King County
Department of Natural Resources & Parks
Solid Waste Division

Waste Monitoring Program

2006 Material Recovery Facility (MRF) Assessment

November 2006

PREPARED BY:
Cascadia Consulting Group, Inc.

In cooperation with WIH Resource Group

Acknowledgments

This study would not have been possible without the cooperation and assistance of the management and operators of the four Material Recovery Facilities (MRFs) who generously agreed to participate. Studies of this kind are an imposition on their time and their cooperation is greatly appreciated. Special thanks are given to the following MRFs which hosted and assisted sampling activities in addition to providing tonnage data and market information.

- Allied Waste, Rabanco Recycling Center (Third & Lander) in Seattle,
- Waste Management, Cascade Recycling Center in Woodinville,
- Smurfit-Stone, Renton Reclamation Plant, in Renton, and
- Waste Connection, Recycling Center in Tacoma.

Market information and quantity and composition data resulting from the collection and sorting of material samples at each of the MRFs was obtained under confidentiality agreements and is not presented within this report. Instead, the data from individual facilities was aggregated.

Thanks to the numerous material brokers, end-users, and industry experts for their time, insight, and information on recycled commodity markets and specifications.

And finally, thank you King County and City of Seattle staff for assistance in identifying a separate sorting location.

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Executive Summary

The King County Solid Waste Division commissioned Cascadia Consulting Group to conduct this assessment of Puget Sound Material Recovery Facilities (MRFs). The objective was to investigate, document, and provide recommendations to address real or perceived issues related to:

1. incoming material,
2. quantity and types of MRF residuals disposed, and
3. product contamination.

This assessment is intended to help the County and cities decipher the cause and nature of the issues and, if necessary, develop policies to address them. This 2006 study will support King County and the cities' waste reduction and recycling efforts and will be used to help guide the 2001 Comprehensive Solid Waste Management Plan Update.

By obtaining and hand-sorting 100 samples, the assessment examined the composition of incoming commingled recyclables, residuals disposed, and four products (newspaper, mixed paper, PETE, and glass). Samples of material were obtained from Allied Waste's Rabanco Recycling Center (Third & Lander) in Seattle, Waste Management's Cascade Recycling Center in Woodinville, Smurfit-Stone's Renton Reclamation Plant, and Waste Connection's Recycling Center in Tacoma. The research also included interviews of MRF operators, material brokers, and end users to document market-driven specifications for recycled products, identify processing constraints, and develop MRF performance standards and metrics.

The following sections of the Executive Summary present summary level findings, conclusions, and recommendations drawn from the research conducted. Additional detail can be referenced in the accompanying report and appendices.

Material Flow and Associated Issues

After conducting an extensive waste composition study along with interviews of various material brokers and MRF operators, Cascadia mapped the flow of the incoming, residual, and product streams and noted the tonnages associated with each stream. As illustrated in Figure 1 below, 410,100 tons of incoming materials enter Puget Sound MRFs where it is separated and processed according to commodity type. This incoming stream of recyclables contains 29,800 tons of contaminants, such as food and non-recyclable plastics, and marginally recyclable materials. Marginally recyclable materials are items that are acceptable in the incoming stream of at least one, but not all, Puget Sound MRFs.

After processing, MRFs dispose of 29,600 tons of residual material. Of the residual disposed, 7,000 tons are recyclable material and 17,000 tons consist of contaminants. The product streams analyzed (newspaper, mixed paper, glass, PETE) contained nonconforming recyclables (i.e., PETE bottles in bales of newspaper product) as well as quantities of contaminants.

While recommendations to the aforementioned problems will be discussed later in the report, the primary issues affecting the flow of materials in and out of Puget Sound MRFs include:

- The adverse impact of glass shards and fines in incoming, process, and product streams,
- Contamination in incoming streams,
- The loss of recyclables in the residual streams landfilled by the four Puget Sound MRFs,
- Prohibitives in product streams, and
- The loss of recyclables in product streams produced by the four Puget Sound MRFs.

Figure 1. Summary of Material Streams, Issues, and Recommendations

INCOMING STREAM

Issues:

- Contamination

Recommendations for improving the incoming stream:

- Initiate education programs to eliminate contamination
- Promote uniform countywide list and definitions of recyclables

PROCESSING

Issues:

- Glass
- Contamination removal
- Loss of recyclables

Recommendations for improving the residual stream:

- Separate glass
- Adopt MRF performance standards:
  - Loss of recyclables: RR/IR< 2%
  - Removal of contamination: RC/IC > 75%

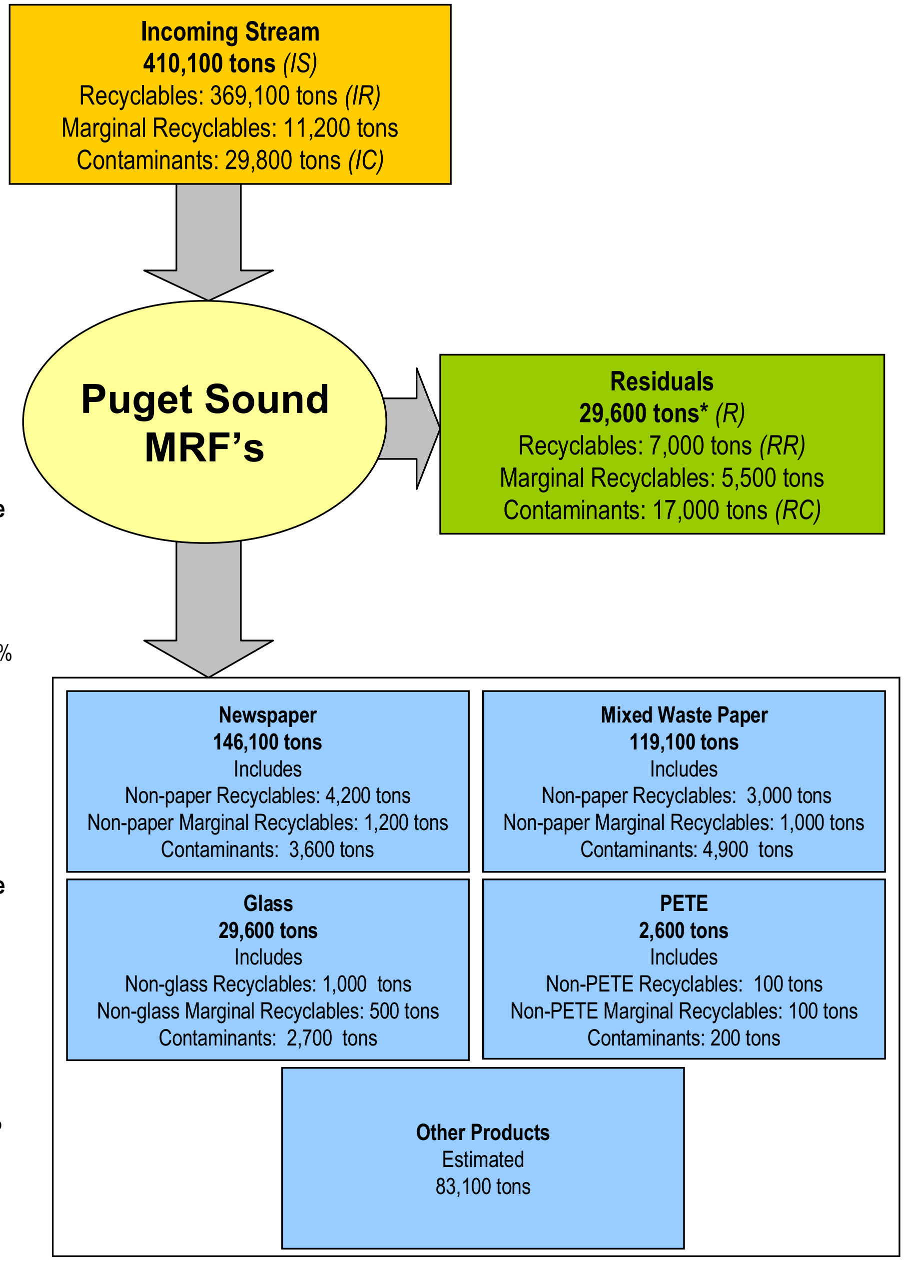
PRODUCT STREAM

Issues:

- Glass
- Prohibitives
- Loss of recyclables

Recommendations for improving the product stream:

- Separate glass
- Initiate education programs to eliminate contamination
- Promote uniform countywide list and definitions of recyclables
- Adopt MRF performance standards:
  - Removal of contamination: RC/IC > 75%



* Components do not sum to total recyclables due to rounding.

CONCLUSIONS

Based on the sampling data and interviews of MRF operators, processors, and end-users, the following conclusions were drawn.

INCOMING STREAM

- **Glass, shredded paper, and increasing amounts of non-recyclable plastics in the incoming commingled stream pose challenges for Puget Sound MRFs.** These materials adversely affect MRF operations, lead to higher levels of residuals and degrade product quality.
    - **Glass** was cited as the number one processing issue by MRF operators. These operators complained about the presence of fiber contaminated with glass shards. In addition, end-use paper mills reported that glass "sandblasts" equipment and increases operational costs. Plastics processors commented that glass is an issue for them because it clogs their screening equipment.
    - **Shredded paper** is particularly problematic for glass processors. In particular, it interferes with the optical sorting process used to color separate and decontaminate glass for use by bottle makers. MRF operators also complained that shredded paper clogs star screens during processing.
    - **Non-recyclable plastics** contribute significantly to the residual stream as well as contamination in product streams. MRF operators mentioned that unacceptable plastics consisting of contaminated containers and non-recyclable packaging plastics (e.g., blister packs) are an issue for them.
- **Puget Sound MRFs capture and dispose of slightly more than half (58%) of incoming contaminants.** The remainder of incoming contaminants is either marketed as a secondary product (e.g. durable plastic) or ends up in product streams.
- **The anticipated supply of commingled recyclables in 2010 exceeds the current processing capacity.** Appendix E provides additional detail.
    - Forecasted quantities of recyclables based on only population and economic growth (not inclusive of additional recycling programs) show the future supply of recyclables exceeds the current processing capacity. The current system must be expanded. This expansion could include increased operational times at existing facilities, expansion of existing sort lines and/or additional equipment to improve sorting efficiency, or entirely new sorting lines or facilities. One final option is for the existing Puget Sound MRFs to subcontract the processing of some portion of their incoming stream to another party.
    - If MRFs adjust operations and/or invest in additional equipment, potential future processing capacity can accommodate forecasted quantities of recyclables at current economic and population growth rates. It is likely that the future capacity could also accommodate increased quantities resulting from moderately aggressive recycling programs.

RESIDUAL STREAM

- **Residual rates at the four Puget Sound MRFs compare favorably with residual rates of other MRFs.** Residual rates for the Puget Sound MRFs range from 3% to 10%. Nationally, residual rates range from a low of 2-3% to over 50%. In California, a survey of 40 commingled MRFs found the statewide residual rate averaged 14%.
- **While Puget Sound MRFs recover over 98% of incoming recyclables, 7,000 tons are still "lost".** These lost tons are disposed of in the MRF residual stream.

PRODUCT STREAM

- **Glass is an issue for all players along the supply chain.** Glass reduces the life of equipment at the MRFs, intermediary processors, and mills/manufacturers. Extensive screening is required by paper mills and plastics processors, which contributes to three major costs: 1) facility downtime, 2) lost labor for repairs, and 3) new parts and equipment. One domestic mill estimates that they spend an additional $500,000 each year solely to replace their screen basket valves.
- **Material specifications vary widely:**
  - Specifications for each MRF product vary depending on grade and global supply and demand for the commodity.
  - Processors and end-users commonly negotiate and adjust the price paid for MRF products depending on quality.
  - Formal specifications, such as those defined by the Institute of Scrap Recycling Industries (ISRI), serve as guidelines and, as one processor put it, "a starting point." However, MRF performance and product quality is almost never measured against ISRI's formal specifications.
  - Relaxed specifications from offshore mills are pushing domestic mills and industry groups such as ISRI to relax material standards. In particular, ISRI's Paper Stock Industries Chapter may include two new paper grades in 2007: "shredded office paper" and "residential mixed paper." These grades would allow for twice the percentage of prohibitives and outthrows of current office paper grades.
  - The ultimate test to determine if MRF products meet specifications is if they sell. The four MRFs included in this assessment all successfully sell material to market. None of the processors or end-users interviewed indicated they had rejected loads from these MRFs.
- **The recycling marketplace is self-policing:**
  - One domestic paper mill purported, "This is a highly transactional environment…it's relationships, feedback, hopefully improvement, and then you continue to build relationships [with your suppliers]."
  - A plastics processor commented, "We can take anything. We never reject loads; we just downgrade them. First, I give warnings to the supplier if they're not meeting spec. If the problem continues, I downgrade the material. There is a $100 per ton price difference for downgraded plastic [more than 10% contamination] versus material that meets spec."
  - Glass processors report that they accept virtually any glass that enters their facility and adjust payment according to the level of contamination in the load.
- **Brokers and end-users, with the exception of domestic paper mills, are generally satisfied with the quality of products from the four Puget Sound MRFs:**
  - Although paper from the four Puget Sound MRFs does not meet stated specifications, offshore paper mills are very satisfied with the paper from Puget Sound MRFs; domestic mills would prefer higher quality fiber, but are relaxing standards.
  - Glass processors are relatively satisfied with material from the region's MRFs. The tolerance for contaminants in glass largely depends on the material's end-use (bottles versus construction applications).
  - Plastics processors and brokers are satisfied with the quality of PETE despite the fact that PETE from the four MRFs fails to meet the 2% contamination level specification. As one broker commented: "We don't get any news back to the contrary…the material is within the range of acceptance."

- **Non-conforming recyclables are recovered by offshore mills and rarely by domestic mills:**
    - An estimated 8,400 tons of non-conforming recyclables (e.g., PETE bottles in bales of newspaper) are contained in newspaper, mixed paper, PETE, and glass product marketed by the four Puget Sound MRFs. The vast majority, 7,200 tons, of these recyclables are contained in newspaper and mixed paper bales.
    - Based on interviews with the MRF operators and fiber brokers, virtually all of the mixed paper and an estimated 75% to 80% of the newspaper from the Puget Sound region are currently sold to offshore markets.
    - With relatively low-cost labor, offshore mills recover plastic, metal, and larger glass pieces from the fiber bales they import from the U.S. This means an estimated 6,000 tons of non-conforming recyclables are recycled by off-shore end-users.
    - Labor costs for domestic mills are relatively higher, and these mills cannot afford to pick non-conforming recyclables before pulping. As a result, 2,000 to 4,000 tons of non-conforming recyclables are currently "lost" through landfilling. This represents less than 1% of the incoming commingled materials delivered to the four Puget Sound MRFs.

RECOMMENDATIONS

This section presents the consultant's recommendations that are designed to address five key issues identified in the research.

ISSUE 1: THE ADVERSE IMPACT OF GLASS SHARDS AND FINES IN INCOMING, PROCESS, AND PRODUCT STREAMS AT PUGET SOUND MRFS

- Puget Sound MRF operators find glass to be the "number one" problem.
- Excessive amounts of fines resulting from commingled collection "sandblast" equipment and add hundreds of thousands of dollars to yearly O&M costs in domestic paper mills.
- Glass processors cannot sort small fines for bottle markets—the highest and best use for recycled glass—while plastics processors report that glass fragments embed into plastic and are difficult and expensive to remove.

RECOMMENDATIONS

To initiate a process for separating glass in single-stream collection programs:

- **Convene a hauler/processor forum** to identify an acceptable strategy for separating glass in single-stream collection programs. The purpose of this forum would be to discuss and identify the best long term strategy for removing glass from incoming streams at Puget Sound MRFs, and from the product streams produced by these MRFs. Solutions may include:
    - Not collecting glass
    - Implementing a dual stream system
    - Implementing a system of drop-off sites
    - Enhancing front-end processing at MRFs
- **Develop a plan for separating glass** in single-stream collection programs. The County would develop a plan for implementing new collection or processing programs in King County that would achieve the "optimal strategy" identified by private stakeholders in forums proposed above.

- **Work with key stakeholders** including Seattle and other King County municipalities to implement new or modified collection and /or processing programs. Once a plan is formulated and approved by the key stakeholders, the County would coordinate efforts with Seattle and other King County cities to implement the desired programs through new or amended hauler contracts and service level ordinances.

ISSUE 2: CONTAMINATION IN INCOMING STREAMS

- Incoming contaminants that are not captured by the MRFs and disposed of in the residual stream end up in product shipped to end-users.
- Contaminants degrade product quality and contribute to increased end-user costs for additional cleaning, sorting and disposal.
- Contaminants contribute significantly to MRF operating costs as they make up nearly 60% of residual streams from the four Puget Sound MRFs.

RECOMMENDATIONS

To reduce contamination in incoming recycling streams:

- **Promote a standard, uniform set of recyclable materials across the cities and county.** Constant changes overtime and differences from community to community create confusion among residents. In particular, the differences between which plastics are recyclable and non-recyclable from city to city appear to be a key source of confusion for the public. Conflicting messages regarding shredded paper also lead to confusion and contamination; some customers are told to put it in their yard waste bin while others are told that it belongs in the recycling bin.
- **Initiate education programs and improve materials to consistently and clearly define what materials are recyclable and what materials are not.** An effective education program would help to eliminate much of the contamination in products shipped to end-users as well as significant quantities of MRF residuals. The education program would need to emphasize the importance of eliminating contamination, and clearly identify and define both recyclable and non-recyclable materials. Consistent definitions, graphics and messages regarding recyclability will be key to the success of this initiative.

ISSUE 3: THE LOSS OF RECYCLABLES IN THE RESIDUAL STREAMS LAND FILLED BY THE FOUR PUGET SOUND MRFS

- While Puget Sound MRFs attempt to recover all incoming recyclables, 7,000 tons are still "lost" and disposed of in the MRF residual stream.
- Puget Sound MRFs dispose fewer recyclables than many other West Coast MRFs, but the percent of valuable incoming recyclables that are currently land filled with other residuals ranges from 1% to 3%.

RECOMMENDATIONS

To minimize and prevent further losses of valuable recyclables in the residual streams from Puget Sound MRFs:

- **Adopt MRF performance standards to prevent the loss of recyclables in residual streams.** The conventional approach to controlling the loss of recyclables is to set an overall maximum limit on the amount of allowable residuals. However, residual rates are driven in large part by the quantity of incoming contaminants and marginally recyclable materials and cannot be directly controlled by MRF operators. An approach that is more direct in preventing the loss of recyclables and one that is controllable by MRF operators is to set the maximum level of recyclables permitted in MRF residual streams. Based on current performance levels, a reasonable maximum for recyclables in the residual streams of single-stream MRFs is about two percent of incoming recyclables.

ISSUE 4: PROHIBITIVES IN PRODUCT STREAMS

- The level of non-fiber prohibitives (including both contaminants and non-conforming or other recyclables) in paper bales from Puget Sound MRFs exceeds desirable levels for both domestic and offshore markets. Likewise, non-PETE contaminants averaged 15% in bales from the four Puget Sound MRFs, far exceeding reported market specifications.

RECOMMENDATIONS

To limit the amount of contaminants that could potentially degrade products from the four Puget Sound MRFs:

- **Adopt MRF performance standards to control the amounts of incoming contaminants that end up in product streams.** MRFs do not capture all incoming contaminants that then flow through processing systems and compromise the quality of product streams. This issue can be effectively controlled by developing performance standards that require prescribed levels of incoming contaminant removal. The governing metric should be defined in terms of a percentage of incoming contaminants. Based on current performance levels, a reasonable target for contaminant removal would be 60% to 70% of all incoming contaminants.

ISSUE 5: LOSS OF RECYCLABLES IN PRODUCT STREAMS PRODUCED BY THE FOUR PUGET SOUND MRFS

- An estimated 8,400 tons of non-conforming recyclables (not including marginal recyclables) are contained in the newspaper, mixed paper, PETE, and glass products marketed by Puget Sound MRFs. Much of this material is sold to offshore mills where non-conforming recyclable materials, based on our research, are ultimately recovered.
- Recyclable materials that are "lost" through landfilling are largely contained in products shipped to domestic mills that cannot afford to recover these materials. These "lost" tons make up less than 1% of all commingled recyclables processed by the four Puget Sound MRFs.

