

# **Appendix B**

## **Feedstock Generation Multipliers and Conversion Factors**

## RRSI calculation methodology

For this project RRSI derived several distinct data sets.

- **Geographic Distribution Animal Manure**  
 Animal manure was estimated by multiplying the number of animals in a given county (hogs, sheep, or cows) by a species-specific multiplier to arrive at a manure total per county per year. Animal populations were obtained from the *USDA Census of Agriculture, 1992*. Multipliers were obtained from the *On Farm Composting Handbook*.
  
- **Geographic Distribution Paper Waste**  
 Paper waste in the SERBEP region was estimated by adding reported paper production for each mill in a state as reported by the *Lockwood-Post's Directory*. Waste was estimated using paper waste production data from the National Council of the paper Industry for Air and Steam Improvement, Inc. 1997. Each state's total was divided by the number of employees reported in the 1998 County Business patterns to arrive a per employee generation rate. These figures are shown below in Table 1. A geographic distribution was produced by multiplying this generation rate by the number of employees in pulp and paper manufacturing in each county.

**The geographic distribution for the entire United States was calculated by using the above methodology except every state used the SERBEP average at the generation rate. (220 pounds/employee/day)**

**Table 1: Paper Production Employment and Waste Data**

	<b>Paper Production</b> Tons/day	<b>Paper Production</b> Number of Employees	<b>Waste Paper</b> lbs/day	<b>Waste Paper</b> lbs/emp/day
Alabama	20,655	15,455	2,575,679	167
Arkansas	9,430	6,750	1,175,921	174
Florida	8,595	7,080	1,071,794	151
Georgia	22,505	12,439	2,806,425	226
Kentucky	7,165	1,795	893,476	498
Louisiana	24,700	8,110	3,080,090	380
Mississippi	10,896	4,055	1,358,731	335
Missouri	320	70	39,904	570
North Carolina	9,506	8,770	1,185,398	135
South Carolina	10,995	8,485	1,371,077	162
Tennessee	8,235	5,611	1,026,902	183
Virginia	9,976	6,452	1,244,007	193
West Virginia	275	120	34,293	286
<b>Totals</b>	<b>143,253</b>	<b>85,192</b>	<b>17,863,696</b>	<b>210</b>

- Geographic Distribution Food Manufacturing Waste
- The number of employees in every food and beverage manufacturing industry were totaled for each county. This number was then multiplied by a food manufacturing specific multiplier to estimate the level of biomass generated as waste by these industries. Employment figures were provided by the 1998 County Business Patterns survey of the Economic Census. See Method A.
- Geographic Distribution Food Service Waste  
The number of employees in the food service industry were totaled for each county. This number was then multiplied by a food service specific multiplier to estimate the level of biomass generated as waste by these industries.
- Geographic Distribution of Landfill Tip Fees  
Every landfill in the eastern US which reported a tip fee in the Directory and Atlas of Solid Waste Disposal Facilities was plotted onto a contour map of the region. Tip fees were interpolated between landfills to produce a smooth color chart.
- Truck Transportation Costs per Ton per Mile  
See method B.
- Net Value of Waste Disposal Services (at a given distance from Cowpens, SC)  
The great circle distance between each landfill in #5 and Cowpens was calculated. This distance was used to calculate a 2-way transportation cost from #6. This transportation cost was then subtracted from the tip fee charged by each respective landfill.
- Biomass Available (for profitable disposal at Cowpens, SC)  
Data from #1, 2, 3, 4, and 7 were each plotted contour charts. Using sophisticated interpolation techniques, the scattered county by county or landfill site data was then converted into a regular 300x300 grid covering the same area. This step was necessary so that individual biomass production sites could be assigned a tipfee.

Each point in the 300x300 grid was evaluated to see if it would be profitable to haul biomass from that location at the indicated tip fee. If that was the case the production was added into the total. If it would not be profitable then the production was not included.

## Method A

To estimate the biomass disposal in food-manufacturing industries, RRSI first obtained employment figures from the 1998 Economic Census, County Business Patterns. To assign biomass totals to the employment figures, RRSI needed a *per employee generation* to estimate biomass generation based on employment.

