ECONOMIC IMPACT POTENTIAL OF RECYCLING IN OHIO

FINAL REPORT

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COMMISSIONED BY:

OHIO ENVIRONMENTAL PROTECTION AGENCY

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EXECUTIVE SUMMARY

BACKGROUND AND GOALS

The purpose of the Economic Impact of Recycling in Ohio is to develop a low-cost, high impact evaluation that identifies the current statewide waste stream and supports materials management planning. The value proposition of potential recyclables is evaluated to provide information about the revenue-generating potential of those recycled commodities.

This project has three discrete objectives outlined below.

- Objective 1 - Utilize existing data from the State of Ohio information and any other relevant waste characterization studies to provide an accurate description of the present composition of residential and commercial municipal solid waste (MSW) that is disposed within the State of Ohio;

- Objective 2 - Assess the economic value of recyclable materials entering the landfills and assess the potential for job creation through the recovery of these recyclable materials.

- Objective 3 - Provide recommendations on recyclable materials to target for efficient and effective recovery activities.

HIGHLIGHTS AND FINDINGS

For the purposes of the study, a waste sector is identified by the particular generation characteristics that make it a unique portion of the total waste stream. Each state characterization that was reviewed has a different definition of what material was included in their studies based on their statutory definition and their solid waste and recycling program requirements. The characterizations from other states and communities identified 80 different categories of material that were evaluated, however not every category was evaluated within a specific state study. An issue that complicates the development of a waste characterization for the State of Ohio by utilizing previously conducted waste characterizations

studies from other states and municipalities is the "evolving ton", a term being used to describe the shift in the overall composition of the municipal solid waste stream over the past 20 years.

Resource Recycling Systems (RRS) developed a national landfill characterization estimation tool based on 80 different landfill characterization studies. These studies range from individual municipality studies to statewide studies. The development of a waste characterization for the State of Ohio is based on a review of these statewide and municipal waste characterization studies from across the country and then selective analysis and comparison of studies to determine the most appropriate and best fit estimation for the State of Ohio. A summary of the selected comprehensive waste characterization profile for the State of Ohio can be found in Table 1.

Table 1: Characterization of Statewide Disposed Waste
based on National Waste Composition of Residential and Commercial Material

Material Type	TONS	PERCENT of TOTAL
Yard Waste, Food Waste and Organic Subtotal	2,291,521	23.90%
Paper Subtotal	2,042,234	21.30%
Plastic Subtotal	1,502,145	15.67%
Other Non- Recyclable Materials*	1,137,802	11.87%
Other Materials such as Textiles, Batteries, Carpet	1,115,367	11.63%
Total Wood	594,453	6.20%
Metal Subtotal	472,974	4.93%
Electronics Subtotal	239,699	2.50%
Glass Subtotal	191,759	2.00%
Total	**9,587,953**	**100.00%**

- This category is the remainder of waste that could not be classified in characterization studies.

Many states and counties throughout the country conduct waste characterization studies at regular intervals to evaluate recycling program effectiveness, monitor changes in the disposed waste stream, confirm the effectiveness of landfill disposal bans, identify potential diversion opportunities, and otherwise help manage their waste streams. Generation data can be used for strategic planning; developing future legislative initiatives; evaluating effectiveness of current recovery efforts; targeting programs and educational efforts to advance recovery of specific materials; and providing guidance to state agencies and local government. It is critical that characterization data is available when prioritizing budget expenditures for increasing diversion and developing regulatory requirements for specific material diversion.

Economic Impacts of Recycling

The analysis of the economic impact of recycling includes an evaluation of the current market value of recyclable materials, market trends, and a discussion of the recycled commodity market drivers to provide information about the revenue-generating potential of those recycled commodities.

The current value of potentially recyclable materials that are currently landfilled is $260.5 million based on the Midwest Market Indexes in September 2018. The value of the cost of avoided disposal, of potentially recoverable material, based on the average gate rate of $43.42/ton for disposal, is $85.9 million. Other materials that have some value if they can be effectively collected as a separate material stream have a value of $88.1 million. The number of jobs that could potentially be created by recycling of marketable recyclable materials and all material that is currently recyclable but landfilled is 19,799. An additional 1,372 jobs could be created if yardwaste and wood wastes were composted.

Table 2: Estimated Economic Value and Job Creation of
Potentially recoverable Materials Currently Landfilled

Material Category	Tons	Potential Value	Jobs	Avoided Disposal Cost
Total of Potentially Recycled Materials with Market Indexed Value	1,978,314	$260,525,025	13,453	$85,898,394
Total of Other Potentially Recycled Materials	933,227	$88,090,916	6,346	$40,520,735
Total Yardwaste and Wood Waste	3,429,291	Not Calculated*	1,372	$148,899,823
TOTAL	**6,340,833**	**$ 348,615,941**	**21,171**	**$275,318,969**

- - No Value unless converted to compost or other product

An objective of this report is to determine the potential value of recycling that will provide information important to decision makers at the state and local levels.

- The majority of recycling revenue generated by a Material Recovery Facilities (MRF) comes from the denser suite of materials, like fiber, which represents as much as 65% of the weight but about 48% of the value.
- Beginning in 2014, the general trend in overall average commodity revenue has declined as global demand for all commodities, primarily driven by Chinese demand, has declined. This has been exacerbated with the implementation of a new policy in China that limits the import of recycled materials that do not meet strict quality requirements.

- It is difficult to project future prices for recycled commodities as the value is closely linked to global economic growth and is especially sensitive to the growth in industrialization of international markets such as China and India.

The overall benefit gained from recycling depends on a number of questions, such as:

- What is the transport and pre-treatment requirements of the recycled materials?
- What kind of materials are produced?
- What kind of products are to be replaced by different products using new materials?

Waste and recyclables that end up in landfills embody lost energy and loss of materials as inputs to manufacturing and other products. Furthermore, in a landfill, organic residuals decomposing in anaerobic landfill conditions produce landfill gas, primarily methane, which may be of additional concern.

Recommendations

The State of Ohio should evaluate the characterization of waste and recyclables on a regular basis to assess progress towards the recovery of greater quantities of recyclables and to determine how new products and consumer behavior are impacting the composition of the waste stream. These assessments can assist in the identification of materials that should be targeted for more intensive recovery efforts or for the development of end markets for new materials. In addition to measuring the types of materials disposed and recovered, the State of Ohio should focus on:

- Support of increased collection of high value material such as Polyethylene Terephthalate (PET) and High Density Polyethylene (HDPE) containers and metal containers because there are still recoverable quantities in the disposed MSW stream.
- Investigation and support of the future collection and markets for materials that are displacing current recovered material, especially in the packaging materials such as Flexible Packaging, as these materials are growing in volume;
- Measuring contamination rates in disposed material at a MRF (for both particulate matter and moisture) as a means of investigating the impact on the value of material;

- Determining the composition of residuals from MRFs to test recovery efficiency and potential for additional processing, especially given the newly developing quality standards that are being driven by China's new material import requirements.
- Targeted generator sampling of the most prevalent business types (e.g., grocery stores, manufacturing, retail malls, etc.) that generate significant quantities of waste;
- Enhanced research into waste generation indicators for certain waste streams, especially Food Wastes, to improve future understanding of the types of food waste generated by different sectors and to develop sampling plans for this waste stream; and
- Calculating energy values in disposed waste for thermal conversion processes if recovery rates of potentially recyclable material cannot be increased in a cost effective manner.

The State of Ohio can leverage its economic development in recycling infrastructure (e.g. Pratt Industries paper recycling plant in Wapakoneta; Rumpke Industries glass recycling plant in Dayton) and materials management (the Ohio Materials Marketplace) through continued partnerships with industry led recycling infrastructure initiatives and the public/private partnerships that are made possible by these initiatives. Leadership from the state can assist regional and local district based efforts to develop a strong sustainable market based recycling infrastructure that continues to capture valuable recyclables from the ever evolving waste stream. Roadmaps for partnerships can be developed for each of these candidate initiatives that can become the backbone of the state's leadership in sustainable material management.

