C&D Residuals Sampling Protocol Results &Evaluation

Technical Memorandum

Seattle Public Utilities

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1. Introduction

Background

In December of 2012, the City of Seattle adopted Ordinance 124076, which banned the disposal of certain recyclable construction and demolition (C&D) materials, established a C&D processing facility certification program, and required that all permitted C&D projects submit a Waste Diversion Report within 60 days of final inspection approval. To comply with this ordinance and receive compliance certification, C&D processing facilities must ensure that they do not send banned materials to landfill.

The C&D material disposal bans will occur in three phases, as detailed below and effective on the dates noted, with enforcement beginning one year later.

- Phase 1: concrete, asphalt paving, bricks (effective: 1/1/12)
- Phase 2: metal, carpet, cardboard, plastic film wrap, new construction gypsum scrap (effective: 1/1/14)
- Phase 3: unpainted/untreated wood, tear-off asphalt shingles (effective: 1/1/15)

Characterizing the residuals from C&D processing facilities is essential to determining facility compliance with the landfill bans. In this study, Cascadia evaluated two residual sampling protocols (a weight-based, hand sort protocol and a volume-based, visual protocol) to determine the best method for measuring the quantity of banned materials in the residuals stream.

Study Objectives

The objective of this study was to evaluate a protocol to effectively and efficiently measure the amount of banned materials in the residual stream at C&D processing facilities. At each facility that Cascadia visited for this study, the sampling team performed a weight-based characterization and a volume-based characterization for the same residual samples. Then, the team evaluated each protocol by comparing the results of each characterization to determine each method's relative accuracy, rating each protocol's feasibility and the impact on the facility, and measuring the time to characterize each sample for each method. To determine accuracy, the evaluation assessed the reliability of the visual method compared to the weighing method: for this assessment, we assumed that the weighing method was accurate, so any visual results deviating from the weigh-based results were considered inaccurate.

This document presents the results of the protocol testing process. It includes composition results overall, by facility, and by individual residual streams within each facility, as well as an evaluation of the two sampling protocols. This report also includes our recommendations for the characterization and sample selection methods, the number of samples required per quarter, the size thresholds for banned materials, flexibility for material ban adherence, and sampling staff requirements.

2. Testing Process

Overview

This section summarizes Cascadia's process for testing the two residual sampling protocols (weighing method and visual method). The testing process assessed how effectively each of the protocols measures the amount of banned materials the residual streams from a mixed C&D material processing facility.

The residual stream testing process consisted of four steps: Plan and Organize Testing, Select Samples, Characterize Samples, and Analyze Data and Prepare Technical Memorandum. Each of these steps is summarized below.

1. Plan and Organize Testing

Prior to testing the sampling protocols, Cascadia visited each of the four mixed C&D facilities included in this study. While on-site, Cascadia staff worked with facility staff to plan testing procedures to minimizing disruptions to normal facility operations. During the facility site visits, Cascadia staff also identified the residuals streams at each facility, the number and weight of samples required to ensure a representative sample of each stream, and the appropriate sampling method for each stream – Direct Load or Stockpile Method. For detailed explanation of the protocols Cascadia tested, please see the attachments in Appendix 1: Residuals Testing Plan. Refer to Appendix A-1: Material Definitions and Size Thresholds for definitions of the components included in the testing.

The following four mixed C&D facilities were included in this study:

- CDL Recycle
  7201 East Marginal Way S Seattle, WA 98108
- Waste Management's Glacier Recycle Facility
  32300 148th Ave SE Auburn, WA 98092
- Recovery 1
  1805 Stewart Street Tacoma, WA 98421
- Republic Services' Black River Facility
  501 Monster Rd Renton, WA 98059

2. Select Samples

Cascadia tested the sampling protocols over three contiguous weeks, beginning in May, with one day of sampling occurring in June. Field staff visited each facility once per week for a total of three days of testing at each facility. Field staff selected eight samples per facility per day using one of the following two methods:

Stockpile Method

- Field staff visually imposed a 16-cell grid on the stockpiled residual stream.

- Staff then extracted one grab sample from three random cells of the stockpile (cell numbers were preselected prior to sampling). Three grab samples were used to produce a single, composite sample.
- Staff then weighed each composite sample and recorded the net weight onto appropriate field forms.

Direct Load Method

- Cascadia staff directed facility staff to level residual material loaded in a transfer trailer to create a roughly rectangular shape.
- Staff then visually imposed the 16-cell grid over the transfer trailer.
- Cascadia worked with facility staff to extract one grab sample each from three random cells of the trailer (cell numbers were preselected prior to sampling). Three grab samples were used to produce a single, composite sample.
- Staff weighed each composite sample and recorded the net weight onto appropriate field forms.

3. Characterize Samples

Figure 1. Sample Characterization

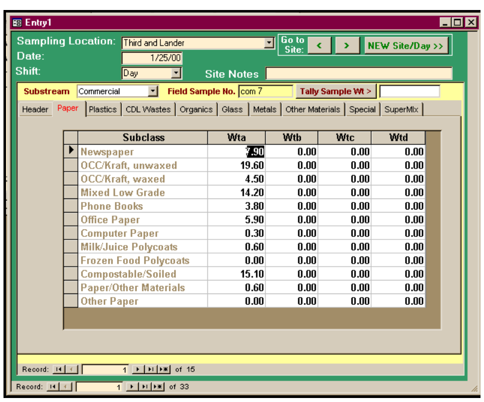
Cascadia field staff characterized a total of 94 samples from the residual streams at all four facilities. Staff characterized each sample into 16 distinct material components using both the weighing and visual based protocols. The 16 components included eight types of materials, with two size specifications for each material. These material types are the materials banned from landfill, and the size specifications represent how large a piece of the material must be to be banned from landfill disposal. The eight material components in the size specifications listed in **Table 1.** Banned Material Sizing are the materials banned from disposal. The remaining eight material components not listed in **Table 1** are below the size threshold listed in the table, and are not banned from landfill disposal. See Appendix A-1: Material Definitions and Size Thresholds for further detail and component definitions.

In the field, Cascadia staff first used the visual protocol to estimate the volume of the banned materials in the sample. Then; field staff used the weighing protocol to hand sorted the sample and weigh banned materials. At the conclusion of each sorting day, the field crew manager conducted a quality control review of the recorded data.

Table 1. Banned Material Sizing

Material	Size Threshold
Concrete/asphalt paving/bricks	>6" in its longest dimension
Metal	>6" in its longest dimension
Carpet	12" in its **shortest** dimension
Cardboard	>8" in its longest dimension
Plastic film wrap	12" in its **shortest** dimension
New construction gypsum scrap	>6" in its longest dimension
Unpainted/untreated wood	>6" in its longest dimension
Tear-off shingles	>8" in its longest dimension

4. Analyze Data and Prepare Technical Memorandum



- Following each sampling event, all sort data was entered into a customized database.
- Entered data was re-checked against the paper forms to eliminate data entry errors.
- At the conclusion of the study, residual stream composition estimates were calculated by aggregating sampling data using a weighted average procedure.
- The results are documented in this Technical Memorandum.

Please refer to the composition calculations in Appendix 1 (listed separately for each protocol: Weighing Composition Calculations and Volume Composition Calculations) and Converting Volumes to Weights in Appendix 2 (only listed for the volume protocol) for a description of the calculation methodologies staff used to prepare the results presented in this memorandum.

3. Residuals Testing Results

This section presents results of Cascadia's evaluation of the weighing and visual protocols. The evaluation includes comparing the results of each characterization method to determine each method's relative accuracy, rating each protocol's feasibility and the impact on the facility, and measuring the time to characterize each sample for each method. Composition estimates for banned materials that resulted from the evaluation process are also provided.

Average Facility Impact & Feasibility

At the end of each sampling day, Cascadia staff completed an assessment of the practicality of each method to characterize C&D processing facility residual streams from each of the four facilities. Cascadia qualified practicality by two criteria – impact and feasibility. **Impact** is defined as the effect of each method on a facility's resources and daily operations. **Feasibility** measured the viability of performing each protocol at facilities under normal operating conditions, including variables like access to materials for sampling.

Table 2 presents the results of the evaluation of the practicality of each method; this assessment includes all of the facilities and residual stream samples characterized, and averages the practicality of both protocols. The average impact to facilities was assessed on a scale of one (low impact) to three (high impact). Cascadia determined the average impact of the protocols was 1.75; the utilization of facility staff and equipment to perform the actions outlined in the protocols accounted for this impact. The average feasibility of performing the protocols was assessed on a scale of one (very feasible) to three (unfeasible). Cascadia evaluated the feasibility of completing the protocols as 1.25 because neither protocol caused significant disruption to normal facility operations. Ultimately, Cascadia determined that both protocols are feasible with moderate impacts to facility operations.

Table 2. Average Facility Impact & Feasibility

	Averages	
Facility	**Impact on Facility***	**Sampling Feasibility****
Facility #1	1	1
Facility #2	2	1
Facility #3	2	2
Facility #4	2	1
All Facilities	**1.75**	**1.25**

*1 is low impact and 3 is high impact

**1 is very feasible and 3 is unfeasible

Average Time Requirements for Sample Collection & Characterization

Cascadia tracked the time required to collect and characterize each sample to measure the time investment requirements for each protocol. Results of the time-based analysis for all of the facilities and residual stream samples collected and characterized are shown in **Table 3.** Sample collection took the same amount of time for both the weighing and visual methods (10:32), since field staff performed both protocols on each collected sample. The average time for sample characterization using the weighing method (12:35) was about one minute more than the visual method (11:42).

Table 3. Average Time Requirements for Sample Collection & Characterization Time

Facility	Sample Method	Averages: Sample Collection Time	Averages: Sample Characterization Time
Facility #1	Weighing	16:14	15:21
Facility #1	Visual	16:14	14:23
Facility #2	Weighing	8:12	15:16
Facility #2	Visual	8:12	14:32
Facility #3	Weighing	10:33	13:55
Facility #3	Visual	10:33	12:57
Facility #4	Weighing	7:09	5:50
Facility #4	Visual	7:09	4:59
All Facilities, Weighing		**10:32**	**12:35**
All Facilities, Visual		**10:32**	**11:42**

Composition Estimates

This section provides the results of the sample characterization using both the weighing and visual methods. Characterization results are presented in three types of tables:

- Overall composition estimates of banned materials in the residual streams from the four C&D processing facilities combined.
- Composition estimates for each of the four C&D processing facilities individually.
- Composition estimates of banned materials for each residual stream.