RRSI estimated this generation rate using the following data and calculations. RRSI first obtained raw data on employment and waste generation for several businesses in the food-manufacturing sector. A total of 14 entities were profiled from the following studies and conversations.

- 1) *Clark County Solid Waste Management Plan*. Black & Veatch, Engineers-Architects, Resource Recycling Systems, Inc., Miller, Canfield, Paddock, & Stone. June 1990.
- 2) *Major Solid Waste Generators in Washtenaw County*. Resource Recycling Systems, Inc. January, 1989.
- 3) *Tri-county Solid Waste Council Business Waste Characterization Report*. Resource Recycling Systems, Inc. 1995.
- 4) *Lucas County Solid Waste Management Plan*. Midwest Environmental Consultants. June 1993.
- 5) *Northeast Indiana Solid Waste Management District: Study of Solid Waste Generation and Composition*. Resource Recycling Systems, Inc. March, 1992.
- 6) Telephone interview with Jerome Siemer, Plant Director, Welches, Lawton, MI. June 18, 1990.
- 7) Telephone interview with Walter Frank, Plant Manager, Honee Bear Canning, Lawton, MI. June 18, 1990.
- 8) Telephone interview with John Staikie, US Poultry and Agriculture Association. January 11, 2001.

RRSI also obtained waste characterization data from the following sources.

- 9) *Estimating Composition and Quantities of Solid Waste generation*. Gershamn, Brinker, and Braton, Inc. 1985
- 10) *Minnesota Solid Waste Composition Study, part 1*. Minnesota Pollution Control Agency, November, 1992.
- 11) *Dakota County Solid Waste Generation and Characterization Study*. Franklin Associates. February 1991.

Combining the waste generation data with the characterization studies allowed RRSI to calculate the total biomass waste disposed of by each business entity and then calculate the weight disposed per employee.

These weights ranged from 2.4 pounds per employee per day to 43.8 pounds per employee per day. The average was 16.0 pounds per employee per day. Table 2 below summarizes the figures for each location.

**Table 2: Observed per employee biomass disposal**

	Number of Employees	Lbs. per employee per day	Reference
Chelsa Milling	270	28.0	2)
Spring Farms Inc.	85	4.7	1)
Young's Jersey Dairy	95	2.4	1)
Bay County	300	4.9	3)
La Fronteriza Inc.	80	26.3	4)
Nabisco Toledo Flour Mill	140	11.8	4)
Ohio Blenders	9	6.7	4)
HyGrade Foods	300	25.6	5)
Honee Bear Canning	15	43.8	7)
Typical Chicken Plant	700	24.3	8)
Welches	280	27.4	6)
<b>Average</b>		<b>16.0</b>	

The animal residuals category represents the content of suspended solids in the offal from animal slaughtering houses. This is a very small section of the inedible portions of the animals processed at each facility. To estimate this quantity, RRSI first calculated the amount of suspended solids in offal per head slaughtered for each of the four major meat animals, cattle, chickens, pigs, and sheep. The suspended solids data are shown below in Table 3. Data in Table 3 was obtained from:

- *Waste Management and Utilization in Food Production and Processing*. Council for Agricultural Science and Technology. October 1995.
- *USDA 1997 Census of Agriculture*. United States Department of Agriculture. 1998.
- 

**Table 3: Suspended solids from animal processing offal**

	Heads	Total Weight of Slaughtered Animals	Gallons of Off-Flow	Total Suspended Solids	Residuals Lbs./year	Residuals lbs./head	Residuals Percentage of Original Weight
Cows	124,742	59,146,899	43,659,700	2,350	857,738	6.876	1.45%
Pigs	86,280	20,679,117	12,942,000	520	56,261	0.652	0.27%
Chicken	5,169,395	12,788,505	29,982,491	1,177	295,019	0.057	2.31%

Next the number of animals slaughtered in each state was calculated from USDA Agriculture Census data. This data was then used to calculate the amount of suspended solids produced by animal slaughtering operations for each state. These figures are shown below in Table 4.