DEVELOPMENT OF A WASTE CHARACTERIZATION

This study is limited to analysis of the statutory definition of municipal residential and commercial solid waste (MSW or solid waste). Each state characterization that was reviewed has a different definition of what material was included in their studies based on their statutory definition and the types of solid waste and recycling program requirements. The characterizations from other states and communities identified 80 different categories of material that were evaluated, however not every category was evaluated within a specific state study. It is important to understand the types and quantities of materials generated, the generating sectors, the quantities that are potentially recoverable and those that are otherwise disposed to enable sound policy and program design, implementation, and program analyses for both the public sector and private sector in the State of Ohio.

MUNICIPAL SOLID WASTE DEFINITIONS

The U.S. Environmental Protection Agency (U.S. EPA) defines Municipal Solid Waste (MSW) as "discards from residential and commercial sources that do not contain regulated hazardous wastes." (U.S. EPA, State Measurement Program Template, 2013) The U.S. EPA has provided a detailed description of materials that are considered MSW and those that are not considered MSW, and the full table is appended to this document. Key considerations in the definition of MSW include:

- MSW excludes waste from industrial operations, manufacturing, construction and demolition, and transportation equipment (automobiles).
- MSW excludes sludges and combustion ash.

Effectively, the U.S. EPA definition of MSW was used in this methodology and is based on the historical management of municipal solid waste throughout the country. Although it is common practice to landfill materials such as municipal sludge, nonhazardous industrial process wastes, and construction and demolition (C&D) debris along with MSW, these materials are not included in the standard scope of MSW or a recycling rate.

Although the State of Ohio has a broad definition of solid waste, the types of materials that the State of Ohio manages in the recycling programs are typically considered to be residential and commercial wastes that do not include industrial process wastes. As stated in the Ohio EPA *State Solid Waste Management Plan 2009*, MSW is "*comprised largely of the products, packaging, food, and yard waste trimmings discarded by residential, commercial, institutional, and industrial generators ISW* (Industrial

Solid Waste*) is comprised of the non-liquid and nonhazardous wastes generated as the result of an industrial or manufacturing process. Technically, non-process waste generated by industries is MSW, not ISW. Practically, however, non-process and process ISW are often combined by the generator and cannot be discreetly measured*".

RECYCLING

Recycling is defined by the U.S. EPA as "*the series of activities by which discarded materials are collected, sorted, processed, and converted into raw material and returned to the economic mainstream by being used in the production of new products. It does not include the use of these materials as a fuel substitute or for energy production*." (U.S. EPA, State Measurement Program Template, 2013). Similar detail identifying the activities by material that are and are not considered recycling is excerpted from "Measuring Recycling: A Guide for State and Local Governments". Key activities that are not considered recycling in this guidance document are:

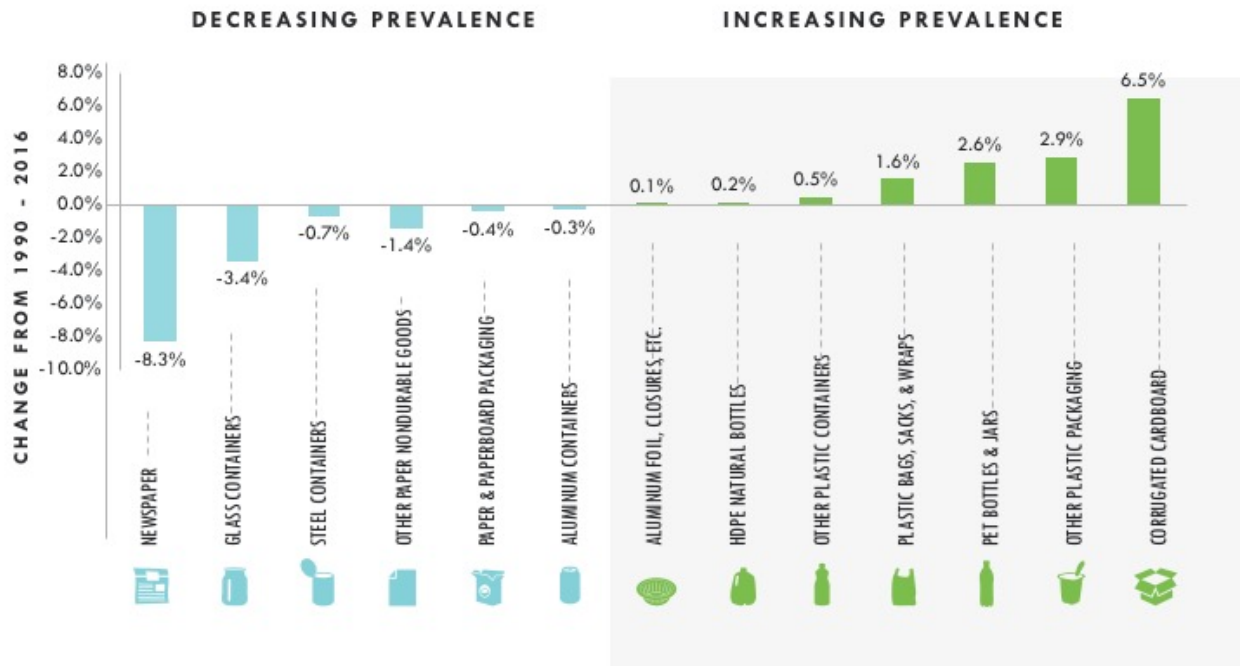
- Combustion of material for energy recovery;
- Backyard (onsite) composting of food scraps and yard trimmings;
- Reuse (e.g. of refillable packaging, textiles, pallets, plastic products, etc.);
- Recycling of non-MSW such as waste from industrial processes; and
- Recycling of wood waste or yard trimmings from Construction and Demolition (C&D) debris.

Although the U.S. EPA provides this guidance document for measuring recycling, every state has different definitions of materials and activities related to managing those materials that are considered for recycling. The varying definitions of recycling, as well as the varying definitions of MSW, by each state can affect the methodology for conducting waste characterizations, including what generating sources and what specific materials are included in a study.

Another consideration that complicates the use of waste characterization studies for the development of a waste characterization for the State of Ohio is the "evolving ton", a term being used to describe the shift in the overall composition of the municipal solid waste stream over the past 20 years. One of the trends responsible for this evolution has been the light weighting of packaging, especially through the use of materials like plastics and aluminum that have displaced materials like glass and steel. More recently, even rigid plastic packaging formats have started to be displaced by rapidly growing formats in flexible packaging. But plastics are not alone in driving the waste shift: Electronic media have played a

major role in changing the composition of our recycling stream by reducing the absolute volume of newspaper and office paper.

FIGURE 1: THE EVOLVING TON



It's also critical to understand that while more types of plastics are getting collected, complexity has increased even within the resin types the recycling system has traditionally handled. In response to growing pressure to recycle more, many companies are shifting to "recyclable" materials, often defining them as those accepted in community recycling programs. One of the best examples of this trend has been Polyethylene Terephthalate (PET) replacing Polyvinyl Chloride (PVC) or Polystyrene (PS) thermoforms and heavier jar and container material like glass. The unforeseen consequence of this well-intentioned transition is the recent diversification of PET in the recycling stream, a phenomenon that has lowered the yield of usable materials (the PET used in clamshells, blisters and ketchup bottles is not the same as that used in a soda bottle).

METHODOLOGY

The development of a waste characterization for the State of Ohio is based on a review of statewide and municipal waste characterization studies from across the country. Additionally, RRS completed a literature review for any new waste characterization studies. RRS developed a national landfill

characterization estimation tool based on 80 different landfill characterization studies. These studies range from individual municipality studies to statewide studies. For each study, RRS standardized the list of materials and summarized the composition of the landfill by percentage of each material. The studies are categorized as coming from low-, medium-, or high-diversion communities, since as more material is diverted from the landfill the composition of the remaining material changes. The Project Team believes that a credible estimation of the percentage of materials that are recyclable, and the value of that material, can be developed for the State of Ohio based on the evaluation of these waste characterization studies.

