITTING

Permitting of a Thermal CT project is expected to be arduous, controversial, expensive, and lengthy based on experience gained in the projects moving forward in the U.S. and Canada. A period of two to three years is required in most cases. Often it is not the actual technical aspects of the permitting that is so expensive and time-consuming but the opposition from environmental and EJ (environmental justice) groups as discussed in the public acceptance section below.

In addition to a Land Use permit and the attendant detailed environmental review, a thermal CT facility will require a solid waste permit from the Colorado Hazardous Materials and Waste Management Division. Additionally, an Application for Stormwater Discharges must be submitted to the Colorado Water Quality Control Division in order to obtain a Heavy and Light Industrial Activity General Permit for stormwater. As part of the stormwater permitting process, a Stormwater Management Plan must be prepared and certified.

Lastly, the type of air permit required depends on the levels of criteria pollutants anticipated for the project. For a thermal CT facility, engine exhaust from producing electricity is the primary source of air emissions. All sources of air emissions in Colorado are required to obtain a construction permit from the Colorado Air Pollution Control Division unless they are specifically exempted. Additionally, all major sources of air emissions in Colorado are required to obtain an Operating Permit if they emit pollutants beyond the level required for a construction permit only. Air emission limits for criteria pollutants differ depending on whether the facility is located in an attainment area or not. New major sources must first obtain a construction permit, and must apply for an operating permit within 12 months of commencing operation.

FUNDING

CT vendors realize that for initial projects, they are not likely to receive financing from the public sector. Therefore, virtually all the vendors will secure their own financing in the form of equity and loans. Many are also working on obtaining grant money to support the projects, and some have received substantial grants and low interest loans already from the Dept. of Energy (DOE) and other federal agencies.

This being said, there may be instances where the City could participate in funding a project, taking advantage of the City's ability to secure low-interest loans that would not be available to a private company.

PUBLIC ACCEPTANCE

Lastly, Thermal CT projects are subject to significant controversy, mostly from environmental groups who support zero waste through complete recycling and composting, and who believe that conversion of organic waste to energy is not the best and highest use. In addition, there is a perception among the public (not justified) that Thermal CT is "incineration in disguise", and that the air emissions are a health issue. Once the first commercial scale Thermal CT projects are in operation, perhaps these attitudes will change, but at this point, when there are no such projects in the U.S., it is difficult to turn these negative attitudes around.

In fact, several jurisdictions are considering anaerobic digestion projects (especially in California) at least in major part because they do not want to go through the agony and opposition in trying to develop a Thermal project.

3.3 Biological (Anaerobic Digestion)

3.3.1 Technical Aspects

Current anaerobic digestion facilities are designed to process from 5 tpd, up to 300 TPD. However, in combination with a comprehensive MRF, total facility capacities of up to 750 TPD are feasible. Some AD technologies (namely "dry fermentation" types) are batch processes, with cycles of 21-28 days which also limit the quantity of waste they can treat. Other high-solids AD technologies are continuous feed.

Anaerobic digestion can be described by four primary steps: (1) pre-processing, or separation/preparation, of the MSW to obtain a prepared organic feedstock; (2) digestion of the prepared organic feedstock; (3) for some anaerobic digestion technologies, post-treatment of the digestate to produce a clean, mature compost, and (4) management and use of the biogas generated during the anaerobic digestion process. These primary steps are described below.

- **Pre-processing.** For source-separated materials (foodwaste and greenwaste in particular) little or no pre-processing is necessary depending on the technology used. For mixed MSW, pre-processing or preparation/separation is necessary for separating biodegradable, organic materials from other waste components as well as for size reduction and preparation of the organic feedstock. Pre-processing can be accomplished using traditional, mechanical sorting processes, or it can employ more innovative and technology-specific approaches (e.g., the water-based preparation/separation system designed by ArrowBio.) Pre-processing will result in residue requiring disposal, generally consisting of broken glass and other inert materials present in the wastestream. Pre-processing can be combined with recovery of traditional recyclables that are not readily biodegradable and not of value in the digestion process. Recovered recyclables from pre-processing may include ferrous metal, aluminum, plastic, and glass. Recent initiatives are underway to sort paper and cardboard as recyclables, particularly when there are high market values for these materials. In general, maximizing the recovery of recyclables and the removal of non-degradable, inert materials during pre-processing will result in higher quality compost at the end of the process.

- **Digestion.** The separation and preparation of biodegradable, organic material from the MSW results in an organic feedstock for the digestion process. The fundamental objective of anaerobic digestion is to produce a large quantity of methane-rich biogas and a small quantity of well-stabilized digestate from the organic feedstock. In all anaerobic digestion technologies, the process occurs in an enclosed, controlled environment (i.e., within the "digester", or "bioreactor"). However, different digestion technologies are available, which produce different results regarding biogas and compost quantity and characteristics. The process may be "wet" or "dry", depending on the percent solids of the organic feedstock in the digester. The process temperature may also be controlled in order to promote the growth of a specific population of microorganisms, with process temperatures ranging from approximately 35-55°C (95-131°F). The process may be conducted in a single-stage or two-stage reactor vessel, and on a continuous or batch basis. Retention times of material in the digester can also vary.

- **Post-processing.** Anaerobic digestion results in a solid byproduct, called "digestate". It consists of organic material that is not readily digestible, along with inorganic material that escaped pre-processing. Digestate varies in consistency. Wet digestion technologies produce a digestate with a thinner, or wetter, consistency than dry digestion technologies, which produce a wet solids mass. The digestate is commonly dewatered, with the liquid returned to the process or managed as a wastewater. The dewatered solids may be screened to remove inorganic materials, and are then aerobically finished, if necessary, to produce stable, mature compost, for sale as a product. The extent of post-treatment required to achieve a stable, mature compost, as well as the quantity of compost produced, varies based on the digestion technology used. Also, depending on the extent of separation and preparation conducted prior to the digestion process, some technologies require more post-processing than others (e.g., some technologies require screening of digestate prior to aerobic finishing, and/or screening of mature compost, in order to improve the quality of the resulting compost for purposes of beneficial use).

- **Biogas Management.** Anaerobic digestion results in a biogas, composed primarily of methane and carbon dioxide. Higher-quality biogas has a higher percentage of methane, with individual digestion technologies producing biogas with methane concentrations ranging from approximately 55% to 80%. Biogas may also include small amounts of contaminants, such as hydrogen sulfide (H_2S). The concentration of H_2S and other contaminants in the biogas generally depends on the characteristics of the waste stream. Commercially available technologies may be utilized to remove contaminants and otherwise improve the quality of the biogas (i.e., achieve a higher percentage of methane), if such a step is necessary for a particular project. Often without any cleanup steps, the biogas can be beneficially used to generate electricity.

The organic fraction of MSW can also be aerobically ("with oxygen") digested through in-vessel systems, covered composting systems, or open windrows to produce either a soil amendment (compost) or a solid fuel.

3.3.2 Environmental Aspects

Like most treatment processes, there will be some emissions from anaerobic digestion (AD) facilities. Air emissions are low due to the enclosed nature of the process, though combustion of the methane-based biogas will produce some criteria air emissions (NOx, CO, hydrocarbons, etc.). However, emissions from AD-CHP are generally lower than other forms of waste disposal and reduce greenhouse gas emissions as compared to landfill disposal.

Additionally, solid and liquid digestate from the AD facility must be dealt with appropriately to prevent unnecessary impacts to the environment. The health risk from the solid and liquid residue from the AD plant should be low as long as source-separated waste is being used (i.e. no chemical contaminants are entering the system from other waste). Also, the digestate is typically processed further aerobically and marketed as a compost product, and this operation will have typical environmental aspects such as dust and odor to be mitigated.

3.3.3 Institutional Aspects

POLICIES

The same policies and framework that may affect the Thermal (Gasification/Pyrolysis) technologies as discussed in Section 3.2.3 also apply to the Biological (Anaerobic Digestion) and are repeated here for convenience.

1. A goal of 50% diversion from landfills; likely to be raised in the future

2. A goal of 10% renewable power generation by 2020

Furthermore, the City has a strong desire to work with local enterprises to advance the use of Renewable Energy Credits (RECs) to raise the value of renewable energy generation as enacted by the State of Colorado.

PERMITTING

Construction and operation of an anaerobic digestion facility will require a Land Use permit and the attendant environmental review, as well as a solid waste permit from the Colorado Hazardous Materials and Waste Management Division. Additionally, an Application for Stormwater Discharges must be submitted the Colorado Water Quality Control Division in order to obtain a Heavy and Light Industrial Activity General Permit for stormwater. As part of the stormwater permitting process, a Stormwater Management Plan must be prepared and certified.

Lastly, the type of air permit required depends on the levels of criteria pollutants anticipated for the project. For an AD facility, engine exhaust from producing electricity is the primary source of air emissions. All sources of air emissions in Colorado are required to obtain a construction permit from the Colorado Air Pollution Control Division unless they are specifically exempted. Additionally, all major sources of air emissions in Colorado are required to obtain an Operating Permit if they emit pollutants beyond the level required for a construction permit only. Air emission limits for criteria pollutants differ depending on whether the facility is located in an attainment area or not. New major sources must first obtain a construction permit, and must apply for an operating permit within 12 months of commencing operation. If the facility converts the biogas to CNG, air emissions from the facility will be very low as no combustion of the gas would take place onsite.

AD projects typically have an easier permitting pathway than thermal technologies because of their simpler format, low temperatures, and favorable public perception, as discussed below. However, it must be remembered that an AD project needs a composting facility to handle the digestate, and the permitting of a new composting facility can be as arduous as permitting the AD facility itself. Many of the existing AD projects in Europe were built at existing composting sites for this reason.

FUNDING

Funding framework is similar to that discussed in Section 3.2.3 for Thermal (Gasification/Pyrolysis) technologies. Because CT vendors realize that for the initial projects, financing from the public sector is unlikely, they generally secure their own financing in the form of equity and loans. Many are also working on obtaining grant money to support the projects, and some have received substantial grants and low interest loans already from the Dept. of Energy (DOE) and other federal agencies. Again, there may be instances where the City could participate in funding a project, taking advantage of the City's ability to secure low-interest loans that would not be available to a private company.

PUBLIC ACCEPTANCE

Lastly, biological CT projects (AD) are supported by the majority of environmental groups and are seen as the next step in moving toward zero waste. Although there is still resistance in the environmental community to the conversion to energy aspect of AD, the fact that the process is biological and also includes a significant composting element is viewed as favorable. In California, the State waste agency, CalRecycle, has gone as far as to develop and certify a programmatic Environmental Impact Report (EIR), that can be used by individual AD projects to support permitting.

The key concern for the public is typically odor, and its control is a critical feature of AD projects, both at the digestion facility and the composting site.

3.4 CONVERSION TECHNOLOGY PROJECT RECOMMENDATIONS

3.4.1 INTRODUCTION

The City is in the process of evaluating system-wide approaches to Zero Waste, renewable energy, and best and highest use of organics from commercial and industrial users; and also to the optimization of existing resources and infrastructure, such as the wastewater treatment plants. The figure below shows the theoretical synergies between various components of such a system.

In a region that has very low waste disposal costs, it is important to look for such synergies and local advantages in order to develop CT projects that are economically feasible. Based on data from other projects, and the strong environmental consciousness in the City, it is likely that a CT project with strong environmental benefits and marginally higher costs per ton would be acceptable; but large increases in cost would not be widely supported either by the public, local businesses or elected officials.

On the other hand, a more positive economic factor is the City's renewable energy goal of 6% of their total power by 2015, and 10% by 2020. The latter represents roughly 215,000 MWh of electricity. In addition, the State of Colorado has "incentivized" the development of renewable energy in the State by awarding multiple values for Renewable Energy Credits (RECs), which in essence raises the value of renewable electricity generated from local biomass from approximately $0.06/kWh to $0.09-$0.12/kWh.

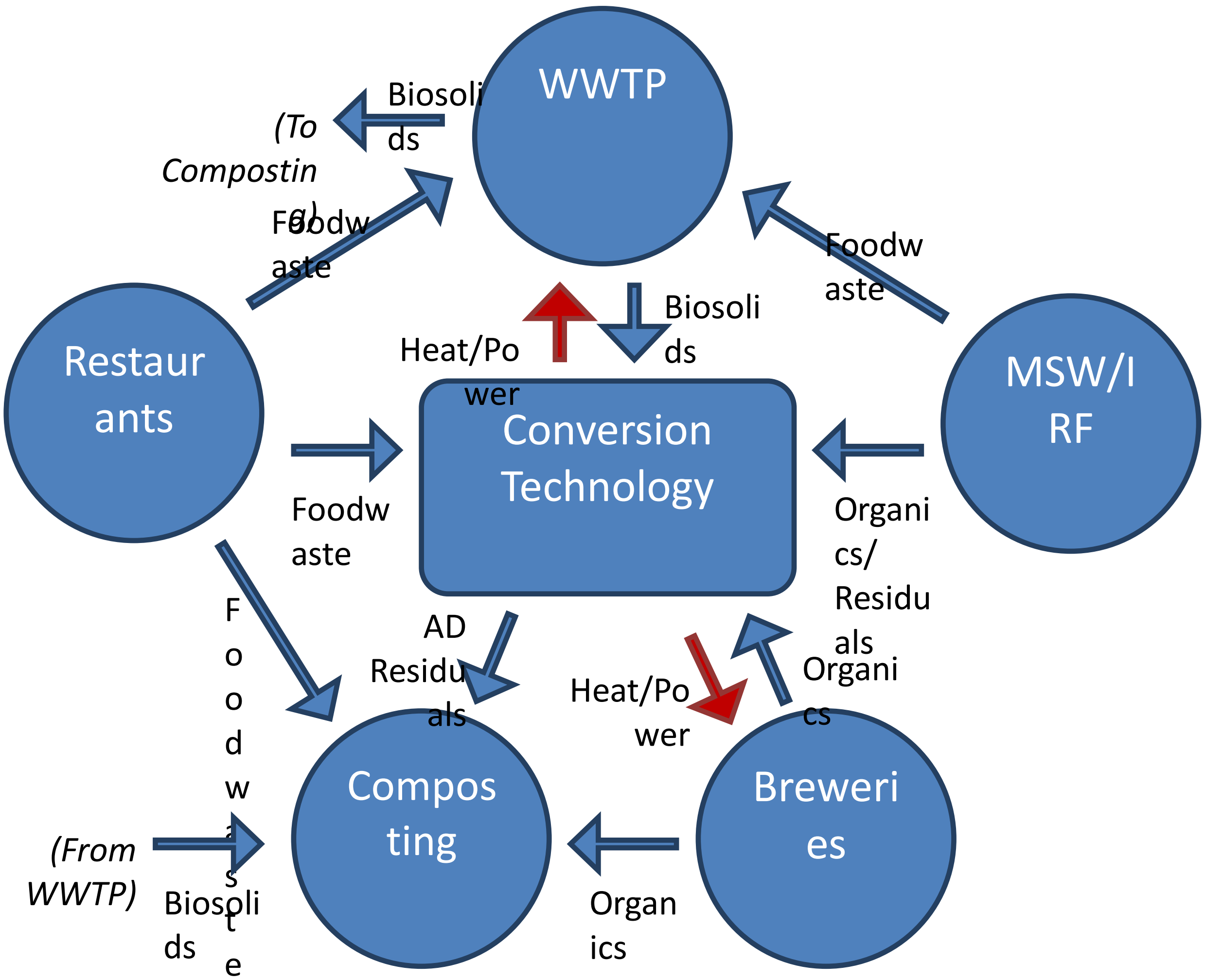


Figure 3 – System Integration Possibilities

Given that the local County landfill still has plenty of life, and very low tipping fees in the $20/ton range. It is unlikely that a large CT facility will be economically feasible, at least for the foreseeable future. But there may be opportunities for smaller, more customized CT projects such as digesters for source-separated food waste and green waste, or CT plants connected with specific large generators like the breweries that produce a consistent organic waste every day. These applications are less expensive, easier to finance and develop, and may offer a feasible "entry level" project for the City.

Another possibility would be to divert source-separated organics to a digester at the Drake Water Reclamation Facility. Several communities throughout the U.S. are evaluating or starting up such projects, particularly where there is excess digester capacity. These treatment plants are already equipped with engines or turbines that combust the digester gas to create electricity or boilers that convert the gas to heat, which can also be a big savings to the project.

The following sections present the four project alternatives that were found to be best suited for the City, both now and for the future.

1. A Demonstration Scale Anaerobic Digestion (AD) Facility
2. Small-Scale Gasification Facility (with select local feedstocks)
3. Commercial scale Gasification or AD Facility (future)
4. Foodwaste Digestion at the Drake WWTP

3.4.2 Project 1 – Demonstration-Scale Anaerobic Digestion Facility (~15 TPD)

Several vendors of anaerobic digestion systems (namely BioFerm and KompoFerm) have the ability to provide small "demonstration scale" facilities that handle from 10 to 15 TPD. BioFerm is currently operating such a facility at the University of Wisconsin (Oshkosh campus) and several projects in California are in development using the SmartFerm system by KompoFerm. For illustrative purposes, the SmartFerm system will be described here. See the figures on the following page.

Key aspects of this project are as follows:

- Feedstock: source separated foodwaste (typically from restaurants, University cafeterias, and supermarkets) blended roughly 50/50 with greenwaste; could also receive organic waste from the breweries, but this material would have to be dried to at least 50% solids before digestion. Waste heat from the engine/generator could be used for this drying purpose – although this takes away from potential revenue from sale of the waste heat.
- System is comprised of:
    - An enclosed building for feedstock receiving and mixing
    - 1 waste receiving chamber
    - 4 digestion chambers
    - 2 composting chambers (optional)
    - 1 gas conditioning system (gas primarily CH_4 and CO_2)
    - 1 engine/generator of approx. 100 kW capacity
- Principal Products: electricity or CNG, compost, and waste heat (sale of the heat is a valuable benefit to the project)
- Area required: Approx. ½ to 1 acre (less area required if co-located at an existing facility)
- Staff: 1 part-time equipment operator; 1 part-time laborer; 1 part-time operations manager
- Capital cost: $1.7 million (approx. $2 million with compost chambers)
- Anticipated tipping fees:
    - $40-$50 per ton foodwaste
    - $30-$40 per ton greenwaste
- Diversion:
    - Approx. 99% (1% residual to landfill disposal)
    - Total diversion: Approx. 4,500 TPY
- Local features:

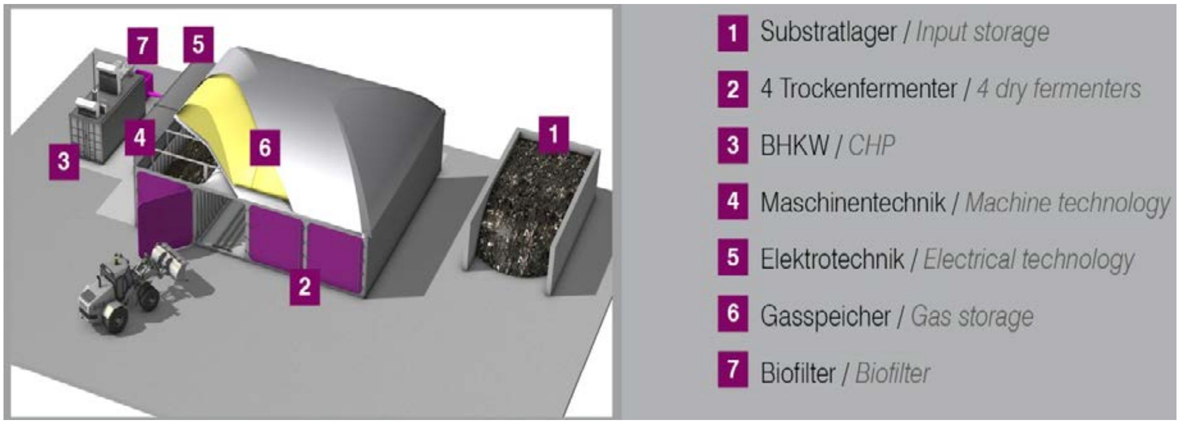
- Could be co-located with the Integrated Recycling Facility (IRF), if space permits. If composting of digestate conducted onsite, final compost product could be given away to IRF users.
- Waste heat from engine/generator could be used at a local brewery or the public ice skating rink, for example, depending on location
- The project could be configured to produce compressed natural gas (CNG) rather than electricity, if the economics are more favorable and the vehicle fuel could be readily used by the City or other transportation company.

The process is quite simple. Material is received, mixed and loaded into the enclosed receiving chamber. Once sufficient material is on hand (roughly every four days or so), one of the digestion chambers that has finished its 21-day cycle is emptied and the new material placed in. With each chamber filled about every four or so days, by the time the fourth chamber is filled, the first chamber is ready to be emptied and reused. The feedstock is then digested anaerobically (no oxygen) for three weeks. Biogas from the process is collected in a bladder on top of the chambers, conditioned, and fed into an engine/generator where it is combusted to make electricity. Digestate (solid residual) from the process can either be trucked to an off-site composting operation or processed onsite in two additional composting chambers. Although the latter is more expensive from a capital cost standpoint, it eliminates extensive trucking to the distant composting site, provides an “in-vessel” environmentally controlled operation, and produces a local compost product. Contamination of the incoming feedstock is estimated at roughly 1%, and this material would need to be landfilled.

Project development would most likely be a public/private partnership with the City providing the land, basic utilities, and Power Purchase Agreement through the PRPA. The vendor would provide all financing, permitting, design, and construction. Operation requires only part-time labor and could most easily be done by City employees manning the IRF, if such a co-location is possible.

Biosolids would not be a suitable feedstock as this material has already been digested at the WWTP.

The facility is expandable and could easily be doubled or tripled in size in the future, space permitting.



Picture 7 – SMARTFERM Dry Fermentation System Rendering & Photo

3.4.3 Project 2 – Small-Scale Thermal Facility (~25-100 TPD)

Throughout N. America there has been renewed focus on small thermal conversion technologies, down to as low as 10 TPD. None of these technologies are yet in commercial use, but the target market is small jurisdictions and large industries. A crucial question is going to be the economics at this small size, where there will be virtually no economy of scale. Clearly, there will need to be other key synergies at work to make such a project feasible. However, these could possibly include:

1. Grants and low-interest loans from the DOE or other government organizations
2. Local industries willing to pay higher costs for waste diversion and energy (heat and/or electricity) in exchange for environmental benefit
3. Special compensation from the City and the PRPA for innovative and renewable energy
4. Tipping fee concessions from CT vendors willing to sacrifice profit to get a first project in the ground

Several vendors of small scale thermal CT systems are in the process of developing, or have already developed, "demonstration scale" facilities with individual modules that handle from 10 to 30 TPD. These include the following (See the figures on the following page):

- IES (International Environmental Systems – Mecca, CA; pyrolysis to electricity)
- GEM America (NJ and the United Kingdom; thermal cracking to electricity or fuels)
- Powerhouse Energy (Pyromex technology – Palm Desert, CA and Germany; gasification to electricity)
- SynTerra (Sacramento, CA; pyrolysis and steam reformation to fuels)
- Crystal Creek Energy (Fort Collins, CO; gasification to electricity)

This is not an exhaustive list as new companies continue to enter or drop out. As in any new field, the list of players is dynamic.

Picture 8 – International Environmental Systems

Picture 9 – SynTerra Energy

Picture 10 – Crystal Creek Energy

Key aspects of this type of project are as follows:

- Feedstock: mixed MSW; can also take wood, tires, plastics, and other high Btu feedstocks available in the City such as spent hops and other residuals from the breweries; some technologies can also take biosolids, but they would need to be dried first.
- Pre-Processing: depending on the feedstocks, pre-processing will vary but will include some removal of recyclables and/or inerts; and preparation of the feedstock for thermal processing (most likely - grinding).
- System is comprised of (depending on feedstock):
  - An enclosed building for feedstock receiving
  - A pre-processing system
  - Gasification (either traditional or plasma arc enhanced); pyrolysis, or thermal cracking
  - Vitrification of inert residue to an aggregate material (unless handling only special feedstocks with no inert material, such as brewery residuals)
  - Production and conditioning of synthesis gas (primarily H and CO)
  - Engine/generators to produce electricity, or
  - Syngas to fuel conversion using the Fischer-Tropsch process, biological conversion, or catalytic conversion, or
  - A combination of power and fuel production
- Principal products: electricity or transportation fuel (ethanol or diesel), aggregate, recyclable commodities, and waste heat (use or sale of this heat can be an important benefit to the project)
- Area required: Up to 2 acres depending on capacity
- Staff: approx. 5-10 employees, mostly skilled workers
- Capital Cost: approx. $5-25 million
- Anticipated tipping fees: Estimate of $50 - $100/ton; will need to be confirmed with further demonstration of commercial-scale operation
- Diversion:
  - approx. 95-99% (1-5% to landfill disposal depending on feedstocks)
  - Total diversion: Approx. 7,500 to 30,000 TPD depending on capacity. However, depending on the type of feedstock, not all this diversion may accrue to the solid waste program.
- Local features:
  - Could be located at the City water or wastewater treatment plants, adjacent to a large industry, or on an industrial parcel. Could also be co-located with the IRF, space permitting.
  - Waste heat and electricity produced could be used at the water reclamation plants, breweries or other industrial applications depending on location
  - Transportation fuels could be used locally

As compared to anaerobic digestion, gasification projects are expensive and complex and require sophisticated operations personnel; however the resulting power or fuel production is much more significant.

Project development would most likely be a public/private partnership with the City providing the land, basic utilities, and Power Purchase Agreement through the PRPA. The vendor would provide all financing, permitting, design, construction, and operation.

3.4.4 PROJECT 3 – FUTURE COMMERCIAL-SCALE GASIFICATION OR ANAEROBIC DIGESTION FACILITY (~300 - 400 TPD)

Although current economic conditions, namely the large remaining landfill capacity and low tipping fees, discourage the development of an MSW-based, commercial scale CT facility, it may be that in the future as landfill capacity dwindles, such a project could become viable.

GASIFICATION FACILITY

The advantage of a commercial-scale thermal facility is that it can essentially replace the landfill, while providing diversion of over 95% of the mixed residual waste being disposed. These plants are powerful generators of renewable electricity or low-carbon fuel. The City currently disposes of roughly 130,000 TPY or about 400-450 TPD. A CT plant of 300-400 TPD would be a perfect fit.

Several gasification projects are in development in the U.S. and Canada of roughly this size as discussed in a previous section:

1. Taylor Biomass (Montgomery, NY; 500 TPD MSW, 450 TPD C&D, 100 TPD wood waste; MSW gasification to electricity)
2. Fulcrum BioEnergy (McCarran, NV; 400 TPD; MSW plasma-arc gasification and alcohol synthesis to ethanol)
3. Plasco Energy (Salinas Valley, CA; 330 TPD; MSW plasma-arc gasification to electricity)
4. Enerkem (Edmonton, Alberta; 300 TPD; MSW plasma-arc gasification and catalytic synthesis to ethanol)
5. INEOS Bio (Vero Beach, FL; 400 TPD; MSW gasification and fermentation to ethanol)

Key aspects of this type of project are:

- Feedstock: mixed MSW as received at the County landfill; can also take tires, plastics and other high Btu feedstocks; biosolids could be a suitable feedstock but would need to be dried to a high solids consistency before gasification. Waste heat from the process could be used for this purpose, but could result in lost revenue if a purchaser of the heat were available.
- Pre-Processing: all plants have a MRF on the front end to: 1) remove recyclables for sale and inerts not convertible in the system; and 2) prepare the feedstock for gasification (grinding). MRFs vary from relatively simple (metal and inerts recovery and grinding) to extensive, full "dirty MRF" systems recovering cardboard, paper, glass, metal and plastic.
- System is comprised of:
    - An enclosed building for feedstock receiving

- A pre-processing MRF system
- Gasification (either traditional or plasma arc enhanced)
- Vitrification of inert residue to an aggregate material
- Production and conditioning of synthesis gas (primarily H and CO)
- Engine/generators of approx. 20 MW capacity, or;
- Gas to fuel conversion using the Fischer-Tropsch process, biological conversion, or catalytic conversion making roughly 10 million gallons per year, or;
- A combination of power and fuel production

- Principal products: electricity or fuel, aggregate, recyclable commodities, waste heat
- Area required: Approx. 6 acres
- Staff: approx. 40 employees, mostly skilled workers
- Capital Cost: approx. $100-150 million
- Anticipated tipping fees: approx. $75-120 per ton (actual cost will be confirmed upon operations start of first N. American plants in 2012)
- Diversion:
  - Approx. 95-99% (1-5% to landfill disposal)
  - Total: approx. 100,000 TPY
- Local features:
  - Could be located at the County landfill, one of the City water reclamation plants or on an industrial parcel
  - Waste heat electricity produced could be used at the treatment plants, breweries or other industrial application depending on location
  - Could provide up to 10% of the ultimate 2020 renewable electricity goal of the City

Project development would most likely be a public/private partnership with the City providing the land, basic utilities, and Power Purchase Agreement through the PRPA. The vendor would provide all financing, permitting, design, construction, and operation.

ANAEROBIC DIGESTION FACILITY

For dealing with an MSW feedstock, anaerobic digestion systems are coupled with an extensive MRF on the front end to not only recover recyclables and remove inert material, but to prepare an organic feedstock for digestion. The City currently disposes of roughly 130,000 TPY or about 400-450 TPD. A commercial scale plant of 300-400 TPD would be a perfect fit.

Two such projects are in development in the U.S.:

1. Mustang Power (Santa Barbara, CA; 600 TPD; MSW digestion to electricity)
2. Los Angeles County Dept. of Public Works (Calabasas, CA; 700 TPD; MSW digestion to electricity)

Key aspects of these types of projects are as follows:

- Feedstock: mixed MSW as received at the County landfill; source separated foodwaste and greenwaste; biosolids would typically not be a suitable feedstock as this material has already been digested at the WWTP.
- Pre-Processing: extensive MRF on the front end to remove recyclables; remove inerts not convertible in the system; and prepare an organic feedstock for digestion.
- System is comprised of:
    - An enclosed building for feedstock receiving
    - An extensive "dirty MRF" system
    - Digestion
    - Composting of digestate (onsite or offsite, in-vessel or windrow)
    - Production and conditioning of biogas gas (primarily CH_4 and CO_2)
    - Engine/generators or turbines of approx. 1-2 MW capacity
- Principal products: electricity, compost, and significant recyclable commodities, waste heat
- Area required: Approx.6 - 10 acres (depending on composting requirement)
- Staff: up to approx. 75 employees (largely associated with the MRF)
- Capital Cost: approx. $25-50 million
- Anticipated tipping fees: approx. $50-75 per ton
- Diversion:
    - Approx. 65% (35% to landfill disposal)
    - Total: approx. 70,000 TPY
- Local features:
    - Could be located at the County landfill, one of the City water reclamation plants or on an industrial parcel
    - Waste heat and electricity produced could be used at the treatment plants, breweries or other industrial application depending on location
    - Could provide up to 1% of the ultimate 2020 renewable electricity goal of the City

A critical component of these projects is the MRF, and the economics are very sensitive to the pricing of the recycled commodities. Although an advantage in the Southern California area, this would not be as advantageous in the City, where the markets for recyclables are not as strong.

Project development would most likely be a public/private partnership with the City providing the land, basic utilities, and Power Purchase Agreement through the PRPA. The vendor would provide all financing, permitting, design, construction, and operation.

3.4.5 Project 4 – Food Waste Digestion at the Drake Water Reclamation Facility

The Colorado State University Civil Engineering Department, in association with the City's Water Reclamation plant staff, is evaluating the feasibility of adding source-separated food waste from local restaurants and University cafeterias to the influent of the Drake Water Reclamation Plant. Currently, the plant is operating below design organic loading; meaning that existing treatment and digestion capacity is underutilized. The addition of foodwaste would provide additional BOD loading and residual solids for digestion and energy generation in the plant's existing system.

The hope is that the addition of food waste will result in a positive economic impact on the plant operation's budget by making better use of the existing infrastructure; while also providing renewable heat and electricity for the City.

For the plant to become a facility for unprocessed food waste, additional capital improvements would be required to screen and prepare the food waste into a form acceptable to the anaerobic digester. Existing Septage facilities, which have the required power, non-potable water, and trash receiving facilities, could be modified to perform this task. A biogas conditioning system would also be required to remove carbon dioxide and siloxanes, but then the gas could be used for power generation and/or converted to CNG for vehicle usage or return to the grid.

At the time of this report, the outcome of this study is still in the offing regarding both the amount of food waste that could be received and the final economics. However, should the results be positive, this could represent a viable means of converting food waste into electricity without having to develop a stand-alone CT plant. As mentioned elsewhere in this report, other communities are experimenting with just such a system including the East Bay Municipal Utility District (EBMUD) in the San Francisco Bay area, and the City of Los Angeles at its Hyperion Treatment Plant, among others.

It should be noted that the foodwaste that could be used as feedstock for this project is likely the same material that could be used in the demonstration AD project.

4.0 CONCLUSIONS

The City is striving for sustainable, system-wide solutions to both waste disposal, carbon reduction and renewable energy. To pursue these goals, the City asked the Sloan Vazquez and Clements team to analyze the City's wastestream and evaluate the feasibility of new conversion technologies to divert portions of it from the landfill and generate renewable energy.

WASTE STREAM ANALYSIS

The 2012 Waste Composition was primarily derived from the integration of hetergeneous data sources; the Larimer and Boulder County Studies. In addition, tonnage data collected by the City and anecdotal information gathered from local waste haulers and recyclers informed the analysis.

The 2012 Waste Composition identified three (3) primary waste streams; residential, commercial, and construction and demolition. Fourteen (14) material categories were selected in order to best identify opportunities for recovery and diversion from landfill disposal.

By applying the 2012 Waste Composition to the described conceptual landfill disposal reduction processes to increase recycling and create energy, the following outcomes are expected:

- 60% reduction in landfill disposal
- Contribution to local economy of $6,100,000 annually
- Generation of at least 3,300,000 kilowatt hours of electricity annually
- 40% rate adjustment to offset the captial and operating costs of the landfill disposal reduction processess

CONVERSION TECHNOLOGIES

Although power pricing for renewable energy projects has increased in recent years to a respectable range of $0.09 to $0.12 per kWh, the other driving forces for conversion technology, namely landfill capacity and tipping fees remain "extensive" and "low" respectively. This indicates that for a conversion technology to be feasible economically, it will most likely include some of the following features:

- be small in scale
- be supported by grants and/or low interest loans
- take advantage of other local waste streams (breweries, ag operations),
- partner with local industries willing to pay more for waste diversion and/or renewable heat, electricity, or fuel in exchange for increased environmental benefit
- take advantage of a Public/Private partnership with the City
- take advantage ofexisting infrastructure such as the under-utilized digesters and energy generation system at the Drake Water Reclamation Plant

In the near to mid-term, the most feasible CT projects for the City are:

1. Demonstration scale AD plant (approx. 15 TPD)for source-separated foodwaste and greenwaste
2. Small scale Thermal plant (25-100 TPD) for specialty feedstocks, possibly including wood recovered at the IRF
3. Addition of foodwaste to the Drake Water Reclamation Plant

In the long-term, the City should continue to track the progress of the first commercial-scale projects to go into operation in the U.S. and Canada over the next two years. Depending on landfill capacity and tipping fees, and refinement of these commercial-scale CT projects, there may be a future nexus where improved economics and environmental benefit make these projects more attractive in the City.

5.0 RECOMMENDATIONS

This section provides several recommendations for the City to consider in moving forward.

Waste Stream Analysis

1. Identify quantities of source-separated foodwaste and other organics for future CT projects
2. Consider municipal investment in solid waste management infrastructure (MRF) to maximize long-term environmental and economic benefits to the community

Conversion Technologies

1. Plan field trips to operating CT facilitiies:
    a. the small AD facility at University of Wisconsin, Osh Kosh
    b. AD and gasification plants in Europe coupled with staff trips for related purposes
2. Issue a Request for Expressions of Interest or Request for Qualifications for a Demonstration AD project to process source-separated foodwaste and greenwaste:
    a. It would be very beneficial if the City could identify a site for the CT project in the request as this shows the vendors that the City is serious and has value to add to the project
    b. Also beneficial to:
        i. include a commitment from the City to purchase renewable electricity through the PRPA at a certain price or price range
        ii. confirm that the City has control over a sufficient amount of foodwaste and greenwaste to feed the project
3. Include the domonstration AD or small scale Thermal CT projects in the broader RFP to be issued by the City early this year for system-wide solutions involving innovative waste management and energy generation
4. Follow the progress of the first generation smsall-scale and commercial scale CT projects currently in permitting or construction in the U.S. and Canada
5. Evaluate synergies with the IRF:
    a. Further refine the design and operation of the IRF to include a demonstration scale AD project as an option
    b. Identify potential waste heat customers
        i. Located within piping distance of the IRF (no more than ___ ft)
        ii. Willing to host the energy generation portion of the AD project which would allow longer distance pumping of the biogas to an industrial location (e.g. a brewery)

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6.0 APPENDICES

6.1 APPENDIX A – FORT COLLINS WASTE COMPOSITION METHODOLOGY

6.2 APPENDIX B – WASTE COMPOSITION STUDIES

6.2.1 BOULDER COUNTY – 2010 WASTE COMPOSITION STUDY

6.2.2 LARIMER COUNTY – TWO-SEASON WASTE COMPOSITION STUDY

6.3 APPENDIX C – WARM GHG EMISSIONS ANALYSIS

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6.1 APPENDIX A – FORT COLLINS WASTE COMPOSITION METHODOLOGY

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Background

The Fort Collins Waste Stream Study consisted of the development of new, data-based waste composition (2012 Waste Composition) of the waste generated from the City of Fort Collins that is currently landfilled. The 2012 Waste Composition is based primarily upon two prior waste composition studies; one prepared for Larimer County (Larimer County Study) and the other for Boulder County (Boulder County Study). In addition, the Project Team referred to tonnage data collected by the City, anecdotal information gathered from Larimer County Public Works/Solid Waste (including the observation of loads disposed at the Larimer County Landfill), local waste collection companies, and recyclers.