**Table 4: Animal residuals in off-flow by state**

State	Hog Residuals lbs/year	Cattle Residuals lbs/year	Chicken Residuals lbs/year	Total Residuals lbs/year	Animal Slaughtering Employees	Residuals lbs/employee/year
Alabama	281,699	68,486	224,857	575,042	20,073	28.65
Arkansas	1,132,011	71,786	447,089	1,650,887	38,365	43.03
Florida	127,808	87,464	138,396	353,667	6,521	54.24
Georgia	996,378	56,109	366,563	1,419,050	38,314	37.04
Kentucky	852,921	101,491	27,394	981,806	7,488	131.12
Louisiana	57,383	39,606	29,677	126,666	4,920	25.75
Mississippi	239,965	53,634	179,372	472,971	18,632	25.38
Missouri	4,199,395	170,802	75,048	4,445,245	16,841	263.95
North Carolina	8,156,217	41,257	257,387	8,454,861	30,650	275.85
South Carolina	406,898	18,153	59,639	484,689	11,288	42.94
Tennessee	610,347	97,366	28,535	736,248	10,393	70.84
Virginia	1,180,731	56,934	129,508	1,367,173	19,870	68.81
West Virginia	33,908	18,153	41,091	93,152	4,880	19.09

From the factors shown above in Table 4 were multiplied by the geographic employment data in from the 1998 County Business Patterns to produce a geographic distribution for suspended animal solids.

## Method B

Transportation costs were estimated by the following method.

### Cost Assumptions:

Cost of fuel	\$1.50 per gallon
Load time	1.5 hours per load
Unload time	0.5 hours per load
average speed	45 mph
Fuel usage	4 Gallons Per Hour
Truck Cost	\$150,000
trailer Cost	\$30,000
Truck Life	7 years
trailer Life	10 years
Maintenance	\$12,000
Tire Life	0.5 years
Tire Cost	\$300 each
Number of tires	14
Amortization rate	7%
Work Week	40 hours
Wage rate	\$18 per hour
Truck Capacity	16 Tons

Therefore the cost of one trip is:

Total Cost = Labor Cost + Fuel Cost + Vehicle Cost Share

Total Cost = Time \* Wage rate + Time \* Fuel Usage \* Fuel Cost +  
Annual Vehicle Cost / Full Work Year \* Time

$$TC = 6 \cdot \left( \frac{mi}{45} + 2 \right) + 18 \cdot \left( \frac{mi}{45} + 2 \right) + \frac{46204.31}{2080} \cdot \left( \frac{mi}{45} + 2 \right)$$

$$TC = 1.026969 \cdot mi + 92.42$$

If:  $TC$  = Total Cost  $mi$  = Round Trip (in miles)

The cost per ton (CPT) is  $TC$  divided by the vehicle capacity, or 16 tons.