RECOMMENDATIONS

To avoid costly public sector intervention in a self regulating market that appears to be functioning well:

- **Let the market determine product specifications, prices, and acceptance policies.** Performance standards designed to regulate product quality are not recommended. Specifications for each of the products examined in this study change with cyclical supply and demand fluctuations, vary from market to market, are different for each end-user, and may even be adjusted from transaction to transaction.

Section 1: Introduction and Objectives

1.1 INTRODUCTION

The King County Solid Waste Division commissioned Cascadia Consulting Group to conduct this assessment of Puget Sound Material Recovery Facilities (MRFs). The objective was to investigate, document, and provide recommendations to address real or perceived issues related to:

4. incoming material,
5. quantity and types of MRF residuals disposed, and
6. product contamination.

This assessment is intended to help the County and cities decipher the cause and nature of the issues and, if necessary, develop policies to address them. This 2006 study will support King County and the cities' waste reduction and recycling efforts and will be used to help guide the 2001 Comprehensive Solid Waste Management Plan Update.

The assessment quantified and characterized the commingled material delivered to MRFs from residential and commercial sources, as well as the material that comes out of MRFs as product or as residual material. The resulting analysis revealed the amounts and types of contaminants in incoming material and outgoing products as well as potentially valuable recyclables that are lost to recycling markets. In addition, the County and cities wish to assess the performance of Puget Sound MRFs and document actual market-driven specifications for recycled products. In sum, this assessment is intended to put to rest any lingering questions regarding whether contamination of recyclables sorted in MRFs poses problems for end users as well as to help develop an action plan to address any documented needs.

This report is organized into five sections. Section 1 briefly summarizes the project objectives and findings. An overview of the methods used during this study is presented in Section 2. Section 3 presents the findings from both the MRF sampling and the stakeholder perspectives. Section 4 presents findings from other MRF studies, in order to provide a benchmark for the Puget Sound MRFs' performance. Section 5 presents recommendations based on the findings of this study to improve MRF performance and Section 6 identifies the key barriers to implementation of the recommendations.

1.2 OBJECTIVES

This MRF assessment focuses on four Puget Sound MRFs that handle a range of recycled materials collected from residents and businesses: Allied Waste's Rabanco Recycling Center (Third & Lander) in Seattle, Waste Management's Cascade Recycling Center in Woodinville, Smurfit-Stone's Renton Reclamation Plant, and Waste Connection's Recycling Center in Tacoma. This assessment focused on commingled recyclables (with and without glass) collected and processed by the four Puget Sound MRFs. Construction and demolition (C&D) recycling is not included in this study.

Cascadia worked with MRFs to quantify and characterize incoming material, residuals, and four select products, newspaper, mixed paper, PETE, and glass. Analysis of the incoming stream provides an indication of the level of contamination MRFs receive from residents and businesses. In addition to sorting recyclables according to commodity and grade, MRFs must also remove this incoming contamination. Composition results of the residuals stream show how much of the material disposed consists of marketable, and therefore valuable, recyclables. Finally, because this assessment sought to address concerns about contamination levels in marketed recyclables from MRFs, four product streams central to the contamination debate were chosen.

This study identifies systemic barriers, develops preliminary performance standards and recommends a method to implement these standards. In addition, Cascadia interviewed end users and material brokers, whose opinions assisted in developing performance standards that will optimize the value of processed recycled materials. Through these interviews, Cascadia identified barriers that might make it difficult for MRFs to meet performance standards and developed recommendations for assessing MRF performance in the future.

Section 2: Summary of Methods

This section provides an overview of the 2006 MRF assessment methodology. As shown, there were five major steps involved in conducting this study. Please see Appendix B for a detailed description of the methodology.

Step 1: Develop Sampling Plan and Select Material Recovery Facilities (MRFs)

- The Material Recovery Facilities (MRFs) selected were: Allied Waste's Rabanco Recycling Center (Third and Lander) in Seattle, Waste Management's Cascade Recycling Center in Woodinville, Smurfit-Stone's Reclamation Plant in Renton, and Waste Connections's Recycling Center in Tacoma.
- A sampling schedule was constructed so that each facility was sampled during two consecutive week-days in April and May, 2006. Operations staff at each facility received no more than 72 hours notice before sampling began.

3rd and Lander	Cascade	Smurfit-Stone	Waste Connections
April 24 and 25	April 13 and 14	May 3 and 4	May 9 and 10

Step 2: Capture and Sort Samples

Capturing Samples

- At each facility, sampling staff coordinated with the facility operations manager to ensure unbiased samples were safely obtained.
- All samples were selected randomly for each of the six material streams: Incoming, Residual, Newspaper, Mixed Paper, Glass, and PETE.
- A total of 100 samples were collected during the 8 days of sampling.
- Each sample weighed 125 pounds with the exception of glass and PETE samples: Glass samples weighed between 3 and 26 pounds, while PETE samples weighed 45 pounds.
- After the samples were captured they were transported by the Sampling Manager to the on or off-site sorting location.

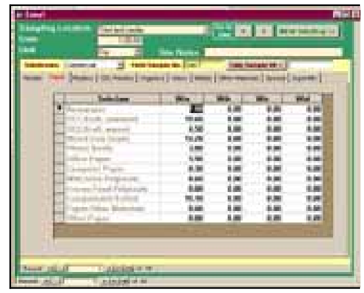
Sorting Samples

- Entire samples were placed on a custom-built sorting table. Material larger than 2" in diameter was hand sorted by the crew into 48 material categories.
- Material that fell through the 2" screen was collected and weighed. A 2.7 pound sub-sample was selected using the cone and quarter method and the sub-sample was then hand-sorted.
- Material smaller than ½" was collected and weighed. A 0.60 pound sub-sample was selected using the cone and quarter method and the sub-sample was then hand-sorted.
- All material categories were weighed at the end of each sort or sub-sort and the weights were recorded on data forms by the Sorting Manager.

Step 3: Obtain Quantity Data

Cascadia requested and obtained calendar year 2005 tonnage data from each MRF. The highly proprietary data included tons of incoming material accepted, residual material disposed, and product (by commodity type) sold. The data obtained from each facility form the basis for the weighted composition analysis and aggregated quantity figures provided in this report.

Step 4: Analyze Data and Prepare Report



- Following each sampling event, all sort data were entered into a customized database and reviewed for data entry errors. At the conclusion of the study, waste composition estimates were calculated by aggregating sampling data using a weighted average procedure. Calendar year 2005 tonnage data provided by each MRF were used to perform these calculations. The weighted average procedure is detailed in Appendix D.
- Once the data were analyzed, an accompanying report was prepared.

Step 5: Interview Stakeholders for End User Assessment

Each MRF included in the assessment was asked to provide a list of brokers, mills and end users that purchase processed recyclables from them. Despite signed confidentiality agreements, two of the four facilities declined to participate in this aspect of the study. From the contacts that were provided, Cascadia interviewed by phone or in person brokers and end-users representing the domestic and export paper industry, domestic glass processors, and domestic and export plastics processors and end-users.

In conducting the MRF assessment, Cascadia was granted access to data and other information each MRF considers highly proprietary. For this reason, the composition and quantity data are presented in aggregate only. Similarly, end market specifications, barriers, and related issues are presented anonymously. It should also be noted that much of the data used in the analysis and presented in the report were provided by the MRFs, and their brokers and end users. Cascadia made every effort to assure the information provided was truly reflective of the marketplace.

Section 3: Findings

This section begins with a presentation of the findings from the material sorting, quantification, and composition analysis (Section 3.1). Section 3.2 describes the results and key themes that emerged from the broker, mill, and end user interviews.

3.1 QUANTITIES AND COMPOSITION RESULTS BY MATERIAL STREAM

This section presents the results of the material sorting, quantification, and composition analysis. The section begins with a description of how the data are interpreted and presented. The remaining subsections present the detailed results for each of the six material streams included in the assessment (incoming, residual, newspaper, mixed paper, glass, and PET).

3.1.1 INTERPRETING THE RESULTS

The data from the sorting process was treated with a statistical procedure that provided two kinds of information for each of the 48 materials:

- The percent-by-weight estimated composition of material represented by the samples examined in this study, and
- The degree of precision of the composition estimates.

All estimates of precision were calculated at the 90% confidence level. The equations used in these calculations appear in Appendix C.

The example below illustrates how the results can be interpreted. The example indicates that the best estimate of the amount of *newspaper* present in the universe of material sampled is 48.0%. The figure 3.9% reflects the precision of the estimate. When calculations are performed at the 90 percent confidence level, we are 90 percent certain that the true percent of the waste stream that is *newspaper* is between 48.0% + 3.9% and 48.0% - 3.9%. In other words, we are 90 percent certain that the actual amount lies between 51.9% and 44.0%.

MATERIAL	EST. PCT.	+ / -
NEWSPAPER	48.0%	3.9%

When interpreting the results presented in the tables and figures in this report, it is important to consider the effect of rounding. To keep the composition tables and figures readable, estimated tonnages are rounded to the nearest tenth of a ton, and estimated percentages are rounded to the nearest tenth of a percent. Due to this rounding, the tonnages presented in the report, when added together, may not exactly match the subtotals and totals shown. Similarly, the percentages, when added together, may not exactly match the subtotals or totals shown. Also, percentages less than 0.05% are shown as 0.0%.

3.1.2 RECYCLABILITY GROUPINGS

Each sample of material was hand sorted into 48 separate material categories, as defined in Appendix A. For analysis purposes, these 48 materials were grouped according to their "recyclability" into recyclable materials, marginally recyclable materials, and contaminants.

Materials grouped as "recyclable materials," such as newspaper and PETE bottles, have strong established markets and are considered acceptable incoming materials at all four Puget Sound MRFs. "Marginally recyclable" materials are those considered acceptable in the incoming stream of at least one, but not all Puget Sound MRFs. Materials were also considered marginally recyclable if least one, but not all facilities have found an end market for the material. For example, the material category *grocery/merchandise bags* is an acceptable incoming material and a marketable material at two facilities, but is considered a contaminant with no available markets at the other two plants. Materials without markets and that are universally unacceptable in the incoming stream of all four facilities were grouped in the "contaminants" category.[1] Table 1 shows the recyclability grouping for each of the 48 materials defined for this assessment.

Table 1: Material Groupings by Recyclability

Recyclable Materials	Marginally Recyclable	Contaminants
OCC/Kraft Bags	Dyed, Fluor., Goldenrod Paper	Carbon Paper
Newspaper	Blueprints	Photographic Paper
Mixed Papers	Printed Wrapping Paper	Hardcover Books
Wet Strength Boxboard	Shredded Paper	Foil Lined Paper
Polycoated and Aseptic	Other Aluminum	Compostable Paper
Aluminum Cans	Mixed Metals	Paper Composites
Tinned Food Cans	Glass Shards	Comp. Gas Cylinders
Other Ferrous	Other PETE Containers	Other Glass
Other Non-Ferrous	HDPE Buckets	Expanded Polystyrene
Container Glass	Other HDPE Containers	Rigid Polystyrene
Glass Cullet	#3,4,5,7 Bottles	Other Packaging
PETE Bottles and Jars	#3,4,5,7 Other Containers	Plastic Trash Bags
HDPE Natural Bottles	Plastic Grocery/Merchandise Bags	Film Products
HDPE Colored Bottles	Non-Bag Packaging Film	Other Film
		Other Plastic Products
		Plastic & Other Materials
		Organics
		Nondistinct Fines
		Other Materials
		HHW/Special

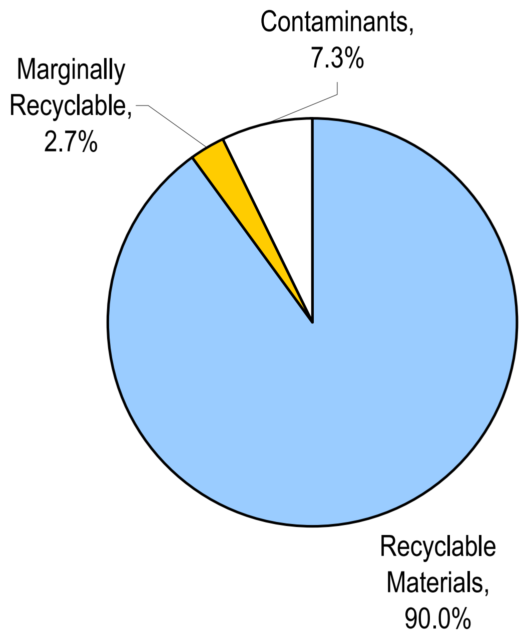
3.1.3 Quantities and Composition of Incoming Material

In 2005, the four Puget Sound area MRFs together received over 410,000 tons of incoming commingled recyclables from residential and commercial sources. Based on the material sampling and tonnage data collected from each

[1] In subsequent sections of the report, the term "non-conforming recyclables" will be used to refer to recyclable materials present in bales of a different product (e.g., PETE bottles in a mixed paper bale). In contrast, contaminants are universally unacceptable in the incoming streams, and therefore products, from all four facilities.

facility, Figure 1 shows the composition of the incoming material grouped by recyclability. Table 1 shows the composition and tonnage estimate for each of the 48 material categories included in this study.

Figure 2: Estimated Composition of Incoming Commingled Material, Four Puget Sound MRFs



- **Contaminants account for 7.3% (29,800 tons) of the incoming commingled material stream.** *Organics* (1.8%, 7,400 tons), *other plastic products* (1.1%, 4,600 tons), and *compostable paper* (1.0%, 4,100 tons) account for the largest share of the incoming contaminant material. *Organics* includes items such as wood, yard waste, food waste, textiles, diapers, and tires. Examples of items included in *other plastic products* are plastic cutlery, vinyl products, Formica, and foam carpet padding. *Compostable paper* includes items such as tissues, paper towels, and greasy pizza boxes.
- **The proportion of contaminants in the incoming material stream ranged from 5% to 10%.** Incoming material samples from each of the four facilities were analyzed separately, providing a range among Puget Sound MRFs.
- **Most of the recyclable material, which makes up about 90% of the incoming material stream, is composed of fiber.** *Mixed paper* (127,400 tons) and *newspaper* (117,800 tons), the largest portions, each make up about 30% of this stream. *OCC/Kraft Bags* accounts for another 16.6%, or about 68,000 tons.
- **Next to paper, glass is the largest fraction of the incoming recyclable materials.** Container glass accounts for about 5%, an estimated 20,900 tons, of the incoming material.
- **Marginally recyclable materials comprise 2.7% (11,200 tons) of the incoming stream.** Shredded paper (1.1%, 4,700 tons) and glass shards (0.5%, 2,000 tons) account for the largest share of marginally recyclable materials.

Table 2: Estimated Composition and Tons of Incoming Commingled Material, Four Puget Sound MRFs (2005 tons)

Material	Est. Pct.	+ / -	Est. Tons	Material	Est. Pct.	+ / -	Est. Tons
Paper	**81.3%**		**333,439.3**	**Plastic**	**6.3%**		**25,998.6**
OCC/Kraft Bags	16.6%	4.4%	67,979.9	PETE Bottles and Jars	1.7%	0.4%	6,807.2
Newspaper	28.7%	6.1%	117,766.4	Other PETE Containers	0.1%	0.1%	599.4
Mixed Papers	31.1%	5.9%	127,428.9	HDPE Natural Bottles	0.6%	0.2%	2,572.9
Wet Strength Boxboard	1.2%	0.4%	4,879.2	HDPE Colored Bottles	0.7%	0.3%	2,985.5
Polycoated and Aseptic	0.4%	0.2%	1,776.3	HDPE Buckets	0.0%	0.0%	60.3
Dyed, Fluor., Goldenrod	0.1%	0.1%	224.9	Other HDPE Containers	0.1%	0.0%	214.1
Blueprints	0.0%	0.0%	0.0	#3,4,5,7 Bottles	0.1%	0.1%	526.1
Carbon Paper	0.0%	0.0%	10.5	#3,4,5,7 Other Containers	0.1%	0.0%	609.9
Photographic Paper	0.0%	0.0%	45.0	Expanded Polystyrene	0.2%	0.1%	717.2
Hardcover Books	0.2%	0.2%	646.1	Rigid Polystyrene	0.1%	0.0%	510.0
Foil Lined	0.0%	0.0%	74.0	Other Packaging	0.4%	0.1%	1,761.7
Printed Wrapping Paper	0.0%	0.0%	39.9	Plastic Trash Bags	0.2%	0.2%	698.7
Compostable Paper	1.0%	0.3%	4,075.9	Grocery/Merch. Bags	0.2%	0.1%	874.5
Shredded Paper	1.1%	0.7%	4,702.8	Non-Bag Packaging Film	0.0%	0.0%	187.1
Paper Composites	0.9%	0.4%	3,789.4	Film Products	0.0%	0.0%	8.6
				Other Film	0.5%	0.2%	2,228.5
Metals	**2.8%**		**11,287.5**	Other Plastic Products	1.1%	0.6%	4,636.8
Aluminum Cans	1.0%	0.4%	3,930.4	Plastic & Other Materials	0.0%	0.0%	0.0
Other Aluminum	0.2%	0.1%	797.7				
Tinned Food Cans	1.3%	0.5%	5,324.1	**Organics**	**1.8%**		**7,368.1**
Other Ferrous	0.2%	0.1%	929.9	Organics	1.8%	1.5%	7,368.1
Other Non-Ferrous	0.0%	0.0%	6.7				
Mixed Metals	0.1%	0.1%	298.7	**Other Materials**	**0.8%**		**3,178.3**
Comp. Gas Cylinders	0.0%	0.0%	0.0	Nondistinct Fines	0.6%	0.4%	2,416.6
				Other Materials	0.2%	0.2%	618.5
Glass	**7.0%**		**28,827.1**	HHW/Special	0.0%	0.0%	143.2
Container Glass	5.1%	2.5%	20,895.1				
Glass Cullet	1.4%	0.6%	5,791.6				
Glass Shards	0.5%	0.3%	2,042.5				
Other Glass	0.0%	0.0%	97.9				
Number of samples:	**25**				**Total Tons:**		**410,098.9**

Table Color Key:

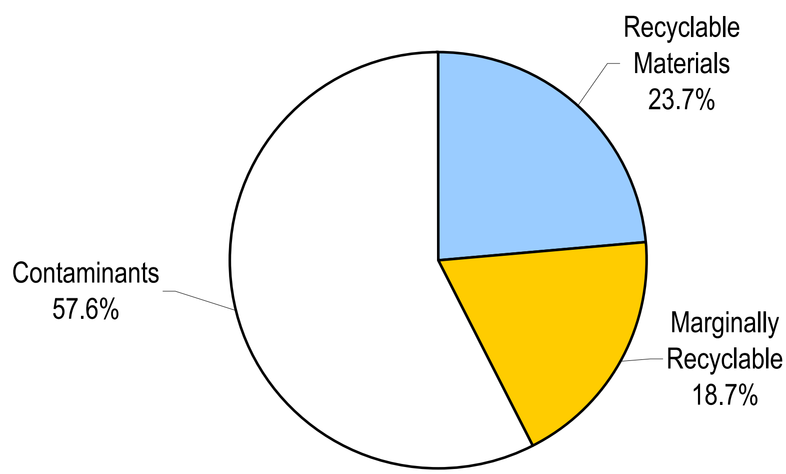
Blue text:	Orange text:	Black text:
Recyclable Materials	Marginally Recyclable Materials	Contaminants

3.1.4 QUANTITIES AND COMPOSITION OF RESIDUAL MATERIAL

Residual materials are items that remain after processing that are then disposed of in landfills. Sampling residual material provides an estimate of the recyclables "lost" to the market place due to disposal. An analysis of residual quantities allows for a calculation of the residual rate, a commonly used benchmark in measuring MRF performance. Simply put, the residual rate is the quantity of residuals divided by the total amount of incoming commingled material.

