Exhibit T

Protocols for Waste Characterization Studies

1. Scope

1.1 The method describes the procedures for measuring the composition of unprocessed municipal solid waste (MSW) by employing manual sorting. The procedure applies to the determination of the mean composition of MSW based on the collection and manual sorting of a number of samples of waste over a selected period of time with a minimum of one week.

1.2 The procedures include those for collection of a representative sorting sample of unprocessed waste, manual sorting of the waste into individual waste components, data reduction, and reporting of results.

1.3 The method may be applied at landfill sites, waste processing and conversion facilities, and transfer stations.

2. Definitions

2.1 Sorting Sample: A 200 to 300 lb portion that is deemed to represent the characteristics of a vehicle load of MSW.

2.2 Unprocessed Municipal Solid Waste: Solid Waste in its discarded form, i.e., waste that has not been size reduced or otherwise processed.

2.3 Waste Component: A category of solid waste composed of materials of similar physical properties and chemical composition, which is used to define the composition of solid waste, e.g.., ferrous, glass, newsprint, yard waste, aluminum, etc.

2.4 Solid Waste Composition or Waste Composition: The characterization of solid waste as represented by a breakdown of the mixture into specified waste components on the basis of mass fraction or of weight percentage.

2.5 Composite Item: An object in the waste that is composed of multiple waste components or dissimilar materials, such as disposable diapers, bi-metal beverage containers, electrical conductor composed of metallic wire encased in plastic insulation, etc.

3. Summary of Methods

3.1 The number of samples to be sorted is calculated based upon statistical criteria selected by the investigators.

3.2 Vehicle loads of waste are designated for sampling, and a sorting sample is collected from the discharged vehicle load.

3.3 The sorting sample is manually sorted into waste components. The weight fraction of each component in the sorting sample is calculated from the weights of the components.

3.4 The mean waste composition is calculated using the results of the composition of each of the sorting samples.

4. Significance and Use

4.1 Waste composition information has wide application and can be used for such activities as solid waste planning, designing waste management facilities, and establishing a reference waste composition for use as a baseline standard in facility contracts and in acceptance test plans.

4.2 The method can be used to define and report the composition of municipal solid waste through the selection and manual sorting samples of waste. Care should be taken to consider the source and seasonal variation of waste, where applicable.

4.3 After performing a waste composition analysis, laboratory analysis may be performed on representative samples of waste components or mixtures of waste components for purposes related to the planning, management, design, testing, and operation of resource recovery facilities.

5. Apparatus

5.1 Sufficient metal, plastic, or fiber containers for storing and weighing each waste component, labeled accordingly. For components that will have a substantial moisture content (e.g., food waste), metal or plastic containers are recommended to avoid absorption of moisture by the container and, thus, the need for a substantial number of weighings to maintain an accurate tare weight for the container.

5.2 A mechanical or electronic weigh scale with a capacity of at least 200 lb, and a precision of at least 0.1 lb.

5.3 Heavy-duty tarps, shovels, rakes, push brooms, dust pans, hand brooms, magnets, sorting table, first aid kit, miscellaneous small tools, traffic cones, traffic vests, leather gloves, hardhats, safety glasses, and leather boots.

6. Precautions

6.1 Review the precautions and procedures with the operating and sorting personnel prior to the conduct of the field activities.

6.2 Sharp objects such as nails, razor blades, hypodermic needles, and pieces of glass are present in solid waste. Personnel should be instructed of this danger and brush waste particles aside while sorting, as opposed to projecting their hands with force into the mixture. Personnel handling and sorting solid waste should wear appropriate protection. Appropriate protection includes heavy leather gloves, hardhats, safety glasses, and safety boots.

6.3 During the process of unloading waste from collection vehicles and of handling waste with heavy equipment, projectiles may issue from the mass of waste. The projectiles can include flying glass particles from breaking glass containers and metal lids from plastic and metal containers that burst under pressure when run over by heavy equipment. The problem is particularly severe when the waste handling surface is of high compressive strength, e.g., concrete. Personnel should be made aware of the danger and wear eye and head protection if in the vicinity of the collection vehicle unloading point, or in the vicinity of heavy equipment, or both.

6.4 Select a location for discharge of designated loads, manual sorting activities, and weighing operation that is flat, level, and away from the normal waste handling and processing areas.