$$CPT = \frac{1.026969 \cdot mi + 92.42}{16}$$

$$CPT = .0128371 \cdot mi + 5.776$$

## Method C: Factor Summary

Data Name	NAICS Code	Geographic Data Source	Generation rate	Factor Source
Hog Manure	n/a	1997 USDA Census of Agriculture	1.46 Tons/year/employee	<i>Manure Management Study</i> , 1992, Pennsylvania State University
Cattle Manure	n/a	1997 USDA Census of Agriculture	9.91 Tons/year/employee	<i>Manure Management Study</i> , 1992, Pennsylvania State University
Chicken Manure	n/a	1997 USDA Census of Agriculture	0.03 Tons/year/employee	<i>On-Farm Composting Handbook</i> , Northeast Regional Agricultural Engineering Service, Cooperative Extension , Ithaca, NY; (607) 255-7654
Animal Food manufacture	31111	1998 County Business Patterns, US Economic Census	4.67 Tons/year/employee	See Method A
Starch and vegetable fats and oils	31122	1998 County Business Patterns, US Economic Census	2.15 Tons/year/employee	See Method A
Sugar and Confectionery	3113	1998 County Business Patterns, US Economic Census	5.11 Tons/year/employee	See Method A
Fruit&Vegetable Preserving	3114	1998 County Business Patterns, US Economic Census	7.99 Tons/year/employee	See Method A
Dairy Product manufacture	3115	1998 County Business Patterns, US Economic Census	0.65 Tons/year/employee	See Method A
Eating and Drinking Places	3116	1998 County Business Patterns, US Economic Census	Varies by State	See Method A
Seafood Product Preparation	3117	1998 County Business Patterns, US Economic Census	varies by State	See Method A
Bakeries	3118	1998 County Business Patterns, US Economic Census	4.80 Tons/year/employee	See Method A
Other Food manufacture	3119	1998 County Business Patterns, US Economic Census	2.92 Tons/year/employee	See Method A
Beverage manufacture	3121	1998 County Business Patterns, US Economic Census	5.00 Tons/year/employee	See Method A
Pulp&paper	3221	1998 County Business Patterns, US Economic Census	varies by State	See Method A
Grocery Stores	4451	1998 County Business Patterns, US Economic Census	1.64 Tons/year/employee	<i>Food Waste Diversion in Florida Report</i> , Center for Biomass Programs, University of Florida's Institute of Food and Agricultural Sciences, Gainesville, FL; (352) 392-1511
Drinking Places	7224	1998 County Business Patterns, US Economic Census	1.64 Tons/year/employee	<i>Food Waste Diversion in Florida Report</i> , Center for Biomass Programs, University of Florida's Institute of Food and Agricultural Sciences, Gainesville, FL; (352) 392-1512
Hotels	72111	1998 County Business Patterns, US Economic Census	1.64 Tons/year/employee	<i>Food Waste Diversion in Florida Report</i> , Center for Biomass Programs, University of Florida's Institute of Food and Agricultural Sciences, Gainesville, FL; (352) 392-1513

## Methodology Bibliography

*1995 Lockwood-Post's Directory of Pulp, Paper, and Allied Trades.* Miller Freeman, Inc. 1994.

*1997 Census of Agriculture.* United States Department of Agriculture. 1998.

*1998 County Business Patterns.* United States Census Bureau. 1999.

*Clark County Solid Waste Management Plan.* Black & Veatch, Engineers-Architects, Resource Recycling Systems, Inc., Miller, Canfield, Paddock, & Stone. June 1990.

*Estimating Composition and Quantities of Solid Waste generation.* Gershamn, Brinker, and Braton, Inc. 1985

*Dakota County Solid Waste Generation and Characterization Study.* Franklin Associates. February 1991.

*Food Waste Diversion in Florida Report,* Center for Biomass Programs, University of Florida's Institute of Food and Agricultural Sciences, Gainesville, FL; (352) 392-1513

Frank, Walter. Plant Manager. Telephone interview, Honee Bear Canning, Lawton, MI. June 18, 1990.

*Lucas County Solid Waste Management Plan.* Midwest Environmental Consultants. June 1993.

*Major Solid Waste Generators in Washtenaw County.* Resource Recycling Systems, Inc. January, 1989.

*Manure Management Study,* 1992, Pennsylvania State University

*Minnesota Solid Waste Composition Study, part I.* Minnesota Pollution Control Agency, November, 1992.

*Northeast Indiana Solid Waste Management District: Study of Solid Waste Generation and Composition.* Resource Recycling Systems, Inc. March, 1992.

*On-Farm Composting Handbook,* Northeast Regional Agricultural Engineering Service, Cooperative Extension, Ithaca, NY; (607) 255-7654 Siemer, Jerome. Plant Director. Telephone interview, , Welches, Lawton, MI. June 18, 1990.

Staikie, John. Telephone interview. US Poultry and Agriculture Association. January 11, 2001.

*Tri-county Solid Waste Council Business Waste Characterization Report.* Resource Recycling Systems, Inc. 1995.

*Waste Management and Utilization in Food Production and Processing.* Council for Agricultural Science and Technology. October 1995.