In 2005, the four Puget Sound area MRFs together disposed of 29,600 tons of residual material. This means a four-facility averaged residual rate of 7.2%. Facility-specific residual rates ranged from a low of 3% to a high of 10%. Based on the material sampling and tonnage data collected from each facility, Figure 3 shows the composition of the residual material, grouped by recyclability. Table 3 shows the composition and tonnage estimates for residual material according to the 48 material categories included in this study.

Figure 3: Estimated Composition of Residual Material, Four Puget Sound MRFs



- **At 57.6% (17,000 tons) contaminants accounted for the majority of the residual stream.** *Organics,* at 17.5% (5,200 tons) comprised the largest portion of the contaminants, followed by *nondistinct fines*, (13.2%, 3,900 tons), *compostable paper* (9.5%, 2,800 tons) and *other materials* (4.7%, 1,400 tons). *Nondistinct fines* includes items such as soil, sand, dirt, and grit. *Other materials* includes items such as construction/demolition waste, ashes, furniture, and electronics.

- **Recyclable materials (7,000 tons) comprised nearly one quarter (23.7%) of the residual stream.** *Other ferrous metal* accounted for an estimated 7.5% and 2,200 tons of the recyclable materials, followed by *mixed papers* (6.0%, 1,800 tons), and *OCC/Kraft bags* (3.1%, 900 tons). *Other ferrous metal* includes ferrous and alloyed ferrous scrap other than tinned food cans. . Anecdotally, the sorting crew observed that a large share of the *other ferrous metal* found in the residual stream consisted of long pieces of metal strapping, which is typically used in packaging applications. Because this strapping can get caught in and damage a MRFs automated sorting equipment, line sorters pull the strapping off the belt as early in the process as possible. Because of the positioning of these sorters, the material they pull off is often disposed in the residual stream. *Mixed paper* includes items such as white and colored ledger, manila folders, junk mail, envelopes, post-it notes, and paper towel tubes. *OCC/Kraft bags* includes unwaxed, uncoated cardboard and Kraft (brown) paper bags.
- **For the four MRFs, the proportion of recyclable materials in residuals ranged from 14% to 41%.** Residual samples from each of the four facilities were analyzed separately, providing a range among Puget Sound MRFs. Facilities that re-run residuals over sorting lines capture additional recyclables in the second pass. The proportion of recyclable materials in the residuals of these facilities is much lower than the level realized by MRFs that do not re-run.
- **Marginally recyclable materials accounted for 18.7% (5,500 tons) of the residual stream.** Marginally recyclable materials includes *shredded paper* (8.9%, 2,600 tons), *mixed metals* (4.4%, 1,300 tons), and *glass shards* (2.9%, 900 tons). Examples of *mixed metals* are engines, electric motors, umbrellas, coated wire, and aerosol cans.

Table 3: Estimated Composition and Tons of Residual Material, Four Puget Sound MRFs (2005 tons)

Material	Est. Pct.	+ / -	Est. Tons	Material	Est. Pct.	+ / -	Est. Tons
Paper	**32.5%**		**9,612.5**	**Plastic**	**13.4%**		**3,959.2**
OCC/Kraft Bags	3.1%	0.9%	908.9	PETE Bottles and Jars	0.5%	0.2%	152.9
Newspaper	2.5%	0.6%	741.1	Other PETE Containers	0.4%	0.1%	108.8
Mixed Papers	6.0%	1.8%	1,781.8	HDPE Natural Bottles	0.2%	0.1%	51.5
Wet Strength Boxboard	0.2%	0.1%	45.1	HDPE Colored Bottles	0.1%	0.1%	32.6
Polycoated and Aseptic	0.2%	0.1%	64.7	HDPE Buckets	0.0%	0.0%	11.0
Dyed, Fluor., Goldenrod	0.0%	0.0%	7.3	Other HDPE Containers	0.2%	0.1%	60.8
Blueprints	0.0%	0.0%	0.0	#3,4,5,7 Bottles	0.0%	0.0%	10.5
Carbon Paper	0.0%	0.0%	0.0	#3,4,5,7 Other Containers	0.5%	0.1%	162.3
Photographic Paper	0.0%	0.0%	11.4	Expanded Polystyrene	1.1%	0.3%	324.3
Hardcover Books	0.0%	0.0%	2.9	Rigid Polystyrene	0.4%	0.1%	105.8
Foil Lined	0.1%	0.0%	16.8	Other Packaging	1.9%	0.3%	563.7
Printed Wrapping Paper	0.0%	0.0%	11.8	Plastic Trash Bags	0.5%	0.2%	156.2
Compostable Paper	9.5%	4.1%	2,820.3	Grocery/Merch. Bags	0.4%	0.1%	113.9
Shredded Paper	8.9%	1.8%	2,629.6	Non-Bag Packaging Film	0.5%	0.2%	151.5
Paper Composites	1.9%	1.9%	570.7	Film Products	0.5%	0.4%	139.2
				Other Film	1.3%	0.3%	371.5
Metals	**14.1%**		**4,177.7**	Other Plastic Products	3.6%	1.3%	1,072.3
Aluminum Cans	0.4%	0.1%	128.1	Plastic & Other Materials	1.3%	0.8%	370.5
Other Aluminum	0.4%	0.2%	112.3				
Tinned Food Cans	1.2%	0.2%	344.5	**Organics**	**17.5%**		**5,170.0**
Other Ferrous	7.5%	3.7%	2,208.0	Organics	17.5%	2.2%	5,170.0
Other Non-Ferrous	0.3%	0.4%	77.3				
Mixed Metals	4.4%	1.5%	1,287.3	**Other Materials**	**18.0%**		**5,310.1**
Comp. Gas Cylinders	0.1%	0.1%	20.1	Nondistinct Fines	13.2%	4.9%	3,901.0
				Other Materials	4.7%	4.0%	1,382.1
Glass	**4.5%**		**1,327.6**	HHW/Special	0.1%	0.1%	27.0
Container Glass	0.2%	0.1%	54.6				
Glass Cullet	1.4%	0.3%	416.8				
Glass Shards	2.9%	3.7%	850.6				
Other Glass	0.0%	0.0%	5.6				
Number of samples:	**25**				**Total Tons:**		**29,557.0**

Table Color Key:

Blue text:	Orange text:	Black text:
Recyclable Materials	Marginally Recyclable Materials	Contaminants

3.1.5 QUANTITIES AND COMPOSITION OF SELECT PRODUCTS

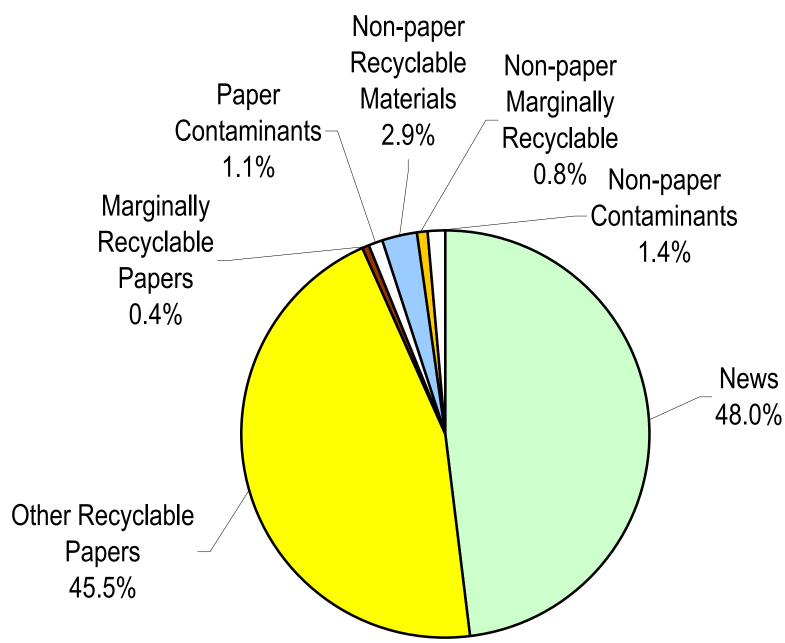
In addition to the incoming and residual material streams, this study included the quantity and composition analysis of four MRF products: newspaper, mixed paper, PETE, and glass. This section presents the findings for each of these material streams.

Newspaper

The newspaper product sorted and marketed at each of the MRFs included in the study differed, but not necessarily in quality. During the April/May sampling season, each MRF produced a different grade of newspaper for its market. For this reason, the relative amount of newspaper versus non-newspaper fiber is much less important than an examination of the non-paper materials found in newspaper product samples. Regardless of the grade, non-paper materials are universally considered prohibitive. However, the tolerance of prohibited items also varies depending on the grade, market conditions (supply/demand), and ultimately, price the market pays for the MRFs newspaper product.

The four Puget Sound area MRFs produced 146,100 tons of newspaper product in 2005. Figure 4 shows the composition of the newspaper product samples, grouped by recyclability. Table 4 shows the composition and tonnage estimates for newspaper samples according to the 48 material categories included in this study.

Figure 4: Estimated Composition of Newspaper Product, Four Puget Sound MRFs



- **Slightly less than half (48.0%) of this product line was composed of newspaper.** Newspaper, as strictly defined by the study, totaled an estimated 70,100 tons. Depending on the grade, market conditions, and price, end users tolerate more or less strictly defined *newspaper* in newspaper product.
- **Other recyclable papers accounted for 45.5% (66,400 tons).** Other recyclable papers includes the materials *OCC/Kraft bags*, *mixed papers*, *wet strength boxboard*, and *polycoated and aseptic*. Of these materials, *mixed paper* was the largest fraction by far, making up 38.8% and 56,700 tons of newspaper product. At 5.1% (7,400 tons), *OCC/Kraft bags* represented the second largest component.

- **Non-paper recyclables comprised 2.9%, or 4,200 tons, of this product stream.** The two most prevalent material types in this category were *PETE bottles and jars* (0.9%, 1,300 tons) and *HDPE natural bottles* (0.5%, 700 tons).
- **Less than 3% (3,600 tons) of newspaper product consisted of contaminants.** Two contaminant categories were defined for this product stream: paper contaminants and non-paper contaminants. Non-paper contaminants (1.4%, 2,000 tons) accounted for a little more than half of the contaminants and were largely made up of *organics* (0.4%, 500 tons), *other plastic packaging* (0.3%, 400 tons), and *other plastic film* (0.2%, 300 tons). Paper contaminants together accounted for slightly more than 1% of the total stream and mostly consisted of *paper composites* (0.8%, 1,100 tons) and *compostable paper* (0.3%, 500 tons). *Other plastic packaging* includes items such as plastic lids and caps. Examples of *other film* include sandwich bags, newspaper bags, candy-bar wrappers, and plastic food wrap. *Paper composites* includes items such as juice cans, oil cans, and metal-bound notebooks.
- **The proportion of non-paper materials in newspaper product ranged from 1% to 13%.** Newspaper samples from each of the four facilities were analyzed separately, providing a range among Puget Sound MRFs.

Table 4: Estimated Composition and Tons of Newspaper Product, Four Puget Sound MRFs (2005 tons)

Material	Est. Pct.	+ / -	Est. Tons	Material	Est. Pct.	+ / -	Est. Tons
Paper	**95.0%**		**138,775.0**	**Plastic**	**2.9%**		**4,292.6**
OCC/Kraft Bags	5.1%	1.9%	7,431.8	PETE Bottles and Jars	0.9%	0.3%	1,269.0
Newspaper	48.0%	3.9%	70,093.2	Other PETE Containers	0.1%	0.1%	157.1
Mixed Papers	38.8%	3.8%	56,651.7	HDPE Natural Bottles	0.5%	0.1%	706.6
Wet Strength Boxboard	1.2%	0.3%	1,702.0	HDPE Colored Bottles	0.2%	0.1%	322.3
Polycoated and Aseptic	0.4%	0.1%	636.6	HDPE Buckets	0.0%	0.0%	0.0
Dyed, Fluor., Goldenrod	0.1%	0.1%	98.7	Other HDPE Containers	0.0%	0.0%	36.4
Blueprints	0.0%	0.0%	0.0	#3,4,5,7 Bottles	0.1%	0.1%	107.8
Carbon Paper	0.0%	0.0%	1.1	#3,4,5,7 Other Containers	0.2%	0.1%	231.8
Photographic Paper	0.0%	0.0%	24.2	Expanded Polystyrene	0.1%	0.0%	115.0
Hardcover Books	0.0%	0.0%	0.0	Rigid Polystyrene	0.1%	0.0%	96.4
Foil Lined	0.0%	0.0%	23.5	Other Packaging	0.3%	0.1%	418.5
Printed Wrapping Paper	0.1%	0.0%	78.6	Plastic Trash Bags	0.0%	0.0%	19.8
Compostable Paper	0.3%	0.1%	452.3	Grocery/Merch. Bags	0.1%	0.0%	199.6
Shredded Paper	0.3%	0.2%	441.5	Non-Bag Packaging Film	0.0%	0.0%	26.4
Paper Composites	0.8%	0.2%	1,139.8	Film Products	0.0%	0.0%	23.2
				Other Film	0.2%	0.0%	342.6
Metals	**0.8%**		**1,192.5**	Other Plastic Products	0.1%	0.1%	195.6
Aluminum Cans	0.3%	0.0%	476.8	Plastic & Other Materials	0.0%	0.0%	24.7
Other Aluminum	0.1%	0.0%	110.2				
Tinned Food Cans	0.3%	0.1%	498.9	**Organics**	**0.4%**		**526.4**
Other Ferrous	0.1%	0.0%	95.5	Organics	0.4%	0.2%	526.4
Other Non-Ferrous	0.0%	0.0%	4.1				
Mixed Metals	0.0%	0.0%	7.0	**Other Materials**	**0.2%**		**228.5**
Comp. Gas Cylinders	0.0%	0.0%	0.0	Nondistinct Fines	0.1%	0.0%	158.3
				Other Materials	0.0%	0.0%	42.0
Glass	**0.8%**		**1,099.9**	HHW/Special	0.0%	0.0%	28.1
Container Glass	0.3%	0.1%	368.6				
Glass Cullet	0.3%	0.1%	443.9				
Glass Shards	0.2%	0.1%	276.6				
Other Glass	0.0%	0.0%	10.8				
Number of samples:	**15**				**Total Tons:**		**146,114.9**

Table Color Key:

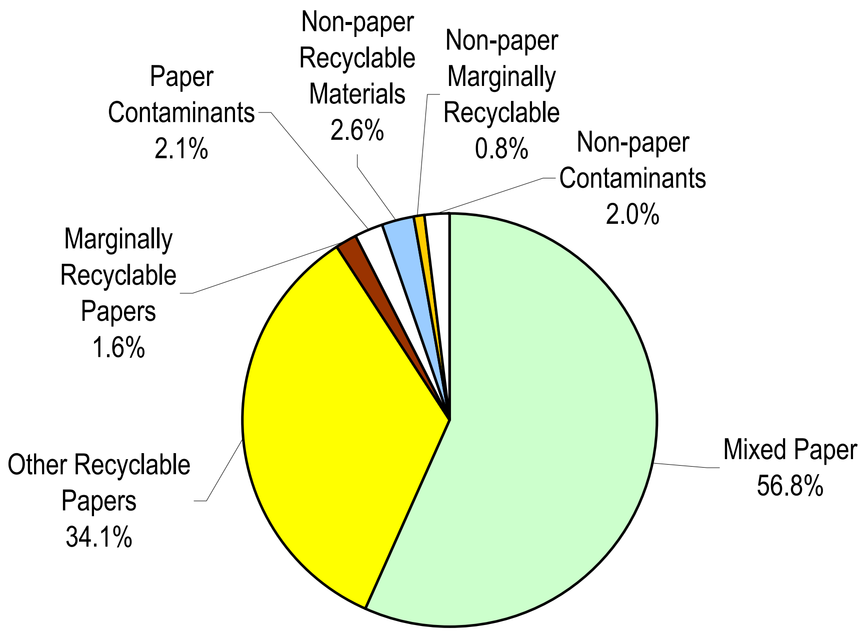
Blue text: Recyclable Materials	Orange text: Marginally Recyclable Materials	Black text: Contaminants
Green highlight: Product	Yellow highlight: Materials Acceptable in Product	

Mixed Paper

Like newspaper, the grade of mixed paper product produced by each of the MRFs differed. Interestingly, one facility produced a #3 grade mixed paper; a grade the Institute of Scrap Recycling Industries (ISRI) lists as "…not currently in use." As discussed further in Section 3.2, real world product specifications do not often match ISRI specifications. Like newspaper, regardless of grade, non-paper materials are universally considered prohibitive in mixed paper product. However, the tolerance for prohibited materials also varies depending on the grade, market conditions (supply/demand), and ultimately on the price the market pays.

The four Puget Sound area MRFs produced 119,100 tons of mixed paper product in 2005. Figure 5 shows the composition of the mixed paper product samples, grouped by recyclability. Table 5 shows the composition and tonnage estimates for mixed paper samples according to the 48 material categories included in this study.

Figure 5: Estimated Composition of Mixed Paper Product, Four Puget Sound MRFs



- **About 57%, or 67,600 tons, of the mixed paper product stream is composed of mixed paper.** As defined for this study, *mixed paper* includes items such as white and colored ledger, magazines, phone books, manila folders, junk mail, post-it notes, and paper towel tubes. Depending on the grade, market conditions, and price, end users tolerate more or less strictly defined *mixed paper* in mixed paper product bales.
- **Other recyclable paper makes up about one-third (34.1 %) of this product stream (40,600 tons).** The largest component of this recyclability category is *newspaper* at 26% (31,000 tons), followed by *OCC/Kraft bags* at 5.8% (6,900 tons).
- **Non-paper recyclable materials accounted for approximately 2.6% (3,000 tons) of the mixed paper product stream.** Non-paper recyclables in mixed paper samples primarily consisted of *PETE bottles and jars* and *aluminum cans.* Each of these materials comprised about 1% of mixed paper samples (1,000 and 800 tons, respectively).

- **Marginally recyclable papers accounted for 1.6% (1,900 tons) of this product stream.** At 1.4% and 1,700 tons, *shredded paper* represented the largest component in the marginally recyclable paper category.
- **Two separate types of contaminants were categorized: paper contaminants (2.1%, 2,500 tons) and non-paper contaminants (2.0%, 2,400 tons).** The most prevalent types of paper contaminant materials were *compostable paper* (0.8%, 900 tons), *paper composites* (0.8%, 900 tons), and *hardcover books* (0.5%, 600 tons). For non-paper contaminants, *organics* (0.6%, 700 tons) and *other film* (0.4%, 400 tons) were the largest components.
- **The proportion of non-paper materials in mixed paper product ranged from 4% to 7%.** Mixed paper samples from each of the four facilities were analyzed separately, providing a range among Puget Sound MRFs.