Each Study provides a waste composition of their respective waste stream by material categories for each generator sector class. The waste composition in these studies were developed by the physical sorting of material samples using well establish industry methodologies.

This Appendix provides a step by step description of the methodology used to produce the 2012 Waste Composition for the City of Fort Collins using the Boulder and Larimer County Studies.

Methdodology

Step One

As shown in Table A1, the Larimer County Study used four waste generator sectors while the Boulder County Study used three. To facilitate the merger of two waste composition results, the generator sector used in each study were aligned or mapped to produce a common set of categories.

Table A1 – Waste Generator Sector Classes by Study

	Larimer County Generator Sector			**Boulder County Generator Sector**
1.	Residential		1.	Residential
2.	Commercial		2.	Industrial, Commercial & Institutional (ICI)
3.	Self-Haul		3.	Mountain Drop Boxes
4.	C&D Debris			

To accomplish this, the Self-Haul tons from the Larimer County Study waste were combined into the Residential Sector category. Traditionally, self-hauls to a landfill originate from residents of the surrounding area. Similarly, the Mountain Drop Boxes from the Boulder County Study were combined into the Commercial Sector category.

Tonnage by generator sector for Larimer and Boulder County for the “Original Sectors” and “Mapped Sectors” is provided in Table A2 and Table A3, respectively.

Table A2 – Larimer County Estimated Tonnage by Generator Sector[3]

Mapped Sectors			Original Sectors		
Generator		Tons	Generator		Tons
1.	Residential	73,835	1.	Residential	63,624
			3.	Self-Haul	10,211
2.	Commercial	55,211	2.	Commercial	55,211
4.	C&D Debris	24,516	4.	C&D Debris	24,516
	TOTAL	153,562		**TOTAL**	153,562

Table A3 – Boulder County Estimated Tonnage by Generator Sector [4]

Mapped Sectors			Original Sectors		
Generator		Tons	Generator		Tons
1.	Residential	102,963	1.	Residential	102,963
2.	Commercial	42,057	2.	Industrial, Commercial, Institutional (ICI)	117,228
			3.	Mountain Drop Boxes	24,516
3.	C&D Debris	75,797			
	TOTAL	220,817		**TOTAL**	220,817

Total for the C&D annual tonnage in the Boulder County Study were taken from table 3-7 of the same Study. The same C&D tons appeared to be counted in Table ES-1 within the Industrial/Commercial/Institutional generator sector. Due to this inclusion, the Industrial/Commercial/Institutional annual total tonnage was reduced by the C&D annual tonnage and moved to the C&D total tonnage so as to not change the overall annual tonnage provided in table 3-7, but allow for proper breakout of the C&D annual tons.

The combined tonnage for both Studies are summarized in Tabel A4.

Table A4 – Larimer and Boulder Counties Combined Tonnage

	Residential	Commercial	C&D	Total
Larimer County	73,835	55,211	24,516	153,562
Boulder County	102,963	42,057	75,797	220,817
TOTAL	176,798	97,268	100,313	374,379
Percent	*47.2%*	*26.0%*	*26.8%*	*100.0%*

[3] "Larimer County, Colorado Two-Season Waste Composition Study", Final Report May 2007, p. 4-3, table 4-1, by Mid Atlantic Solid Waste Consultants.

[4] "2010 WASTE COMPOSITION STUDY" Final Report, December 29, 2010, by MSW Consultants, Cascadia Consulting Group, Prepared for Boulder County Resource Conservation Division.

Step Two

Next, a weighted percentage attributable to each source (Study) by generator sector was calculated as indicated in Table A5. For example, for the Residential Generator Sector, 41.76% of the tonnage originated from the Larimer County Study while 58.24% originated from the Boulder County Study. The weighted percentage will be used to allocate the waste composition percentage results from each individual study to create a unified waste composition.

Table A5 – Weighted Percentage Calculation

	Generator Sector					
	Residential		Commercial		C&D	
SOURCE	**Tons**	**Weighted Percent**	**Tons**	**Weighted Percent**	**Tons**	**Weighted Percent**
Larimer County	73,835	41.76%	55,211	56.76%	24,516	24.44%
Boulder County	102,963	58.24%	42,057	43.24%	75,797	75.56%
TOTAL	176,798	100.00%	97,268	100.0%	100,313	100.00%

Step Three

To facilitate the merger of two waste composition results, the material classifications used in each study were aligned or mapped to produce a common set of classifications. This procedure was done separately for each of the three waste generator sectors (i.e., residential, commercial, and construction & demolition debris). For the residential and commercial generator sectors, the Larimer County Study used ten material classifications while the Boulder used eight as shown in Table A6. The C&D generator sector used an expanded list appropriate for materials in that waste stream and is addressed separately in this document.

Table A6 – Waste Composition Classifications by Study

Boulder County Material Classifications			Larimer County Material Classifications	
1.	Paper		**1.**	Paper Products
2.	Plastic		**2.**	Food Waste
3.	Metal		**3.**	Other
4.	C&D		**4.**	Plastics, Leather, Rubber
5.	Glass		**5.**	Yard Waste
6.	Organics		**6.**	Glass & Ceramics
7.	Problem Waste		**7.**	Textiles
8.	HHW		**8.**	Ferrous Metals
	TOTAL		**9.**	Wood Products
			10.	Non-Ferrous Metals
				TOTAL

Because the Boulder County study used less material classifications, the Larimer County material classifications were re-classified to conform to those used in the Boulder Study.

The material labels used in the Larimer County Study were mapped to match those in the Boulder County study that represented the equivalent material category. Specifically, “Paper Products”, “Plastics, Leather, Rubber” and “Glass & Ceramics” as used in the Larimer County study were assigned to “Paper”, “Plastic”, and “Glass”, respectively, as used in the Boulder County study. Similarly, “Ferrous Metals” and “Non-Ferrous Metals” were assigned to “Metal”; “Food Waste”, “Yard Waste” and “Wood Products” were assigned to “Organics”; and “Other” and “Textiles” were assigned to “Problem Waste”.

Table A7 shows the Larimer County waste composition for the residential sector after mapping the material classifications to match those of the Boulder County Study.

Table A7 – Larimer County Waste Composition – Residential Sector

Residential Generator Sector					
Mapped Larimer County			**Original Larimer County**		
Material Classifications		**Percent**	**Material Classifications**		**Percent**
1.	Paper	31.4%	**1.**	Paper Products	31.4%
2.	Plastic	11.9%	**4.**	Plastics, Leather, Rubber	11.9%
3.	Metal	4.7%	**8.** **10.**	Ferrous Metals Non-Ferrous Metals	3.0% 1.7%
4.	C&D	0.0%			
5.	Glass	3.5%	**6.**	Glass & Ceramics	3.5%
6.	Organics	28.8%	**2.** **5.** **9.**	Food Waste Yard Waste Wood Products	17.4% 8.4% 3.0%
7.	Problem Waste	19.7%	**3.** **7.**	Other Textiles	16.4% 3.3%
8.	HHW	0.0%			

Table A8 shows the Larimer County waste composition for the commercial sector after mapping the material classifications to match those of the Boulder County Study.

Table A8 – Larimer County Waste Composition – Commercial Sector

Commercial Generator Sector					
Mapped Larimer County			**Original Larimer County**		
Material Classifications		**Percent**	**Material Classifications**		**Percent**
1.	Paper	31.6%	**1.**	Paper Products	31.6%
2.	Plastic	15.9%	**4.**	Plastics, Leather, Rubber	15.9%
3.	Metal	5.5%	**8.** **10.**	Ferrous Metals Non-Ferrous Metals	3.5% 2.0%
4.	C&D	0.0%			
5.	Glass	2.7%	**6.**	Glass & Ceramics	2.7%
6.	Organics	31.1%	**2.** **5.** **9.**	Food Waste Yard Waste Wood Products	15.9% 6.3% 8.9%
7.	Problem Waste	18.8%	**3.** **7.**	Other Textiles	15.2% 2.6%
8.	HHW	0.0%			

As previously stated, the construction and demolition debris generator sector had an expanded list of material classifications more appropriate to that waste stream. In this case, the material classifications used in the Boulder County Study were re-classified to conform to those used in the Larimer County Study. Additionally, For the Boulder County Study, “Dirt/Sand” which was included in the “Organics” classification was re-classified into the “Rock/Concrete/Brick” classification for consistency. This adjustment is shown on Table A9.

Table A9 – Boulder County Waste Composition Adjustment

Boulder County				
	Material Categories	**Original Percent**	**Adj**	**Adjusted Percent**
1.	Paper	0.5%		0.5%
2.	Plastic	0.6%		0.6%
3.	Metal	2.1%		2.1%
4.	Glass	0.3%		0.3%
5.	Organics	13.4%	-10.2	3.2%
6.	Problem Waste	0.7%		0.7%
7.	Rock/Concrete/Brick	27.5%	10.2	37.7%
8.	Asphalt Shingles	19.1%		19.1%
9.	Painted/Stained/Treated Wood	12.7%		12.7%
10.	Untreated Dimensional Lumber	3.7%		3.7%
11.	Clean/New Drywall	6.7%		6.7%
12.	Demo/Painted Drywall	8.8%		8.8%
13.	Other C&D	3.9%		3.9%
	TOTAL	**100.0%**		**100.0%**

Table A10 shows the Larimer County waste composition for the construction and demolition debris sector after mapping the material classifications to match those of the Boulder County Study.

Table A10 – Re-classification of Larimer County to Conform to Boulder County

	Original Larimer County Material Categories			Mapped to Boulder County Material Categories	
1.	Paper	0.0%			
2.	Plastic	0.0%			
3.	Metal	2.4%	**10.**	Other Ferrous Metal	2.4%
4.	Glass	3.9%	**9.**	Other Broken Glass	3.9%
5.	Organics	10.9	**5.**	Clean Wood	10.9%
6.	Problem Waste	17.2%	**3.**	Carpet	11.8%
		5.4%	**8.**	Other Inorganics	5.4%
7.	Rock/Concrete/Brick	11.2%	**4.**	Block/Brick/Stone	11.2%
8.	Asphalt Shingles	14.7%	**2.**	Asphalt Shingles	14.7%
9.	Painted/Stained/Treated Wood	6.0%	**7.**	Painted/Stained Wood	6.0%
10.	Untreated Dimensional Lumber	10.3%	**6.**	Other Wood	10.3%
11.	Clean New Drywall				
12.	Demo Painted Drywall	15.1%	**1.**	Drywall	15.1%
13.	Other C&D	8.3%	**11.**	Other	8.3%
	TOTAL	100.0%		TOTAL	100.0%

Step Four

The next step is to combine the two waste compositions into one by applying the percentage weights applicable to each source (Study) for each generator sector (residential, commercial, construction & demolition debris). The percentage weights were calculated in Step One and are shown in Table 12.

The combined waste composition for the residential sector is provided in Table A11.

Table A11 – Combined Waste Composition – Residential Sector

		Boulder County Waste Composition		Larimer County Waste Composition		Combined Waste Composition
	Material Classification	**Percent**	**Weighted at 58.24%**	**Percent**	**Weighted at 41.76%**	**Percent**
1.	Paper	12.5%	7.28%		13.11%	20.39%
2.	Plastic	12.6%	7.34%	11.9%	4.97%	12.31%
3.	Metal	2.6%	1.51%	4.7%	1.96%	3.48%
4.	C&D	4.7%	2.74%	0.0%	0.00%	2.74%
5.	Glass	1.5%	0.87%	3.5%	1.46%	2.34%
6.	Organics	48.0%	27.96%	28.8%	12.03%	39.98%
7.	Problem Waste	18.0%	10.48%	19.7%	8.23%	18.71%
8.	HHW	0.1%	.06%	0.0%	0.00%	0.06%
	TOTAL	**100.0%**	**58.24**	**100.0%**	**41.76%**	**100.00%**

The combined waste composition for the commercial sector is provided in Table A12.

Table A12 – Combined Waste Composition – Commercial Sector

		Boulder County Waste Composition		Larimer County Waste Composition		Combined Waste Composition
	Material Classification	**Percent**	**Weighted at 43.24%**	**Percent**	**Weighted at 56.76%**	**Percent**
1.	Paper	20.20%	8.73%	31.60%	17.94%	26.67%
2.	Plastic	13.70%	5.92%	11.22%	6.37%	12.29%
3.	Metal	4.70%	2.03%	5.50%	3.12%	5.15%
4.	C&D	9.30%	4.02%	0.0%	0.00%	4.02%
5.	Glass	2.90%	1.25%	2.70%	1.53%	2.79%
6.	Organics	35.9%	15.52%	31.14%	17.68%	33.20%
7.	Problem Waste	13.00%	5.62%	17.84%	10.13%	15.75%
8.	HHW	0.30%	.13%	0.0%	0.00%	0.13%
	TOTAL	**100.0%**	**43.24**	**100.0%**	**56.76%**	**100.00%**

The combined waste composition for the construction and demolition debris sector is provided in Table A13.

Table A13 – Combined Waste Composition – Construction & Demolition Debris Sector

		Boulder County Waste Composition		Larimer County Waste Composition		Combined Waste Composition
	Material Classification	**Percent**	**Weighted at 75.56%**	**Percent**	**Weighted at 24.44%**	**Percent**
1.	Paper	0.50%	0.38%	0.00%	0.00%	0.38%
2.	Plastic	0.60%	0.45%	0.00%	0.00%	0.45%
3.	Metal	2.10%	1.59%	2.40%	0.59%	2.17%
4.	Glass	0.30%	0.23%	3.90%	0.95%	1.18%
5.	Organics	3.20%	2.42%	10.9%	2.66%	5.08%
6.	Problem Waste	0.70%	0.53%	17.20%	4.20%	4.73%
7.	Rock/Concrete/Brick	37.70%	28.49%	11.20%	2.74%	31.22%
8.	Asphalt Shingles	19.10%	14.43%	14.70%	3.59%	18.02%
9.	Painted/Stained/Treated Wood	12.70%	9.60%	6.00%	1.47%	11.06%
10.	Untreated Dimensional Lumber	3.70%	2.80%	10.30%	2.52%	5.31%
11.	Clean New Drywall	6.70%	5.06%	0.00%	0.00%	5.06%
12.	Demo Painted Drywall	8.80%	6.65%	15.10%	3.69%	10.34%
13.	Other C&D	3.90%	2.95%	8.30%	2.03%	4.98%
	TOTAL	**100.0%**	**75.56%**	**100%**	**24.44%**	**100.00%**

Step Five

The next step is to expand the construction and demolition debris category within the residential and commercial generator sectors by allocating the proportionate share from the construction and demolition generator sector.

Table A14 provides the steps taken to adjust the combined residential waste composition to include the additional construction and demolition classifications. Column A in Table 22 represents the combined residential waste composition from Table 19. The C&D classification represents 2.74% of the total. However, the C&D classification can be further broken down into the classifications used in the C&D waste generator sector composition. This is accomplished by multiplying the 2.74% (Column B) by the percentage for each material classification from the C&D waste composition (Column C). The resultant amount (Column D) is then added to the combined residential material classification (Column A). The final residential waste composition is shown in Column E.

Table A14 – Residential Waste Composition with Expanded C&D

	A	B	C	D	E
Material Classification		**Resi C&D**	**C&D**	**Adjustment**	
Paper	20.39%				20.39%
Plastic	12.31%				12.31%
Metal	3.48%	2.74%	2.17%	0.06%	3.54%
Glass	2.34%				2.34%
Organics	39.98%	2.74%	5.08%	0.14%	40.12%
C&D	2.74%				
Rock/Concrete/Brick	0.00%	2.74%	31.22%	0.85%	0.85%
Asphalt Shingles	0.00%	2.74%	18.02%	0.49%	0.49%
Wood (Painted/Stained/Treated)	0.00%	2.74%	11.06%	0.30%	0.30%
Untreated Dimensional Lumber	0.00%	2.74%	5.31%	0.15%	0.15%
Clean/New Drywall	0.00%	2.74%	5.06%	0.14%	0.14%
Demo/Painted Drywall	0.00%	2.74%	10.34%	0.28%	0.28%
Other	0.00%	2.74%	4.98%	0.19%	0.19%
Problem Waste	18.71%	2.74%	4.73%	0.13%	18.84%
HHW	0.06%				0.06%
TOTAL	**100.00%**				**100.00%**

The same procedure was followed to complete the commercial waste composition. The results are shown on Table A15.

Table A15 – Commercial Waste Composition with Expanded C&D

	A	B	C	D	E
Material Classification		**Comm C&D**	**C&D**	**Adjustment**	
Paper	26.67%				26.67%
Plastic	12.29%				12.29%
Metal	5.15%	4.02%	2.17%	0.09%	5.24%
Glass	2.79%				2.79%
Organics	33.20%	4.02%	5.08%	0.20%	33.40%
C&D	4.02%				
Rock/Concrete/Brick	0.00%	4.02%	31.22%	1.26%	1.26%
Asphalt Shingles	0.00%	4.02%	18.02%	0.72%	0.72%
Wood (Painted/Stained/Treated)	0.00%	4.02%	11.06%	0.44%	0.44%
Untreated Dimensional Lumber	0.00%	4.02%	5.31%	0.21%	0.21%
Clean/New Drywall	0.00%	4.02%	5.06%	0.20%	0.20%
Demo/Painted Drywall	0.00%	4.02%	10.34%	0.42%	0.42%
Other	0.00%	4.02%	4.98%	0.20%	0.28%
Problem Waste	15.75%	4.02%	4.73%	0.19%	15.94%
HHW	0.13%				0.13%
TOTAL	**100.00%**				**100.00%**

Step Six

The final step is to adjust the waste composition for each waste generator sector by its proportion to the total tonnage represented in the two Studies. This amount was calculated in Table A4 for each generator sector and has been entered into Table A16 in row 3, columns C, E, and G. Each material classification for each generator sector was multiplied by this factor to calculate an adjusted amount. For example, for paper in the residential generator sector, Column 20.39% is multiplied by 47.2% to arrive at 9.63%. This process was followed for each classification and for each generator sector. Finally, the amounts in Column C, E, and F were added for each row and entered into Column H.

Table A16 – Waste Composition Adjustment by Residential, Commercial & CD

A	B	C	D	E	F	G	H
	Residential		Commercial		C&D		TOTAL
Material Classification		**47.2%**		**26.0%**		**26.8%**	
Paper	20.39%	9.63%	26.67%	6.93%	26.67%	0.10%	16.66%
Plastic	12.31%	5.81%	12.29%	3.19%	12.29%	0.12%	9.13%
Metal	3.54%	1.67%	5.24%	1.36%	5.24%	0.58%	3.61%
Glass	2.34%	1.10%	2.79%	0.72%	2.79%	0.32%	2.14%
Organics	40.12%	18.95%	33.40%	8.68%	33.40%	1.36%	28.99%
C&D							
Rock/Concrete/Brick	0.85%	0.40%	1.26%	0.33%	1.26%	8.37%	9.10%
Asphalt Shingles	0.49%	0.23%	0.72%	0.19%	0.72%	4.83%	5.25%
Wood (Painted/Stained/Treated)	0.30%	0.14%	0.44%	0.12%	0.44%	2.96%	3.22%
Untreated Dimensional Lumber	0.15%	0.07%	0.21%	0.06%	0.21%	1.42%	1.55%
Clean/New Drywall	0.14%	0.07%	0.20%	0.05%	0.20%	1.36%	1.47%
Demo/Painted Drywall	0.28%	0.13%	0.42%	0.11%	0.42%	2.77%	3.01%
Other	0.19%	0.09%	0.28%	0.07%	0.28%	1.33%	1.50%
Problem Waste	18.84%	8.90%	15.94%	4.14%	15.94%	1.27%	14.31%
HHW	0.06%	0.03%	0.13%	0.03%	0.13%	0.00%	0.06%
TOTAL	**100.00%**	**47.20%**	**100.00%**	**25.98**	**100.00%**	**26.79**	**100.0%**

Table A17 – Fort Collins 2012 Waste Composition

	Residential	Commercial	C&D	Total	
Material Classification	**Percent**	**Percent**	**Percent**	**Percent**	**Tonnage**
Paper	9.63%	6.93%	0.10%	16.66%	21,658
Plastic	5.81%	3.19%	0.12%	9.13%	11,869
Metal	1.67%	1.36%	0.58%	3.61%	4,693
Glass	1.10%	0.72%	0.32%	2.14%	2,782
Organics	18.95%	8.68%	1.36%	28.99%	37,687
C&D					
Rock/Concrete/Brick	0.40%	0.33%	8.37%	9.10%	11,830
Asphalt Shingles	0.23%	0.19%	4.83%	5.25%	6,825
Wood (Painted/Stained/Treated)	0.14%	0.12%	2.96%	3.22%	4,186
Untreated Dimensional Lumber	0.07%	0.06%	1.42%	1.55%	2,015
Clean/New Drywall	0.07%	0.05%	1.36%	1.47%	1,911
Demo/Painted Drywall	0.13%	0.11%	2.77%	3.01%	3,913
Other	0.09%	0.07%	1.33%	1.50%	1,950
Problem Waste	8.90%	4.14%	1.27%	14.31%	18,603
HHW	0.03%	0.03%	0.00%	0.06%	78
TOTAL	**47.20%**	**25.98**	**26.79**	**100.0%**	**130,000**

6.2 Appendix B – Waste Composition Studies

6.2.1 Boulder County – 2010 Waste Composition Study

6.2.2 Larimer County – Two-Season Waste Composition Study

2010 WASTE COMPOSITION STUDY

Prepared for:
BOULDER COUNTY RESOURCE CONSERVATION DIVISION

Final Report

December 29, 2010

MSWCONSULTANTS

CASCADIA CONSULTING GROUP

ACKNOWLEDGEMENTS

The Project Team of MidAtlantic Solid Waste Consultants (MSW Consultants) and Cascadia Consulting Group would like to thank the management and participating operations staff of the following transfer station, landfill, and private waste collection companies that hosted field data collection events for their assistance during various stages of this project.

- Lisa Friend, Sustainability Planner, Boulder County Commissioners' Office;
- Hillary Collins, Assistant Manager, Boulder County Resource Conservation Division;
- Charles Kamenides, Operations Manager, City of Longmont;
- Gary Horton, General Manager, Western Disposal Transfer Station;
- Larry Shea, Operations Manager, Western Disposal Waste Collection;
- Jeff Burrier, District Manager, Waste Connections, Erie Landfill;
- Chris Gronquist, Operations Manager, Waste Connections, Erie Landfill;
- Scott McDonald, Operations Manager, McDonald Farms.

Additionally, the Project Team would like to thank all of the active municipal solid waste (MSW) public and private haulers, all of which were contacted and surveyed to provide disposal data that was used to both formulate the sampling plan for the field work, and to accurately aggregate the resulting waste composition data. We would also like to thank City of Longmont for providing loads of segregated multi-family wastes to be sampled and sorted at the Erie Landfill.

Prime Contractor

MidAtlantic Solid Waste Consultants, LLC
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Subcontractor

Cascadia Consulting Group

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ES. EXECUTIVE SUMMARY

ES 1. INTRODUCTION

Boulder County has long been at the forefront of progressive waste management and recycling. To better understand the opportunities available for increasing recycling and diversion of wastes in Boulder County, the County retained the Project Team of MidAtlantic Solid Waste Consultants (MSW Consultants) and Cascadia Consulting Group (Cascadia) to conduct a statistically representative analysis of the County's disposed waste stream. This study sought to meet the following objectives:

- Quantify the amount of disposed wastes generated in Boulder County, in total and by generator sector.
- Estimate and compare the composition of wastes from individual generator sectors as well as in the aggregate.
- Provide feedback to recycling and solid waste planners in the County and within incorporated municipalities about the efficacy of existing recycling programs so that those programs can maintain or increase their effectiveness.
- Identify materials that represent future opportunities for increasing diversion in Boulder County.
- Establish a baseline so that future waste composition studies can be performed to inform the County as it makes its way towards its zero waste goal.

For solid waste and recycling planners, it is important to differentiate between the sources of wastes so that recycling and diversion programs can be properly targeted. This study defines the following sub-streams of MSW that were targeted for separate sampling and analysis:

- **Single Family Residential**: Waste generated in single family households.
- **Multi-family Residential**: Waste generated in multi-family apartments and condominiums.
- **Industrial, Commercial and Institutional (ICI)**: Waste generated by industrial, commercial, institutional, and other non-residential sources.
- **Construction and Demolition (C&D)**: Wastes generated as a result of construction, renovation, and demolition activities.

The study also separately obtained and analyzed samples of wastes disposed at the County's foothill transfer station sites.

ES 2. OVERVIEW OF RESULTS

Table ES-1 summarizes the estimated quantity of materials generated in Boulder County that require disposal in a landfill. This information was compiled from a combination of County reports, hauler interviews, and extrapolation of waste generation based on unit generation rates. As shown, Boulder County generated almost 221,000 tons of material that was delivered to a local transfer station or landfill for disposal.

Table ES-1 Estimated Countywide MSW Disposal by Generator Sector

Generator Sector	Tons	Percent
Residential	102,963	46.6%
Industrial, Commercial and Institutional (ICI)	117,228	53.1%
Mountain Drop Boxes	626	0.3%
Total MSW	**220,817**	**100.0%**

Figure ES-1 shows the breakdown of major material groups for the aggregate Boulder County waste stream (encompassing residential and ICI wastes, but excluding C&D). Results are shown in estimated percent composition disposed. As shown, Organics is far and away the largest material group, followed by Paper, Problem Waste, and Plastic.

Figure ES-1 Boulder County MSW Composition, 2010

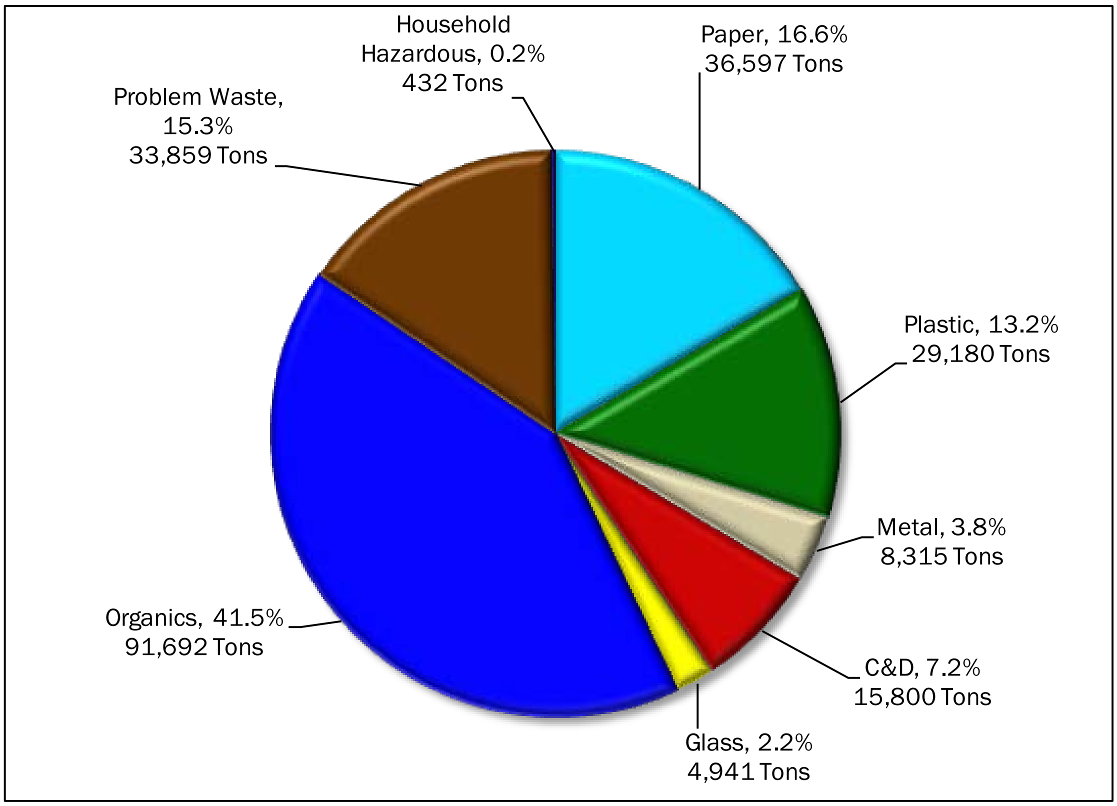

Table ES-2 shows the five most prevalent individual material categories disposed by residential, ICI, and C&D generating sectors. The percent composition is shown in the table.

Table ES-2 Top 5 Most Prevalent Material Categories

Ranking	Residential	ICI	C&D
1	Food Waste (13.1%)	Food Waste (14.9%)	Rock/Concrete/Brick (27.5%)
2	Mixed Yard Waste (12.9%)	Compostable Paper (7.1%)	Asphalt Shingles (19.1%)
3	Textiles/Leather (7.7%)	Corrugated Cardboard (6.7%)	Painted/Stained/Treated Wood (12.7%)
4	Furniture/Bulky Items (6.9%)	Other Rigid Plastics (6.2%)	Dirt/Sand (10.2%)
5	Other Rigid Plastics (6.5%)	Other plastic Film (4.4%)	Demo/Painted Drywall (8.8%)
Top 5	**47.1%**	**39.2%**	**78.3%**

Full results for the County as a whole, as well as for individual generator sectors, is contained in the full report.

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1. INTRODUCTION

1.1. BACKGROUND

Boulder County has long been at the forefront of progressive waste management and recycling. In November 2005 the Board of County Commissioners passed a resolution seeking to achieve Zero Waste (or "darn near") by 2025. Doing so will require an acute focus on changing an entire mindset from waste management to materials management.

To aggressively pursue a zero waste goal, it is critical to understand the amount and composition of the waste stream that is currently being disposed. If wastes are to be turned into resources, it is imperative to know what those resources are. Anecdotal information and available market data suggest that recent history – including the economic downturn in late 2008 and 2009, disruption in the markets for recyclable materials, a crash in the housing and construction market, and the continued changes in product packaging and consumption trends, to name examples – appear to have impacted both waste volume and composition on a national and local scale.

The County retained the Project Team of MidAtlantic Solid Waste Consultants (MSW Consultants) and Cascadia Consulting Group (Cascadia) to conduct a statistically representative analysis of the County's disposed waste stream. This study sought to meet the following objectives:

- Quantify the amount of disposed wastes generated in Boulder County, in total and by generator sector.
- Estimate and compare the composition of wastes from individual generator sectors as well as in the aggregate.
- Provide feedback to recycling and solid waste planners in the County and within incorporated municipalities about the efficacy of existing recycling programs so that those programs can maintain or increase their effectiveness.
- Identify materials that represent future opportunities for increasing diversion in Boulder County.
- Establish a baseline so that future waste composition studies can be performed to inform the County as it makes its way towards its zero waste goal.

1.2. OVERVIEW OF COUNTY WASTE MANAGEMENT SYSTEM

The U.S. Census Bureau indicates a county-wide population of almost 300,000, with approximately two-thirds residing in the cities of Boulder and Longmont. There are a total of 10 incorporated cities and towns in the County, as well as unincorporated area that is spread around the population centers and up into the foothills of the Rocky Mountains.

Solid waste collection and disposal within the County is performed by 19 or more collection companies (and public operations), as well as through citizen self-haul in the rural areas. The cities of Lafayette and Louisville contract for residential waste collection; Longmont provides public collection services to its residents. Additionally, the City of Boulder is predominantly served by Western Disposal, which also owns the in-county transfer station. However, residential collection in the rest of the County, as well as all commercial collection, is provided via open market. While the County receives reports from haulers on collected quantities, these data are provided in the aggregate and do not inform about waste generation by generator sector or by municipality.

Boulder County and its municipalities are aggressive recyclers. Curbside recycling is offered in most of the municipalities, and the County provides a network of drop-off centers for use by residents and small businesses for recycling containers, paper, and yard waste (residents only). Pay-as-you-throw (PAYT) rates are standard in several municipalities. Boulder County owns a recycling processing center where single stream materials are delivered for sortation and sale to markets. The County offers resources to its residents about hard-to-recycle items through a local non-profit organization.

Boulder County's disposed wastes are currently delivered to at least four disposal facilities. However, significant fractions of wastes are delivered to the Western Disposal Transfer Station in the City of Boulder, as well as direct haul to Waste Connection Denver Regional Erie Landfill in Erie, Colorado. Boulder County wastes also end up at the Larimer County Landfill, BFI Foothills Landfill, and Front Range Landfill.

1.3. REPORT ORGANIZATION

The remainder of this report presents the methodology and results of the Boulder County waste composition study. The report is divided into the following sections:

- **Methodology:** This section provides an overview of waste generation and disposal data available from County reports and supplemented with direct surveys, and provides the detailed sampling plan that was developed to govern the study process and to provide statistically defensible data. This section also summarizes the field data collection methods and analytical methods applied in the study.
- **Results:** Detailed results about the composition of the County's landfilled waste are presented in this section. Results are presented in both tabular and graphical format to highlight findings of interest. Results are presented in the aggregate and by generator sector.
- **Appendices:** Supplemental data and field data collection forms are contained in several appendices. Specific appendices include detailed material category definitions for MSW and C&D waste, and field data forms.

2. METHODOLOGY

2.1. INTRODUCTION

Boulder County, Colorado engaged the Project Team of MidAtlantic Solid Waste Consultants (MSW Consultants) and Cascadia Consulting Group (Cascadia) to conduct a waste composition study of Boulder County wastes.

The Project Team submitted a full proposal and approach for conducting a baseline study of waste composition within Boulder County. The Project Team's full approach, including sampling plan development, sampling procedures, field data collection methods, and statistical analysis, was contained in the original proposal. It has been summarized in this section, along with the results of subsequent hauler surveys and waste generation research that was conducted to develop specific sampling targets at the host disposal facilities within and adjacent to Boulder County.

2.2. WASTE GENERATOR SECTORS

This project analyzed the composition of the County's aggregate waste stream, as well as individually from the following generator sectors:

- **Single Family Residential**: Waste generated in single family households.
- **Multi-family Residential**: Waste generated in multi-family apartments and condominiums.
- **Industrial, Commercial and Institutional (ICI)**: Waste generated by industrial, commercial, institutional, and other non-residential source.
- **Construction and Demolition (C&D)**: Wastes generated as a result of construction, renovation, and demolition activities.

The study also separately obtained and analyzed samples of wastes disposed at the County's foothill transfer station sites.

2.3. BOULDER COUNTY WASTE GENERATION AND DISPOSAL

In order to aggregate the results of the waste composition analysis for each of the generator sectors, it is necessary to derive waste generation and waste disposal, both in total and by generator sector. Boulder County has previously expended effort to document its waste generation rate as part of its zero waste planning efforts. Table 2-1 summarizes the three waste generation estimates contained in a March 2009 report that attempted to model waste generation.[1] This report concluded that the best estimate of County waste generation was 344,532 tons, shown in the middle row of the table.

[1] Boulder County Zero Waste Model, Skumatz Economic Research Associates, March 2009.

2. METHODOLOGY

Table 2-1 Boulder County Waste Generation

Source	lbs/ person/ day	Annual Tons Generated
U.S. EPA	4.62	241,538
Skumatz Economic Research Associates	6.59	344,532
Colorado Dept. of Health and Environment	11.6	606,459

Source: Boulder County Zero Waste Model, March 2009.

However, this study did not provide breakdowns of generation by generator sector (residential, ICI), nor did the study compile whether wastes were being disposed, composted, recycled, or otherwise processed or diverted. Subsequent analysis by Boulder County, summarized in the County's Zero Waste Action Plan,[2] estimate the County's recycling rate at 35 percent. However, no prior data is available on the breakdown by generator sector.

To overcome this data limitation, Project Team member Cascadia conducted a survey of County haulers for the purpose of estimating the quantities of waste collected by generator sector and by geographic origin (i.e., municipalities and Boulder County unincorporated areas). Permitted haulers are required to submit disposal reports to the County on an annual basis as a condition of their permit. This information is considered confidential. However, the Project Team was able to review the confidential disposal data, supplemented with direct phone calls to various haulers, as a basis for deriving a representative waste generation and disposal estimates.

Despite good participation by haulers, the confidential hauler reports did not provide 100 percent coverage of all wastes collected in the County. Consequently, the Project Team reviewed the implied residential generation rate from several municipalities based on hauler reports in order to determine an appropriate residential generation rate. In all cases, the resulting estimate of residential waste disposal was higher than the sum of the quantities reported by haulers. This is to be expected because not all haulers reported.

Because of the wide variety of commercial businesses there is no comparable unit generation rate for the Industrial, Commercial and Institutional (ICI) sector. Accordingly, the Project Team estimated ICI waste generation by scaling up the ICI disposal quantities reported in the hauler survey in the same proportion as the residential wastes were scaled up based on the residential waste disposal rates.

The outcome of this exercise, and the implied waste generation and disposal by generator sector, is provided below.

2.3.1 Waste Generation and Disposal Based on Longmont Reports

The City of Longmont was able to provide both residential quantities collected as well as the number of housing units served, which means that the reported generation rate is highly

[2] Boulder County Zero Waste Action Plan Final Draft, December 2010.

defensible. However, Longmont does not provide a curbside collection service for yard waste and organics, unlike some other municipalities and County unincorporated areas. This suggests that use of the Longmont data may slightly overestimate disposed waste quantities. Table 2-2 shows the derived waste generation using the City of Longmont residential generation estimates. As shown, this yields almost identical generation as predicted in the City's Zero Waste Model report in Table 2-1.