It should be noted that the national and world economy experienced the effects of a significant economic downturn in 2008-2009, with the effects impacting several of the studies that were reviewed. While it is beyond the scope of this study to quantify the impacts, it can be qualitatively asserted that waste generation patterns may have been affected and generation of specific types of material have changed for a number of reasons:

- Changes in business activity have resulted in absolute and per-capita decreases in waste generation.
- Construction was lower than average for both residential and non-residential projects.
- Markets for recycled materials, like many commodities markets, dropped precipitously during the recession of 2009 and although the markets rebounded in 2010 and 2011, international markets for recycled commodities did not recover to the levels prior to the recession. The development of China's National Sword program has also negatively impacted markets in 2018.

Each state or regional study was evaluated for inclusion in the tool to ensure compatibility with the existing studies. The studies were reviewed and evaluated on the basis of thoroughness and accuracy (number of samples, geographic and socio-economic sample, seasonal variation of samples, statistically valid sample protocols), date conducted, and relevance to the material types under consideration, particularly those materials related to inclusion of institutional, commercial and industrial sources. The studies were considered accurate if the methodology was based on the ASTM D5231 – 92 Standard Test Method for Determination of the Composition of Unprocessed Municipal Solid Waste or a similar statewide standard that defined sampling protocols that achieved statistically valid results.

Based on the unique characteristics of the waste characterization studies the Project Team performed a statistical analysis of existing composition studies to quantify the effects of each. For example, the

waste characterization for states with landfill bans (or strong policy promoting the diversion of organics) were compared with those without to determine the deviation from the average. This analysis was completed for each of the factors to fully understand the effects of specific policies and conditions now present in the State of Ohio.

RRS reviewed the data from all studies related to their methodology and statistical robustness. All of the major state-wide studies utilized the ASTM D5231-92 standard for the collection of data and data analysis. This test method describes procedures for measuring the composition of unprocessed municipal solid waste (MSW) by employing manual sorting. This test method applies to determination of the mean composition of MSW based on the collection and manual sorting of a number of samples of waste over a selected time period covering a minimum of one week. Data presented include mean percentages by weight, standard deviations, and statistical confidence intervals (90% confidence interval) for each group of data. There were some minor adjustments made in some studies for material categories that were generated from a small number of generators. This included studies where small quantities less than 0.1% of the total) of specific items were quantified, such as paper bags, used motor oil, batteries, aerosol cans, or leaves and grass separate from other brush and trees. Most studies did not include these small quantities or leaves and grass as separate categories so these materials were combined into broader categories, such as including paper bags in "Low Grade Paper".

An approach was developed that utilized the average of the low, medium, and high diversion compositions from the review of waste characterizations studies as well as diversion categorizations for states with yard waste bans. Each of the studies was classified in one of these categories based on its diversion rate (less than 15% for low diversion and greater than 40% for high diversion). Several studies also included a breakdown between residential and the institutional, commercial, and industrial (ICI) categories. Separate characterizations were created specifically for states with a bottle bill to determine the impact of capturing those materials (Glass and PET) outside of the traditional curbside/drop-off collection approach on the relative distribution of materials within the waste stream. By averaging across several studies, generic profiles for low, medium, and high diversion states and communities were developed.

For example, the Project Team reviewed recent landfill characterization studies from certain states, including Pennsylvania, Illinois, Tennessee, and Nebraska, that had specific characterizations for residential material. All four of these states have less than 15% diversion. The percentage of standard

residential recyclables in the residential waste stream was on average 37% and ranged from 35% to 39%. The percentage of standard residential recyclables in the residential waste stream that was landfilled for states categorized as medium diversion (15%–40% statewide) ranged from 19% to 24%. The recycling rate in the State of Ohio, which includes residential and commercial materials, was 28.4% based on the Ohio EPA Annual Diversion Reports (ADR) Review Forms for calendar year 2016. The national average from other characterization studies shows that residential waste is 47% of the waste stream.

The statistical variance and the averages for each of the 80 categories were calculated. The standard deviations in the studies were all within reasonable limits of less than 2% for any specific category with very negligible variances less than 0.2%, except in a few categories. The categories where there were wide discrepancies between the studies were: 1) All Other Paper, 2) Food Waste, 3) Other Compostable Organics, 4) Untreated Wood, and 5) Other Non-recyclable materials. A review of the studies identified the major issue of deviation was how a particular study defined materials for sorting.

An example in the food waste category that illustrates how discrepancies are introduced in characterizations studies is whether food waste that is in a container that had been opened could be counted as a food waste or could be counted in the container category (i.e. plastic container with a lid). In addition, based on the studies reviewed and the work that RRS has been conducting relative to flexible packaging and plastic films, RRS believes that the characterization of materials is changing driven by an emerging category for Flexible Packaging, although many of the studies included this material within the Low Density Polyethylene (LDPE) category.

The final step was to combine the over 80 categories of material that were identified in the characterization states into a classification system that typifies broader categories consistent with market specifications. RRS consolidated the 80 categories into 24 categories that are consistent with currently graded market specifications for the majority of recycled material marketed in the Midwest (See Appendix V: Consolidation of Characterization Categories). An average residential composition or a composition for combined residential and commercial waste can then be generated for the State of Ohio material which does not include imported material.

Each profile related to the average of the low, medium, and high diversion compositions consists of an estimate of per capita generation, and the composition of this material, as well as residential and commercial generation and composition from studies that included separate characterizations of those

sectors. In this manner, a characterization could be applied to each county in Ohio, based on the reported tons generated in that county by sector if the waste generation data in the most recent Landfill Report provides this level of detail.

Comparison of Data

Table 3 illustrates a sample of the comparison of the different analysis conducted to determine the variances between different state studies based on the level of diversion and whether the studies included both residential and commercial wastes sorts. The table for plastic shows the variability of studies for specific categories of material. These characterizations show that there is a difference of 2.13% in the total plastics from the low estimate to the high estimate. The medium diversion characterization is very similar to the bottle bill diversion characterization.

Table 3: Percentage of High-Volume Plastic Landfilled for Characterization Studies Categorized by Diversion Rate

Diversion Scenario	PET bottles	HDPE Bottles Natural	HDPE Bottles not specified/Colored	LDPE (includes some bags, film)	Expanded Polystyrene	Durable and Rigid containers	All other Plastics	Plastic subtotal
Low Diversion - Residential & Commercial	1.09%	0.15%	0.84%	5.73%	1.02%	3.95%	0.65%	13.46%
Medium Diversion - Residential & Commercial	0.63%	0.07%	0.37%	4.00%	0.67%	2.43%	3.27%	11.47%
High Diversion - Residential & Commercial	0.65%	0.10%	0.44%	5.27%	0.49%	0.33%	4.49%	11.77%
Low Diversion - Residential	1.20%	0.30%	0.80%	4.40%	0.70%	3.45%	1.15%	12.00%
Medium Diversion - Residential	0.53%	0.10%	0.63%	4.27%	0.47%	2.07%	2.33%	10.40%
High Diversion - Residential	0.75%	0.00%	0.75%	5.13%	0.38%	0.95%	1.93%	9.88%

All of the Great Lakes states (Illinois, Indiana, Michigan, Minnesota, Ohio, Pennsylvania) that were evaluated have a yard waste ban in place while an additional 15 states that were evaluated have yard waste bans and 11 states have container deposit laws. Only Michigan has a yard waste ban and a container deposit law.[1] The higher percentage of organics in states without organics management

[1] U.S. Composting Council *Regulatory Database* and American Biogas Council *Organics Recycling Policy Factsheet*

programs is primarily driven by higher percentages of leaves and grass. Leaves and grass make up 3.7 - 3.9% of the total waste stream in the states without organics management programs.