6.5 Weigh storage containers each day, or more frequently if necessary, in order to maintain an accounting of the tare weight.

7. Calibration

7.1 All weigh scale equipment shall be calibrated according to the manufacturer's instructions. Take appropriate corrective action if the readings are different than the calibration weights.

8. Procedures

8.1 Secure a flat and level area for discharge of the vehicle load. The surface should be swept clean or covered with a clean, durable tarp prior to discharge of the load.

8.2 Position the scale on a clan, flat, and level surface and adjust the level of the scale if necessary. Check the accuracy and operation of the scale with a known (i.e., reference) weight.

8.3 Weigh all empty storage containers and record the tare weights.

8.4 Determine the number of sorting samples to be sorted. The determination is a function of the waste components to be sorted and the desired precision as applied to each component. Weights of 200 to 300 lb for sorting samples of unprocessed solid waste are recommended. The number of samples is determined using the calculation method described in section 9.1.

8.5 A comprehensive list of waste components for sorting is shown in Table A. A description of some of the waste component categories is given in Table B. Other waste components can be defined and sorted depending upon the purpose of the waste composition determination. The list in Table A is comprised of those components most commonly used to define and report the composition of solid waste. At a minimum, it is recommended that the complement of left-justified categories in Table A be sorted. Therefore, similar breakdowns of solid waste composition are available for purposes of comparison, if desired. Label the storage containers accordingly.

TABLE A. List of Waste Component Categories

Mixed Paper	Other Organics
High Grade Paper	Ferrous
Computer Printout	Cans
Other Office Paper	Other Ferrous
Newsprint	Aluminum
Corrugated	Cans
Plastic	Foil
PET Bottles	Other Aluminum
HDPE Bottles	Glass
Film	Clear
Other Plastic	Brown
Yard Waste	Green
Food Waste	Other Organics
Wood	

TABLE B. Description of Some Waste Component Categories

Category	Description
Mixed Paper	Office paper, computer paper, magazines, glossy paper, waxed paper, other paper not fitting categories of "Newsprint" and "Corrugated
Newsprint	Newspaper
Corrugated	Corrugated medium, corrugated boxes or cartons, brown (kraft) paper (i.e., corrugated) bags
Plastic	All plastics
Yard Waste	Branches, twigs, leaves, grass, other plant material
Food Waste	All food waste except bones
Wood	Lumber, wood products, pallets, furniture
Other Organics/ Combustibles	Textiles, rubber, leather, other primarily burnable materials not included in the above component categories
Ferrous	Iron, steel, tin cans, bi-metal cans
Aluminum	Aluminum, aluminum cans, aluminum foil
Glass	All glass
Other organics/ Non-combustibles	Rock, sand, dirt, ceramics, plaster, non-ferrous non-aluminum metals (copper, brass, etc.), bones

8.6 Vehicles for sampling shall be selected at random during each day of the one-week sampling period, or so as to be representative of the waste stream as agreed to by the affected parties. With respect to random selection of vehicles, any method is acceptable that does not introduce a bias selection. An acceptable method is use of a random number generator. For a weekly sampling period of k days, the number of vehicles sampled each day shall be approximately n/k, where n is the total number of vehicle loads to be selected for determination of waste composition. A weekly period is defined to be 5 to 7 days.

8.7 Direct the designated vehicle containing the load of waste to the area secured for discharge of the load and collection of the sorting sample.

8.8 Direct the vehicle operator to discharge the load onto the clean surface in one contiguous pile, i.e., to avoid gaps in the discharged load. Collect any required information from the vehicle operator prior to the vehicle leaving the discharge area.

8.9 Using mechanical equipment, remove material longitudinally along one entire side of the discharged load, sufficient to form a mass of material which, on a visual basis, is at least four times the desired weight of the sorting sample (i.e., about 1, 000 lb). Mix, cone and quarter this method of selection or a sequence agreed to by all affected parties, for the purpose of eliminating or minimizing biasing of the sample. If an oversize item (e.g., water heater) composes a large weight percentage of the sorting sample, add a notation on the data sheet and weigh it, if possible.