Table 5: Estimated Composition and Tons of Mixed Paper Product, Four Puget Sound MRFs (2005 tons)

Material	Est. Pct.	+ / -	Est. Tons	Material	Est. Pct.	+ / -	Est. Tons
Paper	**94.6%**		**112,656.3**	**Plastic**	**3.0%**		**3,593.8**
OCC/Kraft Bags	5.8%	1.2%	6,934.5	PETE Bottles and Jars	0.9%	0.1%	1,020.5
Newspaper	26.0%	2.9%	30,978.3	Other PETE Containers	0.2%	0.1%	181.2
Mixed Papers	56.8%	3.4%	67,582.1	HDPE Natural Bottles	0.1%	0.0%	171.8
Wet Strength Boxboard	1.3%	0.1%	1,516.7	HDPE Colored Bottles	0.1%	0.1%	161.1
Polycoated and Aseptic	1.0%	0.2%	1,180.7	HDPE Buckets	0.0%	0.0%	0.0
Dyed, Fluor., Goldenrod	0.1%	0.1%	159.9	Other HDPE Containers	0.1%	0.1%	85.1
Blueprints	0.0%	0.0%	0.0	#3,4,5,7 Bottles	0.0%	0.0%	38.1
Carbon Paper	0.0%	0.0%	16.0	#3,4,5,7 Other Containers	0.2%	0.0%	293.1
Photographic Paper	0.0%	0.0%	36.3	Expanded Polystyrene	0.1%	0.0%	176.5
Hardcover Books	0.5%	0.3%	592.2	Rigid Polystyrene	0.1%	0.1%	178.2
Foil Lined	0.0%	0.0%	32.5	Other Packaging	0.3%	0.1%	394.0
Printed Wrapping Paper	0.0%	0.1%	57.8	Plastic Trash Bags	0.0%	0.0%	43.6
Compostable Paper	0.8%	0.1%	941.3	Grocery/Merch. Bags	0.1%	0.0%	160.1
Shredded Paper	1.4%	1.3%	1,715.6	Non-Bag Packaging Film	0.0%	0.0%	26.3
Paper Composites	0.8%	0.2%	912.7	Film Products	0.0%	0.0%	0.0
				Other Film	0.4%	0.1%	447.2
Metals	**1.2%**		**1,413.0**	Other Plastic Products	0.2%	0.0%	186.9
Aluminum Cans	0.7%	0.1%	809.2	Plastic & Other Materials	0.0%	0.0%	30.1
Other Aluminum	0.1%	0.0%	80.9				
Tinned Food Cans	0.3%	0.1%	360.3	**Organics**	**0.6%**		**688.7**
Other Ferrous	0.1%	0.1%	132.3	Organics	0.6%	0.3%	688.7
Other Non-Ferrous	0.0%	0.0%	5.1				
Mixed Metals	0.0%	0.0%	25.2	**Other Materials**	**0.2%**		**263.5**
Comp. Gas Cylinders	0.0%	0.0%	0.0	Nondistinct Fines	0.2%	0.1%	230.9
				Other Materials	0.0%	0.0%	32.6
Glass	**0.4%**		**460.7**	HHW/Special	0.0%	0.0%	0.0
Container Glass	0.0%	0.1%	50.5				
Glass Cullet	0.3%	0.1%	325.9				
Glass Shards	0.1%	0.0%	75.9				
Other Glass	0.0%	0.0%	8.4				
Number of samples:	**15**			**Total Tons**			**119,076.0**

Table Color Key:

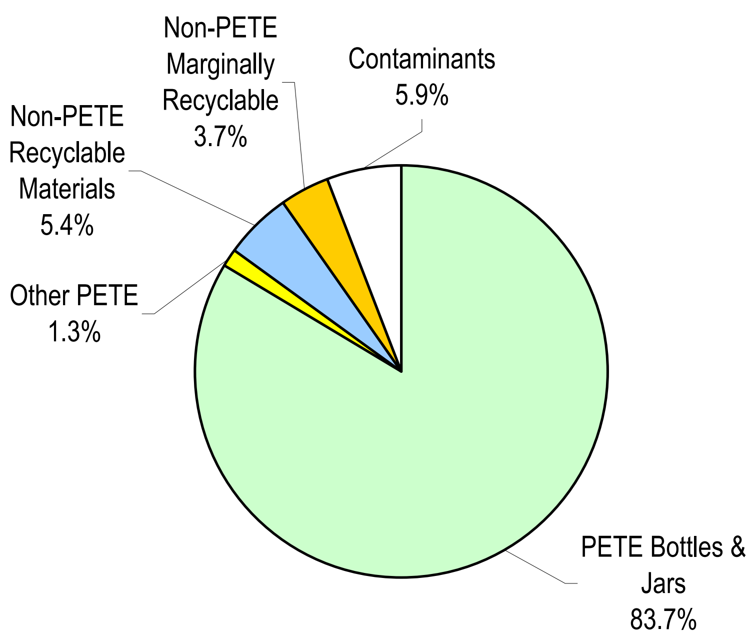
Blue text: Recyclable Materials	Orange text: Marginally Recyclable Materials	Black text: Contaminants
Green highlight: Product	Yellow highlight: Materials Acceptable in Product	

PETE

The PETE product sorted and marketed by each MRF includes all clear or colored polyethylene terephthalate bottles and jars. These containers are narrower at the top than at the bottom and have a neck. When marked for identification, they bear the number 1 in the center of the triangular recycling symbol and may also bear the letters PETE or PET. These containers are usually clear, transparent green, or amber and are commonly used to package water and soft drinks, as well as some brands of liquor, cooking oils, and food (such as peanut-butter).

In 2005, the four Puget Sound area MRFs processed and sold 2,600 tons of PETE. Figure 6 shows the composition of the PETE product sampled, grouped by recyclability. Table 6 shows the composition and tonnage estimates for PETE samples according to the 48 material categories included in this study.

Figure 6: Estimated Composition of PETE Product, Four Puget Sound MRFs



- **About 84% of the PETE sampled consisted of PETE bottles & jars.** This proportion totals 2,200 tons of material.
- ***Other PETE* accounted for a small fraction of the PETE material sampled: 1.3% or 30 tons.** Examples of *other PETE* include opaque black trays used for frozen food packaging and PETE clamshell packaging.
- **About 5% (100 tons) consisted of non-PETE recyclable materials.** Non-PETE recyclable materials primarily includes *HDPE colored bottles* (2.1%, 50 tons) and *HDPE natural bottles* (1.6%, 40 tons).
- **Contaminants in the PETE product stream accounted for 5.9% (200 tons).** *Other plastic packaging* (2.8%, 70 tons) and *organics* (1.8%, 50 tons) comprised the majority of the contaminants in this product stream. Anecdotally, the sorting crew reported that the majority of the *other plastic packaging* consisted of bottle lids, while *organics* primarily consisted of leftover soda and water.

- **Almost 4% (100 tons) of the PETE product stream consisted of non-PETE marginally recyclable materials.** Two materials made up the majority of this category: *#3,4,5,7 other containers* (1.4%, 40 tons) and *#3,4,5,7 bottles* (1.3%, 30 tons).
- **The proportion of non-PETE materials in this product stream ranged from 9% to 19%.** PETE samples from each of the four facilities were analyzed separately, providing a range among Puget Sound MRFs. The sorting crew did not observe operational differences between the four facilities that would explain the performance differences in regards to sorting PETE.

Table 6: Estimated Composition and Tons of PETE Product, Four Puget Sound MRFs (2005 tons)

Material	Est. Pct.	+ / -	Est. Tons	Material	Est. Pct.	+ / -	Est. Tons
Paper	**1.4%**		**36.2**	**Plastic**	**96.2%**		**2,520.9**
OCC/Kraft Bags	0.1%	0.1%	2.6	PETE Bottles and Jars	83.7%	7.4%	2,195.0
Newspaper	0.1%	0.0%	3.9	Other PETE Containers	1.3%	0.8%	33.4
Mixed Papers	0.9%	0.5%	23.2	HDPE Natural Bottles	1.6%	2.3%	42.5
Wet Strength Boxboard	0.1%	0.1%	2.4	HDPE Colored Bottles	2.1%	2.6%	54.2
Polycoated and Aseptic	0.0%	0.0%	0.0	HDPE Buckets	0.7%	0.7%	18.0
Dyed, Fluor., Goldenrod	0.0%	0.0%	0.2	Other HDPE Containers	0.0%	0.0%	0.8
Blueprints	0.0%	0.0%	0.0	#3,4,5,7 Bottles	1.3%	1.2%	34.4
Carbon Paper	0.0%	0.0%	0.0	#3,4,5,7 Other Containers	1.4%	0.8%	36.4
Photographic Paper	0.0%	0.0%	0.0	Expanded Polystyrene	0.1%	0.0%	1.4
Hardcover Books	0.0%	0.0%	0.0	Rigid Polystyrene	0.2%	0.1%	4.2
Foil Lined	0.0%	0.0%	0.0	Other Packaging	2.8%	0.2%	72.2
Printed Wrapping Paper	0.0%	0.0%	0.0	Plastic Trash Bags	0.0%	0.0%	0.0
Compostable Paper	0.0%	0.0%	1.0	Grocery/Merch. Bags	0.0%	0.0%	0.2
Shredded Paper	0.1%	0.0%	2.9	Non-Bag Packaging Film	0.0%	0.0%	0.0
Paper Composites	0.0%	0.0%	0.0	Film Products	0.0%	0.0%	0.5
				Other Film	0.1%	0.0%	3.3
Metals	**0.5%**		**13.9**	Other Plastic Products	0.5%	0.5%	13.1
Aluminum Cans	0.1%	0.0%	2.6	Plastic & Other Materials	0.4%	0.2%	11.5
Other Aluminum	0.0%	0.0%	0.7				
Tinned Food Cans	0.3%	0.4%	8.6	**Organics**	**1.8%**		**47.0**
Other Ferrous	0.0%	0.0%	0.1	Organics	1.8%	0.9%	47.0
Other Non-Ferrous	0.0%	0.0%	0.0				
Mixed Metals	0.1%	0.1%	1.9	**Other Materials**	**0.1%**		**1.6**
Comp. Gas Cylinders	0.0%	0.0%	0.0	Nondistinct Fines	0.1%	0.0%	1.4
				Other Materials	0.0%	0.0%	0.2
Glass	**0.1%**		**2.0**	HHW/Special	0.0%	0.0%	0.0
Container Glass	0.0%	0.0%	0.0				
Glass Cullet	0.0%	0.0%	0.4				
Glass Shards	0.1%	0.0%	1.6				
Other Glass	0.0%	0.0%	0.1				
Number of samples:	**10**				**Total Tons:**		**2,621.7**

Table Color Key:

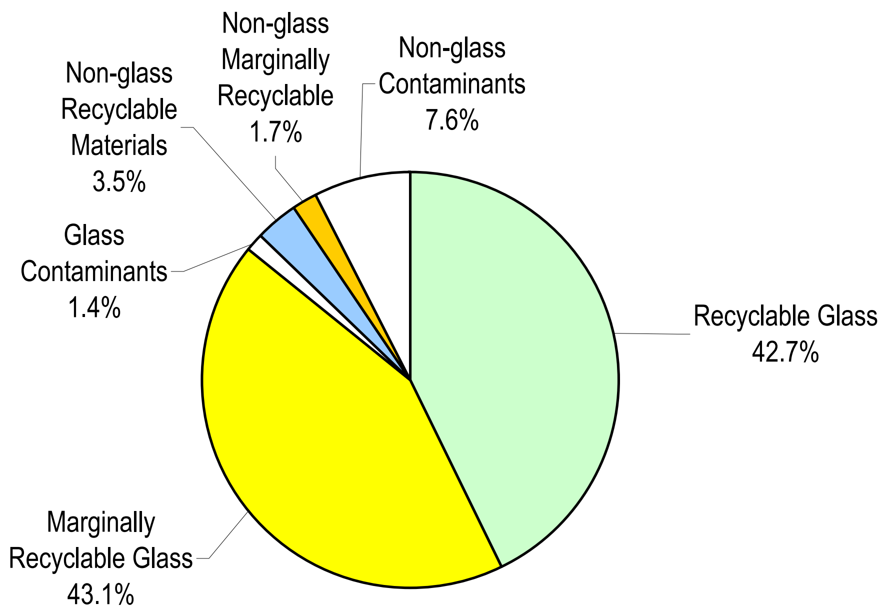
Blue text: Recyclable Materials	Orange text: Marginally Recyclable Materials	Black text: Contaminants
Green highlight: Product	Yellow highlight: Materials Acceptable in Product	

Glass

In the Puget Sound region, glass has traditionally been collected at the curb from residential customers. In some jurisdictions, glass is collected separately from other recyclables, while in other areas glass is included with other recyclables in a single bin. Beginning in 2005, Pierce County stopped collecting glass at the curb; instead, residents must self-haul glass to depots positioned throughout the County. However, the Waste Connections MRF that processes material from Pierce County continues to see some glass in the curbside material collected from residents. This MRF assessment includes glass product delivered to each facility via a commingled stream. Source separated glass (such as from the Seattle, Renton, and Federal Way curbside programs) was not sampled or quantified.

Together, the four Puget Sound area MRFs sold 29,600 tons of glass in 2005. Figure 6 shows the composition of the glass product sampled, grouped by recyclability. Table 7 shows the composition and tonnage estimates for glass samples according to the 48 material categories included in this study.

Figure 7: Estimated Composition of Glass Product, Four Puget Sound MRFs



- **Recyclable glass accounted for less than half (42.7%, 12,600 tons) of glass product sampled.** Recyclable glass includes *glass cullet* and *container glass.* This glass is larger than 1/2 inch and can be recycled into new glass bottles. *Glass cullet* (41.1%, 12,200 tons) accounted for most of the recyclable glass. *Container glass* made up only 1.5% (500 tons) of this product stream. *Glass cullet* includes clear, green, or brown container glass smaller than 2 inches in diameter and larger than ½ inch in diameter. *Container glass* includes glass bottles and jars (whole or in pieces) larger than 2 inches in diameter.
- **Marginally recyclable glass accounted for a larger share than recyclable glass.** The marginally recyclable glass category consists exclusively of *glass shards,* material smaller than ½ inch. Marginally recyclable glass cannot be recycled into new bottles with existing processing technology in King County. Currently, most of this material is used in construction applications. In 2005, an estimated 43.1% (12,800 tons) of the glass product stream consisted of *glass shards*.

- **Glass contaminants comprised 1.4% (400 tons) of the glass product stream.** The only material in this recyclability category, *other glass*, includes items such as window glass, mirrors, light bulbs, and ceramics.
- **In 2005, non-glass contaminants accounted for 7.6% (2,300 tons) of this product stream.** *Other materials* accounted for 2.5% (700 tons), followed by *organics* (1.8%, 500 tons), *other plastic packaging* (0.8%, 200 tons), and *other plastic products* (0.8%, 200 tons).
- **The proportion of non-glass materials in this product stream ranged from 2% to 14%.** Glass samples from each of the four facilities were analyzed separately, providing a range among Puget Sound MRFs.

Table 7: Estimated Composition and Tons of Glass Product, Four Puget Sound MRFs (2005 tons)

Material	Est. Pct.	+ / -	Est. Tons	Material	Est. Pct.	+ / -	Est. Tons
Paper	**5.0%**		**1,489.0**	**Plastic**	**2.7%**		**807.5**
OCC/Kraft Bags	0.5%	0.8%	141.6	PETE Bottles and Jars	0.0%	0.0%	0.0
Newspaper	0.1%	0.1%	26.0	Other PETE Containers	0.0%	0.0%	0.0
Mixed Papers	2.3%	1.2%	691.7	HDPE Natural Bottles	0.0%	0.0%	0.0
Wet Strength Boxboard	0.0%	0.0%	0.0	HDPE Colored Bottles	0.0%	0.0%	0.0
Polycoated and Aseptic	0.0%	0.0%	0.0	HDPE Buckets	0.0%	0.0%	0.0
Dyed, Fluor., Goldenrod	0.0%	0.0%	0.0	Other HDPE Containers	0.0%	0.0%	0.0
Blueprints	0.0%	0.0%	0.0	#3,4,5,7 Bottles	0.0%	0.0%	0.0
Carbon Paper	0.0%	0.0%	0.0	#3,4,5,7 Other Containers	0.0%	0.0%	0.0
Photographic Paper	0.0%	0.0%	0.0	Expanded Polystyrene	0.5%	0.8%	136.6
Hardcover Books	0.0%	0.0%	0.0	Rigid Polystyrene	0.0%	0.0%	0.0
Foil Lined	0.1%	0.2%	32.3	Other Packaging	0.8%	0.7%	231.4
Printed Wrapping Paper	0.0%	0.0%	0.0	Plastic Trash Bags	0.0%	0.0%	0.0
Compostable Paper	0.1%	0.2%	40.1	Grocery/Merch. Bags	0.0%	0.0%	0.0
Shredded Paper	1.6%	0.5%	474.0	Non-Bag Packaging Film	0.0%	0.0%	0.0
Paper Composites	0.3%	0.2%	83.2	Film Products	0.0%	0.0%	0.0
				Other Film	0.7%	0.1%	214.0
Metals	**0.7%**		**205.2**	Other Plastic Products	0.8%	0.6%	225.3
Aluminum Cans	0.0%	0.0%	0.4	Plastic & Other Materials	0.0%	0.0%	0.2
Other Aluminum	0.1%	0.1%	19.3				
Tinned Food Cans	0.0%	0.0%	0.6	**Organics**	**1.8%**		**528.0**
Other Ferrous	0.5%	0.2%	162.8	Organics	1.8%	0.4%	528.0
Other Non-Ferrous	0.0%	0.0%	0.2				
Mixed Metals	0.1%	0.1%	21.9	**Other Materials**	**2.6%**		**766.0**
Comp. Gas Cylinders	0.0%	0.0%	0.0	Nondistinct Fines	0.1%	0.1%	35.0
				Other Materials	2.5%	0.6%	730.9
Glass	**87.2%**		**25,840.0**	HHW/Special	0.0%	0.0%	0.0
Container Glass	1.5%	0.3%	457.7				
Glass Cullet	41.1%	8.5%	12,190.6				
Glass Shards	43.1%	8.3%	12,784.2				
Other Glass	1.4%	1.0%	407.5				
Number of samples:	**10**				**Total Tons:**		**29,635.7**

Table Color Key:

Blue text: Recyclable Materials	Orange text: Marginally Recyclable Materials	Black text: Contaminants
Green highlight: Product	Yellow highlight: Materials Acceptable in Product	

3.2 MRF ASSESSMENT

This section addresses the performance of Puget Sound MRFs. It includes data and the perspectives of end users and material brokers regarding material specifications, product quality, and the effects of contamination in product bales. Based on the characterization data and interviews, this section concludes with recommended performance standards and guidelines. These are designed to minimize the loss of recyclables in residuals and the amount of contamination in MRF products, while permitting Puget Sound MRFs to operate within technological and economic constraints. In sum, this assessment is intended to put to rest any lingering questions regarding whether contamination of commingled recyclables processed in Puget Sound MRFs poses problems for the recycling industry.

3.2.1 ANALYSIS OF INCOMING STREAM

This analysis provides an overview of the contamination and material specific issues and trends associated with commingled recyclables delivered to four Puget Sound MRFs. Findings are based on sampling data presented in Section 3.1 and interviews with MRF operators.

Contamination & Material Specific Issues

Representatives from each of the four MRFs unanimously agreed that the overall level of contamination in the incoming stream, and for three specific materials (glass, shredded paper, and non-recyclable plastics), pose a serious mechanical and economic problem. According to MRF operators, the most problematic materials (in order of priority) are glass, shredded paper, and non-recyclable plastics. In particular, operators complained about the presence of fiber contaminated with glass shards, glass cullet contaminated with paper, shredded paper that clogs star screens during processing, and unacceptable plastics, such as contaminated containers and non-recyclable packaging (e.g., blister packs).

- **Contamination in the incoming stream totaled 7.3% (29,800 tons).** Contaminants primarily included non-recyclable plastics (2.6%, 10,600 tons), non-recyclable paper (2.1%, 8,600 tons), and organics (1.8%, 7,400 tons).
- **Glass is the "number one issue" for MRF processors.** The majority of MRF operators felt that glass should be removed from the current collection system and collected separately at designated drop-off facilities. When collected single-stream, glass containers are broken and shards become embedded in the surrounding fiber throughout collection, transport, and processing. Furthermore, the sand from ground glass wears out belts and machinery. Overall, glass comprised 7.0% of the incoming stream. Despite these relatively small amounts, glass contributes to very sizable problems for MRF operators.
- **Increasing quantities of shredded paper clog screens and contaminate product.** Operators have observed an increase in the amounts of shredded paper present in incoming loads due to confidentiality requirements and the current popularity of home shredding. Shredded paper is too small and light weight to capture with equipment presently used. Instead, it falls through the screens and becomes mixed with glass product or clogs the star screens (which then require frequent replacement). According to the MRF operators, removing shredded paper is difficult and often means sacrificing the recovery of other recyclable materials, including bottle caps and small glass pieces. *Shredded paper* accounted for just 1.1% (4,700 tons) of the incoming material stream.
- **Non-recyclable plastics are a "problem" contaminant.** Non-recyclable plastics accounted for 2.6% (10,600 tons) of incoming material. The sheer volume of these light weight contaminants poses a challenge for MRF operators. Film plastics, in particular, tend to wind around and jam conveyors, causing motors to burn out. Downtime to replace broken machinery proves very costly.