Table 4 provides the characterization for all major categories of materials for states categorized as low, medium or high diversion. The compositions provided in the table show high variance for the paper, organics and other non-recyclable material categories. The discrepancies can be explained because more wood is being generated in the commercial sector, and even though restaurants might be included in the commercial sector, their contribution is a small percentage of the total commercial waste stream than what is seen in the residential stream, and more non-recyclables are present in the commercial stream.

The other comparison that was calculated was to states in the Great Lakes region (Illinois, Michigan, Indiana, Wisconsin, New York, and Pennsylvania). These composition estimates were compared to select an appropriate composition to be applied to the State of Ohio. A comprehensive table of the percentage allocation of all major categories of studies is included in Appendix IV.

Table 4: Percentage of Categories of Landfilled Materials

	Paper subtotal	Plastic subtotal	Metal subtotal	Glass Subtotal	Electronics Subtotal	Total Wood	Organic Subtotal	Oher Hard to Recycle	Other Non-Recyclable Material
Low Diversion - Residential & Commercial	32.69%	13.88%	5.33%	3.28%	2.23%	8.67%	20.79%	6.23%	6.90%
Medium Diversion - Residential & Commercial	21.30%	11.63%	4.93%	2.00%	2.50%	11.87%	23.90%	6.20%	15.67%
High Diversion - Residential & Commercial	18.43%	12.77%	4.80%	2.54%	0.70%	7.61%	36.35%	4.56%	12.24%
Low Diversion - Residential	27.30%	12.75%	5.65%	3.95%	2.15%	6.35%	25.85%	7.65%	8.35%
Medium Diversion - Residential	23.60%	11.10%	4.57%	2.43%	2.50%	6.27%	33.37%	7.70%	8.47%
High Diversion - Residential	18.85%	12.09%	4.87%	2.80%	0.37%	3.77%	32.54%	3.45%	21.28%
Great Lakes Residential	28.09%	13.06%	4.89%	4.14%	2.27%	7.49%	28.75%	7.03%	4.29%
Great Lakes Residential and Commercial	27.52%	14.04%	5.77%	2.88%	2.00%	9.81%	20.92%	5.73%	11.33%

THE STATE OF OHIO WASTE CHARACTERIZATION

RRS recommends utilizing the Medium Diversion Residential and Commercial category of materials listed in Table 5 because the paper, plastic, metal and glass categories are within small percentage differences from the medium and high diversion percentages for both residential and commercial combined, as well as from residential only. This recommendation is the most useful approach for the State of Ohio because solid waste that is currently landfilled in the state is reported with both residential and commercial waste combined.

Table 5: The State of Ohio Waste Characterization by Percentage*

Material Type	Medium Diversion - Residential and Commercial		Medium Diversion - Residential	All Residential and Commercial	GL Residential and Commercial
High Grade - White and Colored Ledger	1.267%		1.167%	1.320%	1.432%
Mixed/ unspecified Office	0.400%		0.567%	0.656%	0.667%
Low Grade - general (OMG), Boxboard, Paper Bags, Phonebooks other recyclables	4.100%		6.000%	5.270%	5.716%
Old Newspaper (ONP)	1.733%		2.833%	2.866%	3.325%
Old Corrugated Cardboard (OCC)	4.867%		2.600%	6.090%	9.090%
Cartons, Aseptics and Poly-coated	0.067%		0.033%	0.234%	0.183%
Compostable/ soiled and all other paper	8.867%		10.400%	9.106%	7.109%
Paper Subtotal	**21.300%**		**23.600%**	**25.542%**	**27.522%**
PET bottles and containers	0.667%		0.833%	1.151%	1.289%
HDPE Bottles Natural & Colored	0.433%		0.733%	0.882%	1.517%
Plastic bottles and #3-7 (general)	0.167%		0.400%	0.644%	0.511%
All other Plastics and Packaging, LDPE, Polystyrene (foam), Durable and Rigid containers and PP tubs)	10.367%		9.133%	10.171%	10.723%
Plastic Subtotal	**11.633%**		**11.100%**	**12.848%**	**14.040%**
Aluminum cans	0.200%		0.300%	0.483%	0.480%
Ferrous metals (includes Tin/Steel Cans, tin)	3.033%		2.667%	3.028%	3.917%
Non-ferrous metals, Aluminum (foil) and Other Metal and Aerosol Cans	1.700%		1.600%	1.818%	1.371%
Metal Subtotal	**4.933%**		**4.567%**	**5.329%**	**5.767%**
Glass - general including containers	1.233%		1.700%	2.460%	2.429%
Other Glass	0.767%		0.733%	0.689%	0.448%
Glass Subtotal	**2.000%**		**2.433%**	**3.149%**	**2.878%**
Electronics - general, computer related, CRT	2.133%		2.067%	1.073%	1.755%
White goods (appliances)	0.367%		0.433%	0.272%	0.244%
Electronics Subtotal	**2.500%**		**2.500%**	**1.345%**	**1.999%**
Wood Subtotal	**11.867%**		**6.267%**	**7.252%**	**9.807%**
Yard waste - general	5.700%		7.867%	3.603%	4.098%
Food	13.067%		17.500%	16.924%	13.291%
Other R/C Organics, Branches and Stumps	**5.133%**		**8.000%**	**3.526%**	**3.530%**
Yard Waste and Organic Subtotal	**23.900%**		**33.367%**	**24.053%**	**20.920%**
Other Textiles, Batteries, Tires, Carpet, Light Bulbs	**6.200%**		**7.700%**	**5.139%**	**5.733%**
Other Non- Recyclable Materials	**15.667%**		**8.467%**	**15.342%**	**11.336%**
Total	**100.000%**		**100.000%**	**100.000%**	**100.000%**

*Numbers may not total due to rounding errors. Percentages are truncated to 3 decimal places.

The estimate based on a medium diversion, including residential and commercial wastes, provides a reasonable approach for the State of Ohio given that the state has a 28.4% diversion rate and that the Ohio waste reporting data combines both residential with commercial material. The medium diversion estimate shows a lower percentage of compostable materials relative to a residential only estimate, where the higher percentages occur when the commercial sector is less representative in the waste stream.

Table 6 represents the characterization of waste by weight based on the total disposed waste (9,587,953 tons) from residential and commercial generators reported on the Ohio EPA ADR Review Forms for calendar year 2016. The estimate weight of landfilled material by category was calculated by multiplying the quantity of total landfilled material by the average percent of material types selected that are representative of the potential characterizations similar to the State of Ohio.

Table 6: State of Ohio, OH Waste Characterization by Weight*

Material Type	Medium Diversion - Residential and Commercial	Medium Diversion - Residential	All Residential and Commercial
High Grade - White and Colored Ledger	121,479	111,859	126,589
Mixed/ unspecified Office	38,352	54,332	62,928
Low Grade - general (OMG), Boxboard, Paper Bags, Phonebooks other recyclables	393,106	575,277	505,247
ONP	166,159	271,659	274,816
OCC	466,646	249,287	583,897
Cartons, Aseptics and Poly-coated	6,424	3,196	22,410
Compostable/ soiled and all other paper	850,164	997,147	873,047
Paper Subtotal	**2,042,234**	**2,262,757**	**2,448,935**
PET bottles and containers	63,952	79,900	110,323
HDPE Bottles Natural & Colored	41,516	70,312	84,600
Plastic bottles and #3-7 (general)	16,012	38,352	61,745
All other Plastics and Packaging, LDPE, Polystyrene (foam), Durable and Rigid containers and PP tubs)	993,983	875,700	975,234
Plastic Subtotal	**1,115,367**	**1,064,263**	**1,231,901**
Aluminum cans	19,176	28,764	46,309
Ferrous metals (includes Tin/Steel Cans, tin)	290,803	255,679	290,327
Non-ferrous metals, Aluminum (foil) and Other Metal and Aerosol Cans	162,995	153,407	174,347
Metal Subtotal	**472,974**	**437,850**	**510,983**
Glass - general including containers	118,219	162,995	235,867
Other Glass	73,540	70,312	66,027
Glass Subtotal	**191,759**	**233,307**	**301,894**
Electronics - general, computer related, CRT	204,511	198,151	102,895
White goods (appliances)	35,188	41,548	26,085
Electronics Subtotal	**239,699**	**239,699**	**128,980**
Wood Subtotal	**1,137,802**	**600,845**	**695,347**
Yard waste - general	546,513	754,252	345,410
Food	1,252,858	1,677,892	1,622,695
Other R/C Organics, Branches and Stumps	492,150	767,036	338,041
Yard Waste and Organic Subtotal	**2,291,521**	**3,199,180**	**2,306,146**
Other Textiles, Batteries, Tires, Carpet, Light Bulbs	**594,453**	**738,272**	**492,772**
Other Non- Recyclable Materials	**1,502,145**	**811,780**	**1,470,996**
Total	**9,587,953**	**9,587,953**	**9,587,953**

*Numbers may not total due to rounding errors. Category equivalents may not be the result of multiplying the total waste generation multiplied by the truncated percentages in Table 5 due to rounding.