8.10 One sorting sample is selected from each collection vehicle load that is designated for sampling. All handling and manipulation of the discharged load, longitudinal sample, and sorting sample shall be conducted on previously cleaned surfaces. If necessary, remove the sorting sample to a secured manual sorting area. The sorting sample may be placed on a clean table for sorting for the convenience of the sorting personnel. The sorting area shall be a previously cleaned, flat, and level surface.

8.11 Position the storage containers around the sorting sample. From the sorting sample, empty all containers such as capped jars, paper bags, and plastic bags of their contents. Segregate each waste item and place it in the appropriate storage container.

8.12 In the case of composite items found in the waste, separate the individual materials where practical and place the individual materials into the appropriate storage containers. Where impractical, segregate and classify the composite item according to the following order:

8.12.1 If there are many identical composite items (e.g., plastic-sheathed aluminum electrical conductor), place them into the waste component containers corresponding to the materials present in the item and in the approximate proportions according to the estimated mass fraction of each material in the item.

8.12.2 If there are only a few of the identical composite item, place them in the storage container corresponding to the material which comprises, on a weight basis, the majority of the item (e.g., place bi-metal beverage cans in the ferrous container).

8.12.3 If composite items represent substantial weight percentages of the sorting sample, a separate category should be established, e.g., composite roofing shingles.

8.12.4 If none of the above procedures is appropriate, place the item(s) (or proportion it (them)) in the storage container labeled "Other Non-Combustible" or "Other Combustible" as appropriate.

8.13 Sorting continues until the maximum particle size of the remaining waste particles is approximately 0.5 in. At this point, apportion the remaining particles into the storage containers corresponding to the waste components represented in the remaining mixture. The apportionment shall be accomplished by making a visual estimate of the mass fraction of waste components represented in the remaining mixture.

8.14 Record the gross weights of the storage containers and of any waste items sorted but not stored in containers. The data sheet shown in Fig. 1 can be used to record gross weights as well as tare weights.

8.15 After recording the gross weights, empty the storage containers and weigh them again, if appropriate. Re-weighing is important and necessary if the containers become moisture-laden, e.g., from wet waste.

8.16 Clean the sorting site as well as the load discharge area of all waste materials.

9. Calculations

9.1 Number of 200 to 300 lb samples.

9.1.1 The number of sorting samples (i.e., vehicle loads) (n) required to achieve a desired level of measurement precision is a function of the component(s) under consideration, and the confidence level. The governing equation for n is:

$$n - (t^* s/e\bar{x})^2 \qquad \text{(I)}$$

where t^* is the student t statistic corresponding to the desired level of confidence, s is the estimated standard deviation, e is the desired level of precision, and $\bar{x}$ is the estimated mean.

All numerical values for the symbols are in decimal notation. For example, a value of precision (e) of 20% is represented as 0.2.

One sorting sample is chosen per vehicle load.

Figure 1, Waste Composition Data Sheet

Day/Date ______________ Collection Company ____________
Site __________________ Vehicle Type _________________
Weather _______________ Route Number ________________
Recorded By __________________

Component	Weight in Pounds			Percent of Total
	Gross	Tare	Net	
Mixed Paper				
High Grade Paper				
Computer Printout				
Other Office Paper				
Newsprint				
Corrugated				
Plastic				
PET Bottles				
HDPE Bottles				
Film				
Other Plastic				
Food Waste				
Wood				
Other Organics				
Ferrous				
Cans				
Other Ferrous				
Aluminum				
Cans				
Foil				
Other Aluminum				
Glass				
Clear				
Brown				
Green				
Other Inorganics				

Totals ________________________________

Notes ____
____
____

Lab Sample Taken? Yes___ No ___

Suggested values of s and of $\bar{x}$ for waste components are listed in Table C. Values of t* are given in Table D for 90% and 95% levels of confidence, respectively.

9.1.2 Estimate the number of samples (n′) for the selected conditions (i.e., precision and level of confidence) and components using equation 1. For the purpose of estimation, select from Table D the t* value for n - - for the selected level of confidence. Since the required number of samples will vary among the components for a given set of conditions, a compromise will be required in terms of selecting a sample size, i.e., the number of samples that will be sorted. The component that is chosen to govern the precision of the composition measurement (and therefore the number of samples required for sorting) is termed the "governing component" for the purpose of this method.