3.2.2 ANALYSIS OF RESIDUAL STREAM

This section examines the residual stream material composition and averaged residual rate for the four Puget Sound MRFs included in the assessment. These data are then compared with benchmark performance metrics developed for other MRFs processing commingled recyclables.

Residual materials are items that remain after processing, which are then disposed of in landfills. Sampling residual material provides an estimate of the recyclables “lost” to the market place due to disposal. An analysis of residual quantities allows for the calculation of the residual rate, a commonly used benchmark in measuring MRF performance. The residual rate is the quantity of residuals divided by the total amount of incoming commingled material.

In 2005, the four Puget Sound area MRFs together disposed of 29,600 tons of residual material. This means a four facility average residual rate of 7.2%. Facility-specific residual rates ranged from a low of 3% to a high of 10%. Except for Portland area MRFs (discussed below), these rates compare favorably with residual rates for other MRFs processing commingled recyclables.

- **Residual rates for commingled MRFs vary widely.** A national unpublished study of thirty MRFs processing commingled materials found that residual rates range from a low of 2-3% to over 30%. The national average residual rate is approximately 15%.
- **The four Puget Sound MRFs perform well, with residual rates lower than MRFs in California**. In a survey conducted for the California Integrated Waste Management Board (CIWMB), the average residual rate for MRFs processing commingled recyclables was 14%. This survey, based on responses from 40 California MRFs, also reported highly variable residual rates: from a low of 2% to a high of 50%. Another study, conducted by Cascadia for a private hauler, found a Bay Area commingled MRFs residual rate exceeded 20%.
- **Portland area commingled MRFs report residual rates of 1% to 2%.** However, these rates are challenged by industry experts who argue that the rates are artificially low due to Portland Metro’s increased focus on reducing MRF residual rates. Industry experts claim that the true quantity of residuals from these MRFs is either simply unreported or passed on to end-users in product bales. Interviews with end-users confirmed this assertion. End-users have found contamination levels in product from the Portland area increasing as agencies there have elevated their focus on residual rates over the last several years.
- **According to MRF operators, “reasonable” residual rates for processing commingled recyclables range from 5% to 10%**. MRF operators view residual rates as largely dependent on the amount of incoming contamination. Incoming contamination is largely, if not entirely, out of the MRF operator’s control. For this reason, a “reasonable” residual rate also depends on the type and source of the recyclables processed. In the view of the MRF operators, incoming recyclables without glass can generally realize a lower residual rate. Also, single-family residential material tends to have less contamination than multi-family and commercial recyclables. The ability to achieve residual rates of 5% to 10% also assumes a high level of processing including a “loop system” where residuals are reprocessed (by being mixed with incoming material) at least once.
- **While Puget Sound MRFs recover over 98% of incoming recyclables, 7,000 tons are still “lost”.** These lost tons are disposed of in the MRF residual stream. Based on the sampling data, recyclables account for 23.7% of the residual stream.
- **Puget Sound MRFs dispose of fewer recyclables than many West Coast MRFs.** In a recent study conducted for the California Integrated Waste management Board (CIWMB), recyclables accounted for 38% of California commingled MRF residuals. Likewise, a study conducted by Cascadia for a Bay Area hauler found that recyclables constituted nearly 40% of residuals for the MRF studied. The fraction of recyclables in the residual stream of Portland area commingled MRFs averaged 20%, with a range from less than 5% to over 35%.
- **The four Puget Sound MRFs capture and landfill over one half (58%) of the incoming contaminants in their residual stream.** Incoming contaminants totaled 29,800 tons, while the quantity of contaminants in the landfilled residual stream totaled 17,000 tons. This means that the MRFs either found secondary markets for some incoming contaminants (such as durable plastic items) or these contaminants end up in product streams.

3.2.3 ANALYSIS OF PRODUCT STREAM

Cascadia conducted interviews with a variety of brokers, processors and end users of recycled newspaper and mixed paper, PETE, and glass. These MRF customers represent both domestic and offshore markets. The following section provides summary conclusions based on these interviews addressing preferred material specifications, operational and financial impacts of off-spec material, and market tolerances for off-spec product.

Paper Specifications, Contamination, and Quality

Interviews with domestic paper mills and offshore paper brokers purchasing recycled newspaper and mixed paper from Puget Sound MRFs offered the following information:

- **Domestic paper mills generally request Paper Stock ISRI specifications for newsprint and mixed paper, but none of their MRF suppliers currently meet these specifications.** To remain competitive, these mills regularly accept material that does not meet ISRI standards. One domestic mill purported, "This is a highly transactional environment…it's relationships, feedback, hopefully improvement, and then you continue to build relationships [with your suppliers]." Another mill that uses recycled newspaper commented, "We've kind of given up [requiring that product meets specifications]. If we rejected based on the #8 ISRI news spec, we would be shut down...the paper would go to other mills." One mill using recycled newspaper reported, "Everybody sends us material with contamination above the ISRI specs." Mills interviewed also mentioned that their high tolerance for off-spec materials is somewhat driven by a desire to retain local suppliers. "We have a couple of goals as a mill – one is to purchase locally," commented one interviewee.
- **Offshore brokers report specifications that tolerate more prohibitives and outthrows than domestic mills.** Offshore mills prefer less than 3-4% prohibitives (non-fiber materials) and outthrows of less than 5% in incoming deliveries of newsprint. The offshore specifications for mixed paper allow for up to 5% prohibitives, and 8% outthrows (e.g., laminated or polycoated paper). In reality, offshore mills are accepting loads with up to 15% prohibitives and outthrows for both newspaper and mixed paper. Domestic mills specify less than 10% outthrows and prohibitives, combined.
- **Puget Sound MRFs do not meet specifications.** According to the sampling data, the level of non-fiber prohibitives in paper bales from the four Puget Sound MRFs ranges from 5.1% in newspaper to 5.4% in mixed paper. These levels exceed the stated specifications for both domestic and offshore markets.
- **The dynamic nature of commodity markets has resulted in two newly proposed paper grades.** With the emergence of more relaxed specifications from offshore markets and the proliferation of paper shredding, the Paper Stock Industries chapter of ISRI is considering adding two new paper grades in 2007 – "shredded office paper" and "residential mixed paper." The shredded office paper grade would allow for twice the level of outthrows and prohibitives currently specified in office paper grades. The residential mixed paper would be comparable with the current grade called soft mixed paper.
- **China Certification and Inspection Group (CCIC) inspectors have never rejected a load of newspaper or mixed paper from Puget Sound MRFs.** China's CCIC program is a formal inspection protocol administered by the national government. Every load of recycled material bound for China is inspected. If inspectors detect more than 10% waste in fiber bales they can reject the load and require shipment back to the U.S. Offshore brokers report that recyclables from Seattle area MRFs have never been rejected because of contamination.
- **Strong incentives exist for MRFs to meet export specifications.** According to the offshore brokers interviewed, companies whose loads are rejected by the CCIC inspectors are placed on a "black list" and may have trouble re-entering the Chinese market. In addition, there is a clear financial incentive for MRFs to send recycled fiber that meets China's standards. If the load reaches China and is rejected, the cost to the MRF is roughly $3,000 for the return trip (versus $250 to send it there).

- **Offshore brokers report that their mills would be more likely to reject loads from Puget Sound MRFs due to moisture than contamination.** Brokers reported that five tons of moisture in 100 tons of recyclable fiber exceeds most offshore mill specifications. However, no material from this region has been rejected by mills on the basis of moisture or contamination.
- **Costs associated with the off-spec material entering domestic mills include disposal fees, labor, equipment replacement and downtime, and the loss of product volume per load delivered.** One domestic mill reported paying approximately $500,000 annually to dispose of garbage. One interviewee commented, "It's very expensive to get rid of the garbage…Pretty much what's happened with the recycling industry is that the cost of disposal has gotten passed on to mills." Another mill is paying approximately $2-4 million annually to replace the 600 tons per day of prohibitives they receive from suppliers. In his words, "Please understand that we pay [the MRF] for the rejected 10%, then we pay for it to be hauled away [and disposed] then we pay again for it to be replaced." Another mill reported, "If we had 2% rejects [in our incoming newspaper stream], we would have a 15% material loss, including the waste ink, ash, and prohibitives. Though 15% is standard, we're experiencing a 20% loss now due to more than 2% rejects. For us, this means lost production, which costs us hundreds of thousands of dollars a year."
- **Domestic mills interviewed unanimously agree that glass poses a major problem because of the sandblasting effect that it has on mill machinery, specifically screening systems.** One mill reported that glass makes up 25%-30% of the contamination coming into their mill. When asked to describe the problems that glass causes, they explained that it gets crushed into quarter-inch chunks after going through their pulper. These glass fines wear down their equipment and are costing them an additional $500,000 each year to replace their screen basket valves. (These costs do not include lost production or the labor for valve replacement.)
- **Domestic mills typically landfill all non-conforming recyclables found in the recycled fiber they process, while offshore mills tend to sort out recyclables by hand before pulping.** Comments from interviewees included:
    - "At this moment, we dispose all non-paper rejects at landfills. We're struggling with this…The metal, we're thinking about whether we could invest electronic devices or magnets to pull this material before it goes into our pulper. Then there's glass that comes out with the staples in our screens – this probably is not a valuable stream to capture for recycling. There is a huge amount of plastic milk jugs that come out of the MRFs. When the plastics come out of our process, they have oily ink attached to their surface. Is this material really recyclable?"
    - "We're not set up for a pick line to sort these materials out before they go through the pulping process. We've considered this possibility, though. It would be a pretty big expense for us."
    - One domestic mill reported that boxboard and wet strength packaging is their biggest outthrow in incoming newspaper bales. They commented that about 70% of this material gets rejected by their pulper because it doesn't pulp up at a fast enough rate. "In our paper, you can see the individual brown threads of Kraft fiber. It's embarrassing."
    - According to offshore brokers, their mill customers typically sort out and recycle aluminum cans, plastic and larger pieces of glass by hand before they enter the pulping process. Plastic bags and other non-paper contaminants are not typically sorted by offshore mills, but are pulped and then disposed.
- **Domestic mills give low quality marks for Puget Sound MRFs for not meeting ISRI specifications; offshore brokers rank MRFs highly, outranking other US MRFs.** Compared to other West Coast commingled MRFs, domestic paper mills rank the quality of recycled fiber from Puget Sound MRFs between 1-3 on a scale of 1-5 (1 being very poor and 5 being very good). Domestic mills ranked the material quality between 1-3, largely because the MRF product bales do not meet ISRI specifications. In sharp contrast, offshore brokers give Puget Sound MRFs a 5 for quality. Offshore brokers compared Puget Sound MRFs with facilities in Oakland (ranked 2), Los Angeles (ranked 3-4) and New York (ranked 2-3). Further, Chinese mills are willing to pay more for recycled paper from Puget Sound MRFs than for paper from other areas of the U.S. Chinese mills find the bales from Puget Sound typically contain less green waste and other garbage than product from other facilities.

PETE Specifications, Contamination, and Quality

The following section summarizes findings based on interviews with processors and brokers that sell recycled PETE bottles to both domestic and offshore markets.

- **Specifications are similar for domestic and overseas markets.** Both markets allow for no more than 2% contamination for PETE bottle stock. Color is also an important consideration. Offshore brokers report that their customers allow up to 30% green or blue colored PETE bottles.
- **According to sampling data, Puget Sound MRFs do not meet contamination specifications.** Based on sampling results, non-PETE contamination averaged 15% in PETE product sampled from the four MRFs.
- **Plastics brokers and processors accept off-spec PETE bales from Puget Sound MRFs.** Though processors and brokers prefer to receive loads with less than 2% contamination, they accept nearly everything they receive, and pay according to material quality. When asked if this region's MRFs meet offshore market specifications, one broker commented: "We don't get any news back to the contrary. Generally, no news is good news. So, the material is within the range of acceptance." Another offshore broker noted that his mills "take everything I send them. Their prices reflect the quality of the material they receive." Another interviewee commented, "We can take anything. We never reject loads; we just downgrade them. First, I give warnings to the supplier if they're not meeting spec. If the problem continues, I downgrade the material. There is a $100 per ton price difference for downgraded plastic [more than 10% contamination] versus material that meets spec."
- **Costs associated with off-spec PETE includes extra sorters and lost profits.** One processor noted that for a 20-ton load he has incurred an increased cost of $600 per day for extra sorters and a $2,000 loss in daily labor costs for sorting contaminants out of product bales.
- **Glass is a serious problem for plastics processors.** At the MRF, glass becomes crushed and embedded in the plastic, making it difficult to separate. According to plastic processors, the only effective way to remove glass fragments from plastic is by melting it. Unfortunately, this process clogs the screen packs. Without glass contamination, plastics processors typically replace screen packs once per day. With glass contamination, they are forced to replace these screens every five minutes. One processor reported costs of an additional $500 per day to replace screen packs due to current levels of glass contamination.
- **Domestic processors generally recycle off-spec materials like other plastics, aluminum, and wire, but dispose of glass and paper residuals.** One processor noted, "We try to recycle as much as possible. Typically, glass and paper gets disposed as garbage." One offshore broker commented, "I didn't see much going to waste in China except for the bottle labels."
- **On a scale of 1 to 5 (1 is very poor and 5 is very good) Puget Sound MRFs ranked 4.** When compared with MRFs in other locales, Puget Sound MRFs scored better (rated 4) than British Columbia (rated 2) and worse than California (rated 5). As one interviewee explained, "I have customers that will not buy PETE bottles from anywhere but California; they believe it's of superior quality because of the bottle bill."

Glass Specifications, Contamination, and Quality

Interviews with processors purchasing container glass from the four Puget Sound MRFs yielded the following information:

- **Processors do not adhere to formal written specifications; loads are inspected on a case-by-case basis.** All processors interviewed said they have no formal specifications. One processor said they accept virtually any glass that enters their facility and adjust payment for the material according to the level of contamination present. Another processor reported that they are very cautious about accepting loads with ceramics and typically accept loads with less than 0.25% ceramics, by weight. If a MRF delivers loads with more than the threshold level of ceramics, the processor may issue a warning to the MRF, pay less for the material, or reject the load altogether to prevent cross contamination with clean glass loads delivered to the facility.
- **Specifications as well as end-user tolerances for off-spec material vary widely depending on the end market.** Glass processors sending materials to bottle manufacturers have a relatively low tolerance for contaminants such as ceramics and metal. If the processor is able to send materials to the construction industry or for landfill cover, their tolerance for contaminants is relatively high.
- **Contaminants such as ceramics and shredded paper pose more challenges than metal and organics.** Glass processors selling material to the glass bottle market identify ceramics as the most critical contaminant. Ceramics compromise the integrity of new bottles by making them easier to break. Shredded paper interferes with optical sorting equipment and poses a problem by sticking to the glass. After sorting, any remaining papers and organics (e.g. corks) are simply burned off in the firing process and are less of a problem for bottle manufacturers than ceramics and metal. During screening, glass processors indicate that small amounts of metal are easily removed by using magnets and eddy currents. However, metals interspersed with glass in the bottle makers' furnaces can damage equipment and interfere with the glass melting process.
- **Glass processors are unable to process fines for bottling markets.** One glass processor noted that 25-30% of the glass they receive from commingled MRFs are "fines" and too small to process. This processor's optical sorting devices are unable to distinguish color in such small particles of glass. While newer optical sorting equipment can handle glass fines, the cost to upgrade is an estimated $225,000 per machine. One glass processor interviewed has three such machines at their facility for handling contaminants and color sorting the glass. While investment in upgraded optical sorting equipment at glass processing facilities may increase material supply for bottling markets, it is important to note that this technology would not reduce equipment wear and product contamination issues caused by glass at the MRFs and non-glass end-users, such as paper mills.[2]
- **Some glass processors blame the shift to commingled recycling for additional operating costs and lower quality material to sell to their customers.** One processor indicated that since taking materials from commingled MRFs, the processing facility's disposal costs have risen 20%. That same processor recently added a pre-processing line to handle the increased contamination from the MRF product, costing the processor an additional $1.5 million each year. In addition, processors indicate they have slowed operations and are paid less by their customers, particularly bottle makers, due to increased contamination.
- **Some processors recover off-spec materials, some do not.** One of the processors interviewed reported recovering recyclable "contaminants" such as plastic containers and aluminum. Paper (largely from bottle labels) is typically landfilled. However, another interviewed processor reported landfilling all off-spec materials delivered to their facility, including plastic and metal bottles, ceramics and paper residuals.
- **On a scale of 1 to 5 (1 is very poor and 5 is very good) glass processors rated Puget Sound MRFs between 2.5 and 4.** One processor mentioned the MRFs would rank as high as 5 if glass was color separated. Another mentioned that they would rank the MRFs higher if they delivered larger pieces of glass because these are easier for their processing equipment to sort. One processor reported that they typically sell about 95 tons for every 100 tons they receive from one of the region's MRFs.

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[2] More detailed information on this issue and associated recommendations can be found in the 2006 Market Assessment Report for Recyclable Materials in King County.

Section 4: Conclusions

This section provides a summary of conclusions, based on the sampling data and interviews of MRF operators, processors, and end-users.

Incoming Stream

- **Glass, shredded paper, and increasing amounts of non-recyclable plastics in the incoming commingled stream pose challenges for Puget Sound MRFs.** These materials adversely affect MRF operations, lead to higher levels of residuals and degrade product quality.
    - **Glass** was cited as the number one processing issue by MRF operators. These operators complained about the presence of fiber contaminated with glass shards. In addition, end-use paper mills reported that glass "sandblasts" equipment and increases operational costs. Plastics processors commented that glass is an issue for them because it clogs their screening equipment.
    - **Shredded paper** is particularly problematic for glass processors. In particular, it interferes with the optical sorting process used to color separate and decontaminate glass for use by bottle makers. MRF operators also complained that shredded paper clogs star screens during processing.
    - **Non-recyclable plastics** contribute significantly to the residual stream as well as contamination in product streams. MRF operators mentioned that unacceptable plastics consisting of contaminated containers and non-recyclable packaging plastics (e.g., blister packs) are an issue for them.
- **Puget Sound MRFs capture and dispose of slightly more than half (58%) of incoming contaminants.** The remainder of incoming contaminants is either marketed as a secondary product (e.g. durable plastic) or ends up in product streams.
- **The anticipated supply of commingled recyclables in 2010 exceeds the current processing capacity.** Appendix E provides additional detail.
    - Forecasted quantities of recyclables based on only population and economic growth (not inclusive of additional recycling programs) show the future supply of recyclables exceeds the current processing capacity. The current system must be expanded. This expansion could include increased operational times at existing facilities, expansion of existing sort lines and/or additional equipment to improve sorting efficiency, or entirely new sorting lines or facilities. One final option is for the existing Puget Sound MRFs to subcontract the processing of some portion of their incoming stream to another party.
    - If MRFs adjust operations and/or invest in additional equipment, potential future processing capacity can accommodate forecasted quantities of recyclables at current economic and population growth rates. It is likely that the future capacity could also accommodate increased quantities resulting from moderately aggressive recycling programs.

Residual Stream

- **Residual rates at the four Puget Sound MRFs compare favorably with residual rates of other MRFs.** Residual rates for the Puget Sound MRFs range from 3% to 10%. Nationally, residual rates range from a low of 2-3% to over 50%. In California, a survey of 40 commingled MRFs found the statewide residual rate averaged 14%.
- **While Puget Sound MRFs recover over 98% of incoming recyclables, 7,000 tons are still "lost".** These lost tons are disposed of in the MRF residual stream.