ECONOMIC IMPACT

The analysis of the economic impact of recycling includes an evaluation of the recyclable market value of materials, market trends, and a discussion of the recycled commodity market drivers. The economic and environmental impact of current and potential recyclables was calculated to provide information about the revenue-generating potential of those recycled commodities. Materials collected and processed in a recycling program are considered commodities, except for the materials that are not identified as acceptable materials and become a residue for disposal when the materials are processed into marketable commodities. This means that the total collected tonnages must yield a value that contributes to healthy, stable recycling programs, in spite of market demand fluctuations and associated price increases or decreases.

Recycling opportunities vary from one municipality to the next. In the State of Ohio, paper, corrugated cardboard, paperboard, plastics (Polyethylene Terephthalate (PET) and High Density Polyethylene (HDPE)), glass, and metal are generally collected. Several municipalities also collect other plastics (#4-7), cartons (gable top and aseptic) and organics. Many cities and towns in the state have privately operated reuse centers, flea markets or second-hand shops, which also help promote recycling and reuse.

THE RECYCLING BUSINESS PROPOSITION

Arrangements with a Material Recovery Facility (MRF) in which haulers or processors rebate some revenue to communities has become a common practice, based on the cost per ton using a blended commodities pricing index. Taking competitive bids for recyclable processing can maximize the revenue that municipalities can receive for the recycled commodities. Many municipalities do not operate a MRF but use a contractor to process and market their recyclables. Communities can choose to request MRF's to share in the market value of materials that are sold, as contracts are prepared. MRF operations are usually covered by the tipping fee and may receive additional compensation based on the prices for recyclables.

Utilizing the Average Commodity Revenue (ACR)[2] index in a contractual approach is one of the mechanisms for a community to hedge the risks of volatile swings in the value of recycled commodities. This approach provides flexibility and helps to maximize revenues. A market share arrangement may include an established floor price, which guarantees a minimum price per ton paid to the community for materials brought to the MRF. The floor price can be fixed based on the market value of a select number of items or the total mix of recyclable materials collected. When the market value of the recyclable tonnages exceeds the established floor price, the community and the MRF share in the value of the sold commodities, based upon an established percentage split.

The ACR is also useful in monitoring fee based contracts where the community pays a fixed fee for processing. Many MRFs have structured their fees under the assumption that the ACR would provide enough material revenue to offset the difference between the fee revenue and the operating costs. Given the recent dramatic downturn in commodity revenue, MRFs have been renegotiating fee based contracts to increase fees to recover costs or dropping materials from collection and processing where the revenue from a specific material does not cover the costs of processing that material.

Figure 2 represents the ACR generated from a representative composition of recovered material over the past 10 years. During the first period from December 2008 to September 2009, the recession was in full-swing, but fiber prices had not yet fallen. The ACR index began to increase in late 2010 carried by the higher fiber prices. The period (January 2011 to November 2011) portrays overall higher prices and the higher ACR price as a result of higher demand. Beginning in 2014, the general trend in overall average commodity revenue has declined as global demand for all commodities, primarily driven by Chinese demand, has declined.

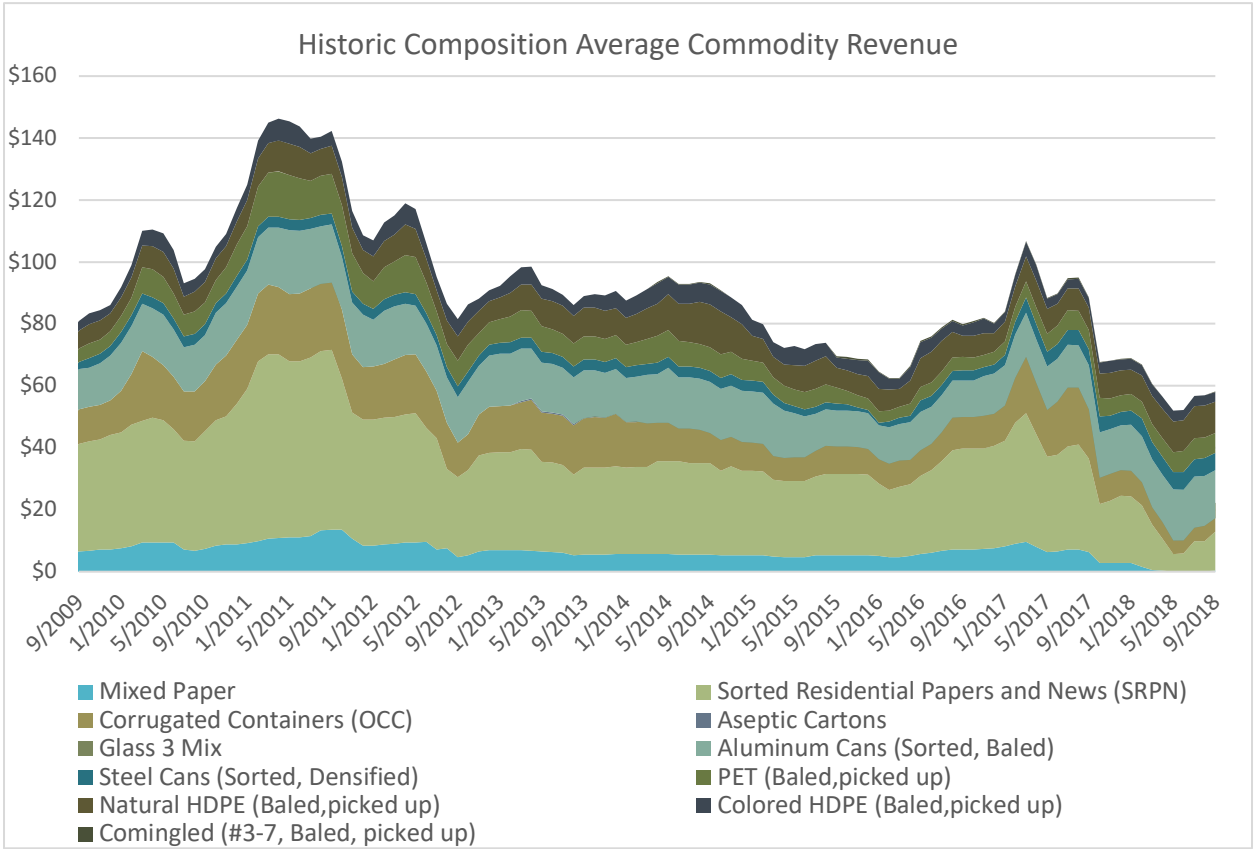
After accounting for negative-value glass, which is not necessarily the market condition in all Ohio market areas due to the presence of Rumpke's glass beneficiation plant, and residue in the recycling

[2] A **commodity price index** is a fixed-weight index or (weighted) average of selected commodity prices, which may be based on spot or futures prices. It is designed to be representative of the broad commodity asset class or a specific subset of commodities, such as energy or metals. It is an index that tracks a basket of commodities to measure their performance.

stream, the blended value per ton, or Average Commodity Revenue value was estimated at $64.85 per ton as of September 2018 in the Midwest region.