The composition results include absolute and relative measures of the accuracy of the visual method compared to the weighing method. It should be noted that in the following tables, the banned materials are a relatively small part of the total residual stream and material amounts are calculated as a ratio of the material weight to the total sample weights. As a result, minor absolute differences *(calculated by subtraction between the protocols*) result in substantial relative differences *(calculated as a ratio between the protocols)*. For example, if the weighing protocol estimates **cardboard>8" in its longest**

dimension to be 2% of the stream and the visual protocol estimates it to be 1% the absolute difference is 1% (2%-1%=1%). However the relative difference is 50% ((2%-1%)/2%=50%).

All results in the following tables are shown rounded to the nearest integer but it is important to recognize that the absolute and relative errors are calculated on the actual composition data at four decimal points, not the rounded numbers shown in the tables.

Overall Composition Estimates for Banned Materials

Table 4 presents a summary of the composition of banned materials found in the four types of residual streams (Mixed C&D, Bulky Items, Light Fines, and Non-recoverable MSW) at the four test facilities. Banned materials in the following table include those components that exceed the proposed size thresholds listed in **Table 1**. Definitions for each material component appear in Appendix A-1: Material Definitions and Size Thresholds. Fines that are less than 2 inches in diameter were not included in the sampling.

The weighing method identified banned materials as 28% of the overall residual stream, while the visual method showed these materials at 27% of the stream. The absolute difference between methods is 0% with a relative difference of -8%. **Tear-off shingles >8" in its longest dimension** was the largest material component of the overall residual stream at 12% based on the weighing method. The greatest amount of variance (relative difference of 107%) between the visual method and the weighing method was for **unpainted/untreated wood >6"in its longest dimension**.

Table 4. Overall Composition Results for Banned Materials

All Streams, All Facilities	**Composition**		**Difference Between Methods**	
(*n* =94 samples)	**Weighing**	**Visual**	**Absolute**	**Relative**
Concrete/Asphalt Paving >6" longest	1%	1%	0%	-7%
Metal >6" longest	3%	2%	-1%	-22%
Carpet >12" shortest	0%	0%	0%	-40%
Cardboard >8" longest	2%	1%	-1%	-45%
Plastic Film Wrap >12" shortest	1%	1%	0%	21%
New Construction Gypsum Scrap >6" longest	0%	1%	0%	63%
Unpainted/Untreated Wood >6" longest	9%	4%	-5%	-107%
Tear-off Shingles >8" longest	12%	16%	4%	26%
Total	**28%**	**27%**	**0%**	**-8%**
% of banned materials > ban size threshold	**93%**	**84%**		

Detailed Composition Results by Facility

The following four tables show detailed composition results for the residual streams at each of the four facilities. These tables provide composition estimates based on the weighing and visual methods, and the confidence intervals for these estimates. An assessment of the accuracy of the visual method is presented in the absolute and relative differences between the visual method results and the weighing method results.

It should be noted that these tables include composition estimates for both the banned material components that **exceed** the proposed size thresholds (28% in **Table 4** by weight and 27% by volume) and banned materials components that are present in amounts **greater than two inches but smaller than the proposed size thresholds** (93% in **Table 4** by weight and 84% by volume)**.**[1] Under the proposed protocol, these smaller materials would not be considered "banned." Materials that are less than two inches in size are considered "fines" and included in these tables as **all other materials**.

Table 5 presents a detailed composition of the residual stream at Facility 1. The weighing method measured banned materials as approximately 26% of the stream, while the visual method measured banned materials as approximately 29% of the stream. The absolute difference between the visual method and the weighing method is approximately -2% and the relative difference is approximately -5%. **Unpainted/untreated wood >6"in its longest dimension** was the most prevalent banned material component as measured by the weighing method, at 10% of the stream.

Table 5. Detailed Composition Results for Facility #1

Facility #1 (*n* =24 samples)	Composition				Difference Between Methods	
	Weighing		Visual		Absolute Difference	Relative Difference
	%	+/-	%	+/-		
Concrete/Asphalt Paving 2"-6" longest	1%	0%	1%	0%	1%	55%
Concrete/Asphalt Paving >6" longest	1%	0%	1%	0%	0%	-16%
Metal 2"-6" longest	0%	0%	0%	0%	0%	38%
Metal >6" longest	4%	1%	4%	1%	1%	13%
Carpet > 2"x2" but < 12"	0%	0%	0%	0%	0%	0%
Carpet >12" shortest	2%	2%	1%	2%	0%	-17%
Cardboard 2"-8" longest	0%	0%	0%	0%	0%	16%
Cardboard >8" longest	3%	1%	2%	0%	0%	-15%
Plastic Film Wrap > 2"x2"	0%	0%	0%	0%	0%	0%
Plastic Film Wrap >12" shortest	2%	1%	2%	1%	0%	9%
New Construction Gypsum Scrap 2"-6" longest	0%	0%	0%	0%	0%	62%
New Construction Gypsum Scrap >6" longest	1%	1%	1%	1%	0%	27%
Unpainted/Untreated Wood 2"-6" longest	1%	1%	2%	0%	0%	18%
Unpainted/Untreated Wood >6" longest	10%	1%	8%	1%	-3%	-36%
Tear-off Shingles 2"-8" longest	0%	0%	1%	1%	1%	85%
Tear-off Shingles >8" longest	1%	1%	4%	2%	3%	66%
All Other Materials	74%	3%	71%	5%	-3%	-4%
Total and Weighted Error	**100%**		**100%**		**-2%**	**-5%**

[1] Materials smaller than banned material thresholds are included in table but will not be counted as banned in final protocol.

Table 6 depicts the composition of the residual stream at Facility 2. The weighing method measured banned materials as approximately 11% of the stream, while the visual method measures banned materials as approximately 25% of the stream. The absolute difference between the visual method and the weighing method is -12%, while the relative difference is -11%. **Tear-off shingles >8" in its longest dimension** was the most significant component as measured by the weighing method, at 4% of the stream.

Table 6. Detailed Composition Results for Facility #2

Facility #2 (*n* =24 samples)	Composition				Difference Between Methods	
	Weighing		Visual		Absolute Difference	Relative Difference
	%	+/-	%	+/-		
Concrete/Asphalt Paving 2"-6" longest	1%	0%	2%	1%	1%	54%
Concrete/Asphalt Paving >6" longest	1%	0%	1%	1%	0%	33%
Metal 2"-6" longest	0%	0%	0%	0%	0%	24%
Metal >6" longest	0%	0%	1%	0%	0%	28%
Carpet > 2"x2" but < 12"	0%	0%	0%	0%	0%	65%
Carpet >12" shortest	0%	0%	0%	0%	0%	100%
Cardboard 2"-8" longest	0%	0%	0%	0%	0%	80%
Cardboard >8" longest	1%	0%	1%	0%	0%	30%
Plastic Film Wrap > 2"x2"	0%	0%	0%	0%	0%	0%
Plastic Film Wrap >12" shortest	0%	0%	0%	0%	0%	34%
New Construction Gypsum Scrap 2"-6" longest	0%	0%	0%	0%	0%	-177%
New Construction Gypsum Scrap >6" longest	1%	0%	1%	1%	1%	60%
Unpainted/Untreated Wood 2"-6" longest	1%	0%	2%	1%	1%	43%
Unpainted/Untreated Wood >6" longest	2%	1%	3%	1%	1%	30%
Tear-off Shingles 2"-8" longest	1%	0%	4%	1%	3%	82%
Tear-off Shingles >8" longest	4%	2%	10%	3%	6%	62%
All Other Materials	89%	3%	75%	5%	-14%	-18%
Total and Weighted Error	**100%**		**100%**		**-12%**	**-11%**

Table 7 provides an analysis of the composition of the residual stream at Facility 3. Per the weighing method, banned materials account for approximately 42% of the stream, while the visual method measured banned materials at approximately 41% of the stream. The absolute difference between the visual method and the weighing method is 0% and the relative difference is -14%. **Tear-off shingles >8" in its longest dimension** was the most prevalent banned material component per the weighing method, at 17% of the stream. **Unpainted/untreated wood>6" in its longest dimension** was the second largest banned component of the stream at 13%, also measured by the weighing method.

Table 7. Detailed Composition Results for Facility #3

Facility #3 (n=22 samples)	Composition				Difference Between Methods	
	Weighing		Visual		Absolute Difference	Relative Difference
	%	+/-	%	+/-		
Concrete/Asphalt Paving 2"-6" longest	0%	0%	1%	0%	0%	51%
Concrete/Asphalt Paving >6" longest	1%	1%	1%	1%	0%	-17%
Metal 2"-6" longest	0%	0%	0%	0%	0%	78%
Metal >6" longest	4%	3%	3%	1%	-1%	-28%
Carpet > 2"x2" but < 12"	0%	0%	0%	0%	0%	0%
Carpet >12" shortest	1%	1%	0%	1%	0%	-49%
Cardboard 2"-8" longest	0%	0%	0%	0%	0%	18%
Cardboard >8" longest	2%	0%	2%	0%	-1%	-54%
Plastic Film Wrap > 2"x2"	0%	0%	0%	0%	0%	0%
Plastic Film Wrap >12" shortest	1%	0%	1%	1%	0%	22%
New Construction Gypsum Scrap 2"-6" longest	0%	0%	0%	0%	0%	33%
New Construction Gypsum Scrap >6" longest	0%	0%	1%	0%	0%	68%
Unpainted/Untreated Wood 2"-6" longest	1%	0%	1%	1%	0%	23%
Unpainted/Untreated Wood >6" longest	13%	3%	6%	1%	-7%	-133%
Tear-off Shingles 2"-8" longest	1%	0%	3%	1%	2%	78%
Tear-off Shingles >8" longest	17%	9%	22%	8%	5%	22%
All Other Materials	58%	7%	59%	8%	1%	2%
Total and Weighted Error	**100%**		**100%**		**0%**	**-14%**

Table 8 depicts the detailed composition of the residual stream at Facility 4. Both the weighing and visual method measured banned materials at approximately 3% of the stream, with the absolute difference between the visual method and the weighing method at -1% and the relative difference at -6%. The most prevalent banned material component according to the weighing method was **cardboard >8" in its longest dimension** which accounts for approximately 1% of the stream.