Table 2-2 Estimated Countywide MSW Generation and Disposal by Generator Sector Based on Reported Longmont Data

Generator Sector	Tons	Percent
Residential	102,963	46.6%
Industrial, Commercial and Institutional (ICI)	117,228	53.1%
Mountain Drop Boxes	626	0.3%
Total Disposed MSW	220,817	100.0%
Recycling Rate (Zero Waste Action Plan)	*35%*	
Implied Waste Generation	*339,718*	

2.3.2 Waste Generation and Disposal Based on City of Boulder and Louisville Estimates

The Project Team was able to derive reasonably accurate estimates of waste disposal quantities from the City of Boulder and from the City of Louisville. These municipalities offer curbside organics collection, as well as single stream recycling and weekly refuse collection. However, it was necessary to estimate the number of households generating these quantities. Table 2-3 summarizes the derived waste generation and disposal estimates based on City of Boulder and Louisville data. As shown in this table, waste generation and disposal was found to be somewhat lower using these assumptions.

Table 2-3 Estimated Countywide MSW Generation and Disposal by Generator Sector Based on Hauler Report Assumptions from the Cities of Boulder and Louisville

Generator Sector	Tons	Percent
Residential	88,973	46.6%
Industrial, Commercial and Institutional (ICI)	101,383	53.1%
Mountain Drop Boxes	626	0.3%
Total MSW	190,982	100.0%
Recycling Rate (Zero Waste Action Plan)	*35%*	
Implied Waste Generation	*293,818*	

2.3.3 WASTE GENERATION AND DISPOSAL USED IN THIS REPORT

The Project Team believes that there are merits to using either the Longmont data or the City of Boulder and Louisville estimates to justify aggregate waste generation and disposal in Boulder County. The resulting projections for residential and ICI waste disposal reasonably reflect the quantity of wastes being disposed. Further, the Mountain Box quantities are directly reported by the County and are therefore accurate.

Because the Longmont generation derivation was based on verified reports of quantities and units served, the Project Team has applied waste composition results to these quantities of wastes disposed, for the purpose of estimating the quantity of disposed material in the waste stream. The resulting disposal estimates may be slightly high for the County as a whole, but are very reasonable in the context of prior County-sponsored studies on waste generation. The final weighting factors and waste disposal quantities used in the remainder of this report are shown in Table 2-4.

2-4 Countywide MSW Disposal Used in This Report

Generator Sector	Tons	Percent
Residential	102,963	46.6%
Industrial, Commercial and Institutional (ICI)	117,228	53.1%
Mountain Drop Boxes	626	0.3%
Total MSW	**220,817**	**100.0%**

As a final comment, it is important to note that it was not possible to obtain defensible estimates of the quantity of construction and demolition (C&D) debris generated and disposed in Boulder County. For this reason, only the composition of C&D is reported. Because of this, aggregate waste composition therefore includes only municipal solid wastes (MSW), but does not attempt to combine C&D debris.

2.4. MATERIAL CATEGORIES

The list of material categories was developed based on a draft list included in the County's RFP. Appendix A contains the material categories and associated definitions used for the manually sorted samples obtained for this project.

The Project Team's approach relies on manual sorting for residential and commercial wastes, and visual surveying for C&D debris. Because of the visual surveying process and because C&D wastes typically have a different mix of commonly-occurring materials, Appendix A also shows the abbreviated list of material categories and associated definitions for visual surveying of C&D wastes. Note that there is a catch-all category in the C&D list called "Mixed MSW." This category was used to record bagged and loose wastes that are often discarded in C&D wastes at *de minimus* levels.

2.5. SEASONALITY AND HOST FACILITIES

The 2010 Study included two four-day seasonal sampling and sorting events, which were held at Western Disposal's transfer station in Boulder and at the privately-owned Erie Landfill. Table 2-5 summarizes the specific seasonal sampling and sorting schedule.

Table 2-5 Field Data Collection Schedule

Day of Week	Summer Season: July 12 - 15	Winter Season: Oct 26 – 29
Monday	Western Disposal TS	N/A
Tuesday	Western Disposal TS	Erie Landfill
Wednesday	Western Disposal TS	Erie Landfill
Thursday	Erie Landfill	Western Disposal TS
Friday	N/A	Western Disposal TS
Saturday	N/A	Western Disposal TS

As shown in the table, the winter season field data collection event required an additional day of sampling and sorting because of high winds at the outset of the data collection event. Despite weather-related delays, samples were successfully obtained across all six days of the work week and at both of the host disposal facilities that were found to receive the majority of wastes generated in the County.

2.6. SAMPLING TARGETS

The Project Team relied on the results of the hauler survey to develop daily sampling targets at each facility during each season. The Project Team worked with individual haulers to identify the date and time of delivery for targeted loads. In most cases, loads were scheduled to be delivered to one of the two host facilities and were obtained upon regular delivery. However, several haulers – including the City of Longmont – dispatched trucks to the Erie Landfill specifically in support of this project.

Table 2-6 summarizes the planned versus actual distribution of samples by generator sector. As shown, the Project Team successfully obtained the targeted number of samples, and was generally able to achieve the targeted sample distribution. The Project Team believes that the samples obtained provide a representative snapshot of the wastes disposed in Boulder County.

Table 2-6 Planned vs. Actual Distribution Samples

Generator Sector		Proposed Manually Sorted Samples	Actual Manually Sorted	Proposed Visually Surveyed Samples	Actual Visually Surveyed Samples
1	Single Family	25	26	0	0
2	Multi-family	10	8	0	0
3	Commercial	35	36	0	0
4	Foothill Transfer Sites	10	10	0	0
5	C&D	0	0	30	37
	Total	**80**	**80**	**30**	**37**

2.7. FIELD DATA COLLECTION PROCEDURES

This section describes in detail the steps that were performed in the field to successfully acquire, sort, weigh, and discard manually sorted samples.

2.7.1 STAFFING AND SORTER TRAINING PLAN

The Project Team managed and conducted all refuse sampling, sorting, and visual surveying required throughout the study. Specifically, field data collection team included the following individuals:

- **Field Supervisor**: MSW Consultants provided a Field Supervisor. The Field Supervisor's lead responsibility was for planning each sampling and sorting event, and for interacting with the facility personnel whose cooperation was needed throughout the field data collection. The Field Supervisor generally led the sampling selection process and oversaw the physical taking of the 200-250 pound samples. The Field Supervisor was ultimately responsible for the successful completion of the project. The Field Supervisor also made visual surveys of the targeted C&D loads as time permitted at each host facility.
- **Crew Chief**: MSW Consultants provided a Crew Chief. The Crew Chief was the second professional staff person. The Crew Chief was responsible for managing the manual sorting area, including crew management, sorting productivity and accuracy, data recording, work site health and safety, and cleaning up at the end of the day.
- **Sorting Labor**: MSW Consultants contracted locally-based light industrial temporary workers to serve as sorting labor. Training and oversight was provided by the MSW Consultants field operations management staff above.

As a final note, MSW Consultants maintained the guidelines in the Safety and Health Plan that was submitted in the proposal which governs our conduct of waste characterization studies.

2.7.2 Load Selection

Daily routes were pre-selected at each facility each day for most waste substreams. C&D loads were systematically selected.

The Field Supervisor interviewed the drivers of selected loads to confirm the geographic origin and type of waste, as well as any other pertinent data. This information was noted on the vehicle selection form, along with a unique identifying number associated with that vehicle on that day. A copy of the weight ticket (if available) for each vehicle was obtained for every incoming truck selected for sampling and sorting.[3]

2.7.3 Taking Random Samples for Manual Sorting

Selected loads of waste designated for sorting were tipped in the designated area at the host facility. From each selected load, one sample of waste was selected based on systematic "grabs" from the perimeter of the load. For example, if the tipped pile is viewed from the top as a clock face with 12:00 being the part of the load closest to the front of the truck, the first samples was taken from 3 o'clock, 6 o'clock, 9 o'clock, 12 o'clock, and then from 1, 4, 7, and 10 o'clock, and so-on .

Figure 2-1 Example of a Grab Sample Staged for Manual Sorting

Once the area of the tipped load was selected, the Field Supervisor coordinated with a facility-provided loader operator to take a "grab" sample of wastes from that point in the tipped load. The loader operator removed a sample of waste that exceeded the targeted sample weight, and placed the grab sample in a secure area to await sorting. This is shown in Figure 2-1.

It should be notes that only one sample was obtained from single family residential and ICI truckloads. Either one or two samples were taken from the foothill transfer site drop boxes. At the two host disposal facilities, the Project Team arranged with Western Disposal and the City of Longmont to have segregated loads of multi-family wastes delivered for sampling and sorting. Because these loads were specially arranged, the Project Team acquired two grab samples from each load. Because of unforeseen weather challenges during the second season, one of the pre-arranged multi-family loads could not be delivered.

[3] Some haulers delivering C&D to the Western Disposal Transfer Station operated under a "flat rate" charge agreement with the facility. These C&D loads were charged by volume rather than weight. For these loads, the field supervisor noted the cubic yardage of the container and the weight was calculated based upon industry standard C&D density estimates.

2. METHODOLOGY

Refuse samples were deposited on a tarp or paved surface designated to receive samples. Each was labeled by its identifying number using a white board. The white board for sample identification stayed with the sample until sorting and weigh out was completed.

2.7.4 MANUAL SORTING

Once each sample was acquired, the material was manually sorted into the prescribed component categories. Plastic 20-gallon bins with sealed bottoms were used to contain the separated components. A picture of the sorting table and bins is shown in Figure 2-2.

Figure 2-2 Sort Table and Bins

Sorters were asked to specialize in certain material groups, with someone handling the paper categories, another the plastics, another the glass and metals, and so on. In this way, sorters became highly knowledgeable in a short period of time as to the definitions of individual material categories.

The Crew Chief monitored the bins as each sample was sorted, rejecting materials that were improperly classified. Open bins allowed the Crew Chief to see the material at all times. The Crew Chief also verified the purity of each component during the weigh-out (discussed below). The materials were sorted to particle size of 2-inches or less by hand, until no more than a small amount of homogeneous fine material ("mixed residue") remained. This layer of mixed 2-inch-minus material was be allocated to the appropriate categories based on the best judgment of the Crew Chief—most often a combination of Other Paper, Other Organics, or Food Waste. Particles falling through a half inch screen were swept into a Fines category.

2.7.5 VISUAL SURVEYING OF C&D LOADS

C&D debris is by nature very different in composition compared to residential and commercial waste collected in compacting vehicles. Where residential and commercial waste loads consist of waste from dozens (commercial) or hundreds (residential) generators, and since most particles are relatively small (less than 12 inches), physical grab sampling and sorting is both practical from an operations standpoint and is also statistically appropriate.

However, C&D debris is very different. C&D typically contains large items that are difficult to "grab" and manually sort, such as drywall, dimensional lumber, and a number of bulky items. Furthermore, grabs of C&D waste frequently miss the densest items in the load – concrete, brick, block and dirt – which sink to the bottom center of the tipped load. Even a 300 pound grab of a C&D load may not come close to representing the full contents of the load.

Since the mid 1990s, the solid waste industry has studied various methods for characterizing C&D debris, and has generally found that visual surveying of C&D loads provides the best combination of accuracy and cost effectiveness to enable a statistically meaningful number of samples to be collected.

The Project Team's protocol for characterizing C&D loads entailed visual surveying of the entire load of C&D. Visual surveying of a load of C&D waste involves detailed volumetric measurements of the truck and load dimensions, followed by the systematic observation of the major material components in the tipped load. The basic steps to visual surveying were:

1. Measure the dimensions of the incoming load prior to tipping and estimate the percent full of the vehicle.
2. Tip the load. If it is a large load, and if possible, have a loader spread out the material so that it is possible to discern dense materials such as block, brick, and dirt that tend to sink to the bottom of the pile.
3. Make a first pass around the load marking the major material categories that are present in the load—cardboard, drywall, dimensional lumber, etc. Estimate the percentage of the load made up of these major materials. If possible, estimate the yardage associated with this material.
4. Make a second pass around the load, noting the secondary material categories contained in the load. Estimate the percentage of the load made up of these materials. If possible, estimate the yardage associated with this material.
5. Validate that the estimated percentages sum to 100 percent, and that the estimated yardage of major material categories is realistic given the overall truck dimensions and volume.

2.8. DATA RECORDING

The MSW Team believes that the weigh-out and data recording process is the most critical process of the sort. The Crew Chief was singularly responsible for overseeing all weighing and data recording of each sample. Once each sample had been sorted, the weigh-out was performed. Each bin containing sorted materials from the just-completed samples was carried over to a digital scale provided by the Project Team. Sorting laborers assisted with carrying and weighing the bins of sorted material, the Crew Chief recorded all data.

The Crew Chief used a waste composition data sheet to record the composition weights, as well as to record other observed or emperical information. Each data sheet containing the sorted weights of each sample were matched up against the Field Supervisor's sample sheet to assure accurate tracking of the samples each day.

The Project Team designed a customized database to manage the data from waste sorting, and the Crew Chief entered the data from the waste sample tally sheets to assure that all handwriting could be deciphered. Entered data was subjected to quality control queries, and any anomalies were resolved against the hand-written information on the sample tally sheets or supervisor's sheet. Specific steps taken to ensure the integrity of data during entry and analysis included:

- Verifying that data forms were obtained for each day the data collection crew was in the field.
- Having the data collection crew keep copies of all forms while the originals were shipped to the office.
- Random checks of the computer-entered data against the paper form, to verify that all numbers were entered and to look for any systematic or random mistakes.

- Encoding the composition analysis formulae into a routine that can be applied consistently to different data sets. (This minimizes errors that could arise from mistyping formulae, etc.)

2.9. STATISTICAL METHODS

Using tested statistical procedures, Project Team member Cascadia developed detailed estimates of waste composition and quantities for each generator sector to statistically represent the County's waste stream.

The statistical confidence interval was calculated for each generator sector and in total. The approach used for calculating the mean weight estimates and the confidence intervals is described below. Confidence intervals were calculated at 90 percent.

Composition estimates represent the ratio of the material's weight to the total material for each noted material component in a particular segment of the waste stream. They are derived by summing each component's weight across all of the relevant samples and dividing by the sum of the total weight of waste/recyclables, as shown in the following equation:

$$r_j = \frac{\sum_i c_{ij}}{\sum_i w_i}$$

where:

c = weight of particular material component

w = sum of all component weights

for i = 1 to n, where n = number of selected samples

for j = 1 to m, where m = number of material components

The confidence interval for this estimate is derived in two steps. First, the variance around the estimate is calculated, accounting for the fact that the ratio includes two random variables (the component and total sample weights). The variance of the ratio estimator equation follows:

$$\hat{V}_{r_j} = \left(\frac{1}{n}\right) \cdot \left(\frac{1}{\overline{w}^2}\right) \cdot \left(\frac{\sum_i \left(c_{ij} - r_j w_i\right)^2}{n-1}\right) \quad \textit{where} \quad \overline{w} = \frac{\sum_i w_i}{n}$$

Second, confidence intervals at the 90% confidence level are calculated for a component's mean as follows:

$$r_j \pm \left(t \cdot \sqrt{\hat{V}_{r_j}}\right)$$

where

t = the value of the t-statistic corresponding to a 90 percent confidence level.

As a final step, the County-wide composition of waste was calculated as the weighted average of the various generator sectors that were individually analyzed. Weighting factors are shown in Table 2-1.

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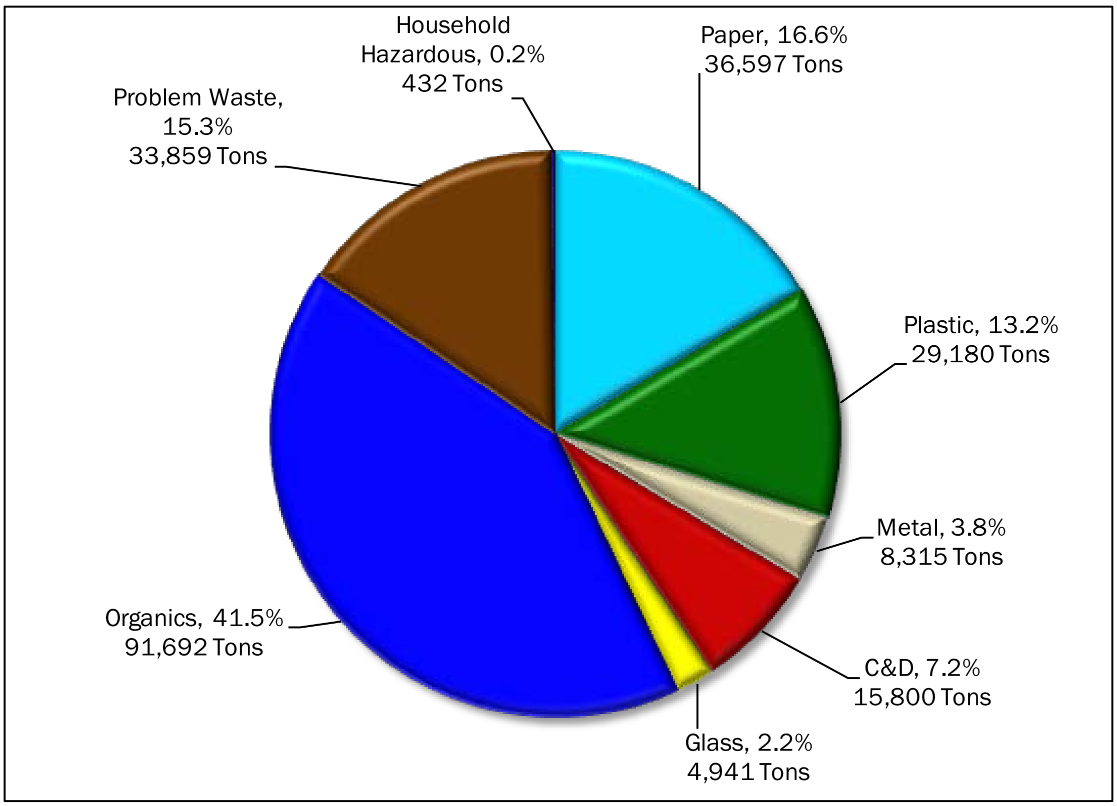
3. RESULTS

3.1. BOULDER COUNTY MSW COMPOSITION

Figure 3-1 shows the breakdown of major material groups for the aggregate countywide municipal solid waste stream (encompassing residential, ICI, and mountain box wastes). Results are shown both in percentage terms as well as the estimated mean tons disposed. As shown, Organics is far and away the largest material group, followed by Paper, Problem Waste, and Plastic.

Figure 3-1 Boulder County MSW Composition, 2010



3. RESULTS

Figure 3-2 shows the top 10 most prevalent material categories in the Boulder County MSW stream. Not surprisingly, Food Waste is the single most prevalent category. However, it is of interest that there appears to be significant fractions of yard wastes (including leaves) and compostable and recyclable papers still in disposed wastes.

Figure 3-2 Top 10 Most Prevalent Material Categories in Boulder County MSW

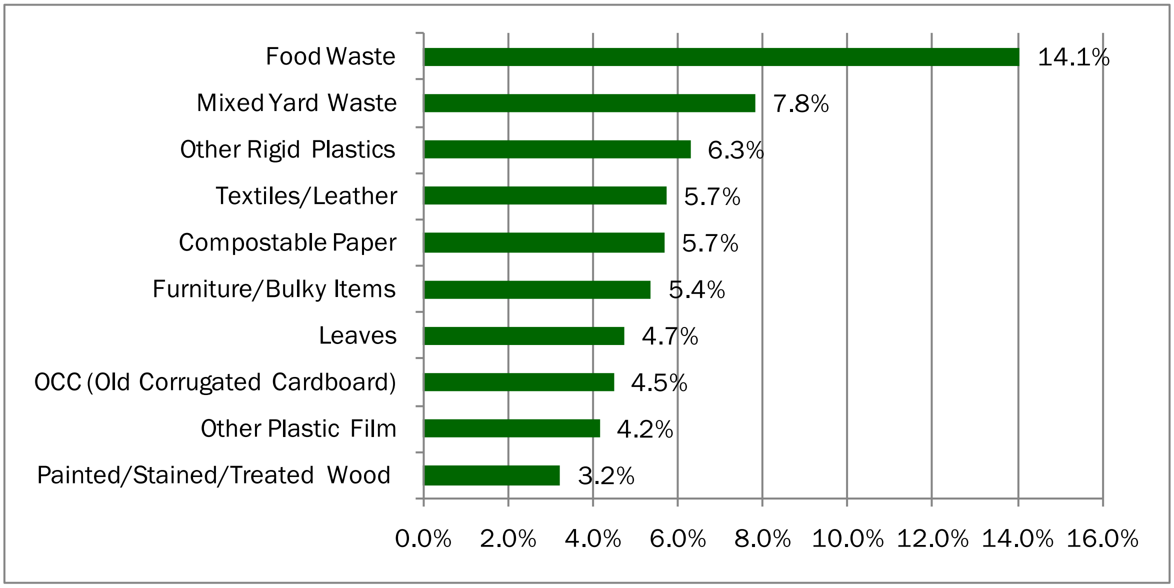


Table 3-1 on the following page provides a detailed statistical profile of Boulder County's disposed MSW stream. For each material category, the estimated disposed tons, mean percent, and lower and upper confidence intervals are shown. Confidence intervals are calculated at a 90 percent level of confidence.

Table 3-1 Boulder County Detailed MSW Composition

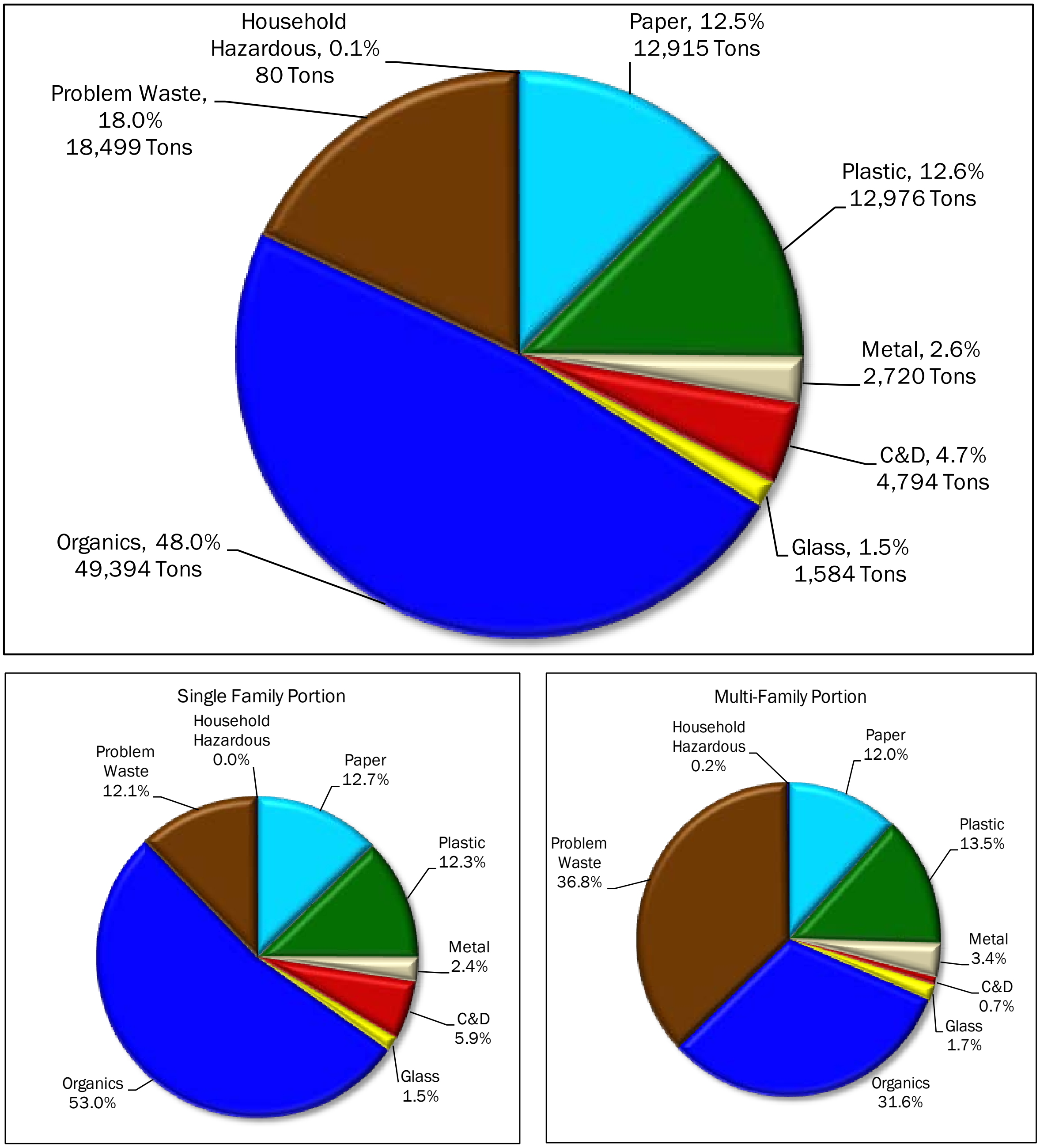
Material		+ / -	Est. Tons	Material		+ / -	Est. Tons
Paper	**16.6%**		**36,597**	**Glass**	**2.2%**		**4,941**
Newsprint	0.8%	0.2%	1,769	Glass Bottles and Jars	1.9%	0.6%	4,103
High Grade Office Paper	0.8%	0.4%	1,824	Other Glass	0.4%	0.2%	838
Shredded Paper	0.3%	0.2%	632				
OCC (Old Corrugated Cardboard)	4.5%	1.2%	9,908	**Organics**	**41.5%**		**91,692**
Magazines/Catalogs	0.9%	0.3%	2,091	Mixed Yard Waste including Small Branches	7.8%	2.5%	17,271
Recyclable Mixed Paper	2.1%	0.3%	4,642	Branches/Limbs and Stumps >6" Diameter	1.3%	0.6%	2,765
Polycoated/Aseptic Containers	0.1%	0.0%	278	Leaves	4.7%	1.6%	10,471
Compostable Paper	5.7%	0.8%	12,559	Food Waste	14.1%	1.7%	31,055
Unrecyclable Mixed Paper	1.3%	0.3%	2,895	Other Untreated Wood	0.5%	0.4%	1,100
				Textiles/Leather	5.7%	1.5%	12,666
Plastic	**13.2%**		**29,180**	Fines/Dirt	2.9%	0.7%	6,318
#1 PET Bottles/Jars	0.5%	0.1%	997	Pallets	2.2%	1.4%	4,769
#2 HDPE Bottles/Jars	0.4%	0.1%	908	Other Organics	2.4%	0.6%	5,277
Bottles #3-7	0.1%	0.0%	194				
Other Plastic Containers <3 Gallons	0.2%	0.1%	479	**Problem Waste**	**15.3%**		**33,859**
Large Plastic Containers >3 Gallons	0.3%	0.2%	732	Large Electronics (Plug-in)	2.2%	1.0%	4,874
Plastic Retail Bags	0.4%	0.1%	781	Small Electronics (Rechargeable)	0.2%	0.2%	468
Other Plastic Film	4.2%	0.6%	9,169	Small Appliances	0.7%	0.5%	1,506
Expanded Polystyrene	0.9%	0.5%	2,019	Diapers/Sanitary Products	1.7%	0.4%	3,728
Other Rigid Plastics	6.3%	1.3%	13,901	Carpet/Padding	3.2%	1.9%	7,019
				Batteries	0.2%	0.2%	482
Metal	**3.8%**		**8,315**	Rubber	0.7%	0.2%	1,524
Aluminum Containers	0.3%	0.1%	570	Tires	0.9%	0.7%	1,981
Aluminum Foil & Trays	0.2%	0.1%	369	Furniture/Bulky Items	5.4%	2.0%	11,868
Ferrous Containers	0.5%	0.1%	1,097	Other Inorganics	0.2%	0.1%	410
Other Ferrous	1.7%	0.7%	3,852				
Other Non-Ferrous	0.9%	0.4%	1,948	**Household Hazardous Waste (HHW)**	**0.2%**		**432**
White Goods	0.2%	0.4%	479	Fluorescent Tubes and Bulbs	0.0%	0.0%	12
				Pharmaceuticals and Syringes	0.0%	0.0%	35
C&D	**7.2%**		**15,800**	Oil-based Paint & Finishes	0.0%	0.0%	0
Aggregate/Concrete/Asphalt/Ceramics	0.5%	0.4%	1,176	Latex Paint & Finishes	0.0%	0.0%	35
Asphalt Shingles	0.0%	0.0%	60	Pesticides	0.0%	0.0%	0
Painted/Stained/Treated Wood	3.2%	1.2%	7,155	Automotive Fluids	0.0%	0.1%	87
Clean Dimensional Lumber	1.7%	1.0%	3,749	Other Household Hazardous Waste	0.1%	0.1%	263
Clean/New Drywall	0.2%	0.2%	349				
Demo/Painted Drywall	0.5%	0.5%	1,031				
Other C&D	1.0%	0.5%	2,279	**Totals**	**100.0%**		**220,817**
				Sample Count	**80**		

Confidence intervals calculated at the 90% confidence level. Percentages for material types may not total 100% due to rounding.

3.2. RESIDENTIAL MSW COMPOSITION

Figure 3-3 presents the breakdown of residential wastes. The top pie chart shows results for all residential wastes (i.e., single family and multi-family). The bottom pie charts split out the composition of single family wastes and multi-family wastes so that the reader can see the difference in the two substreams. Because the majority of residential wastes are generated by single family households, the single family composition dominates multi-family in the overall residential waste stream.

Figure 3-3 Boulder County Residential Waste Composition, 2010



As shown in Figure 3-3, Organics make up almost half of residential wastes. However, the single family profile and the multi-family profiles are significantly different. Organics dominate single family wastes, but in the multi-family waste stream, Problem Materials are the single largest material group. Figure 3-4 shows the top 10 most prevalent material categories in Residential waste. Food waste, yard waste, and leaves are large contributors.

Figure 3-4 Top 10 Most Prevalent Material Categories in Residential Waste

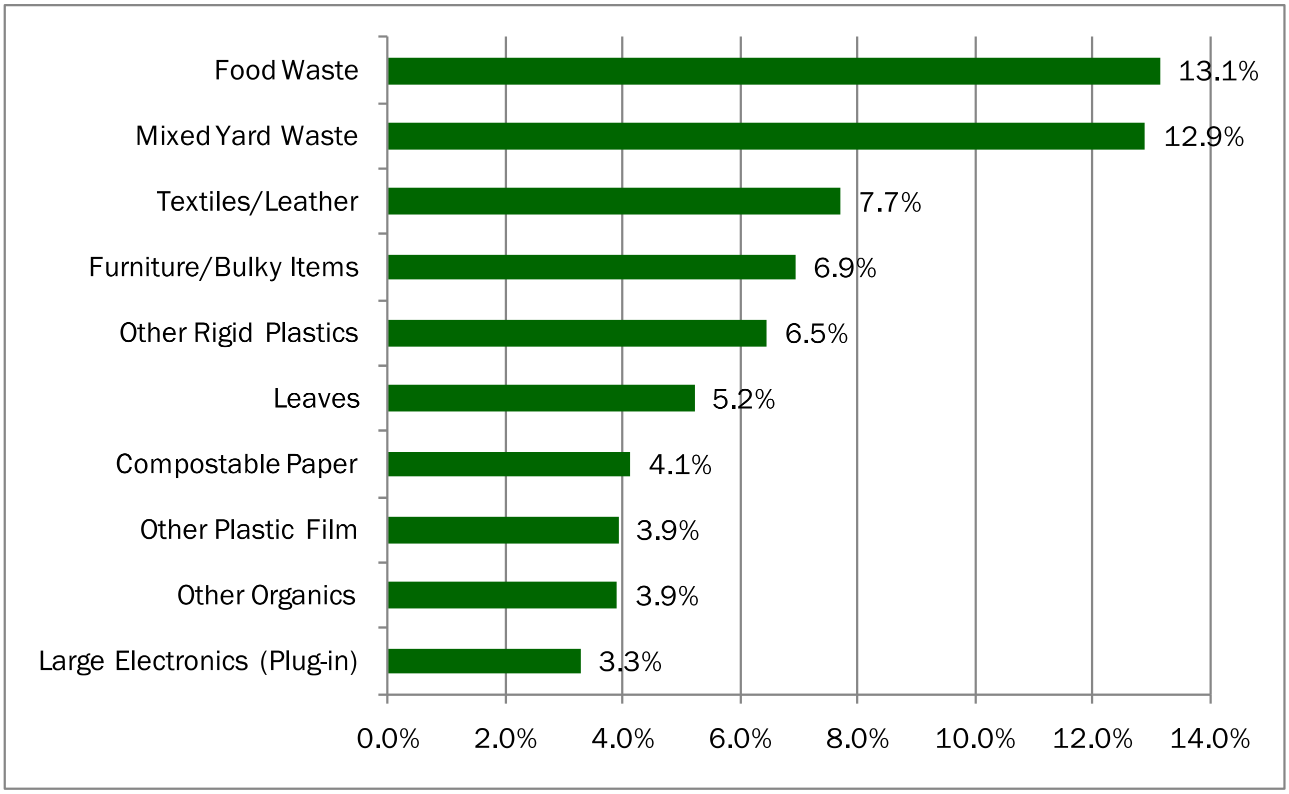


Table 3-2 compares the 10 most prevalent materials in disposed single family and multi-family wastes. This table highlights the significant differences between single family and multi-family materials. Of particular interest are the large fraction of bulky items, furniture, and small appliances in multi-family wastes. The following notable observations are made about multi-family wastes:

- Two of the eight multi-family samples contained television sets, which are categorized as Large Electronics. In both samples, the televisions weighed 30 pounds or more; which caused the relatively high reported fraction of Large Electronics in the multi-family results.
- Three of the eight multi-family samples contained a significant quantity of leaves, which caused the relatively high percentage of this material.

The Project Team notes that these findings suggest that further investigation would be informative, as the relatively low sample size (eight samples) does not provide the level of representativeness that would be needed to better analyze the prevalence of these materials in multi-family wastes. However, the fact that two televisions were found in multi-family samples, as well as a significantly higher fraction of furniture and bulky items, suggests that the multi-family waste stream is significantly different from single family wastes.

Table 3-2 Comparison of Top Ten Materials in the Single Family and Multi-Family Waste

Single Family MSW	%	Multi-Family MSW	%
Mixed Yard Waste	16.6%	Furniture/Bulky Items	18.9%
Food Waste	14.6%	Large Electronics (Plug-in)	9.0%
Textiles/Leather	7.5%	Food Waste	8.4%
Other Rigid Plastics	5.9%	Textiles/Leather	8.3%
Leaves	4.3%	Other Rigid Plastics	8.2%
Compostable Paper	4.2%	Leaves	8.1%
Other Plastic Film	4.1%	Corrugated Cardboard	4.4%
Other Organics	4.0%	Compostable Paper	4.0%
Diapers/Sanitary	3.2%	Small Appliances	3.7%
Furniture/Bulky Items	3.2%	Other Organics	3.5%
	67.6%		76.4%

Table 3-3 provides a detailed statistical profile of the County's Residential waste stream.

Table 3-3 2010 Detailed Residential Waste Composition

Material	Est. Percent	+ / -	Est. Tons	Material	Est. Percent	+ / -	Est. Tons
Paper	**12.5%**		**12,915**	**Glass**	**1.5%**		**1,584**
Newsprint	0.9%	0.4%	934	Glass Bottles and Jars	1.2%	0.3%	1,280
High Grade Office Paper	0.6%	0.5%	586	Other Glass	0.3%	0.1%	304
Shredded Paper	0.4%	0.3%	409				
OCC (Old Corrugated Cardboard)	2.0%	1.4%	2,017	**Organics**	**48.0%**		**49,394**
Magazines/Catalogs	1.0%	0.5%	997	Mixed Yard Waste including Small Branches	12.9%	4.8%	13,284
Recyclable Mixed Paper	2.1%	0.3%	2,136	Branches/Limbs and Stumps >6" Diameter	1.6%	0.9%	1,624
Polycoated/Aseptic Containers	0.1%	0.0%	141	Leaves	5.2%	2.2%	5,366
Compostable Paper	4.1%	0.5%	4,253	Food Waste	13.1%	1.9%	13,539
Unrecyclable Mixed Paper	1.4%	0.5%	1,442	Other Untreated Wood	0.6%	0.9%	622
				Textiles/Leather	7.7%	1.9%	7,932
Plastic	**12.6%**		**12,976**	Fines/Dirt	2.6%	0.6%	2,629
#1 PET Bottles/Jars	0.4%	0.1%	426	Pallets	0.4%	0.5%	376
#2 HDPE Bottles/Jars	0.4%	0.1%	371	Other Organics	3.9%	1.1%	4,022
Bottles #3-7	0.1%	0.1%	126				
Other Plastic Containers <3 Gallons	0.2%	0.1%	191	**Problem Waste**	**18.0%**		**18,499**
Large Plastic Containers >3 Gallons	0.3%	0.2%	282	Large Electronics (Plug-in)	3.3%	1.9%	3,376
Plastic Retail Bags	0.4%	0.1%	422	Small Electronics (Rechargeable)	0.4%	0.4%	385
Other Plastic Film	3.9%	0.9%	4,032	Small Appliances	1.2%	0.9%	1,217
Expanded Polystyrene	0.5%	0.3%	482	Diapers/Sanitary Products	2.9%	0.8%	2,989
Other Rigid Plastics	6.5%	1.5%	6,644	Carpet/Padding	2.2%	1.4%	2,249
				Batteries	0.1%	0.1%	111
Metal	**2.6%**		**2,720**	Rubber	0.4%	0.2%	363
Aluminum Containers	0.3%	0.1%	270	Tires	0.5%	0.5%	547
Aluminum Foil & Trays	0.1%	0.0%	92	Furniture/Bulky Items	6.9%	3.4%	7,143
Ferrous Containers	0.6%	0.1%	589	Other Inorganics	0.1%	0.1%	120
Other Ferrous	1.0%	0.9%	1,069				
Other Non-Ferrous	0.2%	0.3%	223	**Household Hazardous Waste (HHW)**	**0.1%**		**80**
White Goods	0.5%	0.8%	477	Fluorescent Tubes and Bulbs	0.0%	0.0%	4
				Pharmaceuticals and Syringes	0.0%	0.0%	30
C&D	**4.7%**		**4,794**	Oil-based Paint & Finishes	0.0%	0.0%	0
Aggregate/Concrete/Asphalt/Ceramics	0.9%	0.9%	964	Latex Paint & Finishes	0.0%	0.0%	0
Asphalt Shingles	0.0%	0.0%	32	Pesticides	0.0%	0.0%	0
Painted/Stained/Treated Wood	1.9%	0.9%	1,993	Automotive Fluids	0.0%	0.0%	0
Clean Dimensional Lumber	0.7%	0.6%	694	Other Household Hazardous Waste	0.0%	0.0%	46
Clean/New Drywall	0.3%	0.5%	349				
Demo/Painted Drywall	0.0%	0.0%	12				
Other C&D	0.7%	0.5%	750	**Totals**	**100.0%**		**102,963**
				Sample Count	**34**		

Confidence intervals calculated at the 90% confidence level. Percentages for material types may not total 100% due to rounding.