Several trends can be seen in the graph, especially in terms of rank in per ton prices for materials. Aluminum tends to sit much higher in price while experiencing slightly less of the volatility found in #1 and #2 plastics. PET and Colored HDPE have switched rank several times since 2008. In fact, all plastics have experienced peaks and valleys at different points over time. There is less volatility in commingled plastics #1-7 due to the broader range of materials although the unit price is lower due to the mixed bales. Finally, both steel and glass dropped in value due to the current global downturn in commodity values; however, they remain relatively stable compared to other materials.

FIGURE 2: AVERAGE COMMODITY REVENUE (ACR) ANALYSIS

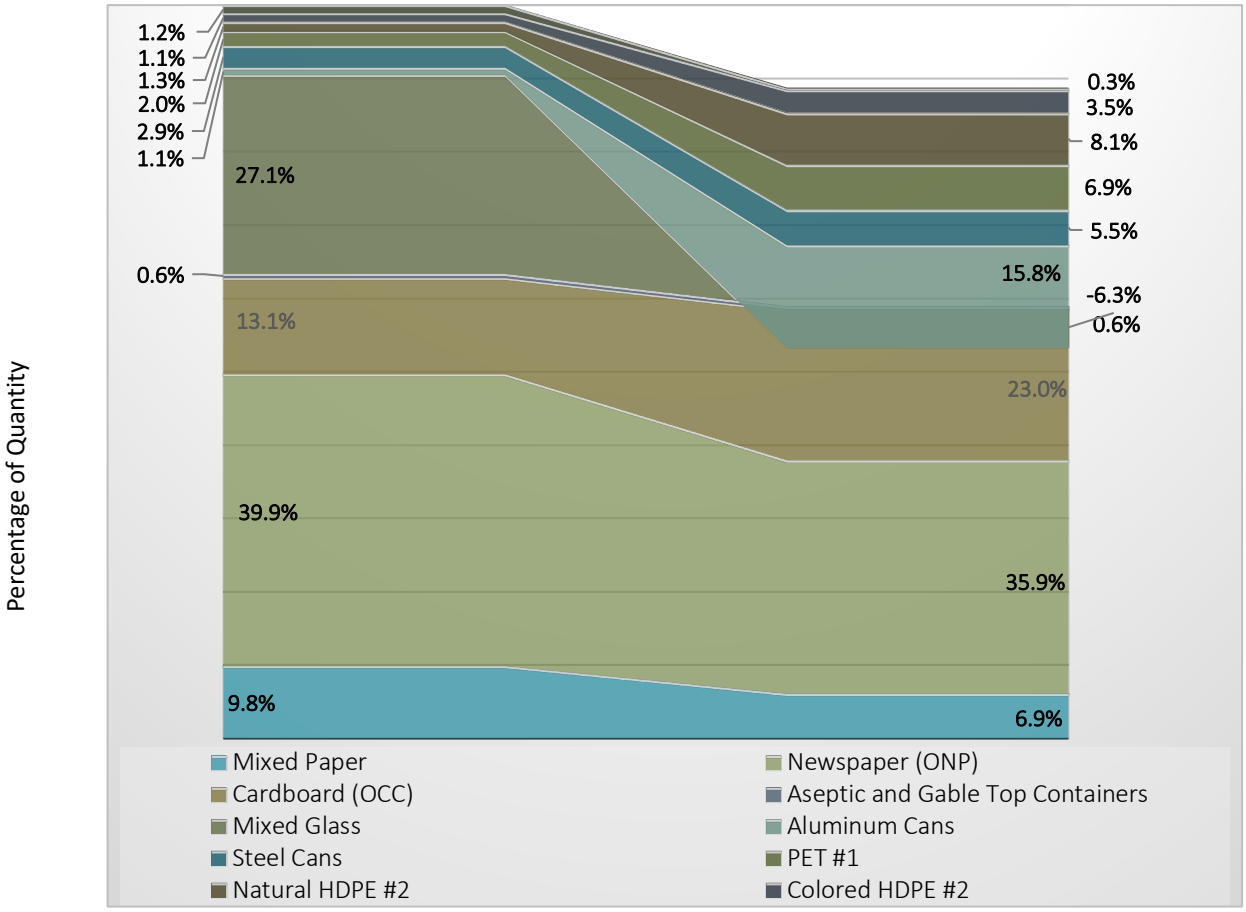


According to the analysis, a majority of recycling revenue comes from the denser suite of materials like fiber, which represents as much as 65% of the weight and about 48% of the value per processed ton generated at an average MRF (see Figure 3). Aluminum, which is about 1.1% of a processed ton by

weight, accounts for about 14.4% of the revenue. Plastics, mostly PET and HDPE, meanwhile, represent about 6.7% of the weight of a processed ton and about 20.8% of the revenue.

An analysis of the ACR approach to commodity sales is illustrated in Figure 3. Pulling from numerous recycling commodity processing reports from MRFs across the U.S., RRS determined the average weight composition of incoming materials to MRFs, which is represented on the left side of the Figure 3. The right side represents the average commodity revenue per ton of processed material and excludes residue. The figure was updated in October 2017 and continually fluctuates with markets and recycling participation. MRF operators frequently adapt their operations to respond to these price indexes or risk missing out on revenue, regardless of equipment, techniques or contamination.

FIGURE 3: THE RECYCLING BUSINESS PROPOSITION



Commodity Price Indexes

There is not one "unifying" Price Index that can be used for calculating an ACR for either historical transactions or current pricing that can be applied for all commodities. RRS recommends the following pricing indices by commodity group, and is very confident that, within the limitations of an index's behavior, the following indices are the best available for tracking current and historical pricing. Readily available indices were thoroughly analyzed, rated and their methods analyzed. RRS conducted confidential interviews with end market representatives and received feedback on each commodity before arriving at the conclusions about market indexes. All the indices have 2 or more years of data for the commodities listed. Each has published methodologies. Finally, each is overwhelmingly preferred by the end markets and traders of the respective commodities.

- Paper- RRS recommends the on-line RISI (aka Official Board Markets (OBM), Yellow Sheet, Pulp and Paper Price Index (PPI)) platform. The paper market by far is the most "social network" and is based on trust relationships, loyalty, quantity, and quality reputation- these matter a lot in the paper world. The language used by the market for trading overwhelmingly is the RISI Pricing, using Institute for Scrap recycling Industries (ISRI) grade specifications, at the beginning of each month. The RISI index historically has been used more as a floor price for most grades, except in the current topsy-turvy market. RISI uses over 80 sources.
- Plastics- Recyclingmarkets.net (RMN). This is the newest recommended index and has not established a firm culture, like RISI or American Metals Market (AMM). It also has the least available research. All players in the plastic value chain believe this is an accurate index for contracting, when it comes to PET or HDPE
- Glass- Recyclingmarkets.net- Glass pricing on RMN is the only authoritative index available. Glass pricing is very freight and quality dependent.
- Metals- American Metal Market (AMM) - Metal trading is the most orderly market and real published market transactions augment market surveys conducted. The metal market is over 100 years old and all pricing is based on London Metal Exchange (LME) pricing for both virgin ingot and scrap (as a percentage of pure aluminum 99.7% ingot). AMM is the trusted source, has twice monthly published pricing, and the LME cash settlement price is the indicator used for both Aluminum Used Beverage Containers (UBC) and steel cans. Deductions are made for quality, moisture, and other services provided by the buyer, so the index price is the ceiling best price.

Although the pricing indices indicated above are used overwhelmingly for the material described, the prices quoted historically are representative points of reference, and not fully accurate for any of them. For instance, while paper trading is a 'relationship-based' activity and the index is the indicator of the floor, plastic markets have more to do with very local conditions and freight, and metal is traded at the index price, less deducts for quality, freight, and services rendered. Finally, glass is very freight-dependent and can't be transported long distances before the freight costs outweigh the market value.