Product Stream

- **Glass is an issue for all players along the supply chain.** Glass reduces the life of equipment at the MRFs, intermediary processors, and mills/manufacturers. Extensive screening is required by paper mills and plastics processors, which contributes to three major costs: 1) facility downtime, 2) lost labor for repairs, and 3) new parts and equipment. One domestic mill estimates that they spend an additional $500,000 each year solely to replace their screen basket valves.
- **Material specifications vary widely:**
    - Specifications for each MRF product vary depending on grade and global supply and demand for the commodity.
    - Processors and end-users commonly negotiate and adjust the price paid for MRF products depending on quality.
    - Formal specifications (such as ISRI) serve as guidelines and, as one processor put it, "a starting point." However, MRF performance and product quality is almost never measured against ISRI's formal specifications.
    - Relaxed specifications from offshore mills are pushing domestic mills and industry groups such as ISRI to relax material standards. In particular, ISRI's Paper Stock Industries Chapter may include two new paper grades in 2007: "shredded office paper" and "residential mixed paper." These grades would allow for twice the percentage of prohibitives and outthrows of current office paper grades.
    - The ultimate test to determine if MRF products meet specifications is if they sell. The four MRFs included in this assessment all successfully sell material to market. None of the processors or end-users interviewed indicated they had rejected loads from these MRFs.
- **The recycling marketplace is self-policing:**
    - One domestic paper mill purported, "This is a highly transactional environment…it's relationships, feedback, hopefully improvement, and then you continue to build relationships [with your suppliers]."
    - A plastics processor commented, "We can take anything. We never reject loads; we just downgrade them. First, I give warnings to the supplier if they're not meeting spec. If the problem continues, I downgrade the material. There is a $100 per ton price difference for downgraded plastic [more than 10% contamination] versus material that meets spec."
    - Glass processors report that they accept virtually any glass that enters their facility and adjust payment according to the level of contamination in the load.
- **Brokers and end-users, with the exception of domestic paper mills, are generally satisfied with the quality of products from the four Puget Sound MRFs:**
    - Although paper from the four Puget Sound MRFs does not meet stated specifications, offshore paper mills are very satisfied with the paper from Puget Sound MRFs; domestic mills would prefer higher quality fiber, but are relaxing standards.
    - Glass processors are relatively satisfied with material from the region's MRFs. The tolerance for contaminants in glass largely depends on the material's end-use (bottles versus construction applications).
    - Plastics processors and brokers are satisfied with the quality of PETE despite the fact that PETE from the four MRFs fails to meet the 2% contamination level specification. As one broker commented: "We don't get any news back to the contrary…the material is within the range of acceptance."
- **Non-conforming recyclables are recovered by offshore mills and rarely by domestic mills:**

- An estimated 8,400 tons of non-conforming recyclables (e.g., PETE bottles in bales of newspaper) are contained in newspaper, mixed paper, PETE, and glass product marketed by the four Puget Sound MRFs. The vast majority, 7,200 tons, of these recyclables are contained in newspaper and mixed paper bales.
- From the sampling data, recyclables found in fiber product (newspaper and mixed paper combined) include *PETE bottles and jars* (2,300 tons), *HDPE colored and natural bottles* (1,400 tons), *aluminum cans* (1,300 tons), *tinned food cans* (900 tons), *glass cullet* (800 tons), *container glass* (400 tons), and *ferrous and non ferrous metal* (200 tons).
- Based on interviews with the MRF operators and fiber brokers, virtually all of the mixed paper and an estimated 75% to 80% of the newspaper from the Puget Sound region are currently sold to offshore markets.
- With relatively low-cost labor, offshore mills recover plastic, metal, and larger glass pieces from the fiber bales they import from the U.S. This means an estimated 6,000 tons of non-conforming recyclables are recycled by off-shore end-users.
- Labor costs for domestic mills are relatively higher, and these mills cannot afford to pick non-conforming recyclables before pulping. As a result, 2,000 to 4,000 tons of non-conforming recyclables are currently "lost" through landfilling. This represents less than 1% of the incoming commingled materials delivered to the four Puget Sound MRFs.

Section 5: Issues and Recommendations

This section presents the consultant's recommendations that are designed to address five key issues identified in the previously presented research. The five issues include:

1. **The adverse impact of glass shards and fines in incoming, process, and product streams,**
2. **Contamination in incoming streams,**
3. **The loss of recyclables in the residual streams landfilled by the four Puget Sound MRFs,**
4. **Prohibitives in product streams, and**
5. **The loss of recyclables in product streams produced by the four Puget Sound MRFs.**

Each of these issues along with the associated recommendations and objective of each are described below. Figure 8, below, also depicts the flow of recyclables analyzed by this study, the identified issues, and recommended actions.

Figure 8. Summary of Material Streams, Issues, and Recommendations

INCOMING STREAM

Issues:

- Contamination

Recommendations for improving the incoming stream:

- Initiate education programs to eliminate contamination
- Promote uniform countywide list and definitions of recyclables

PROCESSING

Issues:

- Glass
- Contamination removal
- Loss of recyclables

Recommendations for improving the residual stream:

- Separate glass
- Adopt MRF performance standards:
  - Loss of recyclables: RR/IR< 2%
  - Removal of contamination: RC/IC > 75%

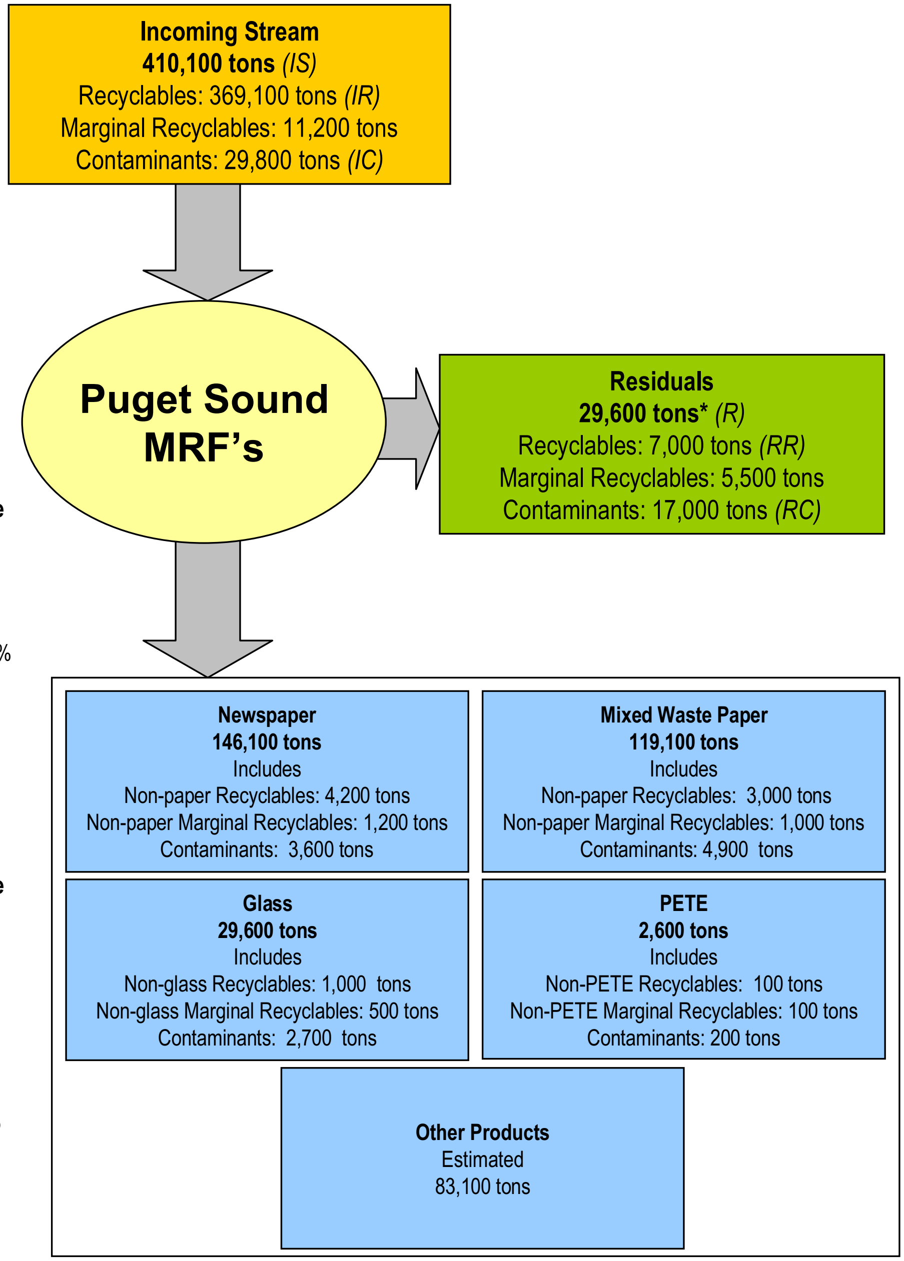
PRODUCT STREAM

Issues:

- Glass
- Prohibitives
- Loss of recyclables

Recommendations for improving the product stream:

- Separate glass
- Initiate education programs to eliminate contamination
- Promote uniform countywide list and definitions of recyclables
- Adopt MRF performance standards:
  - Removal of contamination: RC/IC > 75%



* Components do not sum to total recyclables due to rounding.

5.1 ISSUE 1: THE ADVERSE IMPACT OF GLASS SHARDS AND FINES IN INCOMING, PROCESS, AND PRODUCT STREAMS AT PUGET SOUND MRFS

Glass in commingled recycling streams adversely affects MRFs, mills, and other end-users. Glass contributes to higher equipment replacement costs and is considered to be the "number one" issue by most Puget Sound MRF operators. Domestic paper mills also complain about glass and report that the excessive amount of fines, attributed to commingled collection, "sandblasts" equipment and adds hundreds of thousands of dollars to annual operating and maintenance costs. Plastics processors also report that glass fragments become embedded in plastic and are difficult and expensive to remove. In addition, glass processors are unable to sort small fines for bottle markets, the highest and best use for recycled glass.

5.1.1 RECOMMENDATIONS

The objective of the following recommendations is to initiate a process for separating glass in single-stream collection programs.

Convene a hauler/processor forum to identify an acceptable strategy for separating glass in single-stream collection programs. The purpose of this forum would be to discuss and identify the best long term strategy for removing glass from incoming streams at Puget Sound MRFs, and from the product streams produced by these MRFs. Solutions may include:

- Not collecting glass
- Implementing a dual stream system
- Implementing a system of drop-off sites
- Enhancing front-end processing at MRFs

Considerations in this assessment should include collection, processing, and end-user economics plus sustainability issues such as green-house gas emissions. King County would take the lead in convening the private sector stakeholders including all affected King County haulers and processors in a facilitated discussion designed to identify the optimal strategy for removing glass from incoming commingled streams.[3]

Develop a plan for separating glass in single-stream collection programs. As a second step in this process, the County would develop a plan for implementing new collection or processing programs in King County that would achieve the "optimal strategy" identified by private stakeholders in the above proposed forums. Alternative collection programs for glass such as dual stream or drop-off sites as well as improved processing may need to be developed. Since these new programs would affect both unincorporated and incorporated areas of the County and require the cooperation of Seattle and other King County cities, representatives from all the affected entities would need to be involved, possibly through an inter-jurisdictional working committee

Work with key stakeholders including Seattle and other King County municipalities to implement new or modified collection and /or processing programs. Once a plan is formulated and approved by the key stakeholders, the County would coordinate efforts with Seattle and other King County cities to implement the desired programs through new or amended hauler contracts and service level ordinances. The objective of this effort would be to promote the highest degree of consistency among collection programs while ensuring that opportunities for glass recycling are available to all King County residents.

[3] In the 2006 Market Assessment Report for Recyclable Materials in King County, Cascadia recommended King County and its partners convene a glass "summit" to maximize the potential for color-separated, bottle-to-bottle glass recycling. The hauler/processor forum recommended here would address a separate issue—equipment wear and product contamination issues caused by glass at the MRFs and non-glass end-users, such as paper mills. There is certainly overlap in the stakeholders for both issues. As such, it would be reasonable to assume efforts for both the forum and "summit" could occur simultaneously.

5.2 ISSUE 2: CONTAMINATION IN INCOMING STREAMS

Incoming contaminants that are not captured by the MRFs and disposed of in the residual stream end up in product shipped to end-users. These contaminants degrade product quality and contribute to increased end-user costs for additional cleaning, sorting and disposal. In addition, contaminants that are captured as part of the residual stream make up nearly 60% of these streams from the four Puget Sound MRFs, and contribute significantly to MRF operating costs.

5.2.1 RECOMMENDATIONS

The objective of these recommendations is to establish a uniform set of standard county-wide recyclables with consistent definitions and supporting education programs designed to reduce contamination in incoming recycling streams.

Promote a standard, uniform set of recyclable materials across the cities and county. Efforts to standardize recyclable materials across the County and to provide consistent definitions would help reduce contamination in incoming recyclables. Constant changes overtime and differences from community to community create confusion among residents. In particular, the differences between which plastics are recyclable and non-recyclable from city to city appear to be a key source of confusion for the public. Conflicting messages regarding shredded paper also lead to confusion and contamination; some customers are told to put it in their yard waste bin while others are told that it belongs in the recycling bin.

Initiate education programs and improve materials to consistently and clearly define what materials are recyclable and what materials are not. An effective education program would help to eliminate much of the contamination in products shipped to end-users as well as significant quantities of MRF residuals. The education program would need to emphasize the importance of eliminating contamination, and clearly identify and define both recyclable and non-recyclable materials. Consistent definitions, graphics and messages regarding recyclability will be key to the success of this initiative. This campaign also would benefit greatly through cooperation and assistance from the hauling and processor community. In addition, the County should request help and financial assistance from industry to support the campaign; both the paper and plastics industry would benefit from cleaner product streams and should be encouraged to share in the costs of effective solutions.

5.3 ISSUE 3: THE LOSS OF RECYCLABLES IN THE RESIDUAL STREAMS LAND FILLED BY THE FOUR PUGET SOUND MRFS

Despite the efforts of Puget Sound MRFs to recover all incoming recyclables, 7,000 tons are still “lost” and disposed of in the MRF residual stream. While Puget Sound MRFs dispose fewer recyclables than many other West Coast MRFs, the percent of valuable incoming recyclables that are currently land filled with other residuals range from 1% to 3%.

5.3.1 RECOMMENDATIONS

The objective of the following recommendation is to minimize and prevent further losses of valuable recyclables in the residual streams from the four Puget Sound MRFs.

Adopt MRF performance standards to prevent the loss of recyclables in residual streams. The conventional approach to controlling the loss of recyclables is to set an overall maximum limit on the amount of allowable residuals. However, residual rates are driven in large part by the quantity of incoming contaminants and marginally recyclable materials and cannot be directly controlled by MRF operators. Industry experts in the Portland Metro area also suggest that setting limits on overall residuals drives contaminants into product streams. An approach that is more direct in preventing the loss of recyclables and one that is controllable by MRF operators is to set the maximum level of recyclables permitted in MRF residual streams, as compared to placing limits on the overall stream.

The proposed metric should be expressed as a maximum allowable percentage of incoming recyclables. Based on current performance levels, a reasonable maximum for recyclables in the residual streams of single-stream MRFs is about two percent of incoming recyclables. Effective implementation of this proposed standard can only be achieved through specific contract provisions that carefully define the requirements as well as the associated reporting and enforcement mechanisms. Reporting and enforcement would require audits of incoming tonnages and periodic sampling of incoming and residual streams.

5.4 ISSUE 4: PROHIBITIVES IN PRODUCT STREAMS

The level of non-fiber prohibitives (including both contaminants and non-conforming or other recyclables) in paper bales from Puget Sound MRFs exceeds desirable levels for both domestic and offshore markets. The percentage of non-fiber prohibitives from the four surveyed Puget Sound MRFs ranged from 1% to 13% in newspaper and mixed paper. While offshore mills have more tolerant specifications than domestic mills, they would prefer less than 3% to 4% of non-fiber prohibitives in recycled paper bales. Likewise, non-PETE contaminants averaged 15% in bales from the four Puget Sound MRFs, far exceeding reported market specifications.

5.4.1 RECOMMENDATIONS

The objective of the recommendation below is to limit the amount of contaminants that could potentially degrade products from the four Puget Sound MRFs.

Adopt MRF performance standards to control the amounts of incoming contaminants that end up in product streams. This issue of contaminants in end products is directly related to the failure of MRFs to capture incoming contaminants that then flow through processing systems and compromise the quality of product streams. This issue can be effectively controlled by developing performance standards <u>that require prescribed levels of incoming contaminant removal.</u>

The governing metric should be defined in terms of a percentage of incoming contaminants. Based on current performance levels, a reasonable target for contaminant removal would be 60% to 70% of all incoming contaminants.

Effective implementation of these standards can only be achieved through specific contract provisions that carefully define the requirements as well as the associated reporting and enforcement mechanisms. Reporting and enforcement would require audits of incoming tonnages and periodic sampling of incoming and residual streams.

5.5 ISSUE 5: THE LOSS OF RECYCLABLES IN PRODUCT STREAMS PRODUCED BY THE FOUR PUGET SOUND MRFS

An estimated 8,400 tons of non-conforming recyclables (not including marginal recyclables) are contained in the newspaper, mixed paper, PETE, and glass products marketed by Puget Sound MRFs. Much of this material (virtually all mixed paper and 75% to 80% of newspaper) is sold to offshore mills where non-conforming recyclable materials, based on our research, are ultimately recovered. The recyclable materials that are “lost” through landfilling are largely contained in products shipped to domestic mills that cannot afford to recover these materials. Our research indicates that an estimated 2,000 to 4,000 tons of recyclable materials are land filled rather than recycled at domestic mills and end users. The bottom line is that these “lost” tons represent less than 1% of all commingled recyclables processed by the four Puget Sound MRFs, a relatively small loss of high valued recyclables.

5.5.1 RECOMMENDATIONS

The objective of this recommendation is to avoid costly public sector intervention in a self regulating market that appears to be functioning well.

Let the market determine product specifications, prices, and acceptance policies. Performance standards designed to regulate product quality are not recommended. Specifications for each of the products examined in this study are highly dynamic. They change with cyclical supply and demand fluctuations, vary from market to market, are different for each end-user, and may even be adjusted from transaction to transaction. Fundamentally, processors and end users buy the commodities Puget Sound MRFs produce. This is the truest proof that MRFs meet real world, market driven specifications. Outright rejection of product by end-users is rare and the costs to MRFs of not meeting these market driven specifications is very high. These costs include being “black listed” by offshore markets or having to pay for the rejected material’s return trip and re-processing. These costs provide an effective deterrent to excessive levels of both contaminants and non-conforming recyclables in product streams. Public sector product standards would constitute a secondary overlay of specifications that could not possibly capture the subtle vagaries of the “real” and constantly changing market place. As a result, they would most likely be ignored or circumvented in the absence of an onerous and costly enforcement regime.

Section 6: Barriers to Meeting Performance Standards

MRF operators may encounter barriers in meeting the above proposed performance standards. These include increasing contaminant levels in incoming streams, capacity constraints, and the capital and operating costs associated with meeting these standards. Each of these is described below:

- **Increasing contaminant levels —** With the continuing migration to commingled collection systems for both residential and commercial generators, increasing levels of contamination are unavoidable. If these trends continue, if more glass is added to commingled programs, and if customers are not better informed about what is unacceptable in these programs, it will become more and more difficult for MRFs to meet the proposed contamination removal standards.
- **Capacity Constraints —** The four Puget Sound MRFs are processing increasing amounts of commingled recyclables and consequently face through-put constraints. Slowing down the sorting process or adding new sorting stages to remove contaminants and reduce the loss of recyclables could, in the short term, prevent MRFs from processing current and near-term future amounts of inbound materials. This would have the effect of creating significant stockpiles of unprocessed materials that could exceed the physical storage capacity at these sites and lead to violations of current permitting requirements. In the long term, the MRFs likely would add capacity to handle greater amounts of recyclables, which would add to processing costs.
- **Cost —** Many of these MRFs have invested significantly in both capital and increased operating costs (or are planning to do so) in order to reduce residual levels and clean up product streams. Further improvements to meet the recommended performance standards could prove to create financial burdens that are not justified under current rates and contracts.