3. RESULTS

Table 3-4 compares the single family and multi-family waste stream composition.

Table 3-4 2010 Comparison of Single Family and Multi-Family Waste Composition

	Single Family		Multi-Family			Single Family		Multi-Family	
	Est.		Est.			Est.		Est.	
Material	**Percent**	**+ / -**	**Percent**	**+ / -**	**Material**	**Percent**	**+ / -**	**Percent**	**+ / -**
Paper	**12.7%**		**12.0%**		**Glass**	**1.5%**		**1.7%**	
Newsprint	1.0%	0.4%	0.7%	0.7%	Glass Bottles and Jars	1.2%	0.3%	1.3%	0.7%
High Grade Office Paper	0.7%	0.6%	0.1%	0.1%	Other Glass	0.3%	0.1%	0.4%	0.4%
Shredded Paper	0.5%	0.4%	0.0%	0.0%					
OCC (Old Corrugated Cardboard)	1.2%	0.8%	4.4%	5.4%	**Organics**	**53.0%**		**31.6%**	
Magazines/Catalogs	1.2%	0.7%	0.3%	0.2%	Mixed Yard Waste including Small Branches	16.6%	5.8%	1.1%	1.8%
Recyclable Mixed Paper	2.2%	0.4%	1.7%	0.6%	Branches/Limbs and Stumps >6" Diameter	2.0%	1.1%	0.1%	0.1%
Polycoated/Aseptic Containers	0.1%	0.0%	0.1%	0.1%	Leaves	4.3%	1.9%	8.1%	7.2%
Compostable Paper	4.2%	0.5%	4.0%	0.9%	Food Waste	14.6%	2.2%	8.4%	2.4%
Unrecyclable Mixed Paper	1.6%	0.6%	0.7%	0.5%	Other Untreated Wood	0.8%	1.2%	0.0%	0.0%
					Textiles/Leather	7.5%	2.3%	8.3%	3.5%
Plastic	**12.3%**		**13.5%**		Fines/Dirt	2.7%	0.7%	2.0%	1.4%
#1 PET Bottles/Jars	0.4%	0.1%	0.6%	0.5%	Pallets	0.5%	0.6%	0.0%	0.0%
#2 HDPE Bottles/Jars	0.4%	0.2%	0.3%	0.2%	Other Organics	4.0%	1.3%	3.5%	2.4%
Bottles #3-7	0.1%	0.1%	0.1%	0.1%					
Other Plastic Containers <3 Gallons	0.2%	0.1%	0.1%	0.1%	**Problem Waste**	**12.1%**		**36.8%**	
Large Plastic Containers >3 Gallons	0.3%	0.3%	0.1%	0.1%	Large Electronics (Plug-in)	1.5%	1.5%	9.0%	5.1%
Plastic Retail Bags	0.4%	0.1%	0.3%	0.2%	Small Electronics (Rechargeable)	0.5%	0.5%	0.0%	0.0%
Other Plastic Film	4.1%	1.0%	3.5%	1.8%	Small Appliances	0.4%	0.5%	3.7%	3.4%
Expanded Polystyrene	0.5%	0.4%	0.3%	0.2%	Diapers/Sanitary Products	3.2%	1.1%	1.8%	0.9%
Other Rigid Plastics	5.9%	1.7%	8.2%	3.1%	Carpet/Padding	2.1%	1.6%	2.5%	3.0%
					Batteries	0.1%	0.1%	0.0%	0.0%
Metal	**2.4%**		**3.4%**		Rubber	0.3%	0.1%	0.6%	0.6%
Aluminum Containers	0.2%	0.1%	0.4%	0.2%	Tires	0.6%	0.6%	0.4%	0.6%
Aluminum Foil & Trays	0.1%	0.0%	0.1%	0.1%	Furniture/Bulky Items	3.2%	3.0%	18.9%	7.7%
Ferrous Containers	0.5%	0.2%	0.7%	0.3%	Other Inorganics	0.1%	0.1%	0.0%	0.0%
Other Ferrous	1.3%	1.2%	0.2%	0.1%					
Other Non-Ferrous	0.3%	0.3%	0.1%	0.0%	**Household Hazardous Waste (HHW)**	**0.0%**		**0.2%**	
White Goods	0.0%	0.0%	2.0%	3.2%	Fluorescent Tubes and Bulbs	0.0%	0.0%	0.0%	0.0%
					Pharmaceuticals and Syringes	0.0%	0.0%	0.0%	0.0%
C&D	**5.9%**		**0.7%**		Oil-based Paint & Finishes	0.0%	0.0%	0.0%	0.0%
Aggregate/Concrete/Asphalt/Ceramics	1.2%	1.1%	0.1%	0.1%	Latex Paint & Finishes	0.0%	0.0%	0.0%	0.0%
Asphalt Shingles	0.0%	0.0%	0.1%	0.1%	Pesticides	0.0%	0.0%	0.0%	0.0%
Painted/Stained/Treated Wood	2.5%	1.2%	0.2%	0.4%	Automotive Fluids	0.0%	0.0%	0.0%	0.0%
Clean Dimensional Lumber	0.9%	0.8%	0.0%	0.0%	Other Household Hazardous Waste	0.0%	0.0%	0.2%	0.2%
Clean/New Drywall	0.4%	0.7%	0.1%	0.1%					
Demo/Painted Drywall	0.0%	0.0%	0.0%	0.0%					
Other C&D	0.9%	0.6%	0.3%	0.3%	**Totals**	**100.0%**		**100.0%**	

Confidence intervals calculated at the 90% confidence level. Percentages for material types may not total 100% due to rounding.

3.3. ICI WASTE COMPOSITION

Figure 3-5 presents the breakdown of ICI wastes by material group. The largest material group in the ICI sector was found to be Organics, followed by Paper, Plastics and Problem Waste.

Figure 3-5 Boulder County ICI Waste Composition, 2010

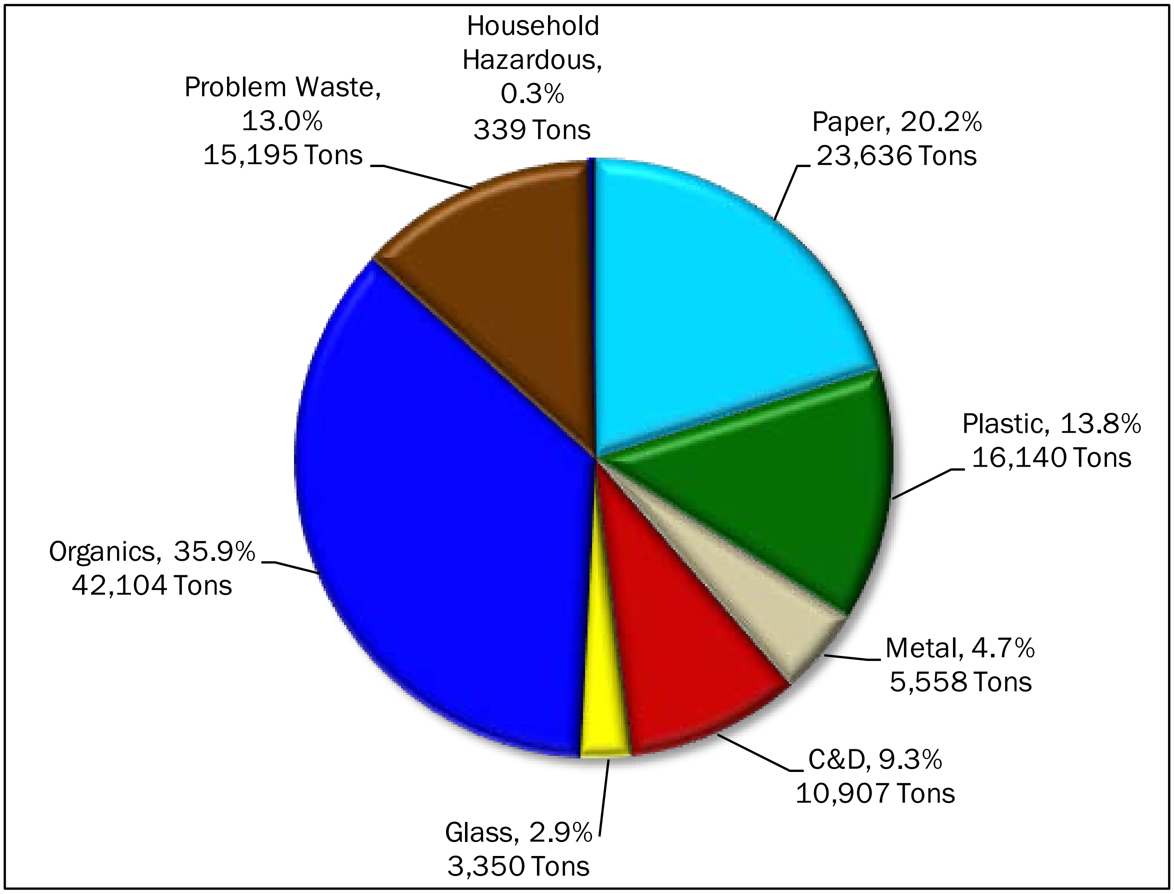


Figure 3-6 compares the 10 most prevalent materials in disposed ICI waste. As in residential waste, food scraps are the most prevalent single item. However, compostable paper and corrugated cardboard are more prevalent in ICI waste compared to residential waste.

Figure 3-6 Top 10 Most Prevalent Material Categories in ICI Waste

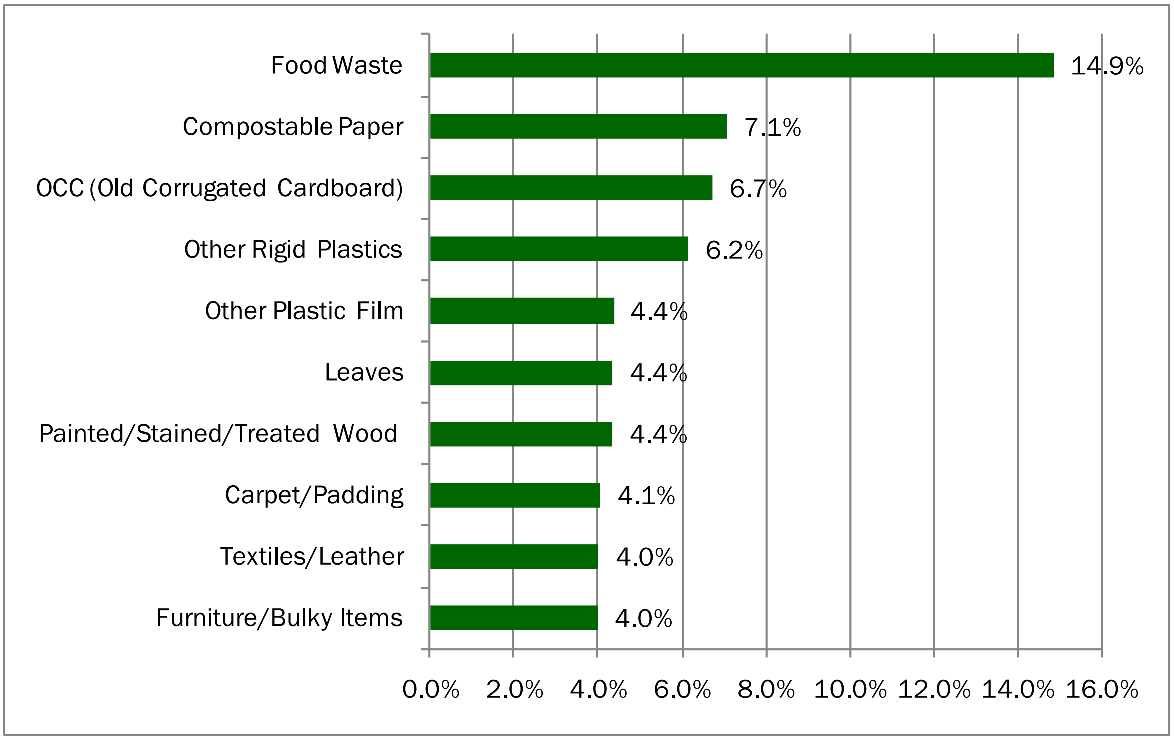


Table 3-5 provides a detailed statistical profile of the County's ICI waste stream.

Table 3-5 2010 Detailed ICI Waste Composition

Material	Est. Percent	+ / -	Est. Tons	Material	Est. Percent	+ / -	Est. Tons
Paper	**20.2%**		**23,636**	**Glass**	**2.9%**		**3,350**
Newsprint	0.7%	0.2%	828	Glass Bottles and Jars	2.4%	1.2%	2,822
High Grade Office Paper	1.1%	0.7%	1,238	Other Glass	0.5%	0.4%	528
Shredded Paper	0.2%	0.2%	223				
OCC (Old Corrugated Cardboard)	6.7%	1.8%	7,889	**Organics**	**35.9%**		**42,104**
Magazines/Catalogs	0.9%	0.3%	1,091	Mixed Yard Waste including Small Branches	3.4%	2.1%	3,956
Recyclable Mixed Paper	2.1%	0.5%	2,498	Branches/Limbs and Stumps >6" Diameter	1.0%	0.7%	1,140
Polycoated/Aseptic Containers	0.1%	0.0%	135	Leaves	4.4%	2.4%	5,105
Compostable Paper	7.1%	1.4%	8,287	Food Waste	14.9%	2.8%	17,415
Unrecyclable Mixed Paper	1.2%	0.5%	1,445	Other Untreated Wood	0.4%	0.3%	460
				Textiles/Leather	4.0%	2.2%	4,714
Plastic	**13.8%**		**16,140**	Fines/Dirt	3.1%	1.1%	3,685
#1 PET Bottles/Jars	0.5%	0.2%	569	Pallets	3.7%	2.6%	4,381
#2 HDPE Bottles/Jars	0.5%	0.1%	535	Other Organics	1.1%	0.3%	1,249
Bottles #3-7	0.1%	0.0%	67				
Other Plastic Containers <3 Gallons	0.2%	0.1%	288	**Problem Waste**	**13.0%**		**15,195**
Large Plastic Containers >3 Gallons	0.4%	0.3%	450	Large Electronics (Plug-in)	1.2%	0.9%	1,445
Plastic Retail Bags	0.3%	0.2%	358	Small Electronics (Rechargeable)	0.1%	0.1%	75
Other Plastic Film	4.4%	0.7%	5,119	Small Appliances	0.2%	0.2%	286
Expanded Polystyrene	1.3%	0.8%	1,535	Diapers/Sanitary Products	0.6%	0.3%	722
Other Rigid Plastics	6.2%	2.1%	7,220	Carpet/Padding	4.1%	3.4%	4,762
				Batteries	0.3%	0.3%	369
Metal	**4.7%**		**5,558**	Rubber	1.0%	0.4%	1,156
Aluminum Containers	0.3%	0.1%	299	Tires	1.2%	1.2%	1,422
Aluminum Foil & Trays	0.2%	0.2%	277	Furniture/Bulky Items	4.0%	2.2%	4,683
Ferrous Containers	0.4%	0.2%	504	Other Inorganics	0.2%	0.2%	274
Other Ferrous	2.4%	1.0%	2,778				
Other Non-Ferrous	1.4%	0.7%	1,700	**Household Hazardous Waste (HHW)**	**0.3%**		**339**
White Goods	0.0%	0.0%	0	Fluorescent Tubes and Bulbs	0.0%	0.0%	8
				Pharmaceuticals and Syringes	0.0%	0.0%	4
C&D	**9.3%**		**10,907**	Oil-based Paint & Finishes	0.0%	0.0%	0
Aggregate/Concrete/Asphalt/Ceramics	0.2%	0.1%	212	Latex Paint & Finishes	0.0%	0.0%	35
Asphalt Shingles	0.0%	0.0%	25	Pesticides	0.0%	0.0%	0
Painted/Stained/Treated Wood	4.4%	2.2%	5,102	Automotive Fluids	0.1%	0.1%	87
Clean Dimensional Lumber	2.6%	1.8%	3,045	Other Household Hazardous Waste	0.2%	0.2%	205
Clean/New Drywall	0.0%	0.0%	0				
Demo/Painted Drywall	0.9%	0.9%	1,019				
Other C&D	1.3%	0.9%	1,504	**Totals**	**100.0%**		**117,228**
				Sample Count	**36**		

Confidence intervals calculated at the 90% confidence level. Percentages for material types may not total 100% due to rounding.

3.4. COUNTY DROP-BOX WASTE

Figure 3-7 presents the breakdown of wastes collected at the Foothill Transfer sites. As shown, the waste that is deposited at these sites has significantly different composition from other residential and ICI wastes in Boulder County.

Figure 3-7 Boulder County Foothill Transfer Site Waste Composition, 2010

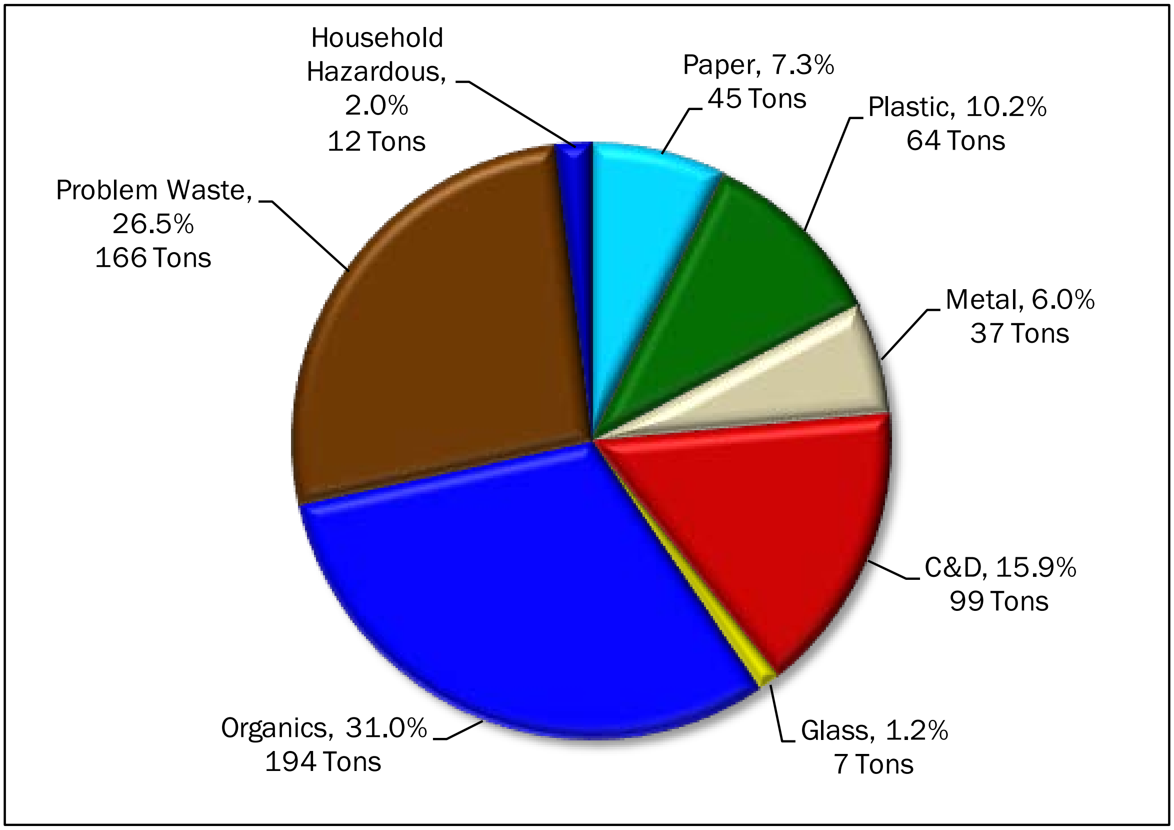
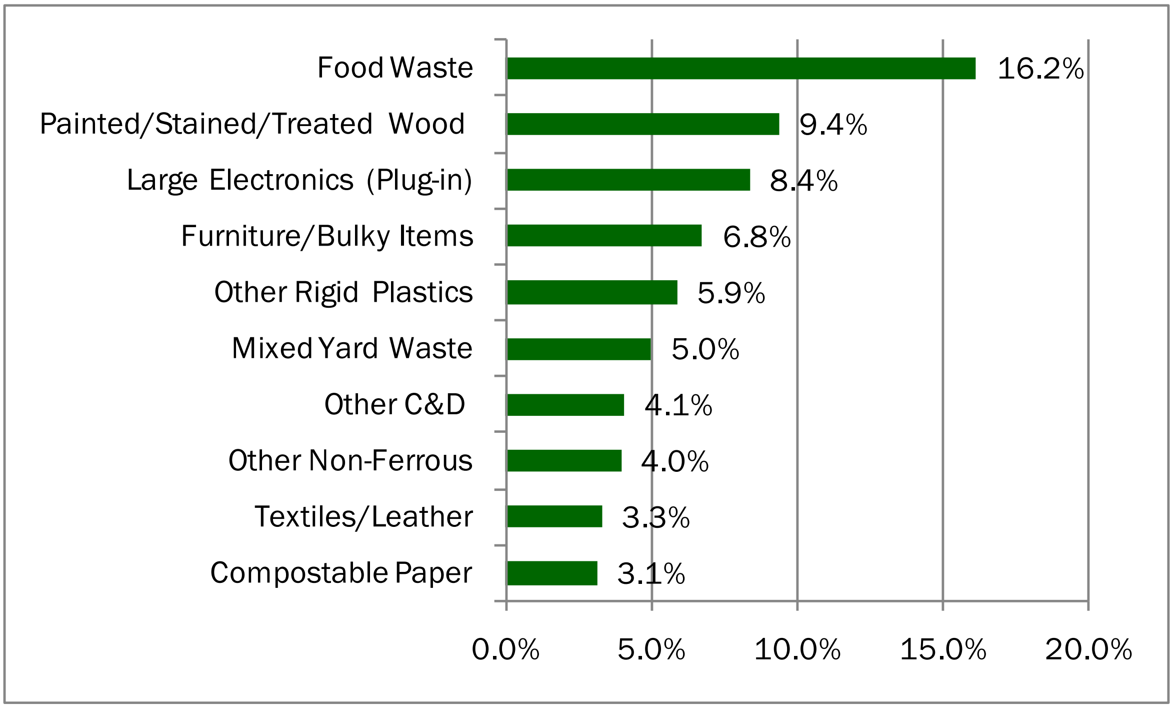


Figure 3-8 summarizes the 10 most prevalent materials from Foothill Transfer Sites. While Food Waste is once again the most prevalent item, a number of C&D-related material categories were also found in large fractions.

Figure 3-8 Top 10 Most Prevalent Material Categories in County Drop-box Waste



It should be noted that one of the Foothill Transfer Site samples contained two large electronic items that collectively totaled 58 pounds. An insufficient number of samples were obtained from Foothill Transfer Sites to discern if this sample was an outlier, and further investigation would be needed to determine the prevalence of large electronics.

Table 3-6 provides a detailed statistical profile of the County's Foothill Transfer Site waste.

Table 3-6 2010 Detailed Foothill Transfer Site Waste Composition

Material	Est. Percent	+ / -	Est. Tons	Material	Est. Percent	+ / -	Est. Tons
Paper	**7.3%**		**45**	**Glass**	**1.2%**		**7**
Newsprint	1.0%	0.5%	7	Glass Bottles and Jars	0.2%	0.2%	2
High Grade Office Paper	0.0%	0.0%	0	Other Glass	0.9%	0.7%	6
Shredded Paper	0.0%	0.0%	0				
OCC (Old Corrugated Cardboard)	0.2%	0.3%	1	**Organics**	**31.0%**		**194**
Magazines/Catalogs	0.4%	0.6%	2	Mixed Yard Waste including Small Branches	5.0%	0.4%	31
Recyclable Mixed Paper	1.1%	0.2%	7	Branches/Limbs and Stumps >6" Diameter	0.0%	0.0%	0
Polycoated/Aseptic Containers	0.2%	0.2%	1	Leaves	0.0%	0.0%	0
Compostable Paper	3.1%	0.6%	20	Food Waste	16.2%	1.2%	101
Unrecyclable Mixed Paper	1.2%	1.4%	8	Other Untreated Wood	2.8%	4.6%	18
				Textiles/Leather	3.3%	1.8%	21
Plastic	**10.2%**		**64**	Fines/Dirt	0.7%	0.7%	5
#1 PET Bottles/Jars	0.3%	0.1%	2	Pallets	2.0%	2.4%	12
#2 HDPE Bottles/Jars	0.3%	0.2%	2	Other Organics	1.0%	0.0%	6
Bottles #3-7	0.2%	0.0%	1				
Other Plastic Containers <3 Gallons	0.1%	0.1%	1	**Problem Waste**	**26.5%**		**166**
Large Plastic Containers >3 Gallons	0.0%	0.0%	0	Large Electronics (Plug-in)	8.4%	12.0%	52
Plastic Retail Bags	0.2%	0.1%	2	Small Electronics (Rechargeable)	1.2%	1.7%	7
Other Plastic Film	2.8%	0.8%	18	Small Appliances	0.5%	0.3%	3
Expanded Polystyrene	0.4%	0.1%	2	Diapers/Sanitary Products	2.8%	2.5%	17
Other Rigid Plastics	5.9%	0.6%	37	Carpet/Padding	1.2%	1.8%	7
				Batteries	0.3%	0.2%	2
Metal	**6.0%**		**37**	Rubber	0.8%	0.6%	5
Aluminum Containers	0.2%	0.3%	1	Tires	2.0%	3.4%	13
Aluminum Foil & Trays	0.1%	0.0%	1	Furniture/Bulky Items	6.8%	1.8%	42
Ferrous Containers	0.6%	0.8%	4	Other Inorganics	2.6%	3.7%	16
Other Ferrous	0.8%	0.8%	5				
Other Non-Ferrous	4.0%	4.5%	25	**Household Hazardous Waste (HHW)**	**2.0%**		**12**
White Goods	0.3%	0.5%	2	Fluorescent Tubes and Bulbs	0.0%	0.0%	0
				Pharmaceuticals and Syringes	0.0%	0.0%	0
C&D	**15.9%**		**99**	Oil-based Paint & Finishes	0.0%	0.0%	0
Aggregate/Concrete/Asphalt/Ceramics	0.2%	0.3%	1	Latex Paint & Finishes	0.0%	0.0%	0
Asphalt Shingles	0.5%	0.8%	3	Pesticides	0.0%	0.0%	0
Painted/Stained/Treated Wood	9.4%	6.9%	59	Automotive Fluids	0.0%	0.0%	0
Clean Dimensional Lumber	1.7%	0.7%	11	Other Household Hazardous Waste	1.9%	3.0%	12
Clean/New Drywall	0.0%	0.0%	0				
Demo/Painted Drywall	0.0%	0.0%	0				
Other C&D	4.1%	4.6%	26	**Totals**	**100.0%**		**626**
				Sample Count	**10**		

Confidence intervals calculated at the 90% confidence level. Percentages for material types may not total 100% due to rounding.

3.5. C&D WASTE COMPOSITION

Figure 3-9 presents the breakdown of C&D waste by material group. Unsurprisingly, C&D materials make up over 82 percent of C&D waste, with Organics contributing most of the remainder.

Figure 3-9 C&D Waste Composition, 2010

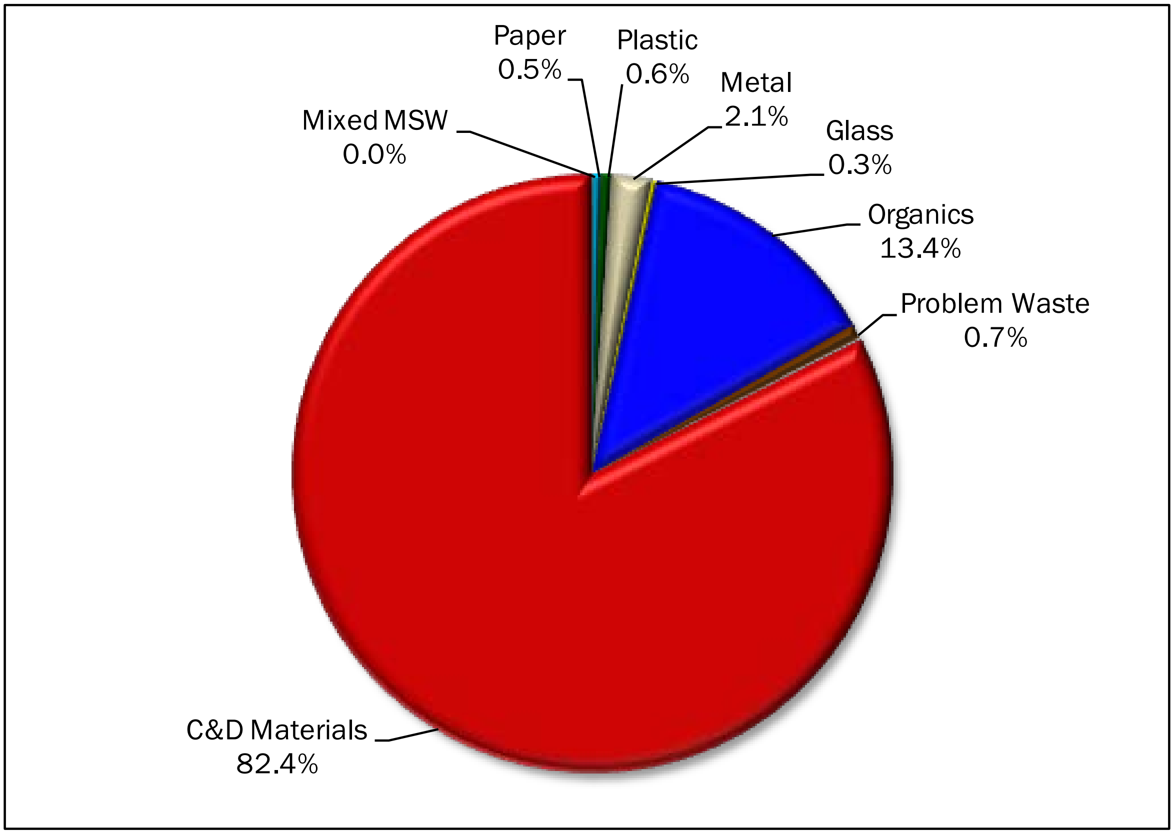


Figure 3-10 compares the 10 most prevalent materials in disposed C&D waste. Rock/Concrete, Asphalt Shingles, Painted/Stained Wood and Drywall are the most prevalent items.

Figure 3-10 Top 10 Most Prevalent Material Categories in C&D Waste

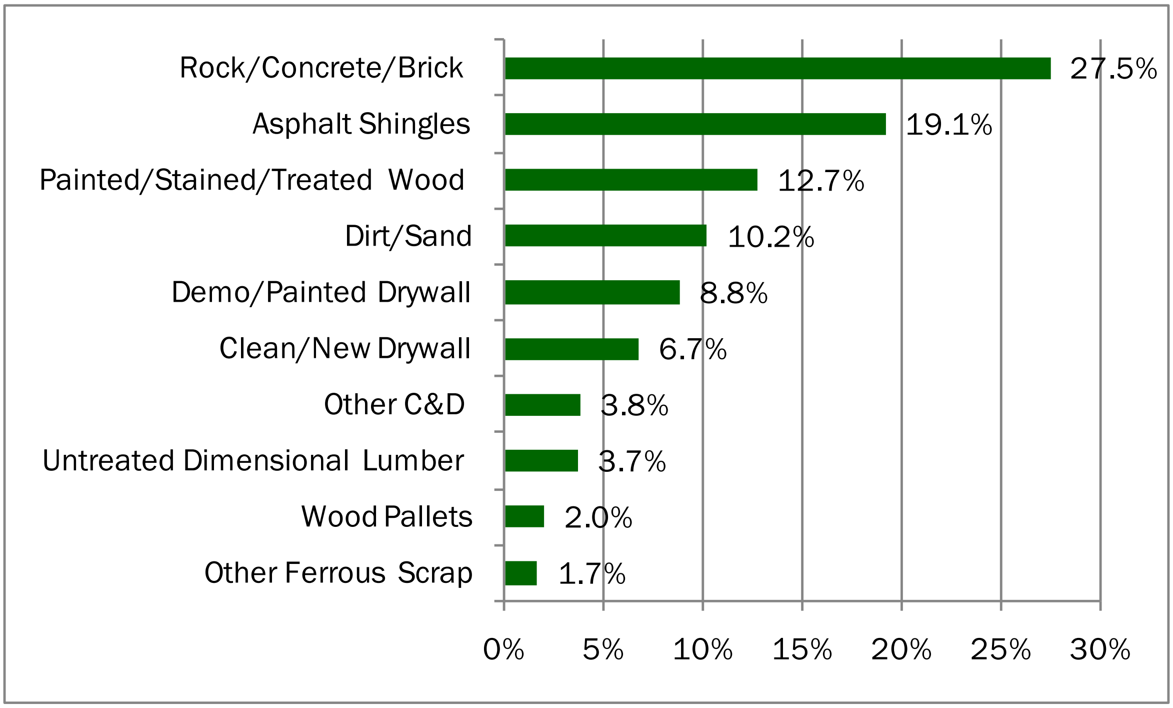


Table 3-6 provides a detailed statistical profile of the County's C&D waste stream.

Table 3-7 2010 Detailed C&D Waste Composition

Material	Est. Percent	+ / -	Est. Tons	Material	Est. Percent	+ / -	Est. Tons
Paper	**0.5%**		**381**	**Problem Waste**	**0.7%**		**559**
Uncoated OCC-Recyclable	0.1%	0.0%	51	Electronics	0.0%	0.0%	0
Other Paper	0.4%	0.4%	329	Small Appliances	0.3%	0.5%	240
				Carpet/Padding	0.3%	0.3%	250
Plastic	**0.6%**		**424**	Batteries	0.0%	0.0%	0
PET Bottles-Beverage	0.0%	0.0%	1	Tires	0.0%	0.0%	0
Film Packaging	0.0%	0.0%	25	Furniture/Bulky Items	0.1%	0.1%	70
Other Plastic	0.5%	0.4%	398	Fluorescent Light Bulbs	0.0%	0.0%	0
				Household Hazardous Waste	0.0%	0.0%	0
Metal	**2.1%**		**1,615**				
Aluminum Containers	0.0%	0.0%	4	**C&D Materials**	**82.4%**		**62,442**
Other Ferrous Scrap	1.7%	1.7%	1,254	Rock/Concrete/Brick	27.5%	19.4%	20,861
Non-ferrous Metal	0.4%	0.4%	325	Asphalt Shingles	19.1%	11.5%	14,499
White Goods	0.0%	0.1%	32	Painted/Stained/Treated Wood	12.7%	7.3%	9,624
				Untreated Dimensional Lumber	3.7%	2.1%	2,792
Glass	**0.3%**		**226**	Clean/New Drywall	6.7%	5.8%	5,111
Glass Bottles and Jars	0.0%	0.0%	0	Demo/Painted Drywall	8.8%	6.5%	6,670
Glass	0.3%	0.4%	226	Other C&D	3.8%	3.0%	2,885
Organics	**13.4%**		**10,130**	**Mixed MSW**	**0.0%**	**0.0%**	**19**
Yard Waste	1.2%	1.4%	905				
Wood Pallets	2.0%	2.5%	1,508				
Dirt/Sand	10.2%	9.2%	7,716	**Totals**	**100.0%**		**75,797**
				Sample Count	**37**		

Confidence intervals calculated at the 90% confidence level. Percentages for material types may not total 100% due to rounding.

Figure 3-11 shows the C&D waste stream subdivided by material groups that are more closely associated with C&D waste.