Pricing indices have performed poorly in predicting the downturn pricing accurately. As late as October 2017, a short surge in the buying of China-bound commodities resulted in higher than actual November prices, though orders continued to fall, and import/export licenses levels were curtailed. The indices have also been conservative, until March 2018, in predicting magnitude of price movement relative to real prices experienced, especially for bulk grade paper.

The State of Ohio should not underestimate the impact of the Chinese policies to short-term or long-term pricing and its use of market indices. It reflects a changing Chinese recycled scrap industry paradigm from a volume-based economy to a quality-based economy for scrap imported there. Short term is a resultant unmet demand inside China, with prices, for instance, of Old Corrugated Cardboard (OCC) reaching $600 per short ton. This structural shift is changing world recovered paper patterns.

To further understand pricing dynamics, the State of Ohio is best served by becoming a bigger part of the market community. Some of the following best practices will augment price understanding. The State of Ohio should become part of the End Market Community by shepherding resources towards the following activities:

- Join local, state and North American Associations for each type of commodity;
- Build a network of go-to contacts: traders, MRFs, mills, and exporters and keep regular contact. Paper especially requires this outreach and local pricing is best determined having this as an input to index pricing behavior;
- Understand recovered markets through tours and discussions;
- Use other Indices and Periodicals to check pricing and trends.

JOBS AND ECONOMIC DEVELOPMENT

Based on published reports of job creation for recycling, an assessment of the number of jobs created by recycling and an assessment of the number of jobs that could be created by increasing the recycling rate has been performed. Recycling is a diverse industry. Securing these raw materials for manufacturing through recycling is an integrated system that starts with collection of materials from the curb, at drop-off centers or from businesses. The U. S. Recycling Economic Information Study (REI)[1] identified 26 different types of recycling businesses from collection to manufacturing, such as processing, equipment manufacturing, foundries, education, and training. A study[3] on the state of composting in the U.S. stated the "Utilizing 10,000 tons of finished compost annually in green infrastructure can sustain one new business. For every 10,000 tons of compost used annually by these businesses, 18 full time equivalent jobs can be sustained." The report further states that composting operations alone sustain four jobs for every 10,000 tons per year they process.

Potentially recyclable materials encompass newspapers, bottles and cans, glass, steel, textiles, organics, industrial materials such as asphalt, concrete, fly ash, construction and demolition debris, and electronics. The list of potentially recyclable materials is lengthy and could be increased with targeted governmental support.

Studies have been undertaken over the past years that look at recycling and waste diversion activities (also called materials management) with an eye to determining what impact recycling and waste diversion have on the economy, both in individual states as well as on the United States as a whole. Recycling is cost competitive with other extractive industries. As a driver of economic activity, the recycling industry compares favorably to heavy industries, such as automobile manufacturing and mining. It outpaces the solid waste disposal industry for job creation (see Table 7 below) and recycling adds value to materials and contributes to growing the labor force. Recycling supports U.S. manufacturing jobs and increases U.S. competitiveness through cost savings. The following table identifies the range of jobs that are related to the use of recycled material and the potential of job creation if all potentially recyclable materials were recovered.

[3] State of Composting in the U.S., Institute for Local Self-Reliance, July 2014

Table 7: Recycling Jobs Created

Types of Operation	Jobs per 10,000 TPY*
Computer Reuse	296
Textile Reclamation	85
Misc. Durables Reuse	62
Wooden Pallet Repair	28
Recycling-based Manufacturers	25
Paper Mills	18
Glass Product Manufacturers	26
Plastic Product Manufacturers	93
Conventional Materials Recovery Facilities	10
Composting	4
Landfill & Incineration	1

*TPY = tons per year of recycled material

Table 8 presents the calculated potential level of economic impact per 10,000 tons of additional diversion, including the creation of 68 jobs plus an additional 4 jobs related to processing organics at compost facilities. An estimate of the annual cost to recover 10,000 tons, which includes trucks for collection, carts and MRF operations as well as potential market revenue and the avoided disposal costs, provides an overview of the potential economic growth of increased diversion. The economic growth will come from the market value of recovered material, investment in collection and processing infrastructure, job growth, efficiencies in transport and collection, and decreased disposal costs for local government.

Table 8: Economic Development Impact of processing 10,000 Tons of Recyclables

Single-stream Material (10,000 Tons)	
Annual Capital Investment[4]	
Collection Trucks	$406,250
Carts	$500,000
MRF Infrastructure	$1,225,000
	$2,131,250
Market Efficiencies[5]	
Avoided Disposal	$434,200
Material Value*	$648,500
	$1,082,700
Job Growth	
Material Collection	10
MRF Operations	10
Plastic Manufacturing	9
Glass Manufacturing	4
Paper Mills	10
Recycling-Based Manufacturers	25
Total Number of Jobs with Recycling	**68**
Compost Processing	4
Total Number of Jobs with Composting	**72**

- Based on Average ACR - Midwest

Across the state, local communities have varied programs collecting a range of different materials. Some include glass; others do not. Some collect all plastic; others just plastic bottles. Many communities have moved to single-stream programs, others still source separate at drop-off convenience centers or collect material in dual streams (fiber and containers). Some single-stream programs accept cartons (gable-top containers and juice/wine/soup boxes), which are a growing portion of the waste stream, and others do not. These are just a few examples of the variation in collection and

[4] Collection trucks: 10 @ $325,000 each = $3.25 million, investment amortized over 8 years (principal only) equals $406,250. Carts: @ $50/95-gallon cart, estimated 50,000 carts needed per 10,000 tons per year (400 pounds per household per year), amortized over 5 years (principal only). MRF Infrastructure: Building amortized over 20 years, equipment over 10.

[5] Avoided Disposal: Residential disposal cost estimate based on $43.42/ton tipping fee. Material Value:% mix of single-stream material based on Resource Recycling "A Common Theme," Collins, S. February 2012. Value is based on pricing from material value chart above.

processing programs. The consistent collection of recyclable material that meet end market specifications will impact markets and job creation.

The U.S. Scrap Recycling Industry Creates Jobs in the State of Ohio

An analysis of the impact of jobs related to the scrap recycling industry conducted by the Institute of Scrap Recycling Industries (ISRI) that includes residential, commercial and industrial recycling provides a broad overview of the impact on the State of Ohio. The ISRI analysis stated the following conclusions:

> "From the earliest known uses of scrap thousands of years ago, to the optical scanners, x-rays, air jets, high-tech shredders and other technologically advanced equipment used today; scrap recycling has evolved into a major industry dedicated to transforming end-of-life products to create new commodity grade materials that boost national, state and local economies.
>
> With a continuing societal focus on protecting our natural resources, energy savings and reducing greenhouse gas emissions, the scrap recycling industry is recognized as one of the world's first green industries, while playing a prominent role as an economic leader, job creator, major exporter and environmental steward. In fact, the people and firms that purchase, process and broker old scrap to be manufactured into new products provide 16,673 people with good jobs in Ohio.[6]

Table 9: The Economic Impact of the Scrap Recycling Industry[2]

	Direct	Supplier	Induced	Total
Jobs	8,376	10,003	11,719	30,098
Wages	$628,080,000	$641,625,800	$572,732,400	1,842,438,200
Economic	$2,537,825,50	2,214,870,500	1,949,230,00	6,701,926,000

[6] Based on the Economic Impact of the Scrap Recycling Industry in the United States (2015), produced for the Institute of Scrap Recycling Industries, Inc. by John Dunham and Associates, 2017.