Table 8. Detailed Composition Results for Facility #4

Facility #4 (n=24 samples)	Composition				Difference Between Methods	
	Weighing		Visual		Absolute Difference	Relative Difference
	%	+/-	%	+/-		
Concrete/Asphalt Paving 2"-6" longest	0%	0%	0%	0%	0%	-6%
Concrete/Asphalt Paving >6" longest	0%	0%	0%	0%	0%	0%
Metal 2"-6" longest	1%	1%	2%	2%	1%	60%
Metal >6" longest	0%	0%	0%	1%	0%	41%
Carpet > 2"x2" but < 12"	0%	0%	0%	0%	0%	0%
Carpet >12" shortest	0%	0%	0%	0%	0%	0%
Cardboard 2"-8" longest	0%	0%	0%	0%	0%	-95%
Cardboard >8" longest	1%	1%	1%	1%	0%	-60%
Plastic Film Wrap > 2"x2"	0%	0%	0%	0%	0%	0%
Plastic Film Wrap >12" shortest	0%	0%	0%	0%	0%	0%
New Construction Gypsum Scrap 2"-6" longest	0%	0%	0%	0%	0%	28%
New Construction Gypsum Scrap >6" longest	0%	0%	0%	0%	0%	0%
Unpainted/Untreated Wood 2"-6" longest	0%	0%	0%	0%	0%	-2230%
Unpainted/Untreated Wood >6" longest	0%	0%	0%	0%	0%	-13%
Tear-off Shingles 2"-8" longest	0%	0%	0%	0%	0%	90%
Tear-off Shingles >8" longest	0%	0%	0%	0%	0%	0%
All Other Materials	97%	1%	97%	2%	-1%	-1%
Total and Weighted Error	**100%**		**100%**		**-1%**	**-6%**

Composition of Banned Materials by Stream

The following four tables show composition results for the four types of residual streams generated at the four facilities. These tables provide composition estimates based on the weighing and visual methods, along with the absolute and relative differences between the two methods.

The four types of residual streams included in this study are defined as:

- **Mixed C&D –** This stream contained mixed construction and demolition material that is leftover after processing.
- **Bulky Items** – Bulky items are defined as large pieces of material and C&D debris that are separated from loads prior to processing.
- **Light Fines** – This stream contained lighter materials such as plastics, paper, and wood that were separated during processing.
- **MSW –** This stream is mostly non-C&D materials that were separated prior to or during processing.

Table 9 provides an analysis of the samples taken from the mixed C&D residual streams not recovered by sorting operations at the facilities. Cascadia characterized a total number of 78 samples from this type of residual stream. The weighing method measured banned materials at approximately 35% of the stream, while the visual method measured these materials at 33% of the stream. The absolute difference between the visual method and the weighing method was 0%, with the relative difference was -8%. **Tear-off Shingles >8" in its longest dimension** was the most prevalent component of this stream measured by the weighing method, at 16%. **Unpainted/untreated wood>6" in its longest dimension** was the second largest material component measured by the weighing method, at 10% of the stream.

Table 9. Composition of Banned Materials for the Mixed C&D Stream

Mixed C&D (*n* =78 samples)	Composition		Difference Between Methods	
	Weighing	Visual	Absolute	Relative
Concrete/Asphalt Paving >6" longest	1%	1%	0%	-7%
Metal >6" longest	4%	3%	-1%	-26%
Carpet >12" shortest	1%	0%	0%	-43%
Cardboard >8" longest	2%	1%	-1%	-40%
Plastic Film Wrap >12" shortest	1%	1%	0%	22%
New Construction Gypsum Scrap >6" longest	0%	1%	0%	64%
Unpainted/Untreated Wood >6" longest	10%	5%	-5%	-101%
Tear-off Shingles >8" longest	16%	20%	4%	22%
Total and Weighted Error	**35%**	**33%**	**0%**	**-8%**

Table 10 presents composition tables for the bulky materials stream. This stream contains large materials that were separated from the loads prior to processing. Cascadia characterized a total of six samples from this stream. According to the weighing method, banned materials were approximately 42% of the stream, while the visual method measured banned materials at 31% of the stream. The absolute difference between the visual method and the weighing method was -2%, with a relative difference of -19%. **Unpainted/untreated wood >6" in its longest dimension** was the most prevalent banned material component, measured by the weighing method, accounting for 22% of the stream. **Plastic film wrap>12" in its shortest dimension** and **metal>6" in its longest dimension** each account for 6% of the stream by the weighing method.

Table 10. Composition Results of Banned Materials for the Bulky Stream

Bulky (*n* =6 samples)	Composition		Difference Between Methods	
	Weighing	Visual	Absolute	Relative
Concrete/Asphalt Paving >6" longest	0%	0%	0%	0%
Metal >6" longest	6%	6%	1%	10%
Carpet >12" shortest	4%	4%	0%	-4%
Cardboard >8" longest	4%	3%	0%	-10%
Plastic Film Wrap >12" shortest	6%	5%	0%	-9%
New Construction Gypsum Scrap >6" longest	0%	0%	0%	0%
Unpainted/Untreated Wood >6" longest	22%	12%	-10%	-86%
Tear-off Shingles >8" longest	0%	0%	0%	83%
Total and Weighted Error	**42%**	**31%**	**-2%**	**-19%**

Table 11 presents the composition of the light fines stream. The light fines stream contained lighter materials such as plastics, paper, and wood that were separated during processing. A total of seven samples were sorted from this stream. Banned materials accounted for approximately 24% of the steam

as measured by the weighing method, and 22% of the stream as measured by the visual method. The absolute difference between the visual method and the weighing method is -2% and the relative difference is -25%. **Unpainted/untreated wood >6” in its longest dimension** was the most significant material component, at 18% of the stream measured according to the weighing method. **Cardboard>8” in its longest dimension** and **tear-off shingles >8” in its longest dimension**, each account for approximately 3% of the stream, per the weighing method.

Table 11. Composition Results of Banned Materials for the Light Fines Stream

Light Fines (*n* =7 samples)	**Composition**		**Difference Between Methods**	
	Weighing	**Visual**	**Absolute**	**Relative**
Concrete/Asphalt Paving >6" longest	0%	0%	0%	0%
Metal >6" longest	0%	0%	0%	82%
Carpet >12" shortest	0%	0%	0%	0%
Cardboard >8" longest	3%	2%	-1%	-64%
Plastic Film Wrap >12" shortest	0%	0%	0%	0%
New Construction Gypsum Scrap >6" longest	0%	1%	1%	59%
Unpainted/Untreated Wood >6" longest	18%	7%	-11%	-143%
Tear-off Shingles >8" longest	3%	12%	9%	77%
Total and Weighted Error	**24%**	**22%**	**-2%**	**-25%**

Table 12 shows the composition of the MSW stream. The non-recoverable MSW stream contained mostly non-C&D materials that were separated prior to or during processing. Cascadia characterized a total of three samples from this stream. Banned materials accounted for 2% of the stream by weight and 1% when measured by the visual method. There was an absolute difference of 0% between the visual method and the weighing method, and a relative difference of -1%. **Cardboard >8” in its longest dimension** was the most significant component at 1% of the stream, based on the weighing method.

Table 12. Composition Results of Banned Materials for the MSW Stream

MSW (*n* =3 samples)	**Composition**		**Difference Between Methods**	
	Weighing	**Visual**	**Absolute**	**Relative**
Concrete/Asphalt Paving >6" longest	0%	0%	0%	0%
Metal >6" longest	0%	0%	0%	41%
Carpet >12" shortest	0%	0%	0%	0%
Cardboard >8" longest	1%	1%	0%	-60%
Plastic Film Wrap >12" shortest	0%	0%	0%	0%
New Construction Gypsum Scrap >6" longest	0%	0%	0%	0%
Unpainted/Untreated Wood >6" longest	0%	0%	0%	-13%
Tear-off Shingles >8" longest	0%	0%	0%	0%
Total and Weighted Error	**2%**	**1%**	**0%**	**-1%**

Conclusions

- **Both methods are feasible with moderate impact to facilities.** Based on our experience in the field, we found that each of the protocols could be performed at each facility with limited impact to facility operations and staff. Both the weighing and visual protocols required Cascadia field staff to utilize facility staff and equipment to collect samples, causing a slight deviation from normal operations. Cascadia rated the average impact to facilities at 1.75. The average impact to facilities was assessed on a scale of one (low impact) to three (high impact). Staff measured the feasibility of methods at 1.25. The average feasibility of performing the protocols was assessed on a scale of one (very feasible) to three (unfeasible).

- **On average, the weighing protocol required less than one minute more to complete than the visual protocol.** Cascadia tracked the time required to collect and characterize each sample. Sample collection time was the same for both the weighing and visual protocols at 10:32, because field staff performed both protocols on the same sample. Weighing each material component took 12 minutes and 35 seconds, while the visual estimation required only slightly less time, at 11 minutes and 42 seconds.
- **Proposed size thresholds appear appropriate for all banned materials, except wood.** The majority of the material characterized was above the recommended threshold, with very little material falling under the banned size ranges. Overall, 93% of all banned material types exceeded threshold limits when measured by the weighing method. Less than 7% fell between the 2" and proposed size thresholds.

  Based on our experience from the testing process, large quantities of wood are present in the residual stream, in part due to the screening process at some of the facilities. The screens permit wood that is less than 2 inches in width to pass through into the residual stream (regardless of the length). This wood is often long enough to be considered within the banned material size threshold under current size threshold definitions, but is too slender to be recovered without further processing. Adding a width requirement to the current size threshold would remove these long, slender pieces of wood from the banned material category. (i.e. wood material that is >6" in its longest dimension and <2" in its widest dimension would not be considered as banned).
- **Stockpile sampling was the most effective sampling method.** Cascadia found that stockpile sampling, when available, was the easiest and most efficient method for the collection of samples. Sampling from transfer trailers required appropriately sized equipment to fully access 100% of the containers' contents. In addition, collecting material directly out of transfer trailers was difficult, time consuming, and potentially damaging to the container. Both sampling methods required the utilization of facility equipment and staff.