Figure 3-11 C&D Waste Composition by C&D Material Category

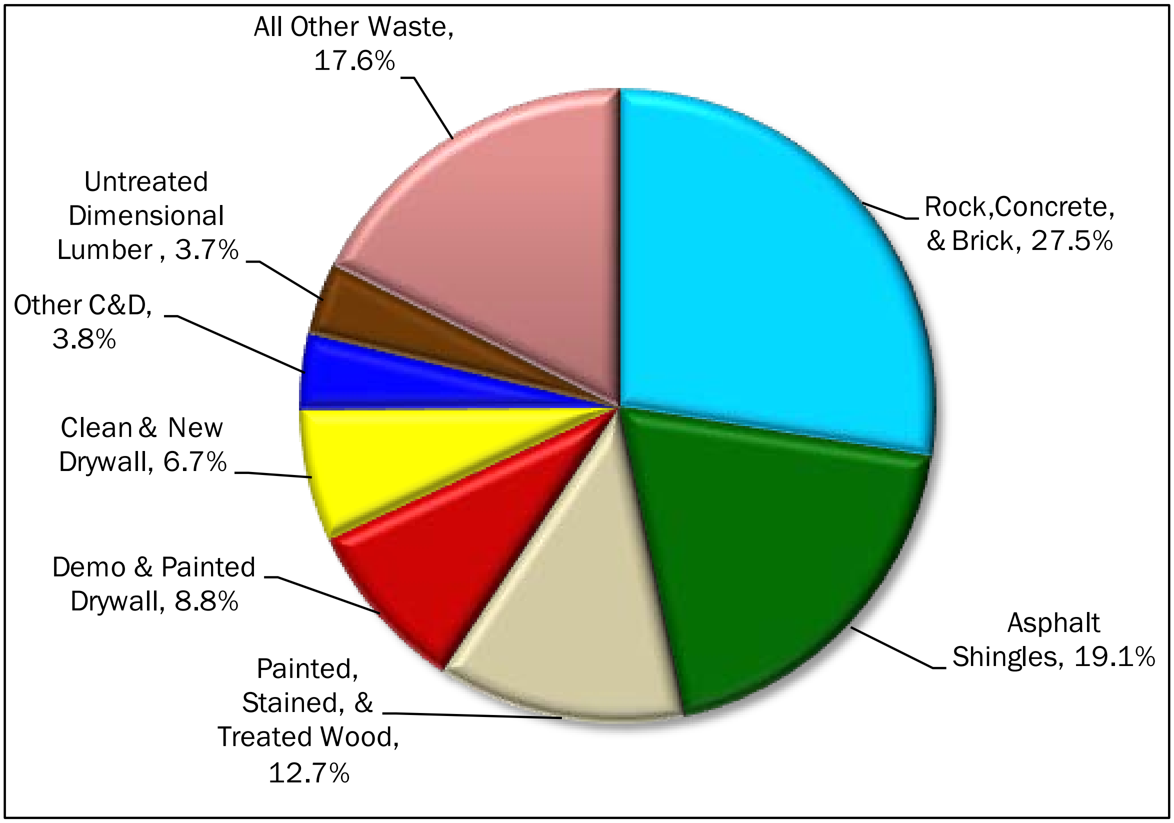


Table 3-8 shows how individual material categories were combined to create the pie chart in Figure 3-11.

Table 3-8 Mapping of C&D Material Categories to Groups

Material Group Name	Material Categories Included	Percent
Metals	All metal categories	5.7%
Organics	All organics categories	4.3%
Wood	All wood categories including wood pallets	28.1%
Concrete/Brick/Block	Concrete/Brick/Block	13.2%
Drywall	Clean and demo drywall	5.2%
Shingles	Shingles	29.5%
Other C&D	Other C&D, ceramics and C&D PVC	6.8%
Bulky Items/Furniture	Bulky items & furniture	2.2%
Carpet/Padding	Carpet & carpet padding	0.9%
Other Waste	All paper, all plastics, all glass, all problem materials, all HHW and textiles	4.2%
Totals		**100.0%**

Note: Totals may not sum due to rounding discrepancies.

3.6. CONCLUSIONS AND RECOMMENDATIONS

- **Inaugural Study**: The 2010 Study served as a good first effort for Boulder County to quantify its waste stream and to estimate the composition of disposed wastes. This study provided at least an initial snapshot of residential wastes, including separate profiles for single and multi-family wastes, as well as for ICI, C&D and mountain site drop-box waste.
- **Availability of Data**: Boulder County appears to have a positive relationship with the private and public haulers that collect wastes in Boulder County, and these haulers were generally cooperative in providing the information needed to plan for and execute this study. However, even with good cooperation, there are gaps in the reported data that were filled based on reasonable estimation techniques. The Project Team especially identifies the C&D waste stream as being in need of a targeted waste generation study, as it was not possible to estimate the quantity of C&D debris generated in the County as part of this study.
- **Opportunities**: Boulder County is clearly doing a good job recycling traditional fiber and container recyclables, as evidenced by the relatively low fractions of these items in disposed waste. The County continues, however, to have opportunities to divert additional wastes from landfill disposal. Organics – and especially yard wastes – remain in the disposed waste stream in significant quantities. Food waste and compostable paper are also prevalent, which is of particular interest because there are markets for composting

these materials commercially in Boulder County. Additionally, the fraction of bulky items and furniture were high enough to suggest that incremental reuse opportunities may exist.

- **Continue Performing Countywide Studies**: Waste composition studies inform about the overall disposed waste stream for local planners. While results are helpful to compare against other municipalities in Colorado and nationally, time series waste composition data will provide the County with an informative commentary on its ongoing recycling and diversion efforts. The County should continue to perform a similar project over five to 10 year intervals.
- **Expanded Multi-family Analysis**: The multi-family sampling and sorting performed for this study was helpful in confirming that the disposed waste stream, and therefore the recycling and diversion outreach and programs that are needed, are significantly different for multi-family dwellings in Boulder County. However, the occurrence of several items in the multi-family waste stream – notably, leaves and large electronics – suggest that more study is needed to defensibly determine if these materials are truly occurring in multi-family wastes to the extent shown, or if these samples represent outliers.
- **Expanded Foothill Transfer Site Analysis**: The Foothill Transfer Site sampling and sorting performed for this study was helpful in confirming that the disposed waste stream at the Transfer Sites is significantly different compared to other waste in Boulder County. However, the occurrence of several items in this waste stream – notably, large electronics, HHW, and bulky items – suggest that more study is needed to defensibly determine if these materials are truly occurring at the drop-sites to the extent shown, or if these samples represent outliers.
- **Focus on C&D**: The generation and disposal of C&D debris follows its own unique local market drivers. Although this study was able to obtain some samples of C&D that were obtained at two facilities, spanning the County's geographic region, it was beyond the scope of this study to defensibly document the generation and distribution of C&D debris, and to determine the composition of C&D debris. Boulder County should consider a more focused effort to characterize C&D as the County continues investigating opportunities to enhance overall recycling rates.

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APPENDIX A

MATERIAL DEFINITIONS

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Boulder County Physical Sort Material Definitions

	No	Material Category	Definition
PAPER	1	Newsprint	Consists of all paper products printed in daily or weekly newspapers, including inserts. Includes other newsprint.
	2	High Grade Office Paper	High grade ledger paper, such as typing and copy paper. Computer paper includes outputs from printers that may have green bars.
	3	Shredded Paper	Low or high grade paper that has been mechanically shredded.
	4	OCC (Old Corrugated Cardboard)	Paperboard containers consisting of Kraft (brown) linerboard with corrugated (fluted medium) fillings. Includes Kraft paper such as bags or wrapping paper.
	5	Magazines/Catalogs	Publications which are printed on glossy paper. This does not include magazines, catalogs, etc., which do not consist of glossy paper throughout (e.g., comic books.)
	6	Mixed Recyclable Paper	All other recyclable paper not covered such as uncoated paperboard, direct mail, molded pulp, phone books, and paperback books.
	7	Polycoated / Aseptic Containers	Aseptic juice boxes and gable top cartons made of coated paperboard.
	8	Compostable Paper	Soiled and used fiber such as tissues and paper including OCC that are soiled with food, such as paper plates, paper cups, pizza boxes, popcorn bags and paper towels. Includes wax coated OCC.
	9	Unrecyclable Paper	All paper that doesn't fit into the categories specified above and items that are primarily paper but include other materials such as plastic or metal. Examples paper or boxboard coated with plastic or metal foil, photographs, laminated paper.
PLASTIC	10	#1 PET Bottles/Jars	Clear or colored blow molded plastic bottles and jars labeled as #1 PET. Examples include plastic beverage bottles (i.e., bottles with a narrow necks) and plastic jars (open mouth jars) such as peanut butter jars.
	11	#2 HDPE Bottles/Jars	Natural or pigmented blow molded plastic bottles and jars labeled as #2 HDPE. Examples include plastic detergent bottles (i.e., bottles with a narrow necks) and plastic jars (open mouth jars) such as sanitizing wipes.
	12	Bottles #3-7	All plastic bottles labeled 3-7. Examples include amber plastic pill bottles, cosmetic bottles, and all unmarked narrow neck bottles. Includes #7 PLA bottles, even though these bottles may not be accepted by local recycling processors.
	13	Other Plastic Tubs and Cups <3 Gallons	Tubs, buckets, and packaging cups that are less than 3 gallons (<3) in size. Examples in this category include margarine, cottage cheese, and yogurt tubs, plastic buckets <3 gallons.
	14	Large Plastic Containers >3 Gallons	Tubs and buckets that are greater than 3 gallons (>3) in size.
	15	Plastic Retail Bags	Plastic film bags used to transport retail merchandise. Includes retail bags, newspaper sleeves, dry cleaner bags and the like.
	16	Other Plastic Film	All other plastic film includes garbage bags, shrink wrap, bubble packing film, construction film, agricultural film, and food packaging film such as bread sacks.

	No	Material Category	Definition
PLASTIC	17	Expanded Polystyrene	Expanded plastic polymer used for protecting items during shipping, storage, or cold or heat. Includes expanded foam trays, packing peanuts, packing blocks, food clamshells, and coolers.
	18	Other Rigid Plastics	All other rigid plastic not elsewhere classified. Items such as food service, cup lids, toothbrushes, toys, and composite items that are made of 50% or more plastic. May include bioplastics.
METAL	19	Aluminum Cans	Aluminum beverage and food containers
	20	Aluminum Foil & Trays	Aluminum foil, trays and pie pans
	21	Ferrous Containers	Fabricated, magnetizable metal containers such as steel or bimetal designed to hold food or beverage products such as soups, vegetables, pet food and juices. Includes two piece containers with aluminum tops other empty spray cans.
	22	Other Ferrous	Ferrous and alloyed ferrous scrap materials originated from residential commercial, or institutional sources which are attracted to a magnet. This category includes wire coat hangers auto parts and composite materials that are made of 50% more ferrous.
	23	Other Non-Ferrous	Non-magnetic metals such as brass, bronze, silver, lead copper, aluminum, zinc and composite non-ferrous materials that are made of 50% or more metal. Items such as insulated wiring or plumbing parts. Stainless steel house wares are also part of this category.
	24	White Goods	Large household appliances such as refrigerators, stoves, air conditioners, and washing machines.
GLASS	25	Glass Bottles and Jars	Clear, green, and brown glass food and beverage containers.
	26	Other Glass	All other glass items such as plate glass such as window and door glass, table-tops; auto glass; heat resistant cookware (Pyrex); pottery; drinking glasses; and. any other glass that was not used for containing food or drinks.
ORGANIC	27	Mixed Yard Waste including Sma	Grass clippings, leaves, flowers, small potted plant roots, and branches less than 2" in diameter.
	28	Branches, Limbs and Stumps	Branches, limbs and logs greater than 2" in diameter
	29	Leaves	Leaves from trees and shrubs. Does not include clippings or trimmings.
	30	Food Waste	Putrescible organic materials which are the by-products of activities connected with the growing, preparation, cooking, processing, or consumption of food by humans or pets. This also includes liquids from beverage contains.
	31	Non-C&D wood	Any wood other than wood generated in the C&D waste stream. Examples include popsicle sticks, chopsticks, pencils, and household items made of wood.
	32	Textiles/Leather	Woven natural or manmade fibers used to make items such as clothing, bedding, curtains, blankets, stuffed animals, cotton diapers, other cloth material. Natural animal skin used to make shoes, belts and other leather goods.
	33	Fines / Dirt	Small fragments that pass through the ¼" sort screen, and miscellaneous fines and dirt.
	34	Wood Pallets	Wood pallets and crating materials commonly used for industrial and commercial packaging and shipping.

	No	Material Category	Definition
ORGANIC	35	Other Organics	Organic material that doesn't fit into the categories specified above, and items that are primarily organic but include other materials such as plastic or metal. Examples include cotton balls, hair, Q-tips, wax, soap, kitty litter, animal feces, and animal carcasses.
PROBLEM MATERIAL	36	Large Electronics (Plug-in)	Any plug-in item that contains a circuit board including, televisions, radio, stereo, computer, and CRT.
	37	Small Electronics (Rechargeable)	Small Consumer Electronics that are rechargeable or contains a replaceable battery these include cell phones, iPods, PDAs, portable handheld calculators, portable digital assistants or other similar devices.
	38	Small Appliances	Small household appliances such as fans, vacuum cleaners, irons, electrical kitchen ware, corded hand drills, and hair driers.
	39	Diapers / Sanitary Products	Diapers and sanitary products.
	40	Carpet/Padding	Natural or manmade fibers woven to make floor covering or floor covering under laments items such as carpets, rugs or padding from residential or commercial buildings, including carpet backing.
	41	Batteries	Any type of battery including lead acid (automotive) batteries. Examples include household batteries such as AA, AAA, D, button cell, 9 volt, and rechargeable batteries used for flashlights, small appliances, tools, watches, and hearing aids.
	42	Rubber	Natural or manmade rubber used to make shoes, hoses, and automobile parts. This category excludes tires.
	43	Tires	Solid or pneumatic rubber or steel belted tires. Includes motorized vehicle and bicycle tires.
	44	Furniture/Bulky Items	Chairs, couches, mattresses, desks, and other oversized items made of multiple materials.
	45	Other Inorganics	All other inorganic items not elsewhere classified
HHW	46	Fluorescent tubes and bulbs	Fluorescent light tubes and compact light bulbs. This category does not include fixtures.
	47	Pharmaceuticals and syringes	All prescription and non-prescription medicine, medicated ointments, mouth wash, lancets, and syringes. Does not include items such as ordinary dandruff shampoo or hand lotions.
	48	Oil-based paint & finishes	Finishes for wood, metal, or other surfaces that have a volatile organic base or solvent. Products such as lacquers, stains, paints, and urethanes.
	49	Latex paint & finishes	Water based lacquers, stains, paints, and urethanes.
	50	Pesticides	Poisons used to eradicate pests such as insects, fungus, or vegetative growth.
	51	Automotive fluids	Used or unused automotive fluids such as motor oil, anti-freeze, brake or hydraulic fluids.
	52	Other HHW	All other household or commercial products not categorized elsewhere characterized as "toxic", "corrosive", "flammable", "ignitable", "radioactive", "poisonous", and "reactive". Items such as lye, untreated medical waste, oven cleaner, some detergents, and solvents.

	No	Material Category	Definition
C&D	53	Aggregate/Concrete/Asphalt/ Ceramics/Etc.	Concrete, brick, stones, cut stone, cement, rocks, ceramic tile and fixtures.
	54	Asphalt Shingles	Asphalt composite shingles and other roofing material made with asphalt. Examples include asphalt shingles and attached roofing tar and tar paper
	55	Painted/stained/Treated wood	Wood that contains an adhesive, paint, stain, fire retardant, pesticide or preservative. Painted or stained lengths of wood from construction or woodworking activities, particle board, OSB, and plywood.
	56	Clean dimensional Lumber	Any dimensional lumber which does not contain an adhesive, paint, stain, fire retardant, pesticide or preservative; includes such items as 2x4s, 2x6s, 4x4s, etc. May contains metal items such as screws and nails.
	57	Clean / New Drywall	Means unpainted or untreated interior wall covering made of a sheet of gypsum sandwiched between paper layers. Examples include unused, broken or whole sheets of sheetrock, drywall, gypsum board, plasterboard, gypsum board, gyproc, and wallboard
	58	Demo/Painted Drywall	Means painted or treated interior wall covering made of a sheet of gypsum sandwiched between paper layers. Examples include unused, broken or whole sheets of sheetrock, drywall, gypsum board, plasterboard, gypsum board, gyproc, and wallboard
	59	Other C&D	Material generated from construction and demolition activities. Items such as PVC pipe, HVAC ducting, caulking or adhesive tubes, used paint brushes, ceiling tiles, ash, and other C&D material not elsewhere classified.

Boulder County C&D Material Categories

	No.	Visual Material Category	Physical Sort Material Category
PAPER	1	OCC (Old Corrugated Cardboard)	Paperboard containers consisting of Kraft (brown) linerboard with corrugated (fluted medium) fillings. Includes yellow and waxed corrugated boxes and Kraft paper such as bags or wrapping paper. Does not include non-corrugated paperboard products such as cereal, shoe, or gift boxes.
PAPER	2	Other Paper	Consists of all other paper products.
PLASTIC	3	PET bottles - beverage	Clear or colored blow molded plastic bottles and jars labeled as #1 PET. These can be clear or colored. Examples include plastic beverage bottles (i.e., bottles with a narrow necks) and plastic jars (open mouth jars) such as peanut butter jars.
PLASTIC	4	Film Plastic	Film plastic wrap, bags, tarps, and other film
PLASTIC	5	Other plastic	All other plastic.
METAL	6	Aluminum Containers	Aluminum containers used for holding beverages, or food.
METAL	7	Ferrous metal	Fabricated, magnetizable metal containers such as steel or bimetal designed to hold food or beverage products such as soups, vegetables, pet food and juices. Includes two piece containers with aluminum tops other empty spray cans.
METAL			Ferrous and alloyed ferrous scrap materials originated from residential commercial, or institutional sources which are attracted to a magnet. This category includes wire coat hangers auto parts and composite materials that are made of 50% more ferrous.
METAL	8	Non-ferrous metal	Non-magnetic metals such as brass, bronze, silver, lead copper, aluminum, zinc and composite non-ferrous materials that are made of 50% or more metal. Items such as insulated wiring or plumbing parts. Stainless steel house wares are also part of this category.
METAL	9	White Goods	Large household appliances such as refrigerators, stoves, air conditioners, and washing machines.
GLASS	10	Glass Bottles	Clear, green, and brown glass food and beverage containers.
GLASS	11	Other Glass	All other glass items such as plate glass such as window and door glass, table-tops; auto glass; heat resistant cookware (Pyrex); pottery; drinking glasses; and. any other glass that was not used for containing food or drinks.
ORGANIC	12	Yard Waste	Grass clippings, leaves, flowers, small potted plant roots, and branches less than <1/4' in diameter. Branches, limbs and logs greater than 6 (>6) inches in diameter Leaves from trees and shrubs. Does not include clippings or trimmings.
ORGANIC	13	Wood Pallets	Wood pallets and crating materials commonly used for industrial and commercial packaging and shipping.
ORGANIC	14	Dirt/Fines	Small fragments that pass through the ¼" sort screen, and miscellaneous fines and dirt.
PROBLEM MATERIALS	15	Electronics	Any plug-in item that contains a circuit board including, televisions, radio, stereo, computer, and CRT.
PROBLEM MATERIALS			Small Consumer Electronics that are rechargeable or contains a replaceable battery these include cell phones, iPods, PDAs, portable handheld calculators, portable digital assistants or other similar devices.
PROBLEM MATERIALS	16	Small Appliances	Small household appliances such as fans, vacuum cleaners, irons, electrical kitchen ware, corded hand drills, and hair driers.
PROBLEM MATERIALS	17	Carpet/Padding	Natural or manmade fibers woven to make floor covering or floor covering under laments items such as carpets, rugs or padding from residential or commercial buildings, including carpet backing.

	No.	Visual Material Category	Physical Sort Material Category
PROBLEM MATERIALS	18	Batteries	Any type of battery including lead acid (automotive) batteries. Examples include household batteries such as AA, AAA, D, button cell, 9 volt, and rechargeable batteries used for flashlights, small appliances, tools, watches, and hearing aids.
	19	Tires	Solid or pneumatic rubber or steel belted tires.
	20	Furniture/Bulky items	Chairs, couches, mattresses, desks, and other oversized items made of multiple materials.
HHW	21	Fluorescent Light Bulbs	fluorescent light tubes and compact light bulbs. This category does not include fixtures.
	22	Household Hazardous Waste	Pharmaceuticals and syringes: All prescription and non-prescription medicine, medicated ointments, mouth wash, lancets, and syringes. Does not include items such as ordinary dandruff shampoo or hand lotions. Oil-based paint & finishes: Finishes for wood, metal, or other surfaces that have a volatile organic base or solvent. Products such as lacquers, stains, paints, and urethanes. Latex paint & finishes: Water based lacquers, stains, paints, and urethanes. Pesticides: Poisons used to eradicate pests such as insects, fungus, or vegetative growth. Automotive fluids: Used or unused automotive fluids such as motor oil, anti-freeze, brake or hydraulic fluids. Household Hazardous Waste means all household or commercial products not categorized elsewhere characterized as “toxic”, “corrosive”, “flammable”, “ignitable”, “radioactive”, “poisonous”, and “reactive”. Items such as lye, untreated medical waste, oven cleaner, some detergents, and solvents.
C&D	23	Rock, concrete, brick	Concrete, brick, stones, cut stone, cement, rocks, ceramic tile and fixtures.
	24	Asphalt Shingles	Asphalt composite shingles and other roofing material made with asphalt. Examples include asphalt shingles and attached roofing tar and tar paper
	25	Painted/stained/Treated wood	Wood that contains an adhesive, paint, stain, fire retardant, pesticide or preservative. Painted or stained lengths of wood from construction or woodworking activities, particle board, OSB, and plywood.
	26	Clean dimensional lumber	Any dimensional lumber which does not contain an adhesive, paint, stain, fire retardant, pesticide or preservative; includes such items as 2x4s, 2x6s, 4x4s, etc. May contains metal items such as screws and nails.
	27	Clean / New Drywall	Means unpainted or untreated interior wall covering made of a sheet of gypsum sandwiched between paper layers. Examples include unused, broken or whole sheets of sheetrock, drywall, gypsum board, plasterboard, gypsum board, gyproc, and wallboard
	28	Demo/Painted Drywall	Means painted or treated interior wall covering made of a sheet of gypsum sandwiched between paper layers. Examples include unused, broken or whole sheets of sheetrock, drywall, gypsum board, plasterboard, gypsum board, gyproc, and wallboard
	29	Other C&D	Material generated from construction and demolition activities. Items such as PVC pipe, HVAC ducting, caulking or adhesive tubes, used paint brushes, ceiling tiles, ash, and other related C&D material.
MSW	30	Mixed MSW	Bagged waste and/or loose wastes that appear to be mixed residential or commercial waste

APPENDIX B

FIELD FORMS

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Boulder County Physical Sort Field Supervisor Daily Targeted Samples

Facility: ______________________________ **Field Supervisor:** ________________________________

Generator Type		Total Needed	Truck Type	Estimated Loads Per Day	Total Sampled
Single Family	SF		RL/SL/SH		
Multi-Family	MF		FL/COMP/OT/SH		
(ICI)	ICI		FL/COMP/OT/SH		
Transfer Trailer	TT		TT		
Total					

Sample ID	Type	Date	Time	Hauler	Truck #	Truck Type	Ticket Number	Weight

Precipitation ______________________________

Notes

Boulder County Refuse Sort Field Data Sheet

Sample ID:____________________ Crew Chief: ____________________________________

Date: ______________________ Time: ________________________________ Location: ________________________

		Material Group	Weight (Circle if net weight)
PAPER	1	Newsprint	
	2	High Grade Office Paper	
	3	Shredded Paper	
	4	OCC (Old Corrugated Cardboard)	
	5	Magazines/Catalogs	
	6	Mixed Recyclable Paper	
	7	Polycoated / Aseptic Containers	
	8	Compostable Paper	
	9	Unrecyclable Paper	
PLASTICS	10	#1 PET Bottles/Jars	
	11	#2 HDPE Bottles/Jars	
	12	Bottles #3-7	
	13	Other Plastic Tubs and Cups <3 Gallons	
	14	Large Plastic Containers >3 Gallons	
	15	Plastic Retail Bags	
	16	Other Plastic Film	
	17	Expanded Polystyrene	
	18	Other Rigid Plastics	
METALS	19	Aluminum Cans	
	20	Aluminum Foil & Trays	
	21	Ferrous Containers	
	22	Other Ferrous	
	23	Other Non-Ferrous	
	24	White Goods	
GLASS	25	Glass Bottles and Jars	
	26	Other Glass	
ORGANICS	27	Mixed Yard Waste including Small Branches	
	28	Branches, Limbs and Stumps	
	29	Leaves	
	30	Food Waste	
	30A	Pumpkin Waste	
	31	Non-C&D wood	
	32	Textiles/Leather	
	33	Fines / Dirt	
	34	Wood Pallets	
	35	Other Organics	
PROBLEM WASTE	36	Large Electronics (Plug-in)	
	37	Small Electronics (Rechargeable)	
	38	Small Appliances	
	39	Diapers / Sanitary Products	
	40	Carpet/Padding	
	41	Batteries	
	42	Rubber	
	43	Tires	
	44	Furniture/Bulky Items	
	45	Other Inorganics	
HOUSEHOLD HAZARDOUS	46	Fluorescent tubes and bulbs	
	47	Pharmaceuticals and syringes	
	48	Oil-based paint & finishes	
	49	Latex paint & finishes	
	50	Pesticides	
	51	Automotive fluids	
	52	Other HHW	
C&D DEBRIS	53	Aggregate/Concrete/Asphalt/ Ceramics/Etc.	
	54	Asphalt Shingles	
	55	Painted/stained/Treated wood	
	56	Clean dimensional Lumber	
	57	Clean / New Drywall	
	58	Demo/Painted Drywall	
	59	Other C&D	

Notes

Boulder County Visual Survey Field Data Sheet

Sample ID:____________________ Field Supervisor: _____________________

Circle Generator Sector Residential Non-Residential

Date: __________ Time: ___________

Circle One Activity	Construction	Manufacturing
	Renovation	Retail
	Demolition	Warehouse
	Clean Out	**Other:**

Location ______________________________________

Hauler: _________________________________ Truck Number _________________________

Ticket Number ____________________________ Load YRD or Weight _________________________

Container Dimensions: ______________________ Container Yardage: ________ Percent Full: _______

Trailer Dimensions: ________________________ Container Yardage: ________ Percent Full: _______

		Material Group	% By Volume	% By Volume
PAPER	1	Uncoated OCC - recyclable		
PAPER	2	Other Paper		
				Subtotal 100%
PLASTIC	3	PET bottles - beverage		
PLASTIC	4	Film Packaging		
PLASTIC	5	Other plastic		
				Subtotal 100%
METAL	6	Aluminum Containers		
METAL	7	Other ferrous scrap		
METAL	8	Non-ferrous metal		
METAL	9	White Goods		
METAL	9	White Goods		
				Subtotal 100%
GLASS	10	Glass Bottles and Jars		
GLASS	11	Glass		
				Subtotal 100%
ORGANIC	12	Yard Waste		
ORGANIC	13	Dirt/Sand		
				Subtotal 100%
PROBLEM MATERIAL	14	Electronics		
PROBLEM MATERIAL	15	Small Appliances		
PROBLEM MATERIAL	16	Carpet/Padding		
PROBLEM MATERIAL	17	Batteries		
PROBLEM MATERIAL	18	Tires		
PROBLEM MATERIAL	19	Furniture/Bulky items		
PROBLEM MATERIAL	20	Fluorescent Light Bulbs		
PROBLEM MATERIAL	21	Household Hazardous Waste		
				Subtotal 100%
C&D MATERIALS	22	Rock, concrete, brick		
C&D MATERIALS	23	Asphalt Shingles		
C&D MATERIALS	24	Painted/stained/Treated wood		
C&D MATERIALS	25	Untreated dimensional lumber		
C&D MATERIALS	26	Pallets		
C&D MATERIALS	27	Usable Durable Items		
C&D MATERIALS	28	Unusable Durable Items		
C&D MATERIALS	29	Clean / New Drywall		
C&D MATERIALS	30	Demo/Painted Drywall		
C&D MATERIALS	31	Other C&D		
				Subtotal 100%
	38	Mixed MSW		
				Subtotal 100%

100%	**Total**

MSWCONSULTANTS

LARIMER COUNTY, COLORADO

TWO-SEASON WASTE COMPOSITION STUDY

Final Report

May 2007

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1. INTRODUCTION

BACKGROUND

The Larimer County Solid Waste Department operates the Larimer County Landfill, a 180-acre municipal solid waste disposal facility just south of Fort Collins. Situated on a 650-acre site, the landfill receives approximately 500 tons of solid waste per day. In addition to the County Landfill, the Solid Waste Department is responsible for an integrated waste management system that includes four transfer stations, five recycling drop-off sites, two permanent household hazardous waste (HHW) collection sites, and a Material Recovery Facility (MRF, a.k.a. Recycling Center). The MRF, which is owned by Larimer County and operated by Waste Management-Recycle America, recently converted to a "single stream" facility, and processes over 100 tons of recyclable containers and paper fiber materials each day.

In any integrated waste management system, it is critical to understand both waste generation and waste composition patterns of the local wasteshed. Regular monitoring of these data improve the Solid Waste Department's ability to operate and maintain current solid waste infrastructure, plan for future facility needs, and evaluate current and potential new source reduction and recycling programs. To this end, in 1998 Larimer County conducted a waste characterization study (1998 Study) to determine the composition of residential, commercial, and self-haul waste disposed at the Larimer County Landfill. The study results have been used to support planning efforts for the County's waste management services and to provide a baseline for monitoring changes in waste disposal.

In the ensuing years since the completion of the 1998 Study, a great deal has changed in Larimer County that has impacted the waste stream. County demographics have evolved significantly. Changes in the private collection and disposal market have caused a shift in waste flows. Further, over time, other more recent waste composition studies have consistently shown that the waste stream itself is changing. Such changes in disposed waste come about because of trends like light-weighting of products and packaging, the ongoing shift from glass and fiber-based packaging to plastic packaging, and fluctuations in residential and commercial construction, renovation, and demolition activities, to name but a few examples.

In 2006, Larimer County retained MSW Consultants, LLC, to perform an updated waste composition study (2006 Study). The 2006 Study seeks to achieve the following objectives:

- Develop statistically defensible estimates of the annual composition of wastes disposed at the Larimer County Landfill;
- Differentiate between the composition of Residential, Commercial, Construction and Demolition (C&D), and Self-haul Wastes to enable sector-specific recycling and diversion program evaluation;
- Estimate the quantity of Residential, Commercial, C&D, and Self-haul wastes currently delivered to the Landfill so that a Landfill-aggregate waste composition can be estimated

based on the weighted average contribution of wastes from each of these four generator sectors;

- Evaluate the efficacy of current recycling and diversion programs in place in Larimer County;
- Identify opportunities for incremental recycling and diversion programs that may target disposed materials that are still occurring in high volumes; and
- Enable a comparison of waste composition against the 1998 Study to detect trends in the composition of disposed waste.

REPORT ORGANIZATION

This report presents the background, methodology, and results of the two-season waste composition study that was conducted at the County Landfill. The report is divided into the remaining three sections:

- **Methodology:** This section summarizes the detailed sampling plan that was developed to assure that waste composition results would be statistically representative of the total disposed waste stream and also achieve a meaningful level of statistical validity. This section also summarizes elements of the field data collection methodology.
- **Gate Survey:** Because of limitations to the landfill accounting system, it is not currently possible to tabulate incoming material volumes by waste generator (especially residential and commercial wastes in compactor trucks; and C&D and commercial loose waste in roll-offs and other non-compactor commercial trucks). This section summarizes the methodology and results of a gate survey that was conducted to provide defensible estimates of the quantity of wastes delivered to the facility by the main waste generator classes.
- **Results:** Detailed composition results are presented for the aggregate of disposed waste at the Landfill, as well as for the Residential, Commercial, C&D and Self-Haul streams individually. This section also provides comparative data with the 1998 Study.

ACKNOWLEDGEMENTS

MSW Consultants would like to thank the following parties for their help in accomplishing the field data collection for this project:

- Steve Harem, Larimer County Environmental Specialist; and
- Robert "Dane" Nielsen, Landfill Manager.

The project would not have been successful without the ongoing help and cooperation from these individuals and their staff.

2. METHODOLOGY

SAMPLING PLAN SUMMARY

Prior to conducting any field data collection, a Sampling Plan was developed to assure that the incoming truckloads of waste that were ultimately sampled and sorted were representative of the entire incoming waste stream. This section summarizes the pertinent details of the Sampling Plan that governed field data collection.

SEASONALITY

There were two separate one-week field data collection events. The first field data event started on September 11, 2006 and was completed September 15, 2006; these dates were representative of the "summer" season. The second field data event started on December 4, 2006 and was completed December 8, 2006; these dates were representative of the "winter" season. Collectively, the data from these two seasonal sorts have been combined and analyzed to develop an annual aggregate estimate of the composition of wastes disposed in the County landfill.

WASTE GENERATION SECTORS

For the purposes of this study, a total of four generator sectors were defined:

- **Residential Waste:** Includes residentially generated garbage and trash that is collected by private or public haulers, primarily in compactor vehicles. Residential wastes encompass waste from single family households as well as multi-family apartments and condominiums.
- **Commercial Waste:** Includes municipal solid wastes generated in the commercial, institutional, agricultural, and industrial sectors, and delivered by private haulers primarily in compactor trucks or in compacting roll-off boxes. May include some non-compacted wastes delivered in open top roll-off boxes and in other vehicles. Note that commercial wastes exclude any "special" wastes that may be generated in these sectors.
- **Self-haul Waste:** Encompasses residentially generated wastes that are delivered to the landfill by the actual residential generator. Self-haul waste includes small to mid-size deliveries of waste in cars, pick-up trucks and vans, including those with trailers. Self-haul wastes are recorded separately by the gate house.
- **C&D Waste:** This includes all wastes that are generated as a result of construction, demolition and renovation activities, regardless of who is delivering the wastes. C&D wastes may be delivered by private (or public) haulers in roll-off boxes, and also may be delivered by self-haulers or contractors on construction/demolition/renovation projects (e.g., roofing contractor delivering shingles).

2. METHODOLOGY

SAMPLE SELECTION

MSW Consultants requested, and the County provided, a range of data about incoming material deliveries to the landfill. The following tables were assembled from the incoming material data and provided a basis for targeting a stratified random allocation of incoming loads that reflects the overall delivery patterns at the landfill.

RESIDENTIAL WASTE DELIVERIES AND SAMPLING TARGETS

Larimer County was able to provide summary information on the haulers that delivered virtually 100 percent of the COMPACTED WASTE, which includes all Residential Waste. Table 2-1 estimates the proportion of each hauler's deliveries that are believed to be Residential Waste, and shows the resultant seasonal sampling targets.[1] Further, Table 2-1 shows how close the actual samples were compared to the stratified targets.

Table 2-1 Residential Waste Deliveries (cubic yards, 2005) and Sampling Targets

Hauler	Total COMPACTED WASTE (CY) [1]	Residential Fraction	Residential Volume (CY)	Percentage of Total	Sample Targets	Actual Samples
Canyon Utilities	3,485	80%	2,788	1.7%	0	0
City of Loveland, Solid Waste	39,889	100%	39,889	23.9%	8	9
Dick's Trash Hauling Service	27,143	75%	20,357	12.2%	2	3
GSI (Gallegos Sanitation, Inc.)	91,058	60%	54,635	32.7%	10	11
Ram Waste Systems, Inc.	34,964	60%	20,978	12.6%	4	7
S & S Sanitation	12,464	80%	9,971	6.0%	2	0
Skyline	1,238	100%	1,238	0.7%	0	0
United Waste (new customer)	0	100%	unknown	0.0%	0	1
Waste Management	28,339	60%	17,003	10.2%	2	0
Total	**258,681 [2]**			**100.0%**	**30**	**31**

[1] Unadjusted for compaction.

[2] Column does not sum because several haulers with limited deliveries are not shown.

[1] At the time the sampling plan was developed, calendar year 2005 data was the most current. Interviews with County staff were used to supplement the 2005 data to assure its representativeness.

Note that Larimer County does not track whether incoming waste is residential or commercial waste, and at the time the sampling plan was developed the gate survey had not yet been performed (see Section 3). MSW Consultants interviewed County staff to obtain a "best estimate" of the proportion of each haulers' trucks that were each of the types above. Although this is an imperfect method, we believe the information gathered was suitable for the purposes of developing and implementing a reliable sampling plan. Further, with the completion of the gate survey, we can conclude that these sampling targets were reasonable and fairly reflected a distribution of samples that align with the universe of waste deliveries.

COMMERCIAL WASTE DELIVERIES AND SAMPLING TARGETS

Commercial waste is coded under both the COMPACTED WASTE and the COMMERCIAL LOOSE accounts in the County's accounting system.[2] The County provided a range of supplemental data to illustrate the sources of commercial waste. Table 2-2 summarizes these data, and also reflects a comparison of actual samples against the targeted sample distribution. As shown, the samples obtained in the study were reflective of the sampling targets.

Table 2-2 Commercial Waste Deliveries (cubic yards, 2005) and Sampling Targets

Hauler	COMPACTED WASTE (CY) [1]	COMMERCIAL LOOSE (CY)	Total Delivered (CY)	Percentage of Total	Sample Targets	Actual Samples
CSU (Colorado State University)	32,988	750	33,738	6.5%	2	2
Dick's Trash Hauling Service	27,143	1,429	28,572	5.5%	2	3
GSI (Gallegos Sanitation, Inc.)	145,693	31,569	177,262	34.0%	14	16
Ram Waste Systems, Inc.	55,942	7,979	63,921	12.3%	6	3
Waste Management	45,342	11,143	56,485	10.8%	4	8
All Other Haulers	0	141,324	141,324	27.1%	12	7
Total	**322,444 [2]**	**199,193 [2]**	**521,637 [2]**	**100.0%**	**40**	**39**

[1] Compacted Waste volumes have been adjusted to reflect an average compaction ratio of 4 to 1.