9.1.3 After determining the governing component and its corresponding number of samples (n_o), return to Table D and select the student t statistic (t^*_o) corresponding to n_o. Recalculate the number of samples, i.e., n′ using t^*_o.

9.1.4 Compare n_o to the new estimate of n, i.e., n′, which was calculated for the governing component. If the values differ by more than 10%, repeat the calculations of 9.1.2 and 9.1.3.

9.1.5 If the values are within 10%, select the larger value as the number of samples to be sorted. Refer to Appendix A for a sample calculation of n.

9.2 Component Composition

9.2.1 The component composition of solid waste is reported on the basis of the mass fraction (expressed as a decimal) or percentage of waste component *i* in the solid waste mixture. The reporting is on the basis of wet weight, i.e., the weight of materials immediately after sorting.

9.2.2 The mass fraction of component *i*, mf_i, is defined and computed as:

$$mf_i = \frac{w_i}{\sum_{i=1}^{j} w_i} \qquad (2)$$

where w_i is the weight of component *i* and j is the number of waste components. In those cases where a container is used to store and weigh the materials:

$$w_i = \text{gross weight - tare weight of container} \qquad (3)$$

TABLE C. Values of Mean ($\bar{x}$) and of Standard Deviation (s) for Within Week Sampling to Determine MSW Component Composition[A]

Component	Standard Deviation (s)	Mean ($\bar{x}$)
Mixed Paper	0.05	0.22
Newsprint	0.07	0.10
Corrugated	0.06	0.14
Plastic	0.03	0.09
Yard Waste	0.14	0.04
Food Waste	0.03	0.10
Wood	0.06	0.06
Other Organics	0.06	0.05
Ferrous	0.03	0.05
Aluminum	0.004	0.01
Glass	0.05	0.08
Other Inorganics	0.03	0.06
		1.00

A) The tabulated mean values and standard deviations are estimates based on field test Data reported for municipal solid waste sampled during weekly sampling periods at several locations around the U.S.

TABLE D. Values of t Statistics (t*) as a Function of Number of Samples and Confidence Interval

No. of Samples (n)	90%	95%
2	6.314	12.706
3	2.920	4.303
4	2.353	3.182
5	2.132	2.776
6	2.015	2.571
7	1.943	2.447
8	1.895	2.365
9	1.860	2.306
10	1.833	2.252
11	1.812	2.228
12	1.796	2.201
13	1.782	2.179
14	1.771	2.160
15	1.761	2.145
16	1.753	2.131
17	1.746	2.120
18	1.740	2.110
19	1.734	2.101
20	1.729	2.093
21	1.725	2.086
22	1.721	2.080
23	1.717	2.074
24	1.714	2.069
25	1.711	2.064
26	1.708	2.060
27	1.706	2.056
28	1.703	2.052
29	1.701	2.048
30	1.699	2.045
31	1.697	2.042
36	1.690	2.030
41	1.684	2.021
46	1.679	2.014
51	1.676	2.009
61	1.671	2.000
71	1.667	1.994
81	1.664	1.990
91	1.662	1.987
101	1.660	1.984
121	1.658	1.980
141	1.656	1.977
161	1.654	1.975
189	1.653	1.973
201	1.553	1.972
–	1.645	1.960

APPENDIX A. ESTIMATE OF NUMBER OF SAMPLES FOR ANALYSIS

ASSUMPTIONS

1. Corrugated is selected as the governing component
2. A 90% confidence level is selected
3. A precision of 10% is desired

Therefore:

$s = 0.06$ (from Table C)
$\overline{x} = 0.14$ (from Table C)
$e = 0.10$
$t^* (n - -) = 1.545$ (from Table D)

Using equation 1:

$$n = [t^* \; s/ (e \; \overline{x})]^2$$

$$= \left[\frac{1.645 \; (0.06)}{0.1 \; (0.14)} \right]^2$$

$$= 50$$
$$= n_o$$

Referring again to Table D, for $n = 50$

$t^*90 \; (n = 50) = 1.677$

and,

$$n = \left[\frac{1.677 \; (0.06)}{0.1 \; (0.14)} \right]^2$$

$$= 52$$
$$= n'$$

Since 52 (i.e., n') is within 10% of 50 (i.e., n_o), 52 samples should be selected for analysis.