4. Recommendations

Based on the composition results from the testing process and our evaluation of the weighing and visual protocols, Cascadia recommends the following changes to the draft protocols for assessing the amount of banned materials in the residual streams of C&D processing facilities:

- **Utilize weighing method**. The weighing-based method is the most accurate method for measuring banned materials in the residual streams generated by C&D processing facilities. The visual method produces composition estimates that are substantially different from the weighing method. Materials that make up a small percentage of the waste stream and occur infrequently proved to be more difficult to measure with visual estimation. Additionally, the time savings associated with using the visual method compared to the weighing method are insignificant, less the one minute per sample characterized.
- **Characterize a minimum of 16-20 samples over two days per quarter**. This number of samples will provide reliable data to measure the quarterly amounts of banned materials in a C&D processing facility's residual waste stream. For example, two quarters of testing would provide overall banned residuals percentages that have confidence intervals between +/-10% and +/-20%, depending on the facility.

  We also recommend that sample collection and characterization occur over two randomly selected days each quarter to account for potential seasonal differences in construction materials delivered to processing facilities. In addition, averaging quarterly results over several quarters will attenuate potential outliers created by large quantities of materials such as roofing shingles being delivered on the day of sampling.
- **Revise direct load sampling methods.** Residual materials collected in containers or transfer trailers should be tipped to permit sample selection using the preferred stockpile method. If this method is not an option for transfer trailers, Cascadia recommends sampling directly from the transfer trailer by selecting random "slices" of the material for sampling. Each slice would contain material from the top to the bottom of the trailer. As specified in the proposed protocol, three grab samples would then be removed from the slice for sorting.
- **Utilize current proposed size thresholds for all materials with the exception of wood.** Overall, 93% of all banned materials that were sorted exceeded the proposed size thresholds. These larger components can be effectively sorted and appear to represent the majority of banned materials that would sent to disposal. The one exception is **Unpainted/untreated wood** that enters the residual stream due to the screening process at some facilities. The screens permit wood that is less than 2 inches in width to pass through into the residual stream (regardless of the length). Much of this wood is not practically recoverable. Therefore, Cascadia recommends adding diameter dimensions (>2") to the current banned size threshold for wood. This would eliminate long, slender pieces of wood that are not practically recoverable, with current screening practices, from the banned material category.
- **Provide flexibility in meeting ban requirements.** Due to the differences in materials flow and sorting processes at the four facilities, SPU should permit a high level of flexibility in meeting certification requirements for banned materials. Specifically, Cascadia recommends establishing an overall maximum allowable amount of banned materials residuals to supplement the SPU

proposed material-specific limits. This will allow facilities to potentially exceed individual material limits, as long as the overall amount of banned materials in the residuals is below the overall limit. In addition, Cascadia recommends that any decertification actions be based on two or more consecutive quarters of non-compliance with banned material limits.

- **Utilize experienced, professional staff to select and sort samples of residual material at C&D processing facilities.** Due to the composition and nature of C&D residual materials, Cascadia recommends using trained, professional staff to conduct compliance tests at C&D processing facilities. The use of untrained, inexperienced staff may be potentially hazardous. It should also be noted that the recommendation to conduct eight to ten samples per day assumes that a trained professional crew will be conducting the sample selection and sorting process.

Appendix 1: Residuals Testing Plan

Description of Ordinance

In December of 2012, the City of Seattle adopted Ordinance 124076, which bans the disposal of certain recyclable construction and demolition (C&D) materials, establishes a C&D processing facility certification program, and requires that all permitted C&D projects submit a Waste Diversion Report within 60 days of final inspection approval. These three requirements of Ordinance 124076 are closely related: the most efficient way for C&D projects to recycle materials banned from landfill and meet permitting requirements is to send materials from their projects to certified C&D waste processing facilities.

Disposal Bans for Key Materials

The ordinance proposes three phases for banning recyclable/reusable C&D materials from landfill. Bans for materials in each phase detailed below are effective on the dates noted, with enforcement beginning one year later.

- Phase 1: concrete, asphalt paving, bricks (effective: 1/1/12)
- Phase 2: metal, carpet, cardboard, plastic film wrap, new construction gypsum scrap (effective: 1/1/14)
- Phase 3: unpainted/untreated wood, tear-off asphalt shingles (effective: 1/1/15)

Facility Certification

One of the objectives of the C&D facility certification program is to ensure that processing facilities are recycling or reusing the materials banned from disposal. The basic criteria for facility certification include compliance with solid waste permitting requirements, quarterly reporting on the quantities and types of incoming and outgoing C&D materials, and performance standards for the allowable quantities of targeted recycling material in residuals bound for landfill disposal.

The residual streams are the materials remaining after the mixed C&D processing facilities sort the incoming comingled C&D waste stream and extract reusable or recyclable commodities, such as clean wood or concrete. This project addresses the sampling and testing protocols which could be used to establish whether or not residual performance standards are being met. Recommendations will be made for size dimension thresholds for different targeted materials as well as percentage limitations for those materials in the composite residual samples.

Plan Contents

Cascadia has developed two residual sampling protocols (a weight-based protocol and a volume-based, visual protocol) that measure how effectively a mixed C&D material processing facility is recovering recyclable C&D materials banned from disposal. SPU will select which of these two sampling protocols best measures C&D processing facility performance in a cost-effective manner. A hybrid sampling and testing protocol approach using components of these two methods could also be selected. This document proposes a plan to methodically test each protocol and determine which best meets the City of Seattle's needs.

The protocol that SPU selects will be shared with stakeholders and become a part a rulemaking process for the C&D processing facility certification program.

The first proposed sampling protocol is a weight-based method which involves sorting and weighing the residuals to determine their composition. The second proposed protocol is a volume-based method which involves visually characterizing the residuals to determine their composition by volume. Both protocols provide step-by-step descriptions of how to complete the three key phases of residuals characterization: sample selection, sample characterization, and analysis. Both protocols are intended to be clear enough for use by parties that monitor facility certification.

The testing plan is presented here, and is divided into the following sections:

- Definition of Universe
- Numbers and Allocation of Samples
- Sampling Calendar
- Sample Selection
- Sample Characterization
- Evaluation

The weight and visual protocols, and the supporting documents for each, are presented in the attachments that follow the testing plan and include the following:

- Attachment A: City of Seattle C&D Processing Residuals Weighing Method Protocol
  - Appendix A-1: Material Definitions and Size Thresholds
  - Appendix A-2: Field Forms
- Attachment B: City of Seattle C&D Processing Residuals Visual Method Protocol
  - Appendix B-1: Material Definitions and Size Thresholds
  - Appendix B-2: Field Forms
  - Appendix B-3: Conversion Factors

Protocol Testing Plan

Definition of the Universe

The protocols describe methods to characterize C&D processing facility residuals – the materials remaining after C&D processing extracts materials for recycling and reuse. Residuals are not recycled; they are usually disposed in landfills, used as alternative daily cover (ADC), or in one case, used as industrial waste stabilizer (IWS) in special waste landfills. The protocol testing process will include samples of residuals from the following four mixed C&D processing facilities which were part of a 2012 Residual Sampling Study and have agreed to continue to participate:

- CDL Recycle
  7201 East Marginal Way S Seattle, WA 98108
- Waste Management's Glacier Recycle Facility
  32300 148th Ave SE Auburn, WA 98092
- Recovery 1
  1805 Stewart Street Tacoma, WA 98421
- Republic Services' Black River Facility
  501 Monster Rd Renton, WA 98059

Number and Allocation of Samples

Every C&D processing facility included in this study has at least one stream of residual materials that is not recovered for recycling. The number of streams is determined by the type of materials the facility processes, the size of the materials in the incoming C&D stream, and the sorting technologies that the processing facility uses. The number and type of residual streams at each of the four facilities included in this protocol testing process are listed in **Table 13**. Stream types are based on information provided by facility managers and are current as of April 2013.

Table 13: Number and Type of Residual Stream from Sort Lines by Facility

Facility	Number of Residual Streams	Type of Residual Stream	End Use or Destination of Residual Streams
Facility 1	2	Non-Recoverable Mixed C&D Non-Recoverable Bulky Items	Direct Disposal in Landfill Direct Disposal in Landfill
Facility 2	1	Non-Recoverable Mixed C&D	Industrial Waste Stabilizer at Landfill
Facility 3	1	Non-Recoverable Mixed C&D (includes Light Fines from processing)	Direct Disposal in Landfill
Facility 4	2	Non-Recoverable Mixed C&D Non-Recyclable MSW	Alternative Daily Cover (ADC) at Landfill Direct Disposal in landfill

Cascadia will sample and characterize each residual stream using two independent protocols: a weighing method (hand-sorted and weighing of subsamples) and a visual method (visual assessment of subsamples with conversion to weights using accepted conversion factors). At each facility, eight samples will be selected per day; Cascadia will first visually assess and then hand-sort each sample, for a total of 16 characterizations per day.

es of materials in each stream.

Table 14 presents the number of sampling days assigned to each facility and the number of composite samples allocated to each residual stream within each facility, per day and overall. Allocations are based on relative quantities of materials in each stream.

Table 14: Number of Samples by Facility and Residual Stream

Facility	Days of Sampling	Residual Streams	Samples Per Residual Stream per Day	Total Visual Characterizations	Total Weight-based Characterizations
Facility 1	3	Non-Recoverable Mixed C&D	6	18	18
		Non-Recoverable Bulky Items	2	6	6
Facility 2	3	Non-Recoverable Mixed C&D	8	24	24
Facility 3	3	Non-Recoverable Mixed C&D (Includes Light Fines from processing)	8	22*	22*
Facility 4	3	Non-Recoverable Mixed C&D	7	21	21
		Non-Recoverable MSW	1	3	3
Totals				94	94

*Two samples from Facility 3 were eliminated from the analysis.