[2] Column does not sum because haulers with limited deliveries are not shown.

[2] A statistically insignificant portion of commercial waste is also delivered as Commercial Minimum Loads. This was excluded from the analysis.

2. METHODOLOGY

Self Haul Deliveries and Sampling Targets

Self haul wastes are wastes delivered in cars, trucks, and other vehicles not specifically designed for waste hauling. Larimer County maintains close track of self-haul wastes in the landfill accounting system. Table 2-3 summarizes the quantities and coding of self-haul wastes. Table 2-3 also shows the actual samples that were obtained in comparison to the targeted number of samples. Note that MSW Consultants was able to obtain significantly more samples than originally expected; this additional data will further increase the statistical validity of the findings.

Table 2-3 Self Haul Waste Deliveries (cubic yards, 2005) and Sampling Targets

Landfill Account	Volume (CY)	Percent of Total	Sample Targets	Actual Sampled
Minimum Load in Car	1,687	1.1%	0	0
Minimum Load in Truck	3,188	2.1%	2	2
Loose Waste in Car	8,970	5.9%	4	4
Loose Waste in Truck	136,930	90.8%	54	70
Total	**150,775**	**100.0%**	**60**	**76**

C&D Deliveries and Sampling Targets

C&D Waste is coded as such at the County Landfill. Table 2-4 summarizes the estimated C&D waste deliveries, sampling targets, and actual samples obtained. MSW Consultants was again able to obtain significantly more samples for this generator sector.

Table 2-4 C&D Waste Deliveries (cubic yards, 2005) and Sampling Targets

Landfill Account	Volume (CY)	Percent of Total	Sampling Targets	Actual Sample
C&D Waste coded as COMMERCIAL LOOSE [1]	49,798	23.6%	14	0
Compacted C&D [2]	7,833	3.7%	2	2
C&D Debris in Car	194	0.1%	0	0
Commercial C&D Waste	148,356	70.2%	42	72
C&D Debris in Truck	5,150	2.4%	2	2
Total	**211,331**	**100.0%**	**60**	**76**

[1] Estimated at 25 percent of total COMMERCIAL LOOSE for purposes of sampling plan development.

[2] No adjustment has been made for compaction based on limited ability to compact C&D debris.

We note that the fraction of C&D waste in COMMERCIAL LOOSE was unknown during development of the sampling plan. Although the gate survey (see the following section) validated the sampling plan, it was determined during the field data collection that is was not possible to screen incoming COMMERCIAL LOOSE vehicles to determine that they in fact contained C&D. For this reason, the targeted COMMERCIAL LOOSE samples were shifted to loads that were definitively recorded in the landfill accounting system as being C&D waste.

SAMPLING TARGET SUMMARY

Table 2-5 summarizes the targeted and the actual number of physical and visual samples obtained each season for each of the four waste generator classes targeted in the study.

Table 2-5 Proposed Sampling Targets vs Actual Sampled Targets by Generator Class

Generator Class	Targeted Samples	Actual Samples	Difference
Residential – Physical Sorts	30	31	+1
Commercial – Physical Sorts	40	39	-1
C&D Debris – Visual Estimates	60	76	+16
Self Haul – Visual Estimates	60	76	+16
Total	190	222	+32

As shown, MSW Consultants achieved or exceeded sampling targets for three of the four waste generator classes. Commercial waste generator sampling fell one sample shy of the target. This shortfall was due to the practical challenges associated with waste sampling. Specifically, on days the sorting team is in the field, it cannot be predicted the order and timing of the targeted incoming loads of waste. MSW Consultants made every effort to meet the detailed, stratified sampling targets as shown in Table 2-1 through 2-4, and in general succeeded in this effort. We do not believe the one sample shortfall in the commercial waste stream will significantly degrade the results of the analysis. Further, given the much higher inherent variation in the composition of C&D and self-haul wastes, we believe the extra samples obtained for these generator classes will improve the statistical validity of results for these sectors.

FIELD SAMPLING AND SORTING METHODS

Field sampling and sorting methods generally conformed with ASTM standards, refined based on the extensive experience of MSW Consultants in performing numerous similar studies. The following sections summarize field sampling and sorting procedures.

2. METHODOLOGY

LOAD SELECTION

For all four waste generator sectors, the MSW Consultants Field Supervisor remained in communication with the gate attendant(s) to obtain assistance in identifying the loads to be sampled. Each day, the Field Supervisor had a list of targeted deliveries. (For example, on Monday there may have been one Loveland truck, three GSI trucks, one Waste Management truck, etc.). Gate attendants were asked to notify the Field Supervisor when any of these deliveries arrived. The Field Supervisor attempted to take a sample from the targeted incoming loads, although retained freedom to exercise professional judgment in taking alternate loads based on timing and availability of the sort crew and landfill support personnel.

The Field Supervisor further interviewed the drivers of selected loads to obtain information such as origin of the load, waste generating sector, hauler, vehicle type and number, and other data. This information was noted on the vehicle selection form, along with a unique identifying number associated with that vehicle on that day. A summary of the physically sampled loads is shown as Exhibit 1.

We note that even though the County alerted its primary haulers that this study was taking place so that drivers were not caught by surprise, some of the drivers said they lost the Gate Ticket or did not want to divulge any information about the incoming load. In these instances, the sampling selection data was completed to the greatest extent possible.

SIZE OF PHYSICALLY SORTED AND VISUALLY SURVEYED SAMPLES

Consistent with industry literature, we attempted to take samples that weighed between 200 and 250 pounds for all manually-sorted samples. Table 2-6 below summarizes the average, maximum and minimum sample weights from the summer and winter seasons

Table 2-6 Sample Weight Summary

Generating Sector	Number of Samples	Number of Samples <200 Lbs	Minimum Sample Lbs	Maximum Sample Lbs	Average Sample Lbs
Residential	31	2	155	265	219
Commercial	39	2	170	558	253

As shown in Table 2-6, the average weights of the two seasonal sorts were 219 pounds for the residential and 253 pounds for the commercial sectors, both within or even slightly above the target sample sizes. We note that a total of four samples out of the 70 taken fell below the target sample weight. This reflects the inherent differences in density of tipped wastes. As described further below, samples were taken with the help of a loader taking a scoop from the tipped load. In instances where the wastes in a grab sample were especially "fluffy" (i.e., less dense), even a full bucket of waste may not have achieved the 200 pound target. MSW Consultants does not believe the small number of light samples will bias the results, and upon further analysis of these individual samples to confirm that none were clear outliers, we have opted to include them in the statistical analysis.

Visually surveyed samples consisted of the entire load. Load weights for self-haul and C&D waste may range from less than 100 pounds (for car and small truck loads) up to 10+ tons (for C&D loads containing a large fraction of cement block and other dense materials). Table 2-7 below summarizes the cubic yards (CY) and estimated weights for the self-haul and C&D generating sectors.

Table 2-7 Self-Haul and C&D Cubic Yardage and Weight Summary

Generating Sector	Number of Samples	Cubic Yardage			Tons		
		Min	Max	Avg	Min	Max	Avg
Self-Haul	76	0.3	30	6.6	0.1	11.5	1.3
C&D	76	1	40	10.8	0.06	12.9	3.4

As expected, C&D loads were larger on average than self-haul loads.

MATERIAL CATEGORIES

Material categories were selected to meet two main objectives. First, the categories were intended to provide meaningful breakdowns of the waste stream from the perspective of evaluating current and potential future source reduction, diversion and recycling programs. Second, the categories were established such that they could be aligned with the results of the 1998 Study for the purpose of evaluating changes in the waste stream.

A total of 45 material categories were ultimately defined for this study. The material categories, detailed definitions, and a mapping of 2006 Study to 1998 Study material categories is included as Appendix A.

TAKING SAMPLES FOR PHYSICAL SORTING

Selected loads of residential and commercial wastes were tipped in a designated area on the landfill face near the sorting area. From each selected load, a sample of waste was selected based on systematic "grabs" originating from the perimeter of the load. MSW Consultants uses a systematic grabbing methodology that pre-selects the location of the grab prior to tipping of the load. For example, if the tipped pile is viewed from the top as a clock face with 12:00 being the part of the load closest to the front of the truck, the first samples will be taken from 3 o'clock, 6 o'clock, 9 o'clock, 12 o'clock, and then from 1, 4, 7, and 10 o'clock, and so-on.

Once the area of the tipped load to be grabbed was selected, the Field Supervisor coordinated with a loader operator to take a grab sample of wastes from that point in the tipped load. The loader operator used the loader (both provided by Larimer County) to remove a sample of waste weighing at least 250 pounds. This sample was deposited on a tarp designated to receive samples. Each sample was labeled by its identifying number using brightly colored spray paint, and digitally photographed.

2. METHODOLOGY

PHYSICAL SORTING

Once the sample had been acquired and placed on a tarp, the material was manually sorted into the prescribed component categories. Plastic 18-gallon bins with sealed bottoms were used to contain the separated components.

Sorters were trained to specialize in certain material groups, with someone handling the paper categories, another the plastics, another the glass and metals, and so on. In this way, sorters became highly knowledgeable in a short period of time as to the definitions of individual material categories.

The Crew Chief monitored the bins as each sample was being sorted, requiring a re-sort of materials that were improperly classified. Open bins allowed the Crew Chief to see the material at all times. The Crew Chief also verified the sorting accuracy of each component during the weigh-out. The materials were sorted to particle size of 2-inches or less by hand, until no more than a small amount of homogeneous material remained. This layer of mixed 2-inch-minus material was allocated to the appropriate categories based on the best judgment of the Crew Chief—most often a combination of Other Paper, Other Organics, or Food Waste. The overall goal was to sort each sample directly into component categories in order to reduce the amount of indistinguishable fines or miscellaneous categories. Note that the sorting methodology included the use of a customized, sturdy framed sort table that has a removable screen sized at ½ inch. Small particles passing through the screen were swept into a separate container and recorded in their own material category called "Fines" (categorized under the Organics material group).

VISUAL SURVEYING

Visual surveying of a load of self-haul or C&D waste involved detailed volumetric measurements of the truck and load dimensions, followed by the systematic observation of the major material components in the tipped load. The basic steps to visual surveying are:

1. Measure the dimensions of the incoming load prior to tipping and (if possible) estimate the percent full of the vehicle.
2. Tip the load. If it is a large load, and if conditions permit, have a loader spread out the material so that it is possible to discern dense materials such as block, brick, and dirt that tend to sink to the bottom of the pile.
3. Make a first pass around the load marking the major material categories that are present in the load—cardboard, drywall, dimensional lumber, etc. Estimate the percentage of the load made up of these major materials. If possible, estimate of the yardage associated with this material.
4. Make a second pass around the load, noting the secondary material categories contained in the load. Estimate the percentage of the load made up of these materials. Because the MSW Consultants Field Supervisor conducting this study is highly experienced in visual surveying of C&D and Self Haul loads, this step also included estimating the actual weight, in pounds, of each of the material identified in the load. Volume and weight estimates will be reconciled in the QC process.

5. Validate that the estimated percentages sum to 100 percent, and that the estimated weight and volume of major material categories is realistic given the overall truck dimensions and volume.

Because some residential and commercial waste was included in self-haul and C&D waste, the field data form included a category for "Mixed MSW." Mixed MSW has been apportioned back into the self-haul and C&D composition estimates based on the composition of residential and commercial waste observed in the physical sorting.

DATA RECORDING

The weigh-out and data recording process is arguably the most critical process of the sort. The Crew Chief was singularly responsible for overseeing all weighing and data recording of each sample. Once each sample had been sorted, and fines swept from the table, the weigh-out was performed. Each bin containing sorted materials from the just-completed samples were carried over to a digital scale provided by MSW Consultants. Sorting laborers assisted with carrying and weighing the bins of sorted material, the Crew Chief recorded all data.

The Crew Chief used a waste composition data sheet to record the composition weights. Each data sheet containing the sorted weights of each sample was matched up against the Field Supervisor's sample sheet to assure accurate tracking of the samples each day.

Visual survey sheets were filled out by the Field Supervisor, who could easily match them up against the master sample sheet.

Data sheets were entered into a spreadsheet each evening to assure that sample weights were meeting targeted minimum levels, and that sample data appears to be reasonable.

CONCLUSION

Field data collection methods closely followed industry-standard procedures. With almost no precipitation during the field data collection events, MSW Consultants believes that external contamination from moisture was minimal to nil. Given the careful logistical management of the sample collection process, the field data collection was performed with no known problems. The resulting data meet the objective of being representative of disposed wastes within each of the four generator classes targeted in the study.

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3. GATE SURVEY

INTRODUCTION

The Larimer County Landfill tracks incoming waste quantities based on several categories, including Loose Waste, Compacted Waste, C&D Debris, and a range of special wastes such as tires, rip-rap, and tree limbs. The landfill further tracks whether deliveries are in a car, a truck, or a commercial vehicle, as there are different state-imposed surcharges on each type of delivery vehicle. Table 3-1 summarizes the quantities of wastes received for calendar year 2006 based on the landfill's gatehouse coding system.

Table 3-1 2006 Incoming Waste Quantities [1]

Transaction Type	Material Description	Cubic Yards
MIN CAR	Loads delivered in a car that are less than ½ CY	2,481
MIN COMM	Loads delivered in a commercial non-compacting vehicle that are less than ½ CY	261
MIN TRK	Loads delivered in a pick-up truck that are less than ½ CY	2,427
LOOSE CAR	Loose waste delivered in a car	15,012
LOOSE COMM	Loose waste delivered in a commercial vehicle	129,047
XFERSTATION	Transfer trailers from Estes Park, Berthoud, or Wellington	56,425
LOOSE NO X	Commercial wastes with no disposal charge	1,418
LOOSE TRK	Loose waste delivered in a pick-up truck	120,641
ROADSIDE	Commercial waste from roadside cleaning	86
COMPACTED	Waste delivered in commercial compacting vehicles	263,781
COMPCT C&D	C&D Debris delivered in commercial compacting vehicles	592
C&D CAR	C&D delivered in a car	223
C&D COMM	C&D delivered in a commercial non-compacting vehicle	117,383
C&D TRK	C&D delivered in a pick-up truck	4,290
Totals [2]		**714,067**

[1] Source: Larimer County

[2] This table excludes Rip/Fill, Tree limbs, Animal carcasses, Non-friable asbestos, Tires, Appliances, and Auto bodies.

Given the transaction codes shown above, Larimer County landfill gate records are limited for two reasons. First, it is not possible to query the database in such a way as to subdivide deliveries by generator sector. Second, the landfill does not have scales and consequently all deliveries, whether loose or compacted, are recorded in cubic yards. Although the Landfill accounting software stores material densities and the corresponding weight estimate, the County reports waste deliveries based on volume.

Because of these limitations, a comprehensive survey of incoming vehicles was performed to better estimate the true proportion of material from the following four main generator classes:

- Residential (compactor trucks),
- Commercial,
- Construction and Demolition (C&D), and
- Self haul (personal cars and pick-up trucks).

METHODOLOGY

MSW Consultants conducted a gate survey of incoming vehicles over a one-week period from September 14 through September 20, 2006. The survey was performed from the time the facility opened until close (i.e., 7:00 am to 4:00 pm) each day during this period, except Sunday. Sunday deliveries were found to be predominantly self-haul and therefore did not need to be surveyed.

Based on a review of detailed gatehouse records, two delivery codes were targeted in the survey: COMPACTED WASTE and COMMERCIAL LOOSE waste. The MSW Consultants Surveyor remained in or outside the gate houses and interviewed drivers of incoming truckloads that were recorded as COMMERCIAL LOOSE or COMPACTED WASTE definitions (either by gate attendants or by the automated attendant). (Although out of scope, vehicles that were recorded as C&D COMM [Commercial C&D Waste] were also surveyed, primarily because the roll-off, dump, and other non-compacting vehicles that deliver C&D COMM are also the type of vehicle that typically deliver COMMERCIAL LOOSE.) Upon confirming that an incoming vehicle was among the two targeted classifications (primarily the compactor trucks and roll-offs), MSW Consultants staff interviewed the driver to determine the origin of the waste and the generator type. The data was recorded on a customized field data form that recorded the proportion, by volume, of the waste contained in that load that was (i) residential, (ii) commercial, (iii) C&D, or (iv) Other. The survey form also recorded the transaction/ticket number for each surveyed vehicle.

The Surveyor moved between the automated entry way and the two staffed entries to capture the majority of incoming COMPACTED and COMMERCIAL LOOSE loads. To overcome the potential for missing any incoming loads, MSW Consultants provided a survey form to the gate attendants in each gate house to supplement data collected by MSW Consultants during especially busy times. Table 3-2 summarizes the vehicles surveyed.

Table 3-2 Summary of Vehicles Surveyed

WASTE TYPE	Number of Vehicles	Number of Vehicles Surveyed	Percentage Surveyed
C&D COMM	243	184	75.7%
COMPACTED	265	252	95.1%
LOOSE COMM[1]	266	208	78.2%
Total	**774**	**644**	**83.2%**

[1] Excludes Transfer Trailers, which are also recorded as LOOSE COMM

A total of 664 incoming vehicles were surveyed during the 5 day period, or about 111 vehicles per day. Of the targeted loads, 75.7 percent of the C&D COMM, 95.1 percent of the COMPACTED and 78.2 percent of the LOOSE COMM were surveyed. The LOOSE COMM waste delivered in transfer trailers from a known origin were excluded from the survey.

Table 3-3 provides a parallel summary of the proportion of all incoming cubic yards that were surveyed. As shown, just shy of 90 percent of all incoming cubic yards were captured in the survey for all waste types. Although this is not perfect coverage, we believe it is sufficient to derive the estimated breakdown of incoming wastes by generator sector.

Table 3-3 Summary of Cubic Yards Surveyed

WASTE TYPE	Incoming Yardage	Yards Surveyed	Percentage Surveyed
C&D COMM	2,008	1,652	82.3%
COMPACTED	5,304	4,765	89.8%
LOOSE COMM[1]	2,497	2,183	87.4%
Total	**9,809**	**8,600**	**87.7%**

[1] Excludes Transfer Trailers, which are also recorded as LOOSE COMM

At the conclusion of the gate survey, Larimer County provided MSW Consultants with a complete data dump of all landfill gate transactions from that week, including ticket number, material volume, type of waste, gate attendant on duty, etc. MSW Consultants entered all data obtained in the gate survey and mapped the survey data to the facility transaction data. Once mapped, the two data sets provide a very detailed breakdown of the proportion of each incoming material type for the targeted week. Results of this process are contained in the following section.

3. GATE SURVEY

RESULTS

The surveyed field data was mapped to the ticket number of the accounting file submitted to MSW Consultants. Table 3-4 shows the total cubic yards in the various material categories delivered during the week of the survey.

Table 3-4 Gate Survey Results (Cubic Yards)

MATERIAL	Residential	Commercial	C&D	Other	Total
C&D COMM	75	108	1,458	11	1,652
COMPACTED	2,769	2,182	81	209	5,071
LOOSE COMM	368	1,145	462	209	2,183
Total	**3,212**	**3,434**	**2,001**	**260**	**8,906**

Table 3-5 reflects the percentage breakdown observed in the gate survey.

Table 3-5 Gate Survey Results (Percent by Volume)

MATERIAL	Residential	Commercial	C&D	Other	Total
C&D COMM	4.6%	6.5%	88.3%	0.7%	100.0%
COMPACTED	54.2%	44.1%	1.7%	0.8%	100.0%
LOOSE COMM	16.8%	52.4%	21.2%	9.6%	100.0%

As shown, COMPACTED waste was found during the week-long survey to be slightly more residential than commercial. LOOSE COMM was found to be predominantly waste from commercial generators, although a significant amount was found in the survey to be C&D waste. Although some of this may be the result of mis-classification of the load at the gate, the gate survey found that C&D is often mixed with commercial waste and therefore the entire load rightfully is classified as LOOSE COMM. Not surprisingly, C&D COMM waste was confirmed to be primarily C&D. "Other Waste" identified in the survey included limbs/land clearing, rip-rap, and the other categories of wastes tracked in the County's landfill accounting system.

ANNUAL PROJECTIONS

Table 3-6 below summarizes calendar year 2006 material volumes received at the landfill. This table shows the allocation of the various material categories tracked by the current accounting system.

Table 3-6 2006 Annual Waste Quantities (cubic yards) by Generating Sector, Raw Data [1]

Material	Residential	Commercial	Self Haul	C&D	Other	Annual Cubic Yards
MIN CAR	0	0	2,481	0	0	2,481
MIN COMM	0	261	0	0	0	261
MIN TRK	0	0	2,427	0	0	2,427
LOOSE CAR	0	0	15,012	0	0	15,012
LOOSE COMM	Unknown					129,047
XFERSTATION	Unknown					56,425
LOOSE NO X	0	1,418	0	0	0	1,418
LOOSE TRK	0	0	120,641	0	0	120,641
ROADSIDE	0	86	0	0	0	86
COMPACTED	Unknown					263,781
COMPCT C&D	0	0	0	592	0	592
C&D CAR	0	0	0	223	0	223
C&D COMM	0	0	0	117,383	0	117,383
C&D TRK	0	0	0	4,290	0	4,290
Totals [2]	**0**	**1,765**	**140,561**	**122,488**	**0**	**714,067**

[1] Source: Larimer County Landfill

[2] Excludes Rip/Fill, Rip/Fill F, Tree Car, Tree Comm, Tree Trk, Tree Disc, Tree Trunk, Tree Xmas, Animal carcasses, Non-friable asbestos, Tires, Appliances, and Auto bodies.

As shown in the table, the LOOSE COMM, XFERSTATION, and COMPACTED categories cannot be allocated to a generator type. MSW Consultants applied the results of the gate survey to allocate the LOOSE COMM and COMPACTED wastes to the appropriate generator class. Further, we assume that XFERSTATION loads contain a mix of residential, commercial, self haul and C&D waste roughly in proportion to the direct-haul quantities received at the Larimer County landfill. Based on these assumptions, Table 3-7 applies the results of the gate survey to allocate all wastes to the appropriate generator sector.

Table 3-7 2006 Annual Waste Volume (cubic yards) by Generator, Allocated [1]

Material	Residential	Commercial	Self Haul	C&D	Other	Annual Cubic Yards
MIN CAR	0	0	2,481	0	0	2,481
MIN COMM	0	261	0	0	0	261
MIN TRK	0	0	2,427	0	0	2,427
LOOSE CAR	0	0	15,012	0	0	15,012
LOOSE COMM	21,739	67,669	0	27,302	12,337	129,047
LOOSE NO X	0	1,418	0	0	0	1,418
LOOSE TRK	0	0	120,641	0	0	120,641
ROADSIDE	0	86	0	0	0	86
COMPACTED	144,021	113,479	0	4,200	2,081	263,781
COMPCT C&D	0	0	0	592	0	592
C&D CAR	0	0		223	0	223
C&D COMM	5,358	7,646	0	103,598	782	117,384
C&D TRK	0	0		4,290	0	4,290
Subtotal [2]	*117,118*	*190,559*	*140,561*	*140,205*	*15,200*	*657,643*
Percent of Total	*28.3%*	*30.1%*	*19.7%*	*19.8%*	*2.2%*	*100.0%*
XFERSTATION	15,968	16,984	11,116	11,172	1,241	56,425
GRAND TOTAL	133,086	207,543	151,677	151,377	16,441	714,068

[1] Larimer County data allocated based on the results of the gate survey

[2] Excludes Rip/Fill, Rip/Fill F, Tree Car, Tree Comm, Tree Trk, Tree Disc, Tree Trunk, Tree Xmas, Animal carcasses, Non-friable asbestos, Tires, Appliances, and Auto bodies.

As shown, the Larimer County landfill received 714 thousand yards of waste in 2006. Of this amount 28.3 percent was residential waste delivered by commercial haulers, 30.1 percent was commercial waste delivered by commercial haulers, and 19.7 percent was delivered by self-haulers. C&D wastes made up 19.8 percent, and other wastes were 2.2 percent.

The composition of wastes from each of these generator sectors will be addressed in Section 4 of this report. The weighted average aggregate waste composition will be based on the weighting factors derived in this gate survey.

As a final step, MSW Consultants applied density estimates for the different waste types to convert Table 3-7 from volume to weight. These density estimates are based on other density data points available to MSW Consultants, Larimer County, the U.S. Environmental Protection Agency (EPA), as well as on truck body manufacturer specifications. The following densities were used to convert volume to weight:

- COMPACTED – 750 Lbs/CY

- COMPACTED C&D – 625 Lbs/CY
- XFERSTATION – 600 Lbs/CY
- C&D COM , C&D TRUCK, and C&D CAR – 325 Lbs/CY
- LOOSE COM and MIN COMM – 200 Lbs/CY
- MIN TRUCK, LOOSE NOX, LOOSE TRUCK, and ROADSIDE – 150 Lbs/CY
- MIN CAR and LOOSE CAR – 100 Lbs/CY

Table 3-8 applies these density factors to each type of waste to calculate the total weight of the incoming material categories.

Table 3-8 2006 Annual Waste Quantities (Tons) by Generator, Allocated [1]

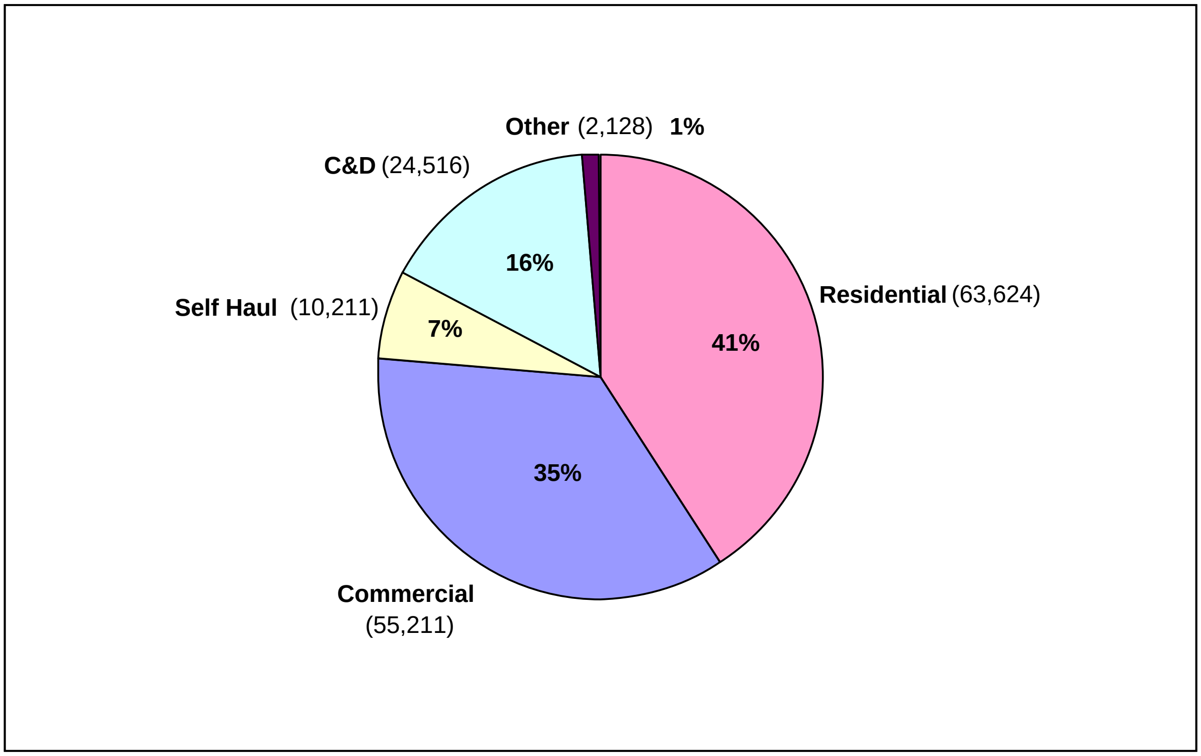
Material	Residential	Commercial	Self Haul	C&D	Other	Annual Tons
MIN CAR	0	0	124	0	0	124
MIN COMM	0	26	0	0	0	26
MIN TRK	0	0	182	0	0	182
LOOSE CAR	0	0	751	0	0	751
LOOSE COMM	2,174	6,767	0	2,730	1,234	12,905
XFERSTATION	9,242	7,282	0	270	134	16,927
LOOSE NO X	0	0	106	0	0	106
LOOSE TRK	0	0	9,048	0	0	9,048
ROADSIDE	0	0	0	0	6	6
COMPACTED	52,208	41,136	0	1,523	754	95,621
COMPCT C&D	0	0	0	185	0	185
C&D CAR	0	0	0	36	0	36
C&D COMM	0	0	0	19,075	0	19,075
C&D TRK	0	0	0	697	0	697
Total	**63,624**	**55,211**	**10,211**	**24,516**	**2,128**	**155,689**
Percentage	***41%***	***35%***	***7%***	***16%***	***1%***	***100%***

[1] Larimer County data allocated based on the results of the gate survey

[2] Excludes Rip/Fill, Rip/Fill F, Tree Car, Tree Comm, Tree Trk, Tree Disc, Tree Trunk, Tree Xmas, Animal carcasses, Non-friable asbestos, Tires, Appliances, and Auto bodies.

As shown, the Larimer County landfill was estimated to receive 155,689 tons of waste in 2006. Of this amount 41 percent by weight was Residential waste, 35 percent was Commercial waste, and 7 percent was delivered by Self-haulers. C&D wastes made up 16 percent, and Other Wastes were one percent. Figure 3-1 summarizes the relative contribution of disposed wastes (by weight) of each of the generator classes in Table 3-8. These percentages are used in Section 4 to aggregate the composition data by generator class.

Figure 3-1 2006 Annual Waste Quantities (Tons) by Generator



4. RESULTS

STATISTICAL MEASURES

This section presents the results of the study. The following statistical measures are used uniformly throughout the section:

- **Sample Mean:** For each generator class, the sample mean composition is the average of the weight-based percentage composition of the individual samples from that generator class. This value, while a good estimate, is unlikely to be identical to the population mean value. To better understand the meaningfulness of the sample mean, other statistical measures are needed.
- **Standard Deviation**: The standard deviation measures how widely values within the data set are dispersed from the sample mean. A higher standard deviation denotes higher variation in the underlying samples for each material.
- **Confidence Intervals**: The confidence intervals reflect the upper and lower range within which the population mean can be expected to fall. Confidence intervals require the following "inputs":
  - The "level of confidence", or how sure one wants to be that the interval being constructed will actually encompass the population mean;
  - The sample mean, around which the confidence interval will be constructed;
  - The sample standard deviation, which is used as a measure of the variability of the population from which the sample was obtained; and
  - The number of sampling units that comprised the sample (aka sample size).
- **Coefficient of Variance**: This measure was used in the 1998 Study, although has not been duplicated for the 2006 Study. Also called the *relative standard deviation*, this measure divides the standard deviation by the mean. In so doing, it enables a normalized comparison of variance among material categories that may appear in the waste stream in significantly different absolute terms. For example, comparing the standard deviations of Food Waste and Rubber/Leather is not meaningful, because there is a significant amount of Food Waste disposed and only trace amounts of Rubber/Leather. However, the coefficient of variance can be compared directly—the category with the larger coefficient has a more variable composition.

Throughout this section, confidence intervals have been calculated at a 90 percent level of confidence, meaning that we can be 90 percent sure that the population mean falls within the upper and lower confidence intervals shown. In general, as the number of samples increases, the width of the confidence intervals decreases, although the more variable the underlying waste stream composition, the less noticeable the improvement for adding incremental samples.

4. RESULTS

ADJUSTING FOR CONTAMINATION

Note that the results shown in this report have not been adjusted for contamination.

During the collection, tipping, and sorting of samples of residential and commercial wastes, moisture and particulate matter of some material categories cross-contaminate other material categories. For example, liquids in food waste may be absorbed by the various paper categories; broken glass particles may embed or adhere to foam plastics or textiles. Based on testing performed in other studies, the impact of contamination is minimal for many categories, but can be significant for some. The following categories from the 2006 Study are most likely to be impacted by moisture and particulate contamination:

- All of the grades of paper:
- Expanded Polystyrene;
- Plastic Film Bags;
- Other Rigid Plastic, which encompasses food and deli trays that may be heavily contaminated; and
- Other Aluminum, which often includes foil and tins that are heavily food-encrusted.

It was beyond the scope of this project to develop contamination correction factors for these material categories. However, readers should recognize that the annual quantities that are calculated in this section of the report overstate the actual quantity of these materials that are being disposed. Further, the annual quantities of food wastes and possibly certain other organic wastes (e.g., Yard Waste) would likely be greater than that shown, as much of the moisture that contaminates the paper likely originated from these organics. Had there been no cross-contamination of moisture and particulates, the disposed quantity of the more absorbent material categories would be at least marginally lower, and the disposed content of moisture-containing categories would have been marginally higher, than what is shown in this section.

AGGREGATION OF DATA BY GENERATOR SECTOR

As discussed in the previous section, a week-long gate survey was performed to develop a defensible breakdown of the incoming quantity of wastes from each of the four main generator sectors targeted in the study. Table 4-1 summarizes the annual wastes disposed by generator sector based on the results of the gate survey.

Table 4-1 Waste Disposal by Generator Sector

Sector	2006 Tons Disposed	Percent of Total
Residential	63,624	41.4%
Commercial	55,211	36.0%
Self-Haul	10,211	6.6%
C&D Debris	24,516	16.0%
Total	**153,562**	**100.0%**

Note: The gate survey also identified "Other" waste categories such as rip/fill, tree limbs, etc. For the purpose of developing weighting factors for the Residential, Commercial, Self-haul and C&D generator sectors, the Other category has been excluded and the remaining percentages re-calculated based on the sum of these four generator sectors. See Table 3-8 for details.

The percentages in the far right column of Table 4-1 are used as weighting factors to develop an aggregate composition of all waste delivered to the Larimer County Landfill.

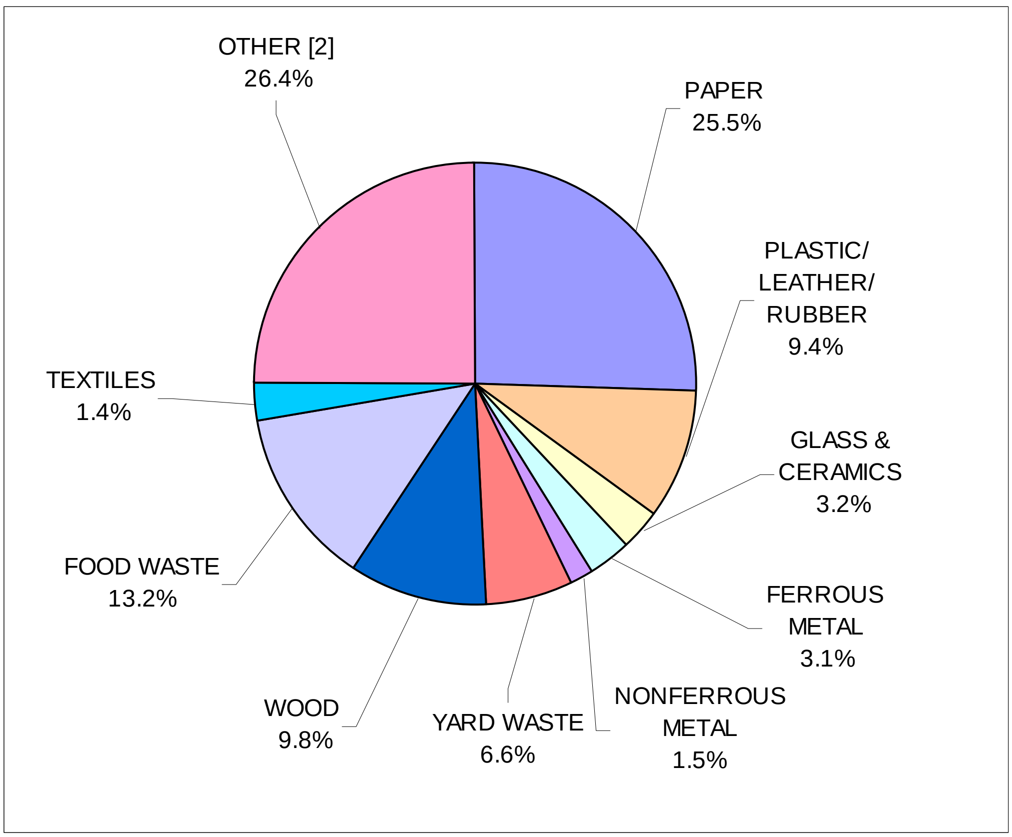
4. RESULTS

RESULTS

AGGREGATE COMPOSITION, ALL WASTE DELIVERIES

Figure 4-1 presents a graphical breakdown of the major material categories entering the Larimer County Landfill from the Residential, Commercial, Self-Haul, and C&D sectors. Note that these material groups have been defined to be directly comparable to the 1998 Study (discussed later in this section). As shown in the Figure, the Paper material group makes up over one quarter of the aggregate waste stream, while Food Waste is the single most prevalent material category. Although the "Other Waste" category is actually the largest material group shown in the Figure, this category comprises 14 different material categories and includes primarily materials generated from C&D activities, which accounts for the size of the group as a whole.

Figure 4-1 Aggregate Composition (Percent by Weight), All Wastes Delivered to Landfill [1]



[1] Excludes rip-rap, tree limbs, and other homogeneous categories that are tracked separately in the landfill accounting system.