Appendix A: SAMPLING MATERIAL DEFINITIONS

PAPER

1. **Corrugated Cardboard (OCC/Kraft Bags)—**Kraft linerboard, containerboard cartons and shipping boxes with corrugated paper medium (unwaxed). This category also includes Kraft (brown) paper bags. Excludes waxed and plastic-coated cardboard, solid boxboard, and bags that are not pure unbleached Kraft.
2. **Old Newspaper (ONP)—**printed groundwood newsprint and other minimally bleached groundwood. Includes newspaper inserts.
3. **Mixed Papers—**papers such as white ledger, colored ledger, computer cards, copy machine paper, manila folders and envelopes, junk mail, windowed and non-windowed envelopes, magazines, thermal copy paper (NCR paper), receipts, post-it-notes, fax paper, toilet paper and paper towel tubes. This category also includes other recyclable papers used in packaging, including chipboard and other solid boxboard (non-wet strength boxboard only).
4. **Wet Strength Boxboard—**coated boxboard commonly used for soda and beer packaging and frozen pizza boxes.
5. **Polycoated and Aseptic—**paper packaging made of bleached and unbleached paperboard coated with film. This includes polycoated milk and juice containers, frozen food containers, ice cream boxed and cartons, and aseptic juice and soup containers, including those with plastic spouts attached.
6. **Dyed, Fluorescent, Goldenrod—**heavily dyed papers such as Astrobrights.
7. **Blueprints—**drafting papers commonly used in architectural and engineering designs.
8. **Carbon Paper—**paper coated on one side with a layer of a loosely bound dry ink or pigmented coating, usually bound with wax. It is used for making one or more copies simultaneous with the creation of an original document.
9. **Photographic Paper—**glossy, coated papers used for photographs.
10. **Hardcover Books—**books with an inflexible, hard exterior cover.
11. **Foil Lined—**papers lined with foil (excluding aseptic packaging) such as juice concentrate, microwave trays with foil lining, and fast food wrappers.
12. **Printed Wrapping Paper—**gift wrapping paper.
13. **Compostable Paper—**includes waxed paper/cardboard, tissues and paper soiled with food, such as paper plates, pizza boxes, and paper towels.
14. **Shredded Paper—**paper of any type that has been shredded.
15. **Paper Composites—**items that are primarily paper, but combined with other materials, such as juice cans and Crisco cans with metal bottoms attached, oil cans, metal-bound notebooks, and other similar packages or products.

GLASS

16. **Container Glass—**bottles or jars, of any color, used for food, soft drinks, beer, and wine. If broken, the piece must be larger than 2 inches in diameter.
17. **Glass Cullet—**broken container glass, of any color, smaller than 2 inches in diameter and larger than ½ inch in diameter.

18. **Glass Shards—**broken container glass smaller than ½ inch in diameter.
19. **Other Glass—**window glass, mirrors, light bulbs, cooking wear, and other glass and ceramic products which are not easily recyclable.

METALS

20. **Aluminum Cans—**beverage cans composed of aluminum only.
21. **Other Aluminum—**other types of aluminum containers such as pans and trays; includes foil and foil products or packages and all other aluminum materials including furniture, house siding, cookware, lids from aluminum cans, and scrap.
22. **Tinned Food Cans—**tin-plated steel cans (food cans) and their lids, does not include other bi-metals such as cat food cans, paint cans, or other type of steel cans.
23. **Other Ferrous—**ferrous and alloyed ferrous scrap materials derived from iron, including household, industrial, and commercial products including empty aerosol and other cans and containers. This category includes scrap iron and steel to which a magnet adheres, and stainless steel to which a magnet does not adhere. Metals that are significantly contaminated are not included.
24. **Other Non-Ferrous—**metals that are not materials derived from iron, including copper, brass, bronze, aluminum bronze, lead, pewter, zinc, and other metals to which a magnet will not adhere. Metals that are significantly contaminated are not included.
25. **Mixed Metals and Other Materials—**composite metal products and metals combined with other materials, such as engines, electric motors, umbrellas, coated wire, and aerosol cans.
26. **Compressed Gas Cylinders—**metal gas tanks and cylinders most often used to contain propane or butane.

PLASTICS

27. **PETE Bottles and Jars—**all clear or colored PETE (polyethylene terephthalate) bottles and jars. These containers are narrower at the top than at the bottom and have a neck. When marked for identification, it bears the number 1 in the center of the triangular recycling symbol and may also bear the letters PETE or PET. The color is usually clear, transparent green, or amber. A PETE bottle usually has a small dot left from the manufacturing process, not a seam. It does not turn white when bent. Examples include soft drink and water bottles, some liquor bottles, cooking oil bottles, aspirin bottles, and some food jars such as peanut-butter, pastry containers, and similar items.
28. **Other PETE Containers—**PETE (polyethylene terephthalate) containers (other than bottles and jars). When marked for identification, it bears the number 1 in the center of the triangular recycling symbol and may also bear the letters PETE or PET. A PETE container usually has a small dot left from the manufacturing process, not a seam. Examples include opaque black trays used for frozen food packaging and non-food clamshell packaging.
29. **HDPE Natural Bottles---**natural HDPE (high-density polyethylene) bottles and jars. These containers are narrower at the top than at the bottom and have a neck. This plastic is cloudy white, allowing light to pass through it. When marked for identification, it bears the number 2 in the triangular recycling symbol. Examples include milk jugs, water jugs, and some juice bottles.
30. **HDPE Colored Bottles—**HDPE Colored Bottles means colored HDPE (high-density polyethylene) containers and jars. These containers are narrower at the top than at the bottom and have a neck. This plastic is a solid color, preventing light from passing through it. When marked for identification, it bears the number 2 in the triangular recycling symbol. Examples include detergent bottles, some shampoo and hair-

care bottles, empty motor oil, empty antifreeze, and other empty vehicle and equipment fluid bottles, and some food containers such as for coffee and non-dairy creamer.

31. **HDPE Buckets—**all types of HDPE (high-density polyethylene) buckets used for food or other product packaging, or other uses. This plastic is usually a solid color, preventing light from passing through it. When marked for identification, it bears the number 2 in the triangular recycling symbol on the bottom of the bucket.

32. **Other HDPE Containers—**HDPE (high-density polyethylene) containers not included above. When marked for identification, it bears the number 2 in the triangular recycling symbol. Examples include some margarine, cottage cheese, and yogurt tubs.

33. **#3, #4, #5, #7 Bottles—**bottles and jars made of types of plastic other than HDPE (high-density polyethylene), PETE (polyethylene terephthalate), or PS (polystyrene). These containers are narrower at the top than at the bottom and have necks. Items may be made of PVC (polyvinyl chloride), LDPE (low-density polyethylene), PP (polypropylene), or mixed resins. When marked for identification, these bottles bear the number 3, 4, 5, or 7 in the triangular recycling symbol. Examples include bottles for some salad dressings, vegetable oils, juices, syrups, shampoos, and vitamins.

34. **#3, #4, #5, #7 Other Containers—**plastic containers (other than bottles and jars) made of types of plastic other than HDPE (high-density polyethylene), PETE (polyethylene terephthalate), or PS (polystyrene). Items may be made of PVC (polyvinyl chloride), LDPE (low-density polyethylene), PP (polypropylene), or mixed resins. When marked for identification, these items bear the number 3, 4, 5, or 7 in the triangular recycling symbol. Examples include food containers such as flexible and brittle yogurt cups, some margarine tubs, microwave food trays, clamshell-shaped food containers, and soda crates.

35. **Expanded Polystyrene—**expanded polystyrene packaging, food trays, cups, plates, clamshells, and other packaging.

36. **Rigid Polystyrene—**rigid polystyrene packaging of any type such as food trays, clamshells, yogurt containers, and CD cases.

37. **Other Packaging—**all other non-film packaging that does not fit into the above categories including caps, closures, and other miscellaneous items.

38. **Plastic Trash Bags—**plastic bags sold for use as trash bags, for both residential and commercial use. Does not include other plastic bags like shopping bags that might have been used to contain trash.

39. **Plastic Grocery and Other Merchandise Bags—**plastic shopping bags used to contain merchandise to transport from the place of purchase, given out by the store with the purchase. Includes dry-cleaning plastic bags intended for 1-time use.

40. **Non-Bag Commercial and Industrial Packaging Film—**film plastic used for large-scale packaging or transport packaging. Examples include shrink-wrap, mattress bags, furniture wrap, and film bubble wrap.

41. **Film Products—**plastic film used for purposes other than packaging. Examples include agricultural film (films used in various farming and growing applications, such as silage greenhouse films, mulch films, and wrap for hay bales), plastic sheeting used as drop cloths, and building wrap.

42. **Other Film—**other plastic film that does not fit into any other type. Examples include other types of plastic bags (sandwich bags, zipper-recloseable bags, newspaper bags, produce bags, frozen vegetable bags, bread bags), food wrappers such as candy-bar wrappers, mailing pouches, bank bags, X-ray film, metallized film (wine containers and balloons), and plastic food wrap.

43. **Other Plastic Products—**primarily rigid or solid consumer items including dishware, utensils and other household items, straws and other single-use plastic cutlery, vinyl products, all-plastic furniture and toys, car parts, and hangers. Also includes thermoset plastics such as formica, fiberglass, and foam materials, consisting primarily of polyurethane, used for carpet padding, packaging, and other applications (not including insulation).

44. **Plastic and Other Materials—**items that are predominantly made of plastic, but are combined with other materials, such as kitchenware and car parts with wood or metal components.

ORGANICS

45. **Organics** includes all of the following materials**:**

Dimensional Lumber/Engineered Wood—both clean and painted wood commonly used in construction for framing and related uses, including 2 x 4's, 2 x 6's, and sheets of plywood, strandboard, and particle board. Includes pallets and crates.

Treated Wood—wood treated with preservatives such as creosote, including dimension lumber. This category may also include some treated plywood, strandboard, chemically treated wood and other wood.

Contaminated Wood—wood contaminated with other wastes in such a way that they cannot easily be separated, but consisting primarily (over 50 percent) of wood. Examples include wood with sheetrock attached.

Roofing and Siding Wood—painted or unpainted wood from demolition or construction waste that is commonly used for siding or roofing buildings. This category includes only wood products, such as cedar shingles or shakes.

Stumps—stumps of trees and shrubs, with any adhering soil.

Large Prunings—other natural woods, such as logs and branches in excess of four inches in diameter (four inches is the limit used for defining prunings as yard wastes).

Yard Wastes—leaves, grass clippings, garden wastes, and brush up to four inches in diameter.

Other Wood—other types of wood including wood products that do not fit into the above categories.

Food Wastes—leftovers and wastes from food preparation. Includes food in the original or other container when the container weight is less than 10% of the total weight, and liquids poured out from bottles and other containers.

Textiles: Clothes & Other Recyclables—fabric materials including natural and man-made textile materials such as cottons, wools, silks, woven nylon, rayon, polyesters and other materials. This category includes clothing, rags, curtains, and other fabrics.

Other Textiles—carpets/upholstery, shoes, and other nonrecyclable products including leather products.

Disposable Diapers—diapers and similar products made from a combination of fibers, synthetic, and/or natural, and made for the purpose of a single use. Diapers that are all cloth and not originally intended for single use will be classified as a textile. This category includes fecal matter contained within, sanitary napkins and tampons, and adult disposable protective undergarments.

Rubber Products (except tires and foam rubber)—items made of natural and synthetic rubber, including door mats, car parts, hoses, toys, and other products.

Tires—whole tires from automobiles, trucks, motorcycles, bicycles, and other vehicles.

Animal Carcasses—carcasses of small animals and pieces of larger animals, unless the waste is the result of food storage or preparation.

Animal Feces—feces from animals including kitty litter and bedding.

Miscellaneous Organics—hair, wax, soap, and other organics not otherwise classified.

OTHER MATERIALS

46. **Nondistinct Fines—**soil, sand, dirt, grit, and similar nondistinct materials.
47. **Other Materials** includes all of the following materials:

Construction/Demolition Waste (except wood)—construction, demolition, or land clearing waste that cannot be placed into one of the above categories, such as concrete, plaster, rocks, gravel, bricks, asphalt shingles and non-wood roofing materials, and insulation of various types (including foam, fiberglass etc.).

Ashes—material remaining after the combustion process, present in the waste stream as ash from fireplaces and wood stoves, used charcoal from grills, and similar materials.

Gypsum Wallboard—calcium sulfate dihydrate sandwiched between heavy layers of Kraft-type paper.

Furniture/Mattresses—furniture and mattresses made of mixed materials and in any condition.

Household Appliances—small household appliances such as stereos, radios, toasters, broilers, can openers and blenders.

Printers/Copiers/Fax Machines—computer printers (both inkjet and laser), facsimile machines, and photo copying machines.

Office Electronics—items such as computer central processing units (CPUs), scanners, personal digital assistants (PDAs), and computer peripherals including keyboards and mouses.

Miscellaneous Inorganics—non-construction plaster of paris, concrete items, rock, and materials not otherwise classified.

HOUSEHOLD HAZARDOUS / SPECIAL WASTE

48. **Household Hazardous / Special Waste** includes all of the following materials:

Used Oil—used lubricating oils, primarily used in cars but including other types with similar characteristics and oil filters.

Vehicle Batteries—car, motorcycle, and other lead-acid batteries used for motorized vehicles.

Household Batteries—batteries of various sizes and types, as commonly used in households, excluding alkaline and button cell batteries.

Alkaline/Button Cell Batteries—alkaline and button cell batteries.

Latex Paint—water-based paints and similar products.

Oil-Based Paint—solvent-based paints, varnishes, and similar products.

Solvents and Thinners—various solvents, including chlorinated and flammable solvents, paint strippers, solvents contaminated with other products such as paints, degreasers and some other cleaners if the primary ingredient is (or was) a solvent, and alcohols such as methanol and isopropanol.

Adhesives and Glue—glues and adhesives of various sorts, including rubber cement, wood putty, glazing and spackling compounds, caulking compounds, grout, and joint and auto body fillers.

Cleaners and Corrosives—various acids and bases whose primary purpose is to clean surfaces, unclog drains, or perform other actions.

Pesticides and Herbicides—variety of chemicals whose purpose is to discourage or kill pests, weeds, or microorganisms. Fungicides and wood preservatives, such as pentachlorophenol, are also included.

Gasoline and Fuel Oil—gasoline, diesel fuel, and fuel oils.

Antifreeze/Brake Fluid—automobile and other antifreeze mixtures based on ethylene or propylene glycol; also brake and other automotive fluids (except motor oil)

Medical Waste—wastes related to medical activities, including syringes, intravenous (I.V.) tubing, bandages, medications, and other wastes.

Computer Monitors—computer monitors.

Televisions—televisions.

Cell Phones—cellular telephones.

Laptops/LCD Monitors—Liquid crystal display (LCD) and flat-screen monitors, and laptop and notebook computers that contain these types of monitors.

Mercury-containing waste—items that contain mercury, such as thermometers, thermostats, fluorescent lamps and tubes, jewelry and mercury switches.

Other Hazardous Waste—asbestos-containing wastes if this is the primary hazard associated with the waste; gunpowder, unspent ammunition, picric acid and other potentially explosive chemicals; radioactive materials (smoke alarms are classified as "other plastic"); and other wastes that do not fit into the above categories.

APPENDIX B: DETAILED METHODOLOGY

Sampling Plan

This Sampling Plan details the process by which Cascadia staff collected sampling data from the Material Recovery Facilities (MRFs) included in the assessment.

Facilities Sampled

The MRFs selected for the assessment include four regional facilities processing single stream and dual stream material from King County and surrounding jurisdictions. The facilities include:

- Allied Waste's Rabanco Recycling Center (Third and Lander) in Seattle,
- Waste Management's Cascade Recycling Center in Woodinville,
- Smurfit-Stone's Reclamation Plant in Renton, and
- Waste Connection's Recycling Center in Tacoma.

Sampling Schedule

Each facility was sampled during two consecutive week-days in April. Operations staff at each facility received no more than 72 hours notice before sampling began. Table B-1 shows the schedule of sampling activities.

Table B-1: Schedule of Sampling Activities

3rd and Lander	Cascade	Smurfit-Stone	Waste Connections
April 24 and 25	April 13 and 14	May 3 and 4	May 9 and 10

Obtaining Samples

At each facility, sampling staff coordinated with the facility operations manager to ensure unbiased samples were safely obtained. The following sections detail the process of obtaining incoming material, residual material, and product samples.

Incoming Material Samples

A total of 25 incoming material samples from co-mingled loads was sorted, seven from Cascade and six from each of the remaining facilities. For each sampling day, three (four during Day 1 at Cascade), 125 pound samples of incoming material was randomly chosen for sorting. Using the random number generator in MS Excel, three times (four times during Day 1 at Cascade) between 8:00 am and 3:55 pm were randomly selected for each sampling day. The first incoming vehicle that arrived after the selected time was selected for sampling. Table B-2 shows the randomly selected times for each sampling day.

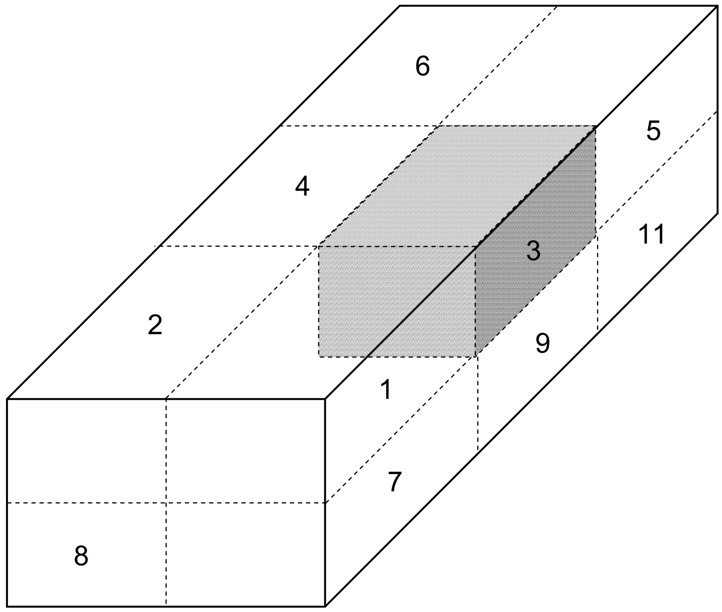
Table B-2: Incoming Vehicle Sampling Times by Day

3rd and Lander		Cascade		Smurfit-Stone		Waste Connections	
Day 1	Day 2	Day 1	Day 2	Day 1	Day 2	Day 1	Day 2
10:10 AM	9:00 AM	11:55 AM	9:05 AM	9:05 AM	9:10 AM	8:15 AM	8:05 AM
10:45 AM	10:30 PM	12:10 PM	3:15 PM	10:15 AM	2:55 PM	12:10 PM	11:05 AM
11:30 AM	2:05 PM	12:55 PM	3:30 PM	11:30 AM	3:15 PM	12:15 PM	11:25 AM
		2:15 PM					

When the randomly selected vehicle arrived, the Sampling Manager interviewed the driver and recorded on the sampling form the load's jurisdiction of origin (city or unincorporated area) and sector (single-family, multi-family, or commercial). However, samples were not stratified by sector and loads from any jurisdiction were considered eligible for sampling.

Once the vehicle dumped the load of recyclables, the Sampling Manager visually divided the load into 12 cells, as illustrated in Figure B-1.

Figure B-1: Visual Overlay Showing "Cells" of Material



The Sampling Manager then communicated with the facility's loader operator to scoop 125 pounds from the randomly selected portion of the load. The randomly selected cell was generated using the RANDBETWEEN function in MS Excel. The cells selected for each sample are shown in Table B-3.

Table B-3: Randomly Selected Cells

3rd and Lander

Day	Sample #	Sampling Time	Cell
Day 1	1	10:10 AM	6
	2	10:45 AM	8
	3	11:30 AM	5
Day 2	4	9:00 AM	3
	5	10:30 PM	5
	6	2:05 PM	2

Smurfit-Stone

Day	Sample #	Sampling Time	Cell
Day 1	14	9:05 AM	1
	15	10:15 AM	1
	16	11:30 AM	10
Day 2	17	9:10 AM	2
	18	2:55 PM	3
	19	3:15 PM	1

Cascade

Day 1	Sample #	Sampling Time	Cell
	7	11:55 AM	8
	8	12:10 PM	1
	9	12:55 PM	8
	10	2:15 PM	11
Day 2	**Sample #**	**Sampling Time**	**Cell**
	11	9:05 AM	10
	12	3:15 PM	7
	13	3:30 PM	3

Waste Connections

Day 1	Sample #	Sampling Time	Cell
	20	8:15 AM	8
	21	12:10 PM	10
	22	12:15 PM	2
Day 2	**Sample #**	**Sampling Time**	**Cell**
	23	8:05 AM	12
	24	11:05 AM	6
	25	11:25 AM	4

If the sorting crew was located on-site, the sampled material was transported by the loader operator directly to the sorting area and placed on a tarp. If the sorting crew was off-site, the loader operator placed the sample into a toter, a roll-off box, or a dump truck for delivery to the sorting location. In any scenario, the Sample Manager ensured all of the selected material, and only the selected material, was appropriately transported to the sorting location.