Sampling Calendar

Cascadia will test the residual sampling protocols over three contiguous weeks in May, four days each week, for a total of twelve sampling days. Cascadia staff will visit each facility once per week for a total of three days of testing at each facility. The sampling calendar is presented in

Table 15 below.

Table 15: May Sampling Calendar by Day of Week and Facility

	Monday	Tuesday	Wednesday	Thursday	Friday
May	13 – Facility 4	14 – Facility 3	15 – Facility 2	16 – Facility 1	17 – No Sampling
	20 – Facility 3	21 – Facility 2	22 – No Sampling	23 – Facility 4	24 – Facility 1
	27 – No Sampling	28 – Facility 4	29 – No Sampling	30 – Facility 2	31 – Facility 3

June	3 – Facility 1	4 – No Sampling	5 – No Sampling	6 – No Sampling	7 – No Sampling

Sample Selection

Cascadia will ensure that samples of the residual streams at each facility are representative of that stream by establishing minimum sample weights. For each facility, Cascadia will establish sample weights for each residual stream by measuring the average particle size in each stream. Residual streams with larger average particle sizes will be assigned larger sample weights. The details of the sample selection processes are specified in Attachment A: City of Seattle C&D Processing Residuals Weighing Method Protocol and in Attachment B: City of Seattle C&D Processing Residuals Visual Method Protocol.

Sample Characterization

Cascadia will test the two proposed protocols by characterizing each sample using both the weight and volume based protocols: first, field staff will visually estimate the volume of the banned materials in the sample (following the protocol described in Attachment B: City of Seattle C&D Processing Residuals Visual Method Protocol); then, field staff will hand sort the sample, and weigh banned materials (following the protocol described in Attachment A: City of Seattle C&D Processing Residuals Weighing Method Protocol). In each method, field staff will use the same material list (Appendix A-1: Material Definitions and Size Thresholds) to characterize each sample.

Evaluation

Cascadia will evaluate the weighing and visual methods and select the method that is appropriate for measuring banned materials in C&D processing facility residual streams using three primary criteria: practicality, reliability, and cost. The three criteria and the assessment process for each are described below.

Practicality (Qualitatively Assessed)

- **Impact**—How does each method impact the daily operations of the facility?
- **Feasibility**—How feasible is it to carry out each method under normal facility operating conditions?

After each sampling day, Cascadia staff will qualitatively assess these two practicality considerations, and will assign a corresponding ranking to each method. The rankings will be on a scale of 1 to 3: for the impact consideration, 1 is the least impact, and 3 is the most impact; for the feasibility consideration, 1 is the least feasible and 3 is the most feasible.

Field staff will take notes and photos to document the assessment.

Reliability (Quantitatively Assessed)

- How reliable is the visual method compared to the weighing method?

Cascadia's field staff will characterize each sample using both protocols. Cascadia will then assess each method's reliability by comparing the results from the visual method with the results from the weighing method for each sample, and calculating the relative amount of variance for each category of banned materials. Evaluation will include results for individual facilities and for each stream and material type to determine best method.

The weighing method provides the exact composition of each sample, whereas the visual method provides a composition estimate that depends on volumetric estimates and the conversion of those volume estimates to weights. The weighing method is therefore more precise than the visual method. This reliability evaluation will determine if the variance in the resulting data is significant enough that the visual method would not be considered reliable by the City of Seattle or C&D facility staff.

Cost (Quantitatively Assessed)

- What is the cost of carrying out each method at each facility?

Cascadia field staff will track the time required to select and characterize each sample and stream, by protocol and facility. Evaluations will also include the costs of training and equipment for each method. Cascadia will then calculate average time and cost per sample for each method.

At the conclusion of the testing process, Cascadia will summarize the evaluation data collected over the three-week testing period and present the results to SPU staff in a working session. At this session, participants will weigh the criteria, assign relative scores to the reliability and cost of each method, and calculate the overall scores for each method. Staff will also note the quantity of visual samples desired to achieve accurate data. Based on these results, the session participants will then select the preferred method for assessing C&D processing facility compliance with Ordinance 124076. Alternatively, the team may elect to combine elements of each tested protocol and develop a hybrid method that integrates the best attributes of the weighing and visual methods.

Attachment A: City of Seattle C&D Processing Residuals Weighing Method Protocol

Objective

The objective of this protocol is to provide a method for determining the amount of banned materials in the residuals stream at certified C&D processing facilities that are processing loads of mixed C&D waste. Banned materials include:

- Concrete, asphalt paving, bricks (bans effective 2012)
- Metal, carpet, cardboard, plastic film wrap, new construction gypsum scrap (bans effective 2014)
- Unpainted/untreated wood, tear-off asphalt shingles (bans effective 2015)

This protocol defines the three main phases of weight-based sample characterization: sample selection, sample characterization, and analysis. Two appendices related to the weighing method follow this protocol: Appendix A-1: Material Definitions and Size Thresholds and Appendix A-2: Field Forms.

Field Work Preparation

Before beginning field work, prepare two sets of field forms:

- *Weight Based Data Form*: During sample selection and weight-based characterization, field staff will complete one of these forms for each characterized sample. The form captures information about the sample's material type composition, by weight. The form also asks field staff to note other relevant sample details, like residual stream of origin and date of sample collection.
- *Sample Placard*: The sample placard will identify each sample in photographs of the sample. The placard contains sample-specific information, including facility and residual stream of origin, sample collection date, and a unique sample id number, which identifies the sample in photographs and in analysis after the characterization.

Examples of these field forms are attached in Appendix A-2: Field Forms. The protocol testing period will use these sample forms, but the forms will change for the final protocol.

Sample Selection

At all facilities, use the following procedure to identify residual streams for sampling and to determine sample weights.

- **Identify all residual streams** at each individual facility, such as screened fines, post-processing residual waste, Alternative Daily Cover (ADC) and "Industrial Waste Stabilizer (IWS). Residual streams are defined as any non-recyclable waste generated from mixed C&D processing that is disposed in a landfill or used as ADC or IWS. Each stream must have a known annual quantity. If annual quantities are not available, combine residual streams prior to sampling.

- For each residual stream, **determine particle size** by measuring the longest dimension in inches of the largest visible particles in the stream.
- **Determine sample weight** for each residual stream based on average particle size, as follows.
  - Fines less than 2”: Excluded from sampling.
  - Particles greater than 2” and less than 6”: 25 lbs.
  - Particles greater than 6” and less than 12”: 100 lbs.
  - Particles greater than 12”: 250-300 lbs.

Option 1: Stockpile Method

Perform the following sampling procedure at facilities with stockpiled residual streams. Sampling will occur before any particle size reduction of stockpiled residual streams.

- Visually superimpose the 16-cell grid picture in Figure 2 below on the stockpiled residual streams. *(Please note that this is an overhead view, as if you were above the pile looking down on it.)*
- Using a digital camera, take photo of stockpile prior to extracting grab samples to identify sampling cells.
- Extract one grab sample each from three randomly selected sections of the stockpile of processing residual. Random cells are selected for sampling using the random number generator in Excel (function RANDBETWEEN). Cell numbers are preselected from the 16-cell grid prior to sampling. These three grab samples will be used to produce a single composite sample. Each grab sample should be approximately the same weight, and when added together, the three samples should generate a sample weight as specified above.
- Place the three grab samples into a single container with a known tare weight. Suitable containers include steel bins and facility equipment such as the bucket of a loader.
- Weigh the containerized sample using a truck scale or a commodity scale.
- Determine the weight of the complete sample by subtracting the tare weight from the gross weight of the containerized sample.
- Record the net weight of the complete sample on the *Sample Data Form* (see Appendix A-2: Field Forms).
- Collect a minimum of eight composite samples over the course of a processing shift. (Note: Eight composite samples will require extracting 24 individual grab samples from the residual stockpile)[2].

[2] In the final protocol, specifications will require two consecutive days of sampling each quarter with 5-8 composite samples required per day (15-24 grab samples), for a total of 10-16 (30-48 grab samples) per quarter and 40-64 (120-194 grab samples) per year (final specified number will depend on results of protocol testing.)

Figure 2. Visual overlay for Stockpile Method showing "cells" of material

Option 2: Direct Load Method

Perform the following sampling procedure at facilities that load residual streams directly into a transport trailer or other container. At these facilities, extract samples from a minimum of 20 cubic yards of processing residual. Sampling will occur before any particle size reduction of the residual stream.

- Level processing residual already loaded in a trailer to a uniform height and extend in one direction to create a roughly rectangular shape.
- Visually superimpose the three dimensional grid pictured in Figure 3. Visual overlay for Direct Load Method showing "cells" of material below on the processing residual. *(Please note that this is a side view, facing the left-hand side of the trailer*)
- Using a digital camera, take photo of load prior to extracting grab samples to identify sampling cells.
- Extract one grab sample each from three randomly selected sections of the processing residual intended for transport trailers. Random cells are selected for sampling using the random number generator in Excel (function RANDBETWEEN). Cell numbers are preselected from the 16-cell grid prior to sampling. These three grab samples will be used to produce a single composite sample. Each individual grab sample should be approximately the same weight, and when added together, the three samples should generate a sample weight as specified above.
- Complete the method by following Steps 4 through 8 of the stockpile method described above.

Figure 3. Visual overlay for Direct Load Method showing "cells" of material

Sample Characterization

Regardless of the sampling method used, perform the following sorting procedures at all C&D processing facilities, and document the resulting data and site observations on the Weight Based Sample Data Form.

- Take each complete sample to a safe sorting location away from vehicle and equipment traffic.
- Tip the complete sample onto the ground.
- Using a digital camera, take a picture of the sample in which a Sample Placard identifying the sample is visible.
- Manually sort the complete sample in its entirety. During this sort, segregate out all of the banned materials that appear to exceed the indicated dimensions noted in **Table 16** below. Appendix A-1: Material Definitions and Size Thresholds for more detailed descriptions of each material. Ensure that no portion of the sample remains unsorted.
- After sorting the complete sample, measure the segregated materials to determine if they exceed the indicated dimensions. Tools such as a "check box" (a wooden frame in 6", 8", and 12" dimensions identified in **Table 16**) are useful for the quick measurement of segregated materials. Materials are placed in the check box frame to quickly estimate their size.
- Place all of the materials that exceed the defined dimensions into separate containers (for example, concrete/asphalt/bricks in one container and metal in another container) where the weight of the individual container is known and can be subtracted from the sample weight. Plastic baskets or refuse cans are suitable for this purpose.
- Use a scale with a minimum accuracy of 0.1 pounds to weigh each separate container.
- Subtract the tare weights from the gross weights of each containerized material in order to determine the net weights of each.