[2] OTHER waste includes C&D materials such as drywall, block/brick/stone, insulation, and asphalt roofing, and miscellaneous organics and inorganics not elsewhere classified including diapers/sanitary products, electronics, bulky items, carpet, tires, fines, and household hazardous waste (HHW).

Figure 4-2 shows the ten most prevalent individual material categories being disposed at the Larimer County Landfill. It is of definite interest that Corrugated Cardboard, Newspaper, Yard Waste, and even Mixed Paper are on the top ten list. These materials are generally easy to separate, and many municipalities offer separate collections for these materials. The appearance of these materials in the top ten may suggest opportunities for Larimer County to increase recycling and diversion somewhat significantly. Interestingly, all of the most prevalent disposed wastes are either compostable (Food Waste, Other Compostable Paper, Yard Waste) or recyclable (Carpet, Film Bags, Clean Wood). However, these wastes are at a minimum difficult or costly to separate, and at the current time there likely is no local market that can accept these materials. In the short term, therefore, many of these materials do not offer significant potential for diversion, although diversion of at least some of these materials may be a longer term opportunity.

Figure 4-2 Ten Most Prevalent Material Categories (Percent by Weight), Aggregate

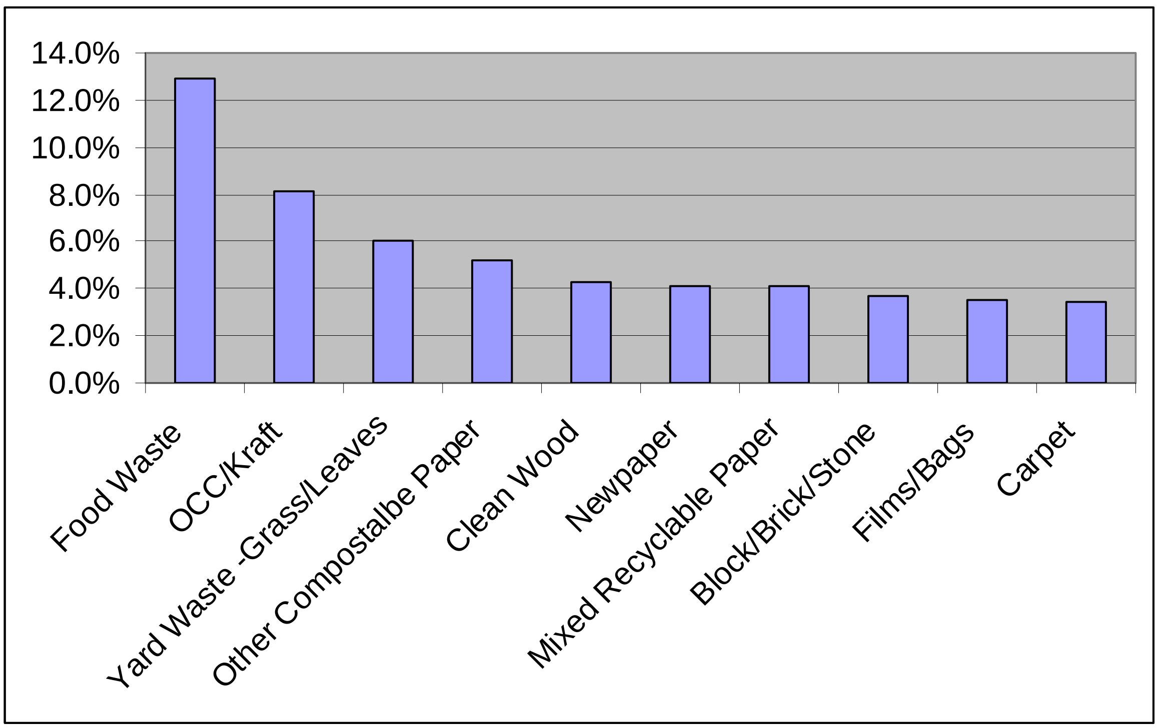
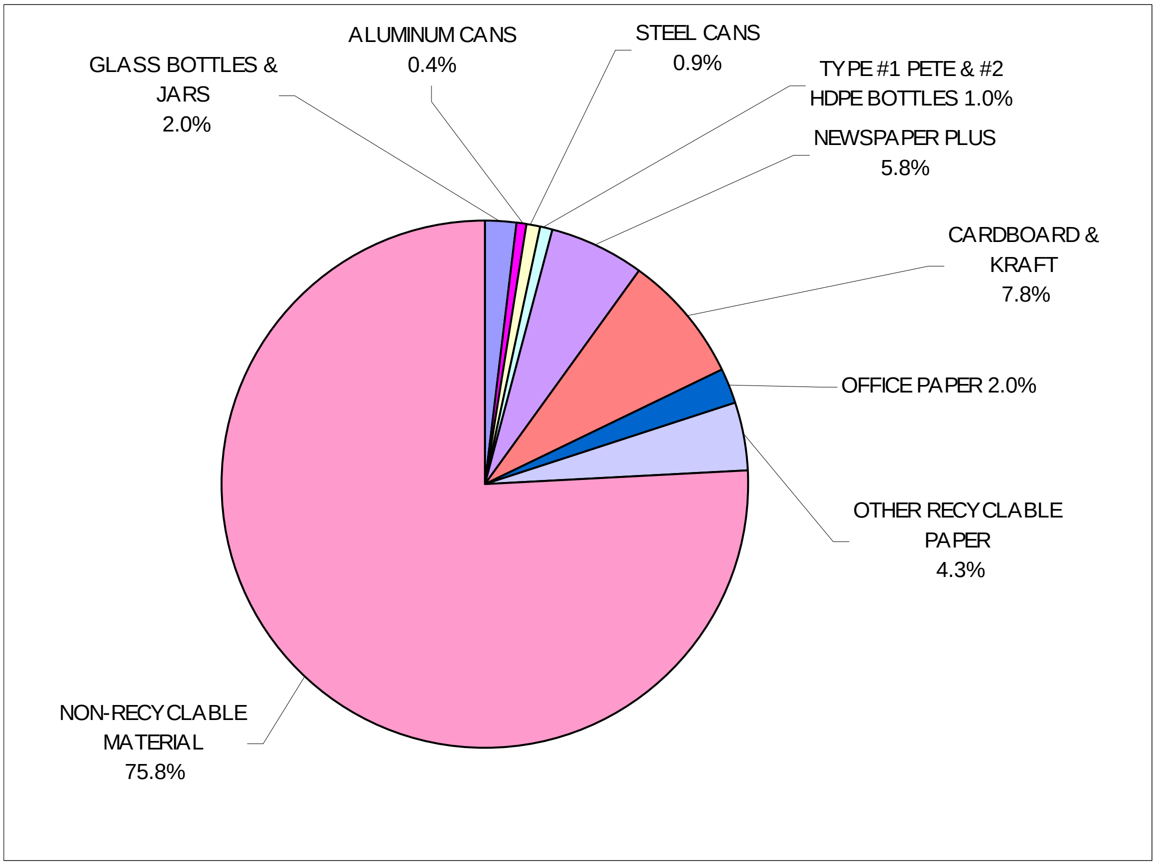


Figure 4-3 shows the breakdown between recyclable materials and non-recyclable materials. The recyclable materials shown in the Figure are specifically those that are included in the program description and educational materials on the County's website. The occurrence of these targeted recyclables in the aggregate waste stream is certainly caused by the incidence of these materials in the commercial, self-haul and/or C&D waste stream. However, some of the disposed recyclables were generated in the residential waste stream as well.

Figure 4-3. Prevalence of Recyclable Materials in Aggregate Disposed Wastes (Percent by Weight)



As shown in Figure 4-3, this study found that over 24 percent of disposed wastes going into the Larimer County landfill could potentially be recycled (unadjusted for source contamination of recyclable material). The largest recyclable material categories in the disposed waste stream include corrugated cardboard/Kraft paper, newspapers (including inserts), and mixed paper (shown below as Other Recyclable Paper).

Conversely, the study found that almost 76 percent of disposed waste is comprised of materials for which there are no local recycling programs. Although the Figure above labels these materials as "non-recyclable," this label applies only because markets for additional recycled materials have not yet developed in Larimer County. Over time, it is expected that there would be opportunities to increase recycling of new materials that are currently being disposed.

Aggregate waste composition data for the County in detailed tabular format, including statistical measures of standard deviation and 90 percent confidence intervals, is contained in Exhibit 2.

COMPARISON OF COMPOSITION BY GENERATOR CLASS

Table 4-2 compares the mean composition of wastes by generator class for the major material groups. There are several items of interest to be seen in this table:

- Residential and Commercial wastes are reasonably similar;
- Residential and Commercial wastes contain a diverse mix of materials encompassing all of the major material groups;
- Self haul and C&D wastes are much more limited in the materials disposed, and their composition differs significantly from Residential and Commercial waste;
- Self-haul wastes contain a significant fraction of Wood and Other waste, the latter of which is largely made up of C&D material categories;
- C&D Debris contains significant amounts of green and woody wastes associated with land clearing, as well as Other waste (i.e., the C&D material categories).

Table 4-2 Comparison of Waste Composition By Generator Class

Material Group	Residential	Commercial	Self-Haul	C&D
Paper	31.4%	31.6%	13.9%	1.0%
Plastic/Rubber/Leather	10.6%	11.2%	4.5%	0.4%
Glass	4.8%	2.7%	2.8%	3.9%
Ferrous Metal	3.0%	3.5%	2.9%	2.5%
Non-ferrous Metal	1.7%	2.0%	0.4%	0.6%
Yard/Land Clearing	8.4%	6.3%	9.5%	27.2%
Wood	3.0%	8.9%	15.0%	1.6%
Food Waste	17.4%	15.9%	0.3%	0.1%
Textiles	2.4%	1.0%	0.3%	0.0%
Other [1]	17.3%	16.9%	48.7%	62.8%
TOTAL	**100.0%**	**100.0%**	**100.0%**	**100.0%**

[1] OTHER waste includes C&D materials such as drywall, block/brick/stone, insulation, and asphalt roofing, and miscellaneous organics and inorganics not elsewhere classified including diapers/sanitary products, electronics, bulky items, carpet, tires, fines, and household hazardous waste (HHW).

Detailed results for the Residential, Commercial, Self-haul and C&D generator classes are shown in Exhibits 3, 4, 5, and 6.

Table 4-3 compares the top 10 individual materials found in the disposed waste stream of each generator sector.

Table 4-3 Comparison of Top 10 Most Prevalent by Generator Sector

Rank	Residential		Commercial		Self-haul		C&D	
1	Food Waste	17.4%	Food Waste	15.9%	Bulky Items	15.8%	Drywall	15.1%
2	Yard Waste	8.0%	OCC/Kraft	13.6%	Yard Waste	9.5%	Asphalt Roofing	14.7%
3	Non Recyclable Paper	7.7%	Yard Waste	6.3%	Other Inorganics	9.1%	Carpet	11.8%
4	Mixed Recyc Paper	6.6%	Non Recyc Paper	5.5%	Carpet	8.0%	Block/Brick/Stone	11.2%
5	Newspaper	6.5%	Film/Bags	4.5%	Clean Wood	7.7%	Clean Wood	10.9%
6	OCC/Kraft	6.0%	Newspaper	4.1%	Clean Wood Block/Brick/Stone	5.8%	Other Wood	10.3%
7	Diapers/Sanitary Products	4.9%	Mixed Recyc Paper	3.6%	OCC/Kraft	4.4%	Painted/Stained Wood	6.0%
8	Films/Bags	4.5%	Clean Wood	3.5%	Mixed Recyc Paper	4.1%	Other Inorganics	5.4%
9	Other Rigid Plastic	3.2%	High Grade Paper	3.5%	Painted/Stained Wood	3.7%	Other/Broken Glass	3.9%
10	Fines	3.1%	Other Rigid Plastic	3.2%	Asphalt Roofing	3.6%	Other Ferrous Metal	2.4%
Top 10		68.0%		63.9%		71.1%		91.8%

COMPARISON WITH 1998 WASTE COMPOSITION STUDY

The 1998 Study was the first attempt made by the County to evaluate the composition of disposed wastes. This section compares the results of the 2006 Study with the original 1998 Study.

Although it is beyond the scope of this project to research and document the potential differences in methodology and/or outcome between the two studies, we offer the following observations that may prevent a perfect comparison of the results:

- **Smaller number of samples in 1998 Study**: The 1998 Study captured 36 Residential samples, 24 Commercial samples, and 12 Self-haul samples. While the Residential sample size is comparable to the 2006 study and should be sufficient to generate reasonable results, it is somewhat likely that the Commercial, and highly likely that the Self-haul sample sizes were insufficient to eliminate the potential for one or more outlier samples to bias the results;
- **Limited material categories in 1998 Study**: The 1998 Study divided the waste stream into 10 material categories. The categories that were selected, while meaningful in identifying macro-level composition of the waste streams, were relatively limited. The

2006 Study utilized a significantly expanded list of material categories, while allowing for results to be mapped to the 1998 Study material categories for direct comparison;

- **Four-season v. Two-season field data collection**: The 1998 Study included a total of four field data collection events, one each in the Spring, Summer, Fall and Winter. For this reason, it is likely that the 1998 Study effectively captured seasonal variation that occurs in waste composition (e.g., an increase in beverage containers being disposed in the hotter summer months; an increase in yard waste disposal in the spring and fall). The 2006 Study captured only two seasons of data—summer and winter—so there is greater potential that the 2006 Study did not fully capture the impact of spring or fall waste composition trends (especially leaf and yard waste generation).
- **Weekly sampling coverage**: The 1998 Study targeted three days of sorting in each of the four seasons, while the 2006 Study encompassed a full week of sampling in each season. In general, the full week of sampling is preferable to assure that representative samples are captured from all geographic areas of the County.
- **Separate Classification of C&D**: The 2006 Study definitively separates C&D wastes and performs a separate composition analysis of these wastes. It is not clear to what extent the 1998 Study segregated commercial and C&D loads, although notations regarding the random sampling of asphalt shingle loads in the commercial stream suggests that the 1998 Study likely applied a different definition of the generator sectors than were used in the 2006 Study.
- **Sampling Strategy**: The 1998 Study used pure random sampling to acquire and sort samples from incoming truckloads. Based on significant up-front analysis of gatehouse data, and subsequently validated based on a gate survey, the 2006 Study utilized stratified random sampling to assure that samples aligned with known delivery patterns.

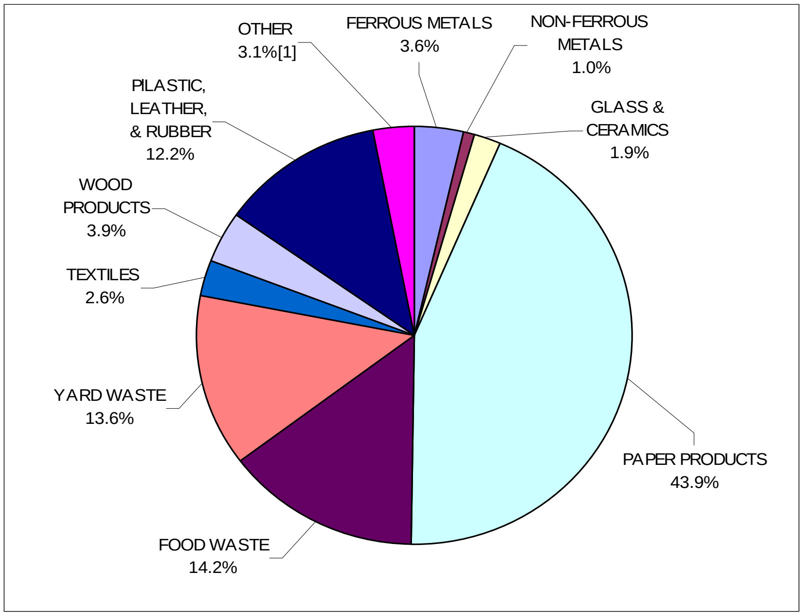
Not all of these differences in methodology may meaningfully prevent a comparison of the 1998 and 2006 Study results. At a minimum, though, it appears likely that the most "apples to apples" comparison of results is within the residential stream. Comparison of self haul and commercial results between the two studies may be somewhat limited.

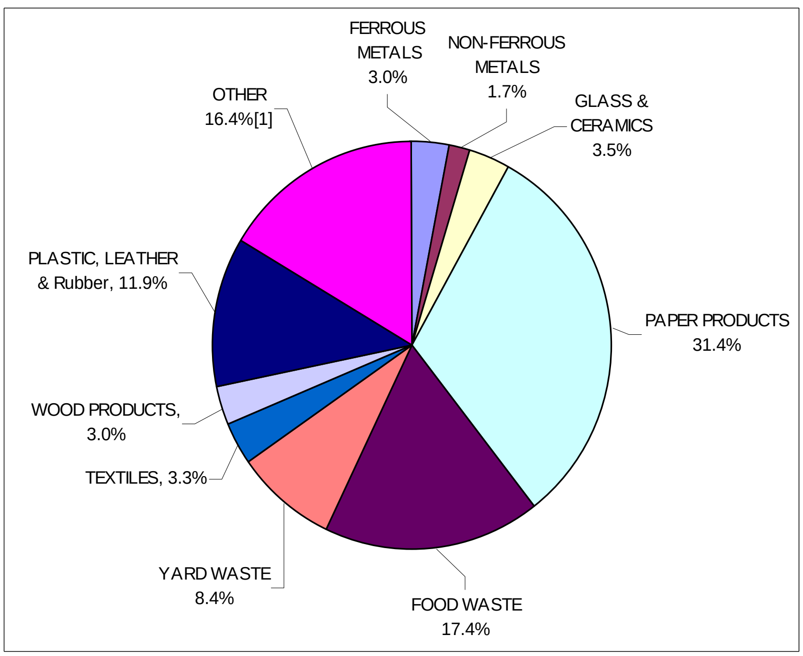
The remaining figures in this section provide a graphical comparison of the 1998 and 2006 Study results:

- Figure 4-4 compares the respective composition of 1998 and 2006 *residential* waste.
- Figure 4-5 compares the 1998 and 2006 *commercial* waste composition, and
- Figures 4-6 compares the *self-haul* waste composition in 1998 and 2006.

Readers will note differences in the waste stream by comparing the relative size of each pie piece in the graphs. Although it was beyond the scope of this study to investigate the reason for changes in the waste stream, we make some limited observations (see following pages). For those interested in more detail, a statistical comparison of the 1998 and 2006 results, containing both the mean composition as well as confidence intervals, is contained in Exhibit 7.

Figure 4-4 Comparison of 1998 (top) and 2006 (bottom) Residential Waste Composition

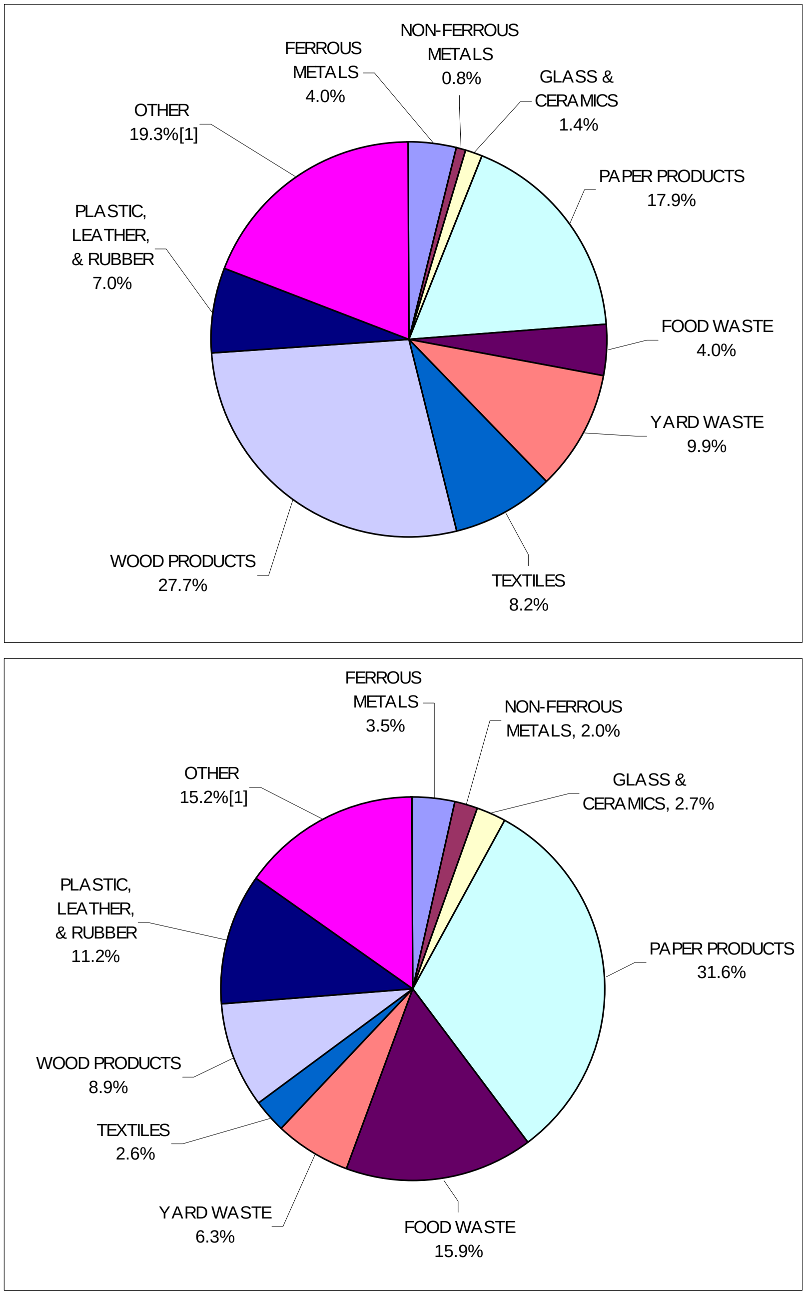




[1] OTHER waste includes C&D materials such as drywall, block/brick/stone, insulation, and asphalt roofing, and miscellaneous organics and inorganics not elsewhere classified including diapers/sanitary products, electronics, bulky items, carpet, tires, fines, and household hazardous waste (HHW).

These results suggest that there have been significant changes in the residential disposed waste stream. First, the fraction of paper has evidently decreased significantly. To some degree this is not surprising, as recovered paper markets were extremely poor through much of the 1990s, and have been much better in recent years. Differences in other categories are harder to explain.

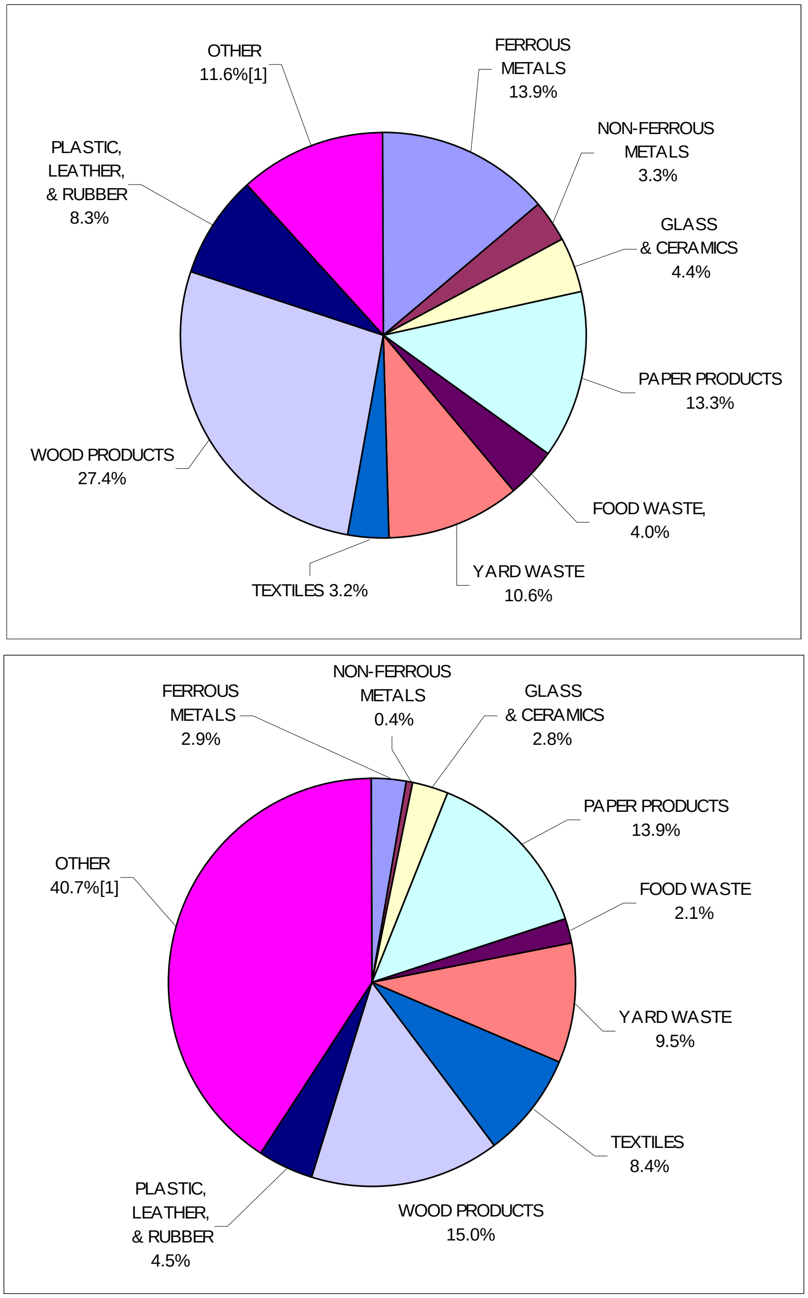
Figure 4-5 Comparison of 1998 (top) and 2006 (bottom) Commercial Waste Composition



[1] OTHER waste includes C&D materials such as drywall, block/brick/stone, insulation, and asphalt roofing, and miscellaneous organics and inorganics not elsewhere classified including diapers/sanitary products, electronics, bulky items, carpet, tires, fines, and household hazardous waste (HHW).

The comparison of the commercial composition results suggests that the definition of the commercial sector differed in the 1998 and 2006 Studies. The significantly greater incidence of wood in the 1998 Study suggests certain loads that would have been characterized as C&D in the 2006 Study may have been included as commercial in the 1998 Study.

Figure 4-6 Comparison of 1998 (top) and 2006 (bottom) Self Haul Waste Composition



[1] OTHER waste includes C&D materials such as drywall, block/brick/stone, insulation, and asphalt roofing, and miscellaneous organics and inorganics not elsewhere classified including diapers/sanitary products, electronics, bulky items, carpet, tires, fines, and household hazardous waste (HHW).

Once again, a comparison of the 1998 and 2006 Study results for self haul waste suggest that a different definition of the self haul generator sector may have been applied. However, it must also be noted that the very small sample size of self haul samples in the 1998 Study resulted in extremely wide confidence intervals, making comparison difficult (see Exhibit 7).

Exhibit 1: Summary of Physical Sample Loads

Summer Season Sort

Sample Number	Date	Sample Type	Time of Delivery	Hauler	Vehicle Type	Generator Type	Origin of Waste
1	9/11/06	Physical	8:00	GSI	Front Load	Commercial	Fort Collins
2	9/11/06	Physical	8:50	WM	Front Load	Commercial	Fort Collins
3	9/11/06	Physical	8:55	GSI	Rear Load	Commercial	Fort Collins
4	9/11/06	Physical	9:50	S&S	Rear Load	Commercial	Loveland
5	9/11/06	Physical	10:10	GSI	Rear Load	Commercial	Fort Collins
6	9/11/06	Physical	10:10	Dick's	Rear Load	Commercial	Fort Collins
7	9/11/06	Physical	10:30	Ram	Rear Load	Residential	Fort Collins
8	9/11/06	Physical	11:10	Dick's	Rear Load	Residential	Fort Collins
9	9/11/06	Physical	12:18	Loveland	Front Load	Residential	Loveland
10	9/11/06	Physical	13:00	GSI	Rear Load	Residential	Fort Collins
11	9/11/06	Physical	15:15	GSI	Front Load	Residential	Fort Collins
12	9/12/06	Physical	9:07	WM	Front Load	Commercial	South Fort Collins
13	9/12/06	Physical	9:07	GSI	Rear Load	Commercial	Loveland
14	9/12/06	Physical	9:35	GSI	Front Load	Commercial	Fort Collins
15	9/12/06	Physical	10:07	CSU	Front Load	Commercial	CSU
16	9/12/06	Physical	10:55	Ram	Rear Load	Residential	Fort Collins
17	9/12/06	Physical	11:00	GSI	Rear Load	Commercial	Wellington
18	9/12/06	Physical	11:30	GSI	Rear Load	Residential	Fort Collins
19	9/12/06	Physical	12:30	Loveland	Front Load	Residential	City of Loveland
20	9/12/06	Physical	12:40	Ram	Rear Load	Commercial	Fort Collins
21	9/12/06	Physical	13:15	Ram	Rear Load	Residential	Fort Collins CSU North
22	9/12/06	Physical	15:00	Loveland	Front Load	Residential	Loveland
23	9/13/06	Physical		Loveland	Rear Load	Residential	Loveland Apartment
24	9/13/06	Physical	8:50	GSI	Front Load	Commercial	Fort Collins
25	9/13/06	Physical	9:55	GSI	Rear Load	Residential	Fort Collins
26	9/13/06	Physical	10:40	S&S	Rear Load	Commercial	Loveland
27	9/13/06	Physical	10:40	GSI	Front Load	Commercial	Fort Collins
28	9/13/06	Physical	11:10	Ram	Rear Load	Commercial	Fort Collins
29	9/13/06	Physical	11:20	GSI	Front Load	Residential	Fort Collins
30	9/13/06	Physical	11:30	Mike's	RO	Commercial	Fort Collins
31	9/13/06	Physical	12:30	Shroder Ro	Trailer	Commercial	Fort Collins
32	9/13/06	Physical	12:40	GSI	Rear Load	Residential	Fort Collins
33	9/13/06	Physical	13:30	RAM	Rear Load	Residential	Fort Collins
34	9/13/06	Physical	13:50	GSI	Rear Load	Residential	Fort Collins
35	9/13/06	Physical	14:30		RO	Commercial	Fort Collins

Exhibit 1: Summary of Physical Sample Loads

Winter Season Sort

Sample Number	Date	Sample Type	Time of Delivery	Hauler	Vehicle Type	Generator Type	Origin of Waste
1	12/5/06	Physical	8:25	CSU	Front Load	Commercial	CSU
2	12/5/06	Physical	9:45	Gullage	Rear Load	Commercial	Fort Collins
3	12/5/06	Physical	11:00	GSI	Rear Load	Commercial	Fort Collins
4	12/5/06	Physical	11:30	WM	Front Load	Commercial	Fort Collins
5	12/5/06	Physical	12:00	GSI	SL	Residential	Fort Collins
6	12/5/06	Physical	13:00	Loveland	Front Load	Residential	Fort Collins South
7	12/5/06	Physical	13:15	RAM	Rear Load	Residential	Fort Collins
8	12/5/06	Physical	14:20	GSI	Rear Load	Residential	Fort Collins
9	12/6/06	Physical	9:20	GSI	Front Load	Commercial	Fort Collins
10	12/6/06	Physical	9:40	GSI	Rear Load	Commercial	
11	12/6/06	Physical	10:45	RAM	SL	Residential	Fort Collins
12	12/6/06	Physical	10:50	GSI	SL	Residential	Fort Collins
13	12/6/06	Physical	11:30	Dick's	Rear Load	Commercial	Fort Collins
14	12/6/06	Physical	11:30	Dick's	Rear Load	Residential	Fort Collins
15	12/6/06	Physical	15:30	RAM	Rear Load	Residential	Fort Collins
16	12/7/06	Physical	9:00	WM	Front Load	Commercial	Fort Collins
17	12/7/06	Physical	9:10	WM	Front Load	Commercial	Fort Collins
18	12/7/06	Physical	9:45	United	Front Load	Residential	BertLoud
19	12/7/06	Physical	10:00	RAM	Rear Load	Commercial	Fort Collins
20	12/7/06	Physical	10:15	GSI	Rear Load	Commercial	Fort Collins/Loveland
21	12/7/06	Physical	10:30	WM	Front Load	Commercial	Loveland
22	12/7/06	Physical	11:30	GSI	Rear Load	Commercial	Loveland-South
23	12/7/06	Physical	11:40	GSI	Front Load	Commercial	All Over
24	12/7/06	Physical	12:15	WM	Front Load	Commercial	Loveland
25	12/7/06	Physical	12:30	Loveland	Rear Load	Residential	Loveland
26	12/7/06	Physical	13:50	Loveland	Front Load	Residential	Loveland
27	12/7/06	Physical	14:30	Loveland	Front Load	Residential	Loveland
28	12/7/06	Physical	15:50	GSI	Rear Load	Residential	Fort Collins
29	12/7/06	Physical	15:15	Loveland	Front Load	Residential	Loveland
30	12/8/06	Physical	9:00	GSI	Front Load	Commercial	Fort Collins
31	12/8/06	Physical	9:20	GSI	Front Load	Commercial	South Fort Collins
32	12/8/06	Physical	10:00	WM	Front Load	Commercial	Loveland
33	12/8/06	Physical	10:20	Dick's	Rear Load	Residential	Outside Ft. Collins
34	12/8/06	Physical	10:35	Dick's	Front Load	Commercial	Fort Collins
35	12/8/06	Physical	11:40	S&S	Front Load	Commercial	BertLoud

Exhibit 2: Aggregate Results

			Weighted Data				2006
			Annual	Standard	Confidence Intrerval		Estimated
			Average	Deviation	Lower	Upper	Quantity
		Material Categories					**152,933**
PAPER	1	OCC/Kraft	7.8%	13.8%	6.3%	9.3%	11,888
	2	Newpaper	4.3%	14.3%	2.7%	5.9%	6,560
	3	Magazines/Glossy	1.5%	19.3%	0.0%	3.6%	2,296
	4	High Grade Paper	2.0%	7.1%	1.3%	2.8%	3,124
	5	Polycoated/Aseptic Containers	0.2%	1.1%	0.1%	0.3%	307
	6	Mixed (Other Recyclable)	4.3%	10.9%	3.1%	5.5%	6,600
	7	Other Paper (Non Recyclable)	5.4%	7.1%	4.6%	6.2%	8,223
		Subtotal	25.5%	29.9%	22.2%	28.8%	38,998
PLASTICS	8	#1 PET Bottles/Jars	0.6%	7.9%	0.0%	1.5%	933
	9	#2 HDPE Bottles/Jars	0.4%	37.2%	0.0%	4.6%	672
	10	#3 - 7 Bottles/Jars	0.4%	1.1%	0.3%	0.6%	673
	11	Expanded Polystyrene	0.6%	1.4%	0.4%	0.7%	888
	12	Films/Bags	3.5%	5.7%	2.9%	4.2%	5,409
	13	Other Ridged Plastic	2.7%	2.5%	2.5%	3.0%	4,189
		Subtotal	8.3%	9.4%	7.3%	9.4%	12,766
GLASS	14	Clear Glass	0.9%	13.6%	0.0%	2.4%	1,328
	15	Green Glass	0.2%	13.9%	0.0%	1.8%	374
	16	Brown Glass	0.9%	2.2%	0.6%	1.1%	1,352
	17	Other Glass/Broken Glass	1.2%	4.9%	0.7%	1.8%	1,878
		Subtotal	3.2%	9.4%	2.2%	4.3%	4,933
METALS	18	Ferrous Cans	0.9%	16.1%	0.0%	2.6%	1,314
	19	Other Ferrous Metals	1.6%	6.0%	0.9%	2.3%	2,450
	20	Aluminum Cans	0.4%	0.8%	0.3%	0.5%	594
	21	Other Aluminum	0.5%	7.4%	0.0%	1.3%	725
	22	Other Non-Ferrous	0.7%	2.7%	0.4%	1.0%	1,024
	23	Appliances	0.6%	4.3%	0.1%	1.1%	906
		Subtotal	4.6%	6.7%	3.8%	5.3%	7,013
ORGANICS	24	Food Waste	13.2%	22.6%	10.7%	15.7%	20,137
	25	Diapers/Sanitary Products	2.3%	13.7%	0.8%	3.9%	3,581
	26	Textiles	1.4%	7.3%	0.6%	2.2%	2,115
	26A	Rubber/Leather	1.0%	2.9%	0.7%	1.3%	1,562
	27	Yard Waste -Grass/Leaves	6.2%	8.0%	5.4%	7.1%	9,529
	28	Land Clearing	0.4%	4.6%	0.0%	0.9%	592
	29	Clean Wood	4.1%	10.9%	2.9%	5.3%	6,334
	30	Painted/Stained Wood	2.6%	7.0%	1.8%	3.4%	3,962
	31	Other Wood	3.0%	12.0%	1.7%	4.3%	4,616
	32	Fines	2.3%	15.2%	0.6%	4.0%	3,520
	33	Other Organics	1.9%	7.2%	1.1%	2.7%	2,920
		Subtotal	38.5%	31.9%	35.0%	42.0%	58,867
INORGANICS	34	Carpet	3.3%	8.1%	2.4%	4.2%	5,109
	35	Drywall	2.6%	14.0%	1.1%	4.2%	4,010
	36	Block/Brick/Stone	3.5%	11.9%	2.2%	4.8%	5,371
	37	Insulation	0.3%	3.8%	0.0%	0.7%	430
	38	Asphalt Roofing	3.1%	11.2%	1.9%	4.4%	4,810
	39	Other C&D Material	1.1%	8.5%	0.2%	2.1%	1,718
	40	Electronics	1.3%	9.1%	0.3%	2.3%	1,978
	41	Bulky Items	1.5%	0.9%	1.4%	1.6%	2,368
	42	Tires	0.2%	10.0%	0.0%	1.3%	283
	43	Other Inorganics	2.0%	9.1%	1.0%	3.0%	3,094
	44	Hazardous Material	0.8%	2.8%	0.5%	1.1%	1,186
		Subtotal	19.8%	18.2%	17.8%	21.9%	30,357
		GRAND TOTAL	100.0%				152,933