Residual Material Samples

During each sampling day, 125 pound samples of residual material were randomly chosen for sorting. A total of 25 residual material samples were sorted, six to seven from each facility.

The residual sampling protocol was determined for each individual facility. Facility tours informed the Sampling Manager of the number of residual ejection points present at each of the four MRFs. Residuals may have been sampled at one ejection point at the end of the sorting line or from the container where residuals from multiple points along the sorting line (under screens or hand picked off the belt) are aggregated for disposal.

If selecting samples from one ejection point at the end of the sorting line, samples were selected according to a randomly selected time. Using the random number generator in MS Excel, randomly selected times during each sorting event was selected by the Sampling Manager. At the selected time, residual material coming off the MRFs processing line was collected in toters. The toters were then transported to the sorting location.

At facilities where there are multiple ejections points, samples were obtained from the waste container where material is aggregated for disposal. Residual samples obtained from waste containers were randomly selected by visually subdividing the container into cells (see Figure B-1 above). Using the RANDBETWEEN function in MS Excel, the Sampling Manager randomly selected a cell, and obtained a 125 pound sample. The Sampling Manager ensured that the sample represented a vertical slice of material from the cell. This prevented sampling bias by capturing lighter materials, which tend to settle on the top, and smaller heavier materials, which tend to settle to the bottom.

Product Samples

Across the four facilities, a total of 50 samples of product were sorted. The products included in this assessment, the number of samples, and sample sizes are as follows[4]:

- PETE bottles: 10 samples (2-3 per facility), 45 pounds per sample.
- Newspaper: 15 samples (3-4 per facility), 125 pounds per sample.
- Mixed paper: 15 samples (3-4 per facility), 125 pounds per sample.
- Glass: 10 samples (2-3 per facility), 3-26 pounds per sample depending on the size of the broken glass.

Depending on the facility, samples of product were either obtained from baled material or were sampled just prior to baling as material cascaded from the sort line into a hoper or bailer. To sample glass, a third sampling method was used.

To obtain samples from baled material, the Sampling Manager first assessed the total number of bales present by product type, and assigned a number (1-x) to each bale. Then, using the RANDBETWEEN function in MS Excel, the Sampling Manager randomly selected 2-4 bales of each product. The Sampling Manager then communicated with the facility's loader operator to obtain the randomly selected bales. The selected bales were transported to the sorting location (if on-site) or placed on a tarp in a roll-off box or dump truck for transport to the off-site sorting location. In either case, the Sampling Manager ensured that all the material, and only the selected material, was appropriately transported to the sorting area.

Once at the sorting location, the bales were placed on a tarp. Again using the RANDBETWEEN function in MS Excel, a randomly selected vertical slice of the bale was selected for sampling. The "slice" included a complete cross section of the bale, from top to bottom, to ensure that any small or loose contaminants that may have settled during processing, compaction, or transport to the sorting location were appropriately captured in the sample. Figure B-2 shows the visual grid that the Sample Manager used to obtain the randomly selected portion of the product bale.

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[4] Sample sizes were determined using statistical calculations developed in Design & Management for Resource Recovery: Volume 3, Quantitative Decision-Making, by Albert J. Klee, 1980, Ann Arbor Science Publishers Inc., Ann Arbor, MI. To determine optimal sample weight for process streams, our analysis used the exponential function $Y=Xe^{0.146X}$.

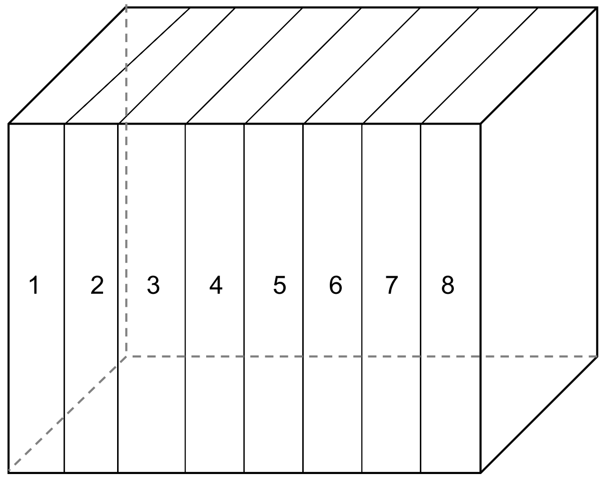
Where:

Y = the optimal sample weight in pounds

X = the characteristic particle size of the material to be sampled, in inches (the "characteristic particle size" is defined as the screen size at which 63.2% of the material passes through)

e = a constant, 2.71828182845904, which is equal to the base of the natural logarithm

Figure B-2: Visual Overlay Showing Portions of Baled Product



To obtain samples of product prior to baling, samples were selected according to a randomly selected time. Using the random number generator in MS Excel, randomly selected times during each sorting event were selected by the Sampling Manager. At the selected time, product material coming off the MRFs processing line was collected in toters. The toters were then transported to the sorting location.

Since processed glass is not baled, the bunkers housing the glass were visually divided into cells, as in Figure B-1. Using the RANDBETWEEN function in MS Excel, the sample manager randomly selected portions of the glass in the bunker for sampling. The glass was shoveled into 5-gallon buckets for transportation to the sorting area.

Sorting Samples

All samples of material, regardless of their type (incoming material, residual material, or product) were sorted using the same four step methodology, outlined below. All material was hand sorted from a custom built table that included a two inch screen, a ½ inch screen, and a base to collect material smaller than ½ inch.

Step 1: Review methodology and sorting categories with the crew. Before the sampling began, all sorting crewmembers reviewed the material definitions in detail. The material definitions are included as Appendix A.

Step 2: Sort Sample Material Larger than 2". The entire sample was placed onto the sorting table and the crew hand-sorted material larger than 2 inches in diameter into the prescribed material categories. The Field Crew Manager then verified the purity of each material component as it was weighed, and recorded the data on the Sample Sheet.

Step 3: Weigh and Subsample 2" to ½" Material. The material falling through the 2 inch screen, but suspended above the ½ inch screen was then collected and weighed. The total weight of this material was recorded on the Sample Sheet. If the total weight was three pounds or less, all material was subsorted. If the 2 inch to ½ inch material totaled more than 3 pounds, using the cone and quarter method, a sub-sample weighing 2.7 pounds was selected and then sorted according to the prescribed material categories. The Field Crew Manager verified the purity of each material component as it was weighed, and recorded the data on the Sample Sheet.

Step 4: Weigh and Subsample Material Smaller than ½". The material falling through the ½ inch screen was collected and weighed. The total weight of this material was recorded on the Sample Sheet. If the total weight was one pound or less, all of the material was subsorted. If the ½ inch minus material totaled more than one pound, using the cone and quarter method, a sub-sample weighing .60 pounds was selected and sorted according to the prescribed material categories. The Field Crew Manager verified the purity of each material component as it was weighed, and recorded the data on the Sample Sheet.

Step 5: Review Data. At the conclusion of each sorting day the Field Crew Manager conducted a quality control review of the data recorded.

APPENDIX C: COMPOSITION CALCULATIONS

To develop waste characterization and quantity profiles for this study, four main steps were taken. These steps are as follows:

1. Calculate the estimated composition of all samples for each material stream at each facility, based on the sample weight.
2. Combine the results from all facilities for each material stream, using a weighted average procedure.
3. Apply tonnage figures for waste to the composition estimates, to derive tonnage estimates for each material.

Composition Calculations

The composition estimates represent the **ratio of the material categories' weight to the total waste** for each material stream at each facility. They are derived by summing each material's weight across all of the selected records and dividing by the sum of the total weight of waste, as shown in the following equation:

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

where:

c = weight of a particular material

w = sum of all material weights

for i = 1 to n

where n = number of selected samples

for j = 1 to m

where m = number of material categories

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 material and total sample weights). The **variance of the ratio estimator** equation follows:

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

where:

$$\overline{w} = \frac{\sum_i w_i}{n}$$

Second, **precision levels** at the 90% confidence interval are calculated for a material's mean as follows:

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

where:

t = the value of the t-statistic (1.645) corresponding to a 90% confidence level

For more detail, please refer to Chapter 6 “Ratio, Regression and Difference Estimation” of Elementary Survey Sampling by R.L. Scheaffer, W. Mendenhall and L. Ott (PWS Publishers, 1986).

Weighted Averages

Each material stream’s composition estimates were calculated by performing a weighted average of that material stream across the four facilities. Because the tonnage estimates from each facility are proprietary, the weighting percentages that were used to perform the composition calculations are not listed in this report. The weighted averaging method is described below.

The **weighted average for an overall composition estimate** is performed as follows:

$$O_j = \left(p_1 * r_{j1} \right) + (p_2 * r_{j2}) + (p_3 * r_{j3}) + \ldots$$

where:

p = the proportion of tonnage contributed by the noted sample group

r = ratio of material weight to total waste weight in the noted sample group

for j = 1 to m

where m = number of material categories

The **variance of the weighted average** is calculated:

$$VarO_j = (p_1{}^2 * \hat{V}_{r_{j1}}) + (p_2{}^2 * \hat{V}_{r_{j2}}) + (p_3{}^2 * \hat{V}_{r_{j3}}) + \ldots$$

APPENDIX D: FIELD FORMS

This appendix presents field forms used in this study in the following order:

- 2 Inch Plus Sample Sheet
- 2 Inch to ½ Inch Sample Sheet
- 2 Inch Minus Sample Sheet
- Sample Tracking Sheet
- Sample Placard

King County MRF Sampling
2 Inch Plus Sample Sheet

Paper	1 OCC/Kraft Bags			
	2 Newspaper			
	3 Other Groundwood			
	4 Mixed Papers			
	5 Wet Strength Boxboard			
	6 Polycoated and Aseptic			
	7 Dyed, Fluor., Goldenrod			
	8 Blueprints			
	9 Carbon Paper			
	10 Photographic Paper			
	11 Hardcover Books			
	12 Foil Lined			
	13 Printed Wrapping Paper			
	14 Compostable Paper			
	15 Shredded Paper			
	16 Paper Composites			
Glass	17 Container Glass			
	18 Glass Cullet			
	19 Glass Shards			
	20 Other Glass			
Metals	21 Aluminum Cans			
	22 Other Aluminum			
	23 Tinned Food Cans			
	24 Other Ferrous			
	25 Other Non-Ferrous			
	26 Mixed Metals			
	27 Comp. Gas Cylinders			

Plastics	28 PETE Bottles and Jars			
	29 Other PETE Containers			
	30 HDPE Natural Bottles			
	31 HDPE Colored Bottles			
	32 HDPE Buckets			
	33 Other HDPE Containers			
	34 #3,4,5,7 Bottles			
	35 #3,4,5,7 Other Containers			
	36 Expanded Polystyrene			
	37 Rigid Polystyrene			
	38 Other Packaging			
	39 Plastic Trash Bags			
	40 Grocery/Merch. Bags			
	41 Non-Bag Packaging Film			
	42 Film Products			
	43 Other Film			
	44 Other Plastic Products			
	45 Plastic & Other Materials			
Or.	46 Organics			
Other	47 Nondistinct Fines			
	48 Other Materials			
	49 HHW/Special			

Sample ID: ____________________

Circle One: PETE MP Incoming

News Glass Residual

Sample Wt: ____________________

King County MRF Sampling
2 Inch to 1/2 Inch Sample Sheet

Paper	1 OCC/Kraft Bags			
	2 Newspaper			
	3 Other Groundwood			
	4 Mixed Papers			
	5 Wet Strength Boxboard			
	6 Polycoated and Aseptic			
	7 Dyed, Fluor., Goldenrod			
	8 Blueprints			
	9 Carbon Paper			
	10 Photographic Paper			
	11 Hardcover Books			
	12 Foil Lined			
	13 Printed Wrapping Paper			
	14 Compostable Paper			
	15 Shredded Paper			
	16 Paper Composites			
Glass	17 Container Glass			
	18 Glass Cullet			
	19 Glass Shards			
	20 Other Glass			
Metals	21 Aluminum Cans			
	22 Other Aluminum			
	23 Tinned Food Cans			
	24 Other Ferrous			
	25 Other Non-Ferrous			
	26 Mixed Metals			
	27 Comp. Gas Cylinders			

Plastics	28 PETE Bottles and Jars			
	29 Other PETE Containers			
	30 HDPE Natural Bottles			
	31 HDPE Colored Bottles			
	32 HDPE Buckets			
	33 Other HDPE Containers			
	34 #3,4,5,7 Bottles			
	35 #3,4,5,7 Other Containers			
	36 Expanded Polystyrene			
	37 Rigid Polystyrene			
	38 Other Packaging			
	39 Plastic Trash Bags			
	40 Grocery/Merch. Bags			
	41 Non-Bag Packaging Film			
	42 Film Products			
	43 Other Film			
	44 Other Plastic Products			
	45 Plastic & Other Materials			
Or.	46 Organics			
Other	47 Nondistinct Fines			
	48 Other Materials			
	49 HHW/Special			

Sample ID: ____________________

Circle One: PETE MP Incoming
News Glass Residual

Total 2"-1/2" Wt: ____________________

2"-1/2" Sample Wt: ____________________

King County MRF Sampling
1/2 Inch Minus Sample Sheet

Paper	1 OCC/Kraft Bags			
	2 Newspaper			
	3 Other Groundwood			
	4 Mixed Papers			
	5 Wet Strength Boxboard			
	6 Polycoated and Aseptic			
	7 Dyed, Fluor., Goldenrod			
	8 Blueprints			
	9 Carbon Paper			
	10 Photographic Paper			
	11 Hardcover Books			
	12 Foil Lined			
	13 Printed Wrapping Paper			
	14 Compostable Paper			
	15 Shredded Paper			
	16 Paper Composites			
Glass	17 Container Glass			
	18 Glass Cullet			
	19 Glass Shards			
	20 Other Glass			
Metals	21 Aluminum Cans			
	22 Other Aluminum			
	23 Tinned Food Cans			
	24 Other Ferrous			
	25 Other Non-Ferrous			
	26 Mixed Metals			
	27 Comp. Gas Cylinders			

Plastics	28 PETE Bottles and Jars			
	29 Other PETE Containers			
	30 HDPE Natural Bottles			
	31 HDPE Colored Bottles			
	32 HDPE Buckets			
	33 Other HDPE Containers			
	34 #3,4,5,7 Bottles			
	35 #3,4,5,7 Other Containers			
	36 Expanded Polystyrene			
	37 Rigid Polystyrene			
	38 Other Packaging			
	39 Plastic Trash Bags			
	40 Grocery/Merch. Bags			
	41 Non-Bag Packaging Film			
	42 Film Products			
	43 Other Film			
	44 Other Plastic Products			
	45 Plastic & Other Materials			
Or.	46 Organics			
Other	47 Nondistinct Fines			
	48 Other Materials			
	49 HHW/Special			

Sample ID: ____________________

Circle One: PETE MP Incoming

News Glass Residual

Total 1/2" Minus Wt: ____________________

1/2" Minus Sample Wt: ____________________

King County MRF Sampling
Sample Tracking

Incoming		Date	SampleID
	Cascade		1
	Cascade		2
	Cascade		3
	Cascade		4
	Cascade		5
	Cascade		6
	Cascade		7
	3rd and Lander		8
	3rd and Lander		9
	3rd and Lander		10
	3rd and Lander		11
	3rd and Lander		12
	3rd and Lander		13
	Smurfit		14
	Smurfit		15
	Smurfit		16
	Smurfit		17
	Smurfit		18
	Smurfit		19
	Waste Connections		20
	Waste Connections		21
	Waste Connections		22
	Waste Connections		23
	Waste Connections		24
	Waste Connections		25

Residuals		Date	SampleID
	Cascade		101
	Cascade		102
	Cascade		103
	Cascade		104
	Cascade		105
	Cascade		106
	3rd and Lander		107
	3rd and Lander		108
	3rd and Lander		109
	3rd and Lander		110
	3rd and Lander		111
	3rd and Lander		112
	3rd and Lander		113
	Smurfit		114
	Smurfit		115
	Smurfit		116
	Smurfit		117
	Smurfit		118
	Smurfit		119
	Waste Connections		120
	Waste Connections		121
	Waste Connections		122
	Waste Connections		123
	Waste Connections		124
	Waste Connections		125

PETE

201

Sample Wt:_______________

Appendix E: REGIONAL MRF CAPACITY ANALYSIS

INTRODUCTION

The four Puget Sound MRFs included in this assessment adjust capacity in direct proportion to incoming material supply. This supply is largely driven by processing contracts with municipalities in King County as well as the surrounding region. To conduct an analysis of MRF capacity, Cascadia interviewed representatives at each of the four facilities. These interviews sought to gauge the industry's perceptions about the region's future supply of recyclables and opportunities for the existing facilities to adjust capacity accordingly.

FINDINGS

The following bullets summarize key findings from the interviews:

- Each facility currently operates at or near full capacity.
- Interviewees universally foresee an increasing supply of recyclables from the region. Increased supply can be attributed to population and economic growth as well as increasingly aggressive recycling programs and goals.
- Increasing supplies of recyclables from municipalities outside of King County (such as Snohomish, Pierce, and other counties), may have a greater impact on future capacity than increases from King County.
- In 2005, King County recyclables (excluding the City of Seattle) represented an estimated 72% of the incoming material accepted at the four MRFs.
- To increase processing capacity, the four Puget Sound MRFs can:
    - Increase the amount of time the facility operates. Facilities cannot, however, operate 24 hours a day, seven days a week, since facility downtime is required for maintenance.
    - Invest in equipment to expand existing sort lines and/or improve the sorting efficiencies of existing sort processes.
    - Add entirely new sorting lines or facilities.
    - Subcontract the processing of some portion of their incoming stream to another party.
- The following table shows current and forecasted tons of commingled recyclables from King County and the region as a whole. The table also includes capacity for the four Puget Sound MRFs in 2005 and potential future capacity if the four facilities increased operational time, invested in additional equipment, and/or incorporated new sort lines. The future capacity does not take into account the potential for added capacity if the MRFs constructed an entirely new facility or if they subcontracted the processing to a third party.

	Actual 2005 Tons	Forecasted 2010 Tons	% Increase	Source of Forecasted 2010 Tonnages
Commingled Recyclables from King County (excluding the City of Seattle)	296,700	341,500	15%	King County staff projections based on population and economic growth (not inclusive of recycling program changes)
Commingled Recyclables from All Jurisdictions (including King County and the City of Seattle)	410,100	472,000	15%	Calculated estimate assuming the supply of recyclables from all jurisdictions will match the increase in supply from King County.
Current & Future MRF Capacity	410,100	640,000	56%	Based on information collected in the capacity analysis interviews. Includes increases in capacity if MRFs increase operational time, invest in additional equipment, and/or incorporated new sort lines. Does not include future potential capacity if MRFs construct entirely new facilities or subcontract processing.

CONCLUSIONS

Interviews with MRF operators and the results of the capacity analysis point to the following three key conclusions:

- Puget Sound MRFs anticipate growth in the supply of commingled recyclables and are poised to handle progressively larger volumes of material.
- Forecasted quantities of recyclables based on only population and economic growth (not inclusive of additional recycling programs) show the future supply of recyclables exceeds the current processing capacity. The current system must be expanded to meet future needs.
- If MRFs adjust operations and/or invest in additional equipment, potential future processing capacity can accommodate forecasted quantities of recyclables at current economic and population growth rates. It is likely that the future capacity could also accommodate increased quantities resulting from moderately aggressive recycling programs.