- Record the gross and tare weights for each of the recoverable materials on the Weight Based Sample Data Form.

Table 16. Banned material sizing

Material	Size Threshold
Concrete/asphalt paving/bricks	>6" in its longest dimension
Metal	>6" in its longest dimension
Carpet	12" in its **shortest** dimension
Cardboard	>8" in its longest dimension
Plastic film wrap	12" in its **shortest** dimension
New construction gypsum scrap	>6" in its longest dimension
Unpainted/untreated wood	>6" in its longest dimension
Tear-off shingles	>8" in its longest dimension

Analysis

Enter data from the Sample Data Forms completed throughout the sample characterization into a database. The database will use the following formulae to conduct the required analysis and generate detailed C&D residual composition estimates.

Composition Calculations

The composition estimates represent the ratio of each material's weight to the total sample weight. They are derived by adding each material's weight across all of the selected records and dividing by the sum of the total sample weight, as shown in the following equation:

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

where:

c = weight of particular material type

w = sum of all material type weights

for *i* 1 to n

where *n* = number of selected samples

for *j* 1 to m

where *m* = number of components

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

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

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

Second, confidence intervals at the 90% confidence level 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).

Appendix A-1: Material Definitions and Size Thresholds

This section lists the materials that the residual characterization will track. Materials are listed in pairs according to the material size banned from the C&D residual stream – the first size threshold in each pair is allowed in the residual stream for disposal, and the second size threshold is banned.

Field staff will use this material list during protocol testing, to ensure that staff weigh and categorize all materials larger than 2 inches. In the final protocol to determine % of total banned materials in the residual bound for landfill disposal, this list of materials will be reduced to only those materials that exceed specified dimensions.

Material	Size Threshold	Definition
Concrete/asphalt paving/bricks	2”-6” in its longest dimension	*Concrete, asphalt paving, and bricks in pieces between 2” and 6” in its longest dimension. Concrete is defined as a hard material made from sand, gravel, aggregate, cement mix, and water. Asphalt means a black or brown, tar-like material mixed with aggregate used as a paving material. Both categories include materials containing steel mesh and/or reinforcement bars, or "rebar". Bricks are defined as complete or partial portions of bricks made of red clay material. Does not include other types of aggregate material.*
Concrete/asphalt paving/bricks	> 6” in its longest dimension	*Concrete, asphalt paving, and bricks in pieces > 6” in its longest dimension. Concrete is defined as a hard material made from sand, gravel, aggregate, cement mix, and water. Asphalt means a black or brown, tar-like material mixed with aggregate used as a paving material. Both categories include materials containing steel mesh and/or reinforcement bars, or "rebar". Bricks are defined as complete or partial portions of bricks made of red clay material. Does not include other types of aggregate material.*
Metal	2”-6” in its longest dimension	*Includes tin/steel food cans, major appliances, other ferrous, aluminum cans, and other non-ferrous metals in lengths between 2”and 6” in its longest dimension. Includes Mixed Recoverable Metal meaning composite, multi-metal products or products with non metal contaminants. The metal content must be more than 90% by weight of the material.*
Metal	> 6” in its longest dimension	*Includes tin/steel food cans, major appliances, other ferrous, aluminum cans, and other non-ferrous metals in lengths > 6” in its longest dimension. Includes Mixed Recoverable Metal meaning composite, multi-metal products or products with non metal contaminants. The metal content must be more than 90% by weight of the material.*
Carpet	> 2”X 2” in area but < 12” in its	*'Carpet' means flooring applications at least 2”X 2” in area that is primarily constructed of a top visible surface of*

	shortest dimension	*synthetic face fibers or yarns or tufts attached to a backing system derived from synthetic or natural materials. It includes broadloom and carpet tiles; it does not include a rug, pad, cushion, or underlayment. Material must be dry and free of excessive contamination such as paint, grease, grime, or dirt*
Carpet	> 12"in its **shortest** dimension	*'Carpet' means flooring applications > 12" in its shortest dimension that is primarily constructed of a top visible surface of synthetic face fibers or yarns or tufts attached to a backing system derived from synthetic or natural materials. It includes broadloom and carpet tiles; it does not include a rug, pad, cushion, or underlayment. Material must be dry and free of excessive contamination such as paint, grease, grime, or dirt.*
Cardboard	2"-8" in its longest dimension	*Cardboard between 2" and 8"in length in its longest dimension. Can have tape, staples and other fasteners*
Cardboard	> 8" in its longest dimension	*Cardboard > 8" in length in its longest dimension. Can have tape, staples and other fasteners*
Plastic film wrap	> 2"X2" in area but < 12"in its shortest dimension	*Plastic film used to package or wrap commercial and industrial product that is at least 2"X 2" in area. Examples include shrink-wrap, and building wrap/Tyvek packaging. Material must be dry and free of excessive contamination such as paint, grease, grime, or dirt.*
Plastic film wrap	> 12" in its **shortest** dimension	*Plastic film used to package or wrap commercial and industrial products in dimensions > 12" in its **shortest** dimension. Examples include shrink-wrap, and building wrap/Tyvek packaging. Material must be dry and free of excessive contamination such as paint, grease, grime, or dirt.*
New construction gypsum scrap	2"-6" in its longest dimension	*Unpainted gypsum wallboard or interior wall covering made of a sheet of gypsum sandwiched between paper layers between 2" and 6" in length in its longest dimension. Examples: This category includes used or unused, broken or whole sheets. Gypsum board may also be called sheetrock, drywall, plasterboard, gypboard, gyproc, or wallboard.*
New construction gypsum scrap	> 6" in its longest dimension	*Unpainted gypsum wallboard or interior wall covering made of a sheet of gypsum sandwiched between paper layers in lengths > 6" in length in its longest dimension. Examples: This category includes used or unused, broken or whole sheets. Gypsum board may also be called sheetrock, drywall, plasterboard, gypboard, gyproc, or wallboard.*

Unpainted/untreated wood	2”-6” in its longest dimension	*Includes unpainted/unstained new and demolition scrap dimensional lumber such as 2 x 4s, 2 x 6s, 2 x 12s, and other residual materials from framing and related construction activities, engineered wood, pallets and crates in lengths between 2” and 6” in length in its longest dimension. Such wood can have nails, screws and metal fasteners. It does not include particle board or laminated veneer wood.*
Unpainted/untreated wood	> 6” in its longest dimension	*Includes unpainted/unstained new and demolition scrap dimensional lumber such as 2 x 4s, 2 x 6s, 2 x 12s, and other residual materials from framing and related construction activities, engineered wood, pallets and crates in lengths > 6” in its longest dimension. Such wood can have nails, screws and metal fasteners. It does not include particle board or laminated veneer wood.*
Tear-off Asphalt Roofing shingles	2”-8” in its longest dimension	*Composite shingles composed of fiberglass or organic felts saturated with asphalt and covered with inert aggregates including asphalt shingles and attached roofing tar and tar paper in lengths between 2” and 8” in its longest dimension.*
Tear-off Asphalt Roofing shingles	> 8” in its longest dimension	*Composite shingles composed of fiberglass or organic felts saturated with asphalt and covered with inert aggregates including asphalt shingles and attached roofing tar and tar paper in lengths > 8” in its longest dimension.*

Appendix A-2: Field Forms

Weight Based Sample Data Form

Step 1: Enter Data

Site: 3&L CDL R1 Glacier

Residuals Stream (circle):

Mixed C&D MSW Bulky

Date: ______________________________

Sample ID: __________________________

Step 2: Photograph Samples

Stockpile/Load PhotoTaken: ☐

Sample Photo Taken ☐

Step 3: Weigh and record sample weight.

Sample Net Weight: __________

Net Weight	Material Type
	Concrete/asphalt paving/bricks 2"-6" (longest)
	Concrete/asphalt paving/bricks >6" (longest)
	Metal 2"-6" (longest)
	Metal >6" (longest)
	Carpet > 2"-2"
	Carpet >12" (shortest)
	Cardboard 2"-8" (longest)
	Cardboard >8" (longest)
	Plastic film wrap > 2"x2"
	Plastic film wrap >12" (shortest)
	New construction gypsum scrap 2"-6" (longest)
	New construction gypsum scrap >6" (longest)
	Unpainted/untreated wood 2"-6" (longest)
	Unpainted/untreated wood >6" (longest)
	Tear-off shingles 2"-8" (longest)
	Tear-off shingles >8" (longest)
lbs	***Grand Total***

Evaluation Notes:

Time Notes:

Selection Time (from request to sample on ground):

____

Characterization Time (from beginning to end of sort):

____

Practicality Notes:

Impact (circle): 1 2 3

____

____

____

Feasibility (circle): 1 2 3

____

____

____

Sample Placard

<table>
<tr><td>

Random Cells:
5 7 15

SAMPLE ID

W-1

RESIDUAL STREAM:
Mixed C&D

</td><td>

DATE: **5/15/2013**

</td></tr>
<tr><td>Facility: CDL Recycle</td><td></td></tr>
</table>

Attachment B: City of Seattle C&D Processing Residuals Visual Method Protocol

Objective

The objective of this protocol is to provide a method for determining the amount of banned materials in the residuals stream at certified C&D processing facilities that are processing loads of mixed C&D. Banned materials include:

- Concrete, asphalt paving, bricks (bans effective 2012)
- Metal, carpet, cardboard, plastic film wrap, new construction gypsum scrap (bans effective 2014)
- Unpainted/untreated wood, tear-off asphalt shingles (bans effective 2015)

This protocol defines the three main phases of the volume-based sample characterization: sample selection, sample characterization, and analysis. Two appendices related to the volume method follow this protocol: Appendix B-1: Material Definitions and Size Thresholds and Appendix B-2: Field Forms.