Exhibit 3: Residential Results

		Materials	Average Percent	Standard Deviation	90%Conf. Interval Lower	90%Conf. Interval Upper	Annual Tons
PAPER	1	OCC/Kraft	6.0%	5.7%	4.4%	7.6%	3,817
	2	Newpaper	6.5%	6.5%	4.7%	8.4%	4,164
	3	Magazines/Glossy	2.8%	2.8%	2.0%	3.6%	1,773
	4	High Grade Paper	1.6%	2.0%	1.0%	2.2%	1,007
	5	Polycoated/Aseptic Containers	0.2%	0.4%	0.1%	0.4%	148
	6	Mixed (Other Recyclable)	6.6%	3.9%	5.4%	7.7%	4,169
	7	Other Paper (Non Recyclable)	7.7%	2.4%	7.0%	8.4%	4,926
		Subtotal	31.4%	9.9%	28.6%	34.3%	20,004
PLASTIC	8	#1 PET Bottles/Jars	0.8%	0.4%	0.7%	1.0%	540
	9	#2 HDPE Bottles/Jars	0.7%	0.6%	0.5%	0.9%	424
	10	#3 - 7 Bottles/Jars	0.8%	0.9%	0.5%	1.0%	499
	11	Expanded Polystyrene	0.6%	0.4%	0.4%	0.7%	352
	12	Films/Bags	4.5%	1.6%	4.0%	5.0%	2,861
	13	Other Ridged Plastic	3.2%	1.6%	2.8%	3.7%	2,053
		Subtotal	10.6%	2.9%	9.7%	11.4%	6,729
GLASS	14	Clear Glass	1.4%	1.0%	1.2%	1.7%	921
	15	Green Glass	0.3%	0.4%	0.2%	0.5%	206
	16	Brown Glass	1.4%	1.7%	0.9%	1.8%	861
	17	Other Glass/Broken Glass	0.4%	0.5%	0.2%	0.5%	228
		Subtotal	3.5%	2.6%	2.7%	4.2%	2,217
METALS	18	Ferrous Cans	1.4%	0.8%	1.1%	1.6%	875
	19	Other Ferrous Metals	0.9%	1.4%	0.5%	1.3%	564
	20	Aluminum Cans	0.7%	0.5%	0.5%	0.8%	429
	21	Other Aluminum	0.5%	0.8%	0.3%	0.7%	311
	22	Other Non-Ferrous	0.5%	1.0%	0.2%	0.8%	327
	23	Appliances	0.7%	3.1%	0.0%	1.6%	438
		Subtotal	4.6%	3.2%	3.7%	5.5%	2,944
ORANICS	24	Food Waste	17.4%	9.1%	14.8%	20.1%	11,097
	25	Diapers/Sanitary Products	4.9%	4.0%	3.8%	6.1%	3,125
	26	Textiles/Rubber/Leather	2.4%	2.0%	1.8%	3.0%	1,521
	26A	Rubber/Leather	1.4%	1.8%	0.8%	1.9%	862
	27	Yard Waste -Grass/Leaves	8.0%	10.4%	5.0%	11.0%	5,085
	28	Yard Waste - Stumps/Logs	0.4%	1.3%	0.0%	0.8%	253
	29	Clean Wood	1.5%	4.6%	0.2%	2.9%	982
	30	Painted/Stained Wood	1.1%	3.4%	0.1%	2.1%	690
	31	Other Wood	0.4%	1.0%	0.1%	0.7%	246
	32	Fines	3.1%	1.5%	2.7%	3.6%	1,989
	33	Other Organics	2.7%	2.8%	1.9%	3.4%	1,687
		Subtotal	43.3%	11.4%	40.0%	46.5%	27,536
INORGANICS	34	Carpet	0.9%	2.2%	0.3%	1.5%	563
	35	Drywall	0.2%	0.8%	0.0%	0.4%	121
	36	Block/Brick/Stone	0.7%	2.0%	0.2%	1.3%	470
	37	Insulation	0.0%	0.1%	0.0%	0.0%	8
	38	Asphalt Roofing	0.0%	0.1%	0.0%	0.1%	22
	39	Other C&D Material	0.8%	1.6%	0.3%	1.2%	499
	40	Electronics	2.2%	5.4%	0.6%	3.7%	1,368
	41	Furniture	0.4%	2.3%	0.0%	1.0%	257
	42	Tires	0.0%	0.0%	0.0%	0.0%	0
	43	Other Inorganic	0.6%	1.5%	0.2%	1.1%	405
	44	Other Hazardous Material	0.8%	1.0%	0.5%	1.0%	481
		Subtotal	6.6%	7.1%	4.6%	8.6%	4,194
		TOTAL	100.0%				63,624

Exhibit 4: Commercial Results

Category	#	Materials	Average Percent	Standard Deviation	90%Conf. Interval Lower	90%Conf. Interval Upper	Annual Tons
PAPER	1	OCC/Kraft	13.6%	11.9%	10.4%	16.9%	7,533
	2	Newpaper	4.1%	10.7%	1.2%	7.0%	2,278
	3	Magazines/Glossy	0.9%	1.1%	0.6%	1.2%	493
	4	High Grade Paper	3.5%	10.9%	0.5%	6.4%	1,925
	5	Polycoated/Aseptic Containers	0.3%	0.6%	0.1%	0.4%	156
	6	Mixed (Other Recyclable)	3.6%	2.7%	2.9%	4.4%	1,993
	7	Other Paper (Non Recyclable)	5.5%	4.4%	4.3%	6.7%	3,049
		Subtotal	31.6%	18.0%	26.7%	36.4%	17,428
PLASTIC	8	#1 PET Bottles/Jars	0.7%	0.6%	0.5%	0.9%	384
	9	#2 HDPE Bottles/Jars	0.4%	0.5%	0.3%	0.6%	240
	10	#3 - 7 Bottles/Jars	0.3%	0.4%	0.2%	0.4%	166
	11	Expanded Polystyrene	0.9%	1.3%	0.5%	1.2%	474
	12	Films/Bags	4.5%	3.6%	3.5%	5.5%	2,482
	13	Other Ridged Plastic	3.2%	2.7%	2.5%	4.0%	1,774
		Subtotal	10.0%	6.3%	8.3%	11.7%	5,520
GLASS	14	Clear Glass	0.7%	0.8%	0.5%	0.9%	391
	15	Green Glass	0.3%	1.2%	0.0%	0.6%	164
	16	Brown Glass	0.8%	1.6%	0.4%	1.3%	464
	17	Other Glass/Broken Glass	0.9%	3.2%	0.0%	1.7%	473
		Subtotal	2.7%	4.1%	1.6%	3.8%	1,493
METALS	18	Ferrous Cans	0.8%	0.9%	0.5%	1.0%	424
	19	Other Ferrous Metals	1.9%	2.9%	1.1%	2.7%	1,043
	20	Aluminum Cans	0.3%	0.3%	0.2%	0.4%	157
	21	Other Aluminum	0.6%	1.3%	0.2%	0.9%	325
	22	Other Non-Ferrous	1.1%	3.2%	0.3%	2.0%	619
	23	Appliances	0.8%	3.8%	0.0%	1.8%	454
		Subtotal	5.5%	5.5%	4.0%	7.0%	3,022
ORANICS	24	Food Waste	15.9%	14.6%	12.0%	19.9%	8,801
	25	Diapers/Sanitary Products	0.7%	2.1%	0.2%	1.3%	405
	26	Textiles	1.0%	2.1%	0.4%	1.6%	541
	26A	Rubber/Leather	1.2%	2.1%	0.6%	1.8%	675
	27	Yard Waste -Grass/Leaves	6.3%	12.1%	3.1%	9.6%	3,490
	28	Yard Waste - Stumps/Logs	0.0%	0.0%	0.0%	0.0%	0
	29	Clean Wood	3.5%	8.7%	1.2%	5.9%	1,939
	30	Painted/Stained Wood	2.6%	6.4%	0.9%	4.3%	1,439
	31	Other Wood	2.8%	6.4%	1.1%	4.6%	1,556
	32	Fines	2.7%	3.6%	1.7%	3.7%	1,495
	33	Other Organics	1.6%	4.7%	0.3%	2.9%	873
		Subtotal	38.4%	18.3%	33.5%	43.4%	21,215
INORGANICS	34	Carpet	1.6%	5.8%	0.1%	3.2%	899
	35	Drywall	0.1%	0.6%	0.0%	0.3%	78
	36	Block/Brick/Stone	2.9%	8.2%	0.7%	5.1%	1,609
	37	Insulation	0.0%	0.0%	0.0%	0.0%	1
	38	Asphalt Roofing	1.5%	8.7%	0.0%	3.9%	833
	39	Other C&D Material	1.7%	4.3%	0.5%	2.8%	919
	40	Electronics	0.6%	1.8%	0.2%	1.1%	355
	41	Furniture	0.7%	4.5%	0.0%	2.0%	401
	42	Tires	0.5%	2.2%	0.0%	1.1%	268
	43	Other Inorganic	0.9%	4.1%	0.0%	2.0%	484
	44	Other Hazardous Material	1.2%	2.6%	0.5%	2.0%	686
		Subtotal	11.8%	14.8%	7.8%	15.8%	6,533
		Total	100.0%				55,211

Exhibit 5: Self-Haul Results

		Materials	Adjusted Average Percent	Adjusted Standard Deviation	Adjusted 90%Conf. Interval Lower	Upper	Annual Tons 2006
PAPER	1	OCC/Kraft	4.4%	16.2%	1.4%	7.5%	425
	2	Newspaper	1.2%	8.2%	0.0%	2.7%	111
	3	Magazines/Glossy	0.3%	0.7%	0.2%	0.4%	28
	4	High Grade Paper	1.9%	4.5%	0.0%	4.4%	186
	5	Polycoated/Aseptic Containers	0.0%	0.1%	0.0%	0.0%	2
	6	Mixed (Other Recyclable)	4.1%	14.8%	1.3%	6.9%	392
	7	Other Paper (Non Recyclable)	1.9%	9.6%	0.1%	3.7%	182
		Subtotal	13.8%	33.0%	7.6%	20.1%	1,326
PLASTIC	8	#1 PET Bottles/Jars	0.1%	0.2%	0.0%	0.2%	9
	9	#2 HDPE Bottles/Jars	0.1%	0.2%	0.0%	0.1%	7
	10	#3 - 7 Bottles/Jars	0.1%	0.2%	0.0%	0.1%	8
	11	Expanded Polystyrene	0.3%	1.4%	0.0%	0.6%	28
	12	Films/Bags	0.5%	2.9%	0.0%	1.1%	49
	13	Other Ridged Plastic	3.3%	11.0%	1.3%	5.4%	319
		Subtotal	4.4%	13.4%	1.8%	6.9%	419
GLASS	14	Clear Glass	0.2%	0.4%	0.1%	0.2%	15
	15	Green Glass	0.0%	0.1%	0.0%	0.0%	3
	16	Brown Glass	0.3%	2.4%	0.0%	0.7%	26
	17	Other Glass/Broken Glass	2.4%	12.2%	0.1%	4.7%	232
		Subtotal	2.9%	13.8%	0.3%	5.5%	276
METAL	18	Ferrous Cans	0.1%	0.3%	0.1%	0.2%	14
	19	Other Ferrous Metals	2.6%	8.8%	0.9%	4.2%	247
	20	Aluminum Cans	0.1%	0.6%	0.0%	0.2%	7
	21	Other Aluminum	0.2%	0.4%	0.0%	0.3%	17
	22	Other Non-Ferrous	0.2%	0.4%	0.0%	0.4%	16
	23	Appliances	0.1%	0.2%	0.0%	0.2%	8
		Subtotal	3.2%	10.6%	1.2%	5.2%	307
ORANICS	24	Food Waste	2.2%	19.3%	0.0%	5.9%	212
	25	Diapers/Sanitary Products	0.5%	1.2%	0.3%	0.7%	49
	26	Textiles	0.5%	2.2%	0.1%	0.9%	45
	26A	Rubber/Leather	0.2%	0.5%	0.0%	0.5%	21
	27	Yard Waste -Grass/Leaves	9.5%	25.5%	4.7%	14.3%	910
	28	Land Clearing	0.2%	0.4%	0.0%	0.4%	17
	29	Clean Wood	7.7%	22.6%	3.5%	12.0%	741
	30	Painted/Stained Wood	3.7%	11.4%	1.6%	5.9%	355
	31	Other Wood	2.9%	7.9%	1.4%	4.4%	277
	32	Fines	0.3%	0.8%	0.2%	0.5%	32
	33	Other Organics	1.9%	13.6%	0.0%	4.5%	183
		Subtotal	29.7%	39.8%	22.2%	37.2%	2,843
INORGANICS	34	Carpet	8.0%	24.8%	3.3%	12.6%	762
	35	Drywall	1.0%	9.1%	0.0%	2.8%	100
	36	Block/Brick/Stone	5.8%	21.9%	1.7%	9.9%	556
	37	Insulation	0.1%	0.3%	0.0%	0.4%	13
	38	Asphalt Roofing	3.6%	14.5%	0.8%	6.3%	342
	39	Other C&D Material	0.1%	0.2%	0.0%	0.1%	8
	40	Electronics	2.4%	12.9%	0.0%	4.8%	225
	41	Bulky Items	15.8%	33.8%	9.4%	22.2%	1,514
	42	Tires	0.1%	0.2%	0.0%	0.3%	10
	43	Other Inorganic	9.1%	23.6%	4.6%	13.5%	871
	44	Other Hazardous Material	0.1%	0.2%	0.0%	0.2%	8
		Subtotal	46.0%	43.5%	37.8%	54.2%	4,411
		TOTAL	100.0%				9,582

Exhibit 6: C&D Results

Category	#	Materials	Adjusted Average Percent	Adjusted Standard Deviation	Adjusted 90%Conf. Interval Lower	Upper	Annual Tons
PAPER	1	OCC/Kraft	0.5%	1.4%	0.2%	0.7%	113
	2	Newspaper	0.0%	0.0%	0.0%	0.0%	7
	3	Magazines/Glossy	0.0%	0.0%	0.0%	0.0%	1
	4	High Grade Paper	0.0%	0.0%	0.0%	0.0%	6
	5	Polycoated/Aseptic Containers	0.0%	0.0%	0.0%	0.0%	0
	6	Mixed (Other Recyclable)	0.2%	0.0%	0.0%	0.4%	46
	7	Other Paper (Non Recyclable)	0.3%	1.1%	0.1%	0.5%	65
		Subtotal	1.0%	3.1%	0.4%	1.6%	239
PLASTIC	8	#1 PET Bottles/Jars	0.0%	0.0%	0.0%	0.0%	1
	9	#2 HDPE Bottles/Jars	0.0%	0.0%	0.0%	0.0%	2
	10	#3 - 7 Bottles/Jars	0.0%	0.0%	0.0%	0.0%	1
	11	Expanded Polystyrene	0.1%	1.2%	0.0%	0.4%	35
	12	Films/Bags	0.1%	0.4%	0.0%	0.2%	17
	13	Other Ridged Plastic	0.2%	0.7%	0.0%	0.3%	43
		Subtotal	0.4%	1.6%	0.1%	0.7%	98
GLASS	14	Clear Glass	0.0%	0.0%	0.0%	0.0%	1
	15	Green Glass	0.0%	0.0%	0.0%	0.0%	0
	16	Brown Glass	0.0%	0.0%	0.0%	0.0%	1
	17	Other Glass/Broken Glass	3.9%	15.8%	0.9%	6.8%	944
		Subtotal	3.9%	15.8%	0.9%	6.8%	947
METAL	18	Ferrous Cans	0.0%	0.0%	0.0%	0.0%	2
	19	Other Ferrous Metals	2.4%	6.4%	1.2%	3.6%	596
	20	Aluminum Cans	0.0%	0.0%	0.0%	0.0%	0
	21	Other Aluminum	0.3%	1.7%	0.0%	0.6%	72
	22	Other Non-Ferrous	0.3%	1.5%	0.0%	0.5%	63
	23	Appliances	0.0%	0.2%	0.0%	0.1%	6
		Subtotal	3.0%	7.5%	1.6%	4.4%	740
ORANICS	24	Food Waste	0.1%	0.0%	0.0%	0.2%	27
	25	Diapers/Sanitary Products	0.0%	0.0%	0.0%	0.0%	1
	26	Textiles	0.0%	0.0%	0.0%	0.1%	8
	26A	Rubber/Leather	0.0%	0.1%	0.0%	0.0%	3
	27	Yard Waste -Grass/Leaves	0.2%	0.0%	0.1%	0.3%	44
	28	Land Clearing	1.3%	11.5%	0.0%	3.5%	322
	29	Clean Wood	10.9%	21.0%	6.9%	14.9%	2,671
	30	Painted/Stained Wood	6.0%	17.1%	2.8%	9.2%	1,478
	31	Other Wood	10.3%	25.5%	5.5%	15.2%	2,537
	32	Fines	0.0%	0.0%	0.0%	0.0%	5
	33	Other Organics	0.7%	4.8%	0.0%	1.6%	177
		Subtotal	29.7%	33.9%	23.3%	36.1%	7,273
INORGANICS	34	Carpet	11.8%	25.7%	6.9%	16.6%	2,886
	35	Drywall	15.1%	32.7%	9.0%	21.3%	3,710
	36	Block/Brick/Stone	11.2%	26.7%	6.1%	16.2%	2,737
	37	Insulation	1.7%	11.4%	0.0%	3.8%	407
	38	Asphalt Roofing	14.7%	31.7%	8.8%	20.7%	3,613
	39	Other C&D Material	1.2%	10.4%	0.0%	3.2%	292
	40	Electronics	0.1%	0.7%	0.0%	0.2%	29
	41	Bulky Items	0.8%	4.6%	0.0%	1.7%	195
	42	Tires	0.0%	0.0%	0.0%	0.1%	6
	43	Other Inorganic	5.4%	19.3%	1.8%	9.1%	1,334
	44	Other Hazardous Material	0.0%	0.0%	0.0%	0.1%	11
		Subtotal	62.1%	37.8%	55.0%	69.2%	15,219
		TOTAL	100.0%				24,516

Exhibit 7: Comparison of 1998 and 2006 Study Results

Residential Waste

Material Group	1998 Study			2006 Study			Difference
	Lower	Mean	Upper	Lower	Mean	Upper	
FERROUS METALS	2.2%	3.6%	5.0%	2.0%	3.0%	3.9%	0.6%
NON-FERROUS METALS	0.8%	1.0%	1.2%	1.3%	1.7%	2.1%	-0.7%
GLASS & CERAMICS	1.4%	1.9%	2.4%	2.7%	3.5%	4.2%	-1.6%
PAPER PRODUCTS	40.8%	43.9%	47.1%	28.6%	31.4%	34.3%	12.5%
FOOD WASTE	11.9%	14.2%	16.5%	14.8%	17.4%	20.1%	-3.2%
YARD WASTE	9.0%	13.6%	18.1%	5.3%	8.4%	11.5%	5.2%
TEXTILES	1.8%	2.6%	3.3%	2.4%	3.3%	4.2%	-0.7%
WOOD PRODUCTS	2.3%	3.9%	5.5%	1.4%	3.0%	4.6%	0.9%
PLASTIC, LEATHER, 7 RUBBER	10.7%	12.2%	13.7%	11.0%	11.9%	12.9%	0.3%
OTHER	2.1%	3.1%	4.2%	13.8%	16.4%	19.0%	-13.3%
TOTAL		**100%**			**100%**		

Commercial Waste

Material Group	1998 Study			2006 Study			Difference
	Lower	Mean	Upper	Lower	Mean	Upper	
FERROUS METALS	2.4%	4.0%	5.5%	2.2%	3.5%	4.8%	0.5%
NON-FERROUS METALS	0.5%	0.8%	1.1%	1.1%	2.0%	2.9%	-1.2%
GLASS & CERAMICS	0.7%	1.4%	2.1%	1.6%	2.7%	3.8%	-1.3%
PAPER PRODUCTS	11.1%	17.9%	24.6%	26.7%	31.6%	36.4%	-13.7%
FOOD WASTE	1.8%	4.0%	6.1%	12.0%	15.9%	19.9%	-12.0%
YARD WASTE	1.8%	9.9%	18.0%	3.1%	6.3%	9.6%	3.6%
TEXTILES	3.9%	8.2%	12.6%	0.9%	2.6%	4.3%	5.6%
WOOD PRODUCTS	17.8%	27.7%	37.6%	5.3%	8.9%	12.6%	18.8%
PLASTIC, LEATHER, & RUBBER	4.6%	7.0%	9.3%	9.4%	11.2%	13.0%	-4.3%
OTHER	9.8%	19.3%	28.7%	11.3%	15.2%	19.1%	4.0%
TOTAL		**100%**			**100%**		

Self-Haul Waste

Material Group	1998 Study			2006 Study			Difference
	Lower	Mean	Upper	Lower	Mean	Upper	
FERROUS METALS	4.3%	13.9%	23.5%	1.0%	2.9%	4.7%	11.1%
NON-FERROUS METALS	1.3%	3.3%	5.4%	0.0%	0.4%	0.9%	2.9%
GLASS & CERAMICS	2.2%	4.4%	6.6%	0.3%	2.8%	5.3%	1.6%
PAPER PRODUCTS	6.5%	13.3%	20.0%	7.6%	13.9%	20.1%	-0.6%
FOOD WASTE	0.7%	4.0%	7.3%	0.0%	2.1%	5.4%	1.9%
YARD WASTE	0.0%	10.6%	23.4%	4.7%	9.5%	14.2%	1.2%
TEXTILES	1.2%	3.2%	5.2%	3.6%	8.4%	13.1%	-5.1%
WOOD PRODUCTS	15.4%	27.4%	39.4%	9.7%	15.0%	20.2%	12.4%
PLASTIC, LEATHER, & RUBBER	6.0%	8.3%	10.5%	2.0%	4.5%	7.1%	3.8%
OTHER	2.8%	11.6%	20.4%	32.3%	40.7%	49.1%	-29.1%
TOTAL		**100%**			**100%**		

C&D Debris (not performed in 1998 Study)

Material Group	2006 Study		
	Lower	Mean	Upper
FERROUS METALS	1.2%	3.5%	1.2%
NON-FERROUS METALS	0.5%	2.0%	0.1%
GLASS & CERAMICS	3.3%	2.7%	0.6%
PAPER PRODUCTS	0.4%	31.6%	0.5%
FOOD WASTE	0.1%	15.9%	0.0%
YARD WASTE	3.1%	6.3%	0.0%
TEXTILES	0.0%	2.6%	0.0%
WOOD PRODUCTS	5.1%	8.9%	22.2%
PLASTIC, LEATHER, & RUBBER	0.4%	11.2%	0.0%
OTHER	7.0%	15.2%	55.8%
TOTAL		**100%**	

Appendix Appendix A: Material Definitions

Material Categories			Description	Recyclable [1]
Paper	**1**	Corrugated Cardboard	Paperboard containers consisting of Kraft (brown) linerboard with corrugated (fluted medium) fillings. Includes yellow and waxed corrugated boxes and Kraft paper such as bags or wrapping paper. Does not include non-corrugated paperboard products such as cereal, shoe, or gift boxes.	Yes
	2	Newspaper	Consists of all paper products printed on daily or weekly newspapers, advertising, catalogs, and other similar items. Publications can be one color (e.g., black and white) or multicolor.	Yes
	3	Magazines/Catalogs	Publications which are printed on glossy paper. This does not include magazines, catalogs, etc., which do not consist of glossy paper throughout (e.g., comic books.)	
	4	Office/Computer Paper	High grade ledger paper, such as typing and copy paper. Computer paper includes outputs from printers that may have green bars.	Yes
	5	Polycoated / Aseptic Containers	Aseptic juice boxes and gable top cartons.	
	6	Mixed (Other Recyclable)	All other recyclable paper not covered such as non-corrugated paperboard boxes, direct mail, and books.	Yes
	7	Other Paper (Non-Recyclable)	All products not covered by the above categories, including soiled and unsoiled tissues, paper towels, napkins, file folders, carbonless paper forms, and tissue (tracing) paper.	
Plastics	**8**	#1 PET Bottles	Clear or colored blow molded plastic bottles (i.e., with a narrow neck) labeled #1 PET.	Yes
	9	#2 HDPE Bottles	Natural or pigmented blow molded plastic bottles (i.e., with a narrow neck) labeled #2 HDPE.	Yes
	10	#3 - 7 Bottles	Blow molded bottles labeled #3, #4, #5 or #7.	
	11	Expanded Polystyrene	Expanded foam packaging, trays or containers labeled #6 PS. Includes foam polystyrene cups and food service containers (i.e., "clamshells") as well as clean service containers and packing "peanuts".	
	12	Films/Bags	Linear, translucent to opaque films/bags, such as grocery bags, dry film, trash and garbage bags.	
	13	Other Ridge Plastic	Rigid plastic not elsewhere classified. Includes plastic tubs, cups, trays, straws, and cutlery. Unmarked plastics such as materials made of multi-composite materials that may contain more than one type of plastic and/or metal, and all other plastics not otherwise described including items such as toys.	

Appendix Appendix A: Material Definitions

Material Categories			Description	Recyclable [1]
Glass	14	Clear Glass	Clear glass food and beverage containers.	Yes
Glass	15	Green Glass	Green Glass food and beverage containers.	Yes
Glass	16	Brown Glass	Brown glass food and beverage containers.	Yes
Glass	17	Other Glass	Includes a variety of miscellaneous glass products such as mirrors, leaded crystal, eyeglasses, and blown glass such as light bulbs, auto glass, windows, TV tubes heat resistant cookware (Pyrex), pottery, and drinking glasses.	
Metals	18	Steel Cans	Fabricated, magnetizable metal containers such as steel or bimetal designed to hold food or beverage products such as soups, vegetables, pet food and juices. Includes two piece containers with aluminum tops.	Yes
Metals	19	Other Ferrous Metals	Ferrous and alloyed ferrous scrap materials originated from residential commercial, or institutional sources which are attracted to a magnet. This category includes wire coat hangers, aerosol cans, and auto parts.	
Metals	20	Aluminum Cans	Aluminum containers used for holding beverages	Yes
Metals	21	Other Aluminum	This category includes all other aluminum products such as lawn chairs, tables, carts, house siding, rain gutters, window frames, cookware, flatware, aluminum foil, other miscellaneous utensils, and die cast aluminum auto or machine parts.	
Metals	22	Other Non-Ferrous	Non-magnetic metals such as brass, bronze, silver, lead copper, and zinc. Stainless steel house wares are also part of this category.	
Metals	23	Appliances	Stoves, refrigerators, dishwashers and all other large and small household appliances including fragments.	
Organics	24	Food Waste	Putrescible organic materials which are the by-products of activities connected with the growing, preparation, cooking, processing, or consumption of food by human beings or domesticated animals.	
Organics	25	Diapers/Sanitary Products	Diapers and sanitary products.	
Organics	26	Textiles	Fabric materials including natural and synthetic fibers such as cotton, wool, silk, nylon, rayon, or polyester; and Products included within this category would be woven clothing, curtains, stuffed toys, pillows, rags, and upholstery.	
Organics	26A	Rubber/Leather	Materials consisting of natural or synthetic rubber and leather. Products included within this category would be belts, handbags, wallets, and mixed items such as footwear.	
Organics	27	Yard Waste	Grass clippings, leaves, brush and prunings.	
Organics	28	Land Clearing	Logs, stumps, trunks, and limbs	
Organics	29	Clean Wood	Unpainted or unfinished (saw cut) lengths of wood from building structures, furniture or vehicles (e.g., cars, boats), pallets and creates.	

Appendix Appendix A: Material Definitions

Material Categories			Description	Recyclable [1]
Organics	30	Painted/Stained /Treated/MfgWood	Painted or stained lengths of wood from construction or woodworking activities, particle board, OSB, plywood, and treated wood	
	31	Other Wood	Other wood products not elsewhere classified. Includes house wares (spoons, bowls), decorative objects, small furnishings, sawdust, and small animal bedding.	
	32	Fines	Any materials passing through the 1/2 inch screen on the sorting table that cannot be categorized.	
	33	Other Organics	All other organic material not otherwise described, including substances such as feces, lint, vacuum bags, and animal litter.	
Inorganic	34	Carpet	Man made fibrous carpets, rugs or padding from residential or commercial buildings, including carpet backing.	
	35	Drywall	Also called sheetrock or gypsum wallboard.	
	36	Block/Brick/Stone	Concrete, brick, stones, cut stone, cement, and rocks	
	37	Insulation	Fiberglass and other inorganic insulation	
	38	Asphalt Roofing	Asphalt shingles or tar paper.	
	39	Other C&D Material	Ceiling tiles, dirt, dust or ash generated from construction and demolition activities. PVC pipe, 5-gallon HDPE buckets, HVAC ducting, and other related C&D material.	
	40	Electronics	Any item that contains a circuit board including, televisions, radio, stereo, computer, and CRT.	
	41	Bulky Items	Chairs, couches, mattresses, desks, and other oversized items made of multiple materials.	
	42	Tires	Solid or pneumatic rubber or steel belted tires.	
	43	Other Inorganic	Other inorganic items not elsewhere classified.	
	44	Hazardous Material	This category includes paints/solvents, flammable liquids, pesticides, corrosives, medical wastes and any other hazardous material not otherwise described.	

[1] These are the materials targeted for recycling in Larimer County's public education information.

Appendix A: Mapping of Material Categories Between 1998 and 2006 Studies

1998 Material Categories			2006 Separated Material Categories
Ferrous Metals	Soup Cans, Scrap Steel, and Auto Parts	18	Steel Cans
		19	Other Ferrous Metals
		23	Appliances
Non-Ferrous Metals	Aluminum Cans/Foil, Electrical Wire, Scrap Metal	20	Aluminum Cans
		21	Other Aluminum
		22	Other Non-Ferrous
Glass & Ceramics	Bottles, Dishes, Etc.	14	Clear Glass
		15	Green Glass
		16	Brown Glass
		17	Other Glass
Paper Products	Junk Mail, Newspaper, Magazines, Cereal Boxes and Cardboard	1	Corrugated Cardboard
		2	Newspaper
		3	Magazines/Catalogs
		4	Office/Computer Paper
		5	Polycoated / Aseptic Containers
		6	Mixed (Other Recyclable)
		7	Other Paper (Non-Recyclable)
Food Waste	Food Waste	24	Food Waste
Yard Waste	Yard Waste	27	Yard Waste
		28	Land Clearing
Textiles	Textiles	26	Textiles
Wood Products	Lumber, Funiture, Etc.	29	Clean Wood
		30	Painted/Stained /Treated/MfgWood
		31	Other Wood
Plastic, Leather & Rubber	Plastic Bags, Plastic Containers, Toys, and Shoes	8	#1 PET Bottles
		9	#2 HDPE Bottles
		10	#3 - 7 Bottles
		11	Expanded Polystyrene
		12	Films/Bags
		13	Other Ridge Plastic
		26A	Rubber/Leather
Other Waste	Rock, Brick, Concrete, Dirts, Drywall, Asphalt Shingles, Flashlight Batteries, Etc.	35	Drywall
		36	Block/Brick/Stone
		37	Insulation
		38	Asphalt Roofing
		39	Other C&D Material
		40	Electronics
		41	Bulky Items
		25	Diapers/Sanitary Products
		34	Carpet
		42	Tires
		43	Other Inorganic
		32	Fines
		33	Other Organics
		44	Hazardous Material

6.3 Appendix C – WARM GHG Emissions Analysis

CLEMENTS
ENVIRONMENTAL

Subject: **Fort Collins, CO - Greenhouse Gas Emissions Analysis and Equivalence Table – WARM Model**

Joe,

Please find attached the Annual Tonnage table and the WARM Model Greenhouse Gas (GHG) Emission Analysis for the Fort Collins job, which includes a GHG Equivalence table that translates GHG savings into more commonplace terms, such as passenger cars removed from the Roadway each year. (As you will see I had to merge some of the materials into broader categories in order to appropriately use the WARM model)

The negative value (i.e., a value in parentheses) indicates an emission reduction. So if you look at the attached WARM GHG analysis, the Baseline waste management scenario is simply landfilling all the material received. The Alternative waste management scenario is recovering approximately 60% of the material that would have gone to the landfill by means of recycling, composting, or combustion (which we are using as the AD/CT category, the WARM model does not include an Anaerobic Digestion or any other type of CT). As you will see, the Baseline scenario calculated to negative 12,060 metric tons of carbon dioxide equivalent (MTCO2E). The Alternative scenario however is negative 100,091 MTCO2E. So therefore, the total change in GHG emissions is **negative 88,031 MTCO2E** per year (the Alternative scenario minus the Baseline).

The total GHG emission reductions associated with using the Alternative scenario is equivalent to the following:

- Removing annual emissions from **16,124** passenger vehicles
- Conserving **9,992,222** gallons of gasoline
- Conserving **36,679,783** cylinders of propane used for home barbeques
- Conserving **460** railway cars of coal

Best Regards,

Carrie Ferrier

Carrie Ferrier
Clements Environmental

(818) 267-5100 ph (818) 782-6712 fax
15230 Burbank Boulevard Suite 103 Sherman Oaks, California 91411

Ft Collins Annual Tonnages

Material	Tons Received	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted
Glass	2,786.0	1393.0	1393.0	-	-
Mixed Paper (general)	21,659.1	8663.7	4331.8	8663.6	-
Mixed Plastics	4,698.0	3288.0	1410.0	-	-
Mixed Recyclables	20,542.8	7119.6	4746.0	-	-
Mixed Organics	41,612.4	-	10,781.8	18,841.5	11,989.1
Mixed MSW	8,184.9	-	8,184.9	-	-
Concrete	11,824.8	5912.4	5912.4	-	-
Asphalt Shingles	6,826.2	1,707.0	5,119.2	-	-

Notes: **Landfilling** –approximately 7 miles (LFG flare); **Recycling** - approximately 7 miles; **Composting** – approximately 7miles ; **Combustion –** approximately 7 miles (AD/CT category)

GHG Emissions Analysis -- Summary Report

Version 11

GHG Emissions Waste Management Analysis for Fort Collins, CO

Prepared by: Clements Environmental

Project Period for this Analysis: 01/01/12 to 01/01/13

Note: If you wish to save these results, rename this file (e.g., WARM-MN1) and save it. Then the "Analysis Inputs" sheet of the "WARM" file will be blank when you are ready to make another model run.

GHG Emissions from Baseline Waste Management ($MTCO_2E$): (12,060)

Commodity	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Total $MTCO_2E$
Glass	-	2,786.0	-	NA	103
Mixed Paper (general)	-	21,659.1	-	NA	(10,576)
Mixed Metals	-	4,698.0	-	NA	174
Mixed Plastics	-	11,865.6	-	NA	439
Mixed Recyclables	-	20,542.8	-	NA	(9,722)
Mixed Organics	NA	41,612.4	-	-	4,316
Mixed MSW	NA	8,184.9	-	NA	2,517
Concrete	-	11,824.8	NA	NA	437
Asphalt Shingles	-	6,826.2	-	NA	252
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GHG Emissions from Alternative Waste Management Scenario ($MTCO_2E$): (100,091)

Commodity	Tons Source Reduced	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Total $MTCO_2E$	Change (Alt - Base) $MTCO_2E$
Glass	0.0	1393.0	1393.0	0.0	NA	(339)	(443)
Mixed Paper (general)	NA	8663.7	4331.8	8663.6	NA	(36,968)	(26,392)
Mixed Metals	NA	3288.0	1410.0	0.0	NA	(17,725)	(17,899)
Mixed Plastics	NA	7119.6	4746.0	0.0	NA	(10,492)	(10,930)
Mixed Recyclables	NA	9785.0	10757.8	0.0	NA	(33,217)	(23,495)
Mixed Organics	NA	NA	10781.8	18841.5	11989.1	(4,057)	(8,373)
Mixed MSW	NA	NA	8184.9	0.0	NA	2,517	0
Concrete	NA	5912.4	5912.4	NA	NA	161	(276)
Asphalt Shingles	0.0	1707.0	5119.2	0.0	NA	30	(223)
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Total Change in GHG Emissions ($MTCO_2E$): (88,031)

Note: a negative value (i.e., a value in parentheses) indicates an emission reduction; a positive value indicates an emission increase.

This is equivalent to…

Removing annual emissions from	**16,124**	Passenger Vehicles
Conserving	**9,992,222**	Gallons of Gasoline
Conserving	**36,679,783**	Cylinders of Propane Used for Home Barbeques
Conserving	**460**	Railway Cars of Coal
	0.00466%	Annual CO_2 emissions from the U.S. transportation sector
	0.00367%	Annual CO_2 emissions from the U.S. electricity sector

a) For explanation of methodology, see the EPA report:
Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks (EPA530-R-06-004)
-- available on the Internet at http://epa.gov/climatechange/wycd/waste/downloads/fullreport.pdf (5.6 Mb PDF file).

b) Emissions estimates provided by this model are intended to support voluntary GHG measurement and reporting initiatives.

c) The GHG emissions results estimated in WARM indicate the full life-cycle benefits waste management alternatives. Due to the timing of the GHG emissions from the waste management pathways, (e.g., avoided landfilling and increased recycling), the actual GHG implications may accrue over the long-term. Therefore, one should not interpret the GHG emissions implications as occurring all in one year, but rather through time.