Field Work Preparation

Before beginning field work, prepare two sets of field forms:

- *Volume Based Sample Data Form*: During sample selection and volume-based characterization, field staff will complete one of these forms for each characterized sample. The form captures information about the sample's material type composition, by volume. The form also asks field staff to note other relevant sample details, like residual stream of origin and date of sample collection.
- *Sample Placard*: The sample placard will identify each sample in photographs of the sample. The placard contains sample-specific information, including facility and residual stream of origin, sample collection date, and a unique sample id number, which identifies the sample in photographs and in analysis after the characterization.

Examples of these field forms are attached in Appendix B-2: Field Forms. The protocol testing period will use these sample forms, but the forms will change for the final protocol.

Sample Selection

At all facilities, use the following procedure to identify residual streams for sampling and to determine sample weights.

- **Identify all residual streams** at each individual facility, such as screened fines, post-processing residual waste, Alternative Daily Cover (ADC) and "Industrial Waste Stabilizer" (IWS). Residual streams are defined as any non recyclable waste generated from mixed C&D processing that is disposed in a landfill or used as ADC or IWS. Each stream must have a known annual quantity. If annual quantities are not available, combine residual streams prior to sampling.

- For each residual stream, **determine particle size** by measuring the longest dimension in inches of the largest particles in the stream.
- **Determine sample weight** for each residual stream based on average particle size, as follows.(same question as under Weighing Method for this section regarding the ADC, …
  - Fines less than 2”: Excluded from sampling.
  - Particles greater than 2” and less than 6”: 25 lbs.
  - Particles greater than 6” and less than 12”: 100 lbs.
  - Particles greater than 12”: 250-300 lbs.

Option 1: Stockpile Method

Perform the following sampling procedure at facilities with stockpiled residual streams. Sampling will occur before any processing of stockpiled residual streams.

- Visually superimpose the 16-cell grid picture in Figure 4 below on the stockpiled residual streams. (Please note that this is an overhead view, as if you were above the pile looking down on it.)
- Using a digital camera, take photo of stockpile prior to extracting grab samples to identify sampling cells.
- Extract one grab sample each from three randomly selected sections of the stockpile of processing residual. Random cells are selected for sampling using the random number generator in Excel (function RANDBETWEEN). Cell numbers are preselected from the 16-cell grid prior to sampling. These three grab samples will be used to produce a single composite sample. Each individual grab sample should be approximately the same weight, and when added together, the three samples should generate a sample weight as specified above.
- Place the three grab samples into a single container with a known tare weight. Suitable containers include steel bins and facility equipment such as the bucket of a loader.
- Weigh the containerized sample using a truck scale or a commodity scale.
- Determine the weight of the complete sample by subtracting the tare weight from the gross weight of the containerized sample.
- Record the net weight of the complete sample on the Volume Based Sample Data Form (see Appendix B-2: Field Forms for an example of this form).
- Collect a minimum of eight composite samples over the course of a processing shift. (Note: Eight complete samples will require extracting 24 individual grab samples from the residual stockpile)[3].

[3] In the final protocol, specifications will require two consecutive days of sampling each quarter with 5-8 (15-24 grab samples) composite samples required per day, for a total of 10-16 (30-48 grab samples) per quarter and 40-64 (120-192 grab samples) per year (final specified number will depend on results of protocol testing.)

Figure 4. Visual overlay for Stockpile Method showing "cells" of materials

Option 2: Direct Load Method

Perform the following sampling procedure at facilities that load residual streams directly into a transport trailer or other container. At these facilities, extract samples from a minimum of 20 cubic yards of processing residual. Sampling will occur before any particle size reduction of the residual stream.

- Level processing residual already loaded in a trailer to a uniform height and extend in one direction to create a roughly rectangular shape.
- Visually superimpose the 3 dimensional grid pictured in Figure 5. Visual Overlay for Direct Load Method Showing "Cells" of Material below on the processing residual. (Please note that this is a side view, facing the left-hand side of the trailer.)
- Using a digital camera, take photo of load prior to extracting grab samples to identify sampling cells.
- Extract one grab sample each from three randomly selected sections of the processing residual intended for transport trailers. Random cells are selected for sampling using the random number generator in Excel (function RANDBETWEEN). Cell numbers are preselected from the 16-cell grid prior to sampling. These three grab samples will be used to produce a single composite sample. Each individual grab sample should be approximately the same weight, and when added together, the three samples should generate a sample weight as specified above.
- Complete the method by following Steps 4 through 8 of the stockpile method described above.

Figure 5. Visual Overlay for Direct Load Method Showing "Cells" of Material

Sample Characterization

Use the visual volumetric six-step process described below to estimate the composition of all samples.

- **Collect information about the sample.** At the sampling area, record information on the Volume Based Sample Data Form including facility, residual stream, and date.
- **Photograph the sample.** Using a digital camera, capture an image in which a Sample Placard identifying the sample is visible.
- **Measure sample volume.** Use a tape measure to record the length, width, and height of the sample on the visual characterization form.
- **Note which materials are present.** On the Volume Based Sample Data Form, note which material types are present in the sample (see **Table 16.** Banned material sizing and **Table 17.** Banned material sizing below). Material types and definitions are listed in Appendix B-1: Material Definitions and Size Thresholds.
- **Estimate composition by volume for each material type.** Consider each material type separately and estimate the percentage of each material type that makes up the sample.

Table 17. Banned material sizing

Material	Size Threshold
Concrete/asphalt paving/bricks	>6" in its longest dimension
Metal	>6" in its longest dimension
Carpet	12" in its **shortest** dimension
Cardboard	>8" in its longest dimension
Plastic film wrap	12" in its **shortest** dimension
New construction gypsum scrap	>6" in its longest dimension
Unpainted/untreated wood	>6" in its longest dimension
Tear-off shingles	>8" in its longest dimension

Analysis

Converting the data that the sample characterization process collected into detailed estimates of the composition of the C&D residuals stream requires converting the volumetric estimates to weight estimates, and performing statistical analysis on the weight estimates.

Enter data from the Sample Data Forms completed throughout the sample characterization into a database. The database will use the following formulae to conduct the required analysis and generate detailed C&D residual composition estimates.

Converting Volumes to Weights

Since data collected to characterize each sample are in the form of volumetric percentages, estimates must be converted to weights using material-specific density factors. These density factors are listed in Appendix B-3: Conversion Factors; sources for these density factors accompany the table.

Using the volume-to-weight conversion factors and the volume estimates obtained during the characterization of each sample, individual material weights are calculated using the following formula:

$$c = m \times s \times v \times d$$

where:

c = the total weight of the specific material in the sample

m = percentage estimate of the material, as a portion of material class (e.g., the extent to which *concrete* constitutes all of the **C&D** in the sample)

s = percentage estimate of the material class, as a portion of all of the material in the sample (e.g., the extent to which **C&D** constitutes all of the material in the sample)

v = total volume of the sample (in cubic yards)

d = density conversion of the material (in pounds/cubic yard)

Composition Calculations

The composition estimates represent the ratio of each material's weight to the total sample weight. They are derived by adding each material's weight across all of the selected records and dividing by the sum of the total sample weight, as shown in the following equation:

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

where:

c = weight of particular material type

w = sum of all material type weights

for *i* 1 to n

where *n* = number of selected samples

for *j* 1 to m

where *m* = number of components

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

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

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

Second, confidence intervals at the 90% confidence level 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).

Appendix B-1: Material Definitions and Size Thresholds

This section lists the materials that the residual characterization will track. Materials are listed in pairs according to the material size banned from the C&D residual stream per Ordinance 124076 – the first size threshold in each pair is allowed in the residual stream for disposal, and the second size threshold is banned.

Field staff will use this material list during protocol testing, to ensure that staff categorizes all materials larger than 2 inches. In the final protocol to determine % of total banned materials in the residual bound for landfill disposal, this list of materials will be reduced to only those materials that exceed specified dimensions.

Material	Size Threshold	Definition
Concrete/asphalt paving/bricks	2”-6” in its longest dimension	*Concrete, asphalt paving, and bricks in pieces between 2” and 6” in diameter in its longest dimension. Concrete is defined as a hard material made from sand, gravel, aggregate, cement mix, and water. Asphalt means a black or brown, tar-like material mixed with aggregate used as a paving material. Both categories include materials containing steel mesh and/or reinforcement bars, or "rebar". Bricks are defined as complete or partial portions of bricks made of red clay material. Does not include other types of aggregate material.*
Concrete/asphalt paving/bricks	> 6” in its longest dimension	*Concrete, asphalt paving, and bricks in pieces > 6” in diameter in its longest dimension. Concrete is defined as a hard material made from sand, gravel, aggregate, cement mix, and water. Asphalt means a black or brown, tar-like material mixed with aggregate used as a paving material. Both categories include materials containing steel mesh and/or reinforcement bars, or "rebar". Bricks are defined as complete or partial portions of bricks made of red clay material. Does not include other types of aggregate material.*
Metal	2”-6” in its longest dimension	*Includes tin/steel food cans, major appliances, other ferrous, aluminum cans, and other non-ferrous metals in lengths between 2”and 6” in its longest dimension. Includes Mixed Recoverable Metal meaning composite, multi-metal products or products with non metal contaminants. The metal content must be more than 90% by weight of the material.*
Metal	> 6” in its longest dimension	*Includes tin/steel food cans, major appliances, other ferrous, aluminum cans, and other non-ferrous metals in lengths > 6” in its longest dimension. Includes Mixed Recoverable Metal meaning composite, multi-metal products or products with non metal contaminants. The*

		metal content must be more than 90% by weight of the material.
Carpet	> 2"X2" in area but < 12" in its shortest dimension	*'Carpet' means flooring applications at least 2"X 2" in area that is primarily constructed of a top visible surface of synthetic face fibers or yarns or tufts attached to a backing system derived from synthetic or natural materials. It includes broadloom and carpet tiles; it does not include a rug, pad, cushion, or underlayment. Material must be dry and free of excessive contamination such as paint, grease, grime, or dirt.*
Carpet	> 12"in its **shortest** dimension	*'Carpet' means flooring applications > 12" in its shortest dimension that is primarily constructed of a top visible surface of synthetic face fibers or yarns or tufts attached to a backing system derived from synthetic or natural materials. It includes broadloom and carpet tiles; it does not include a rug, pad, cushion, or underlayment. Material must be dry and free or dirt.*
Cardboard	2"-8" in its longest dimension	*Cardboard between 2" and 8"in length in its longest dimension. Can have tape, staples and other fasteners*
Cardboard	> 8" in its longest dimension	*Cardboard greater than 8" in length in its longest dimension. Can have tape, staples and other fasteners*
Plastic film wrap	> 2"X2" in area but < 12" in its shortest dimension	*Plastic film used to package or wrap commercial and industrial product that is at least 2"X 2" in area. Examples include shrink-wrap, and building wrap/Tyvek packaging. Material must be dry and free of excessive contamination such as paint, grease, grime, or dirt.*
Plastic film wrap	> 12" in its **shortest** dimension	*Plastic film used to package or wrap commercial and industrial products in dimensions > 12" in its **shortest** dimension. Examples include shrink-wrap, and building wrap/Tyvek packaging. Material must be dry and free of excessive contamination such as paint, grease, grime, or dirt.*
New construction gypsum scrap	2"-6" in its longest dimension	*Unpainted gypsum wallboard or interior wall covering made of a sheet of gypsum sandwiched between paper layers between 2" and 6" in length in its longest dimension. Examples: This category includes used or unused, broken or whole sheets. Gypsum board may also be called sheetrock, drywall, plasterboard, gypboard, gyproc, or wallboard.*
New construction gypsum scrap	> 6" in its longest dimension	*Unpainted gypsum wallboard or interior wall covering made of a sheet of gypsum sandwiched between paper*

		layers in lengths > 6" in length in its longest dimension. Examples: This category includes used or unused, broken or whole sheets. Gypsum board may also be called sheetrock, drywall, plasterboard, gypboard, gyproc, or wallboard.
Unpainted/untreated wood	2"-6" in its longest dimension	*Includes unpainted/unstained new and demolition scrap dimensional lumber such as 2 x 4s, 2 x 6s, 2 x 12s, and other residual materials from framing and related construction activities, engineered wood, pallets and crates in lengths between 2" and 6" in length in its longest dimension. Such wood can have nails, screws and metal fasteners. It does not include particle board or laminated veneer wood.*
Unpainted/untreated wood	> 6" in its longest dimension	*Includes unpainted/unstained new and demolition scrap dimensional lumber such as 2 x 4s, 2 x 6s, 2 x 12s, and other residual materials from framing and related construction activities, engineered wood, pallets and crates in lengths > 6" in its longest dimension. Such wood can have nails, screws and metal fasteners. It does not include particle board or laminated veneer wood.*
Tear-off asphalt roofing shingles	2"-8" in its longest dimension	*Composite shingles composed of fiberglass or organic felts saturated with asphalt and covered with inert aggregates including asphalt shingles and attached roofing tar and tar paper in lengths between 2" and 8" in its longest dimension.*
Tear-off asphalt roofing shingles	> 8" in its longest dimension	*Composite shingles composed of fiberglass or organic felts saturated with asphalt and covered with inert aggregates including asphalt shingles and attached roofing tar and tar paper in lengths > 8" in its longest dimension.*

Appendix B-2: Field Forms

Volume Based Sample Data Form

Step 1: Enter Data

Site: 3&L CDL R1 Glacier

Residuals Stream (circle):

Mixed C&D MSW Bulky

Date: ____________________________

Sample ID: ________________________

Step 2: Photograph Samples

Stockpile/Load PhotoTaken: ☐

Sample Photo Taken: ☐

Step 3: Weigh, measure and record the sample weight and volume.

Sample Net Weight: __________

Sample Volume

_______ft x _______ft x _______ft

Percent of Compositio	**Material Type**
	Concrete/asphalt paving/bricks 2"-6" (longest)
	Concrete/asphalt paving/bricks >6" (longest)
	Metal 2"-6" (longest)
	Metal >6" (longest)
	Carpet > 2"-2"
	Carpet >12" (shortest)
	Cardboard 2"-8" (longest)
	Cardboard >8" (longest)
	Plastic film wrap > 2"x2"
	Plastic film wrap >12" (shortest)
	New construction gypsum scrap 2"-6" (longest)
	New construction gypsum scrap >6" (longest)
	Unpainted/untreated wood 2"-6" (longest)
	Unpainted/untreated wood >6" (longest)
	Tear-off shingles 2"-8" (longest)
	Tear-off shingles >8" (longest)
%	***Grand Total***

Evaluation Notes:

Time Notes:

Selection Time (from request to sample on ground):

____

Characterization Time (from beginning to end of sort):

____

Practicality Notes:

Impact (circle): 1 2 3

____

____

____

Feasibility (circle): 1 2 3

____

____

____

Sample Placard

Random Cells: **5 7 15** **SAMPLE ID** **W-1** **RESIDUAL STREAM:** Mixed C&D	DATE:**5/15/2013**
Facility: CDL Recycle	

Appendix B-3: Conversion Factors

Table 18. Conversion factors by material class

Material	Conversion Factor	Source
Concrete, Asphalt Paving, Bricks	860	CIWMB2004
Tear-off Asphalt Roofing Shingles	731	CIWMB2004
Unpainted/Untreated Wood	169	CIWMB2004
New Construction Gypsum Scrap	467	CIWMB2004
Carpet	147	CIWMB2004
Plastic Film Wrap	22.55	Tellus
Cardboard	53	CIWMB2004
Metal	225	CIWMB2004
Remainder/Composite C&D	416.53	CIWMB2004
Mixed Residue/Fines < 2”	999	FEECO

Sources:

CIWMB 2004 refers to *Targeted Statewide Waste Characterization Study: Detailed Characterization of Construction and Demolition Waste*, performed by Cascadia Consulting Group for California Integrated Waste Management Board, 2006.

Tellus refers to the Tellus Institute, Boston, Massachusetts.

FEECO refers to FEECO International, Complete Systems and Equipment Handbook, 9th printing.

Appendix 2: Summary of Methodology by Facility

Process by Facility

After completing field work, Cascadia staff evaluated the process of completing the protocols at each facility. This section gives a summary of the impact and feasibility of conducting both protocols, the sampling method used, and general observations and comments for each of the four facilities that participated in the study.

Facility 1	
Number of Samples	Cascadia characterized a total of 24 samples from this facility.
Summary of Sampling Method	Cascadia used the Direct Load Method for sampling at this facility. Facility 1 provided two full trailers of material for sampling. Cascadia staff applied the 16-cell grid to both trailers and instructed the facility excavator to take material from each of the 16 cells and dump onto the ground in front of the trailers. Cascadia then hand-pulled each sample from these groups of materials.
Summary of Impact and Feasibility	Cascadia field staff pulled samples from previously filled transfer trailer boxes and required minimal assistance from facility staff (use of excavator and loader). The facility offered plenty of open space for sampling and sorting. Cascadia staff was greatly aided by the ability to use the on-site excavator for sample selection.
General Comments	Each sample often contained the majority of the banned materials, which required time to handle, visualize, and weigh each material. Additionally, due to the large, bulky, stringy, and tangled nature of the piles, the process of hand-pulling samples was protracted and dirty.

Figure 6. Example of Direct Load Method with grab samples

Facility 2	
Number of Samples	Cascadia characterized a total of 24 samples from this facility.
Summary of Sampling Method	Cascadia field staff utilized the Stockpile Method for sampling. Cascadia staff had the assistance of the loader operator for one day of sampling, but hand-pulled samples from the larger piles for the other two sampling days.
Summary of Impact and Feasibility	Facility staff delivered 40 yard boxes containing material for sampling to Cascadia staff. This process was a deviation from normal facility operations as facility staff would normally load residual material into transfer trailers, but it did not seem to impact the overall operation of the facility. Cascadia staff had ample space for safe sorting and sampling execution.
General Comments	Sampling methods were most effective when field staff is able to access all sides of the material pile. If facility operations did not allow for ready access to a stockpile or transfer trailer load (e.g. if material was pushed against a bunker), staff had difficulty sampling from all 16 cells in the grid overlay. Additionally, large and easily tangled materials were difficult to manage without full access (360 degrees) to the pile.

Figure 7. Cascadia field staff hand-pulling samples from larger pile

Facility 3	
Number of Samples	Cascadia characterized a total of 22 samples from this facility.
Summary of Sampling Method	Cascadia utilized the Direct Load Method at this facility.
Summary of Impact and Feasibility	Cascadia field staff needed assistance from two to three facility staff members and use of the excavator was also critical for sampling. Facility 3 provided transfer trailers of material for sampling, but Cascadia staff had to wait for trailer to be filled in order to select samples. Additionally, the excavator at this facility was not big enough to get to the bottom of the trailer, posing difficulty in accessing 100% of the trailer contents. Material at the bottom was only accessible once the top layer of material was removed. Cascadia staff did not have as much space to complete sampling and sorting compared to other facilities.
General Comments	If facility operations require direct trailer sampling, the 16 cell grid could be adjusted to be cells as "slices." Each cell would encompass material from the entire top and bottom of the trailer. Additional suggestions include dumping the contents of the filled trailer to create a more easily accessible pile, or allowing the residual material to accumulate into a stockpile.

Figure 8. Excavator sampling directly from transfer trailer

Facility 4	
Planned vs. Actual Number of Samples	Cascadia characterized a total of 24 samples at this facility.
Summary of Sampling Method	Cascadia field staff had access to two identical stockpiles of material for sampling and collected half the samples from one pile and half from the other. As neither pile was completely accessible (80%), Cascadia staff applied the 16-cell grid to the accessible portion and collected samples from this section. Cascadia staff elected to collect all samples at once because the pile content remained the same throughout all sampling days.
Summary of Impact and Feasibility	Cascadia staff and utilized facility equipment (bobcat and excavator) and two members of site staff for sampling. The facility provided plenty of space to collect and sort samples. This facility had two identical stockpiles available for sampling.
General Comments	A very small percentage of the material at this facility was larger than 2", resulting in smaller samples (minimum of >20lbs). Cascadia field staff sorted through this material for anything over 2".

Figure 9. Picture of residual stream stockpile