ISRI states that 8,376 jobs are being supported by the manufacturing and brokerage operations of the scrap recycling industry in the State of Ohio in 2017.[7] These are good jobs paying an average wage of $61,200. In addition to this, the scrap recycling industry through suppliers and the indirect impact of the industry's expenditures supports 21,722 jobs.[8]

- All of this activity generates $6.7 billion in economic benefits in Ohio.
- When all scrap materials are considered, the U.S. scrap recycling industry accounts for 0.603% of the nation's total economic activity,[9] making it similar in size to the data processing and hosting industry, the dental industry, and the automotive repair industry.
- The value of the scrap sold in Ohio is created through the capital and job intensive processing operations of the American scrap recycling industry that transforms old and obsolete materials into commodities that meet the exacting needs of manufacturers worldwide. This not only benefits workers, but also the government. All told, the scrap recycling industry generates $444.84 million in tax revenues for the federal government and $264.19 million in state and local revenues."

[7] This includes firms involved in the purchasing, processing, recycling and brokering of scrap materials including ferrous and nonferrous metals, paper, electronics, rubber, plastics, glass and textiles.

[8] Direct impacts are those associated with scrap processors and brokers. Supplier impacts are associated with firms providing goods and services to scrap recyclers and brokers, including peddlers, and induced impacts are those resulting from the re-spending of wages by workers in the direct and supplier sectors.

[9] Bureau of Economic Analysis. GDP based on fourth quarter 2017, value of $ 19.386 trillion, see: *Gross Domestic Product: Fourth Quarter and Annual 2017* (Third Estimate); *Corporate Profits: Fourth Quarter and Annual 2016*, March 27, 2017.

ECONOMIC IMPACT OF LANDFILLED RECYCLABLES

RRS estimated the value of materials that are recycled by most programs and that also have known commodity value as published in indexes. Table 10 identifies the quantity of these specific materials and multiplied the quantity of material by a specific market index to determine the values of the material that is currently landfilled. In addition, an estimate of the potential value of materials that are often targeted for recovery but that are not typically collected in curbside collection programs. The three highest value material that are currently landfilled are non-ferrous metals (aluminum), Steel cans, and Old Corrugated Cardboard.

Table 10: Value of Landfilled Material

RECOVERBLE COMMODITY *	TONS	February 2018 $/TON	February 2018 Value	Percent of Total Value
Non-ferrous metals, Aluminum (foil) and Aerosol Cans	162,995	$583.03	$95,031,070	36.5%
Steel Cans (Sorted, Densified)	290,835	$170.23	$49,508,100	19.0%
Old Corrugated Cardboard (OCC)	466,614	$91.50	$42,693,936	16.4%
Aluminum Cans (Sorted, Baled)	19,176	$1,166.06	$22,360,252	8.6%
PET (Baled, picked up)	63,920	$253.30	$16,190,781	6.2%
Soft Mixed Paper (Does not include soiled and Compostable Papers)	552,905	$27.66	$15,294,467	5.9%
Colored HDPE (Bailed, picked up)	35,156	$280.88	$9,874,418	3.8%
Sorted Residential Papers and News (SRPN)	166,191	$46.81	$7,779,844	3.0%
Natural HDPE (Bailed, picked up)	6,392	$540.47	$3,454,686	1.3%
Aseptic Cartons	6,392	$72.35	$462,438	0.2%
Glass 3 Mix	191,759	-$12.50	-$2,396,988	-0.9%
Comingled (#3-7, Baled, picked up)	15,980	$17.02	$272,023	0.1%
TOTAL POTENTIAL RECYCLABLE	**1,978,314**		**$260,525,025**	**100.0%**
Jobs Created from Potential Recoverable		**13,453**		
LDPE (includes some bags, film)	383,518	$ 120.00	$46,022,174	52.2%
Durable and Rigid containers (HDPE Rigid (Baled)	233,307	$ 155.00	$36,162,563	41.1%
Computers	38,352	$ 125.00	$4,793,977	5.4%
Textiles	278,051	$ 4.00	$1,112,203	1.3%
TOTAL OTHER MATERIAL	**933,227**		**$88,090,916**	**100.0%**
Jobs Created from Other Material		**6,346**		
TOTAL RECYCLABLES AND OTHER	**2,911,542**		**$348,615,941**	
Jobs Created Recycling Materials		**19,799**		
RECOVERABLE ORGANICS				
C&D Wood	1,137,770			
Yard Waste and Organics	2,291,521			
TOTAL WOOD AND YARD WASTE	**3,429,291**			
Jobs Created from Composting Organics		**1,372**		
TOTAL	**6,340,833**		**$348,615,941**	
Total Potential Jobs Created		**21,171**		
Avoided Landfill Disposal	**6,340,833**	**$43.42**	**$275,318,969**	

- Selected Materials from Waste Characterization based on Materials with Market Value Published in Indexes

The current value of potentially recyclable materials that are currently landfilled is $260.5 million based on the Midwest Market Indexes in September 2018. The value of the cost of avoided disposal of potentially recyclable material of 1,978,314 tons, based on the average gate rate of $43.42/ton for disposal, is $85.9 million. Other materials that have some value if they can be effectively collected as a separate material stream have a value of $88.1 million. The total of avoided disposal cost for all recyclable and recoverable material is $275.3 million. These market values exhibited volatility, as illustrated in Figure 2: Average Commodity Revenue, so these estimates provide a snapshot of value. The volatility in the value of recycled materials over the past two years is driven by the global decline in commodity demand and the imposition of strict import standards under the Chinese "National Sword" policy for recycled commodities.

The number of jobs that could potentially be created by recycling of marketable recyclable materials and all material that is currently recyclable but landfilled is 19,799. This calculation does not attempt to assess the tradeoff in jobs due to the reduction in jobs required to collect, transfer, landfill or otherwise manage solid waste that is not currently recovered. If collection systems are optimally and efficiently managed, the gain and loss in collection would be a net neutral job change, but job gains would be seen in processing, reprocessing and remanufacturing. An additional 1,372 jobs could be created if yardwaste and wood wastes were composted.

Based on the value proposition and the potential economic value of landfilled material, RRS recommends that the State of Ohio focus on the materials that have high volumes with a strong market or a high value to weight ratio. This means that materials such as clean high value plastics (PET and HDPE) and high value materials with good value (OCC) are good targets. Materials with a low value to weight ratios such as glass are not good targets unless there is a strong local market. Materials that are low value to weight ratios can become a negative value proposition of the markets for those materials where the markets are farther from the point of generation. Transportation costs to move materials to market are the biggest risk for a recycling program.

RECYCLING MARKET TRENDS

The overriding story for recycled commodity markets has been the complete imposition of Chinese inspections and enforcement initiatives under the branded “National Sword” and “Blue Sky 2018” campaigns, and the Chinese World Trade Organization (WTO) ban on unsorted mixed recovered materials and all “human consumed” packaging and post-consumer plastic grades. These actions have all but stopped Sorted Residential Paper and News (SRPN Grade 56), Mixed Paper (Grade 54) and Mixed Plastics from being shipped to China, the world’s biggest consumer of scrap recycling materials, for fear inspections will lead to rejection and demurrage charge backs.

Heavy rejections of all imported materials, especially bales from Material Recovery Facilities (MRFs), along with lower import quotas given to Chinese mills, have even curtailed old corrugated container and aluminum scrap shipments to China. The Chinese ban has resulted in an oversupply of paper that has caused prices to plummet for all bulk paper grades by over 50% through March 2018, compared to 2017 prices. Additionally, the July-announced WTO ban has forced sellers to scramble for new homes. These conditions especially target and limit markets for post-consumer Material Recovery Facility materials.

The orderly supply chain for the previously healthy recycling commodities market has experienced an overall price decline, as indicated in the Average Commodity Revenue. Freight and shipping costs have spiked as new markets are developed that do not have the advantages related to the Chinese export market (Demand, Infrastructure, Freight Backhaul).

Further, the United States, through current administration and court actions, has imposed a series of tariffs and trade sanctions affecting newsprint, aluminum, and steel. In addition, regulations that limit truck driver productivity has created shipping constraints that impact the supply chain. RRS has identified a looming freight crisis due to a severe domestic over-the-road driver shortage, with 500-900 thousand needed in the U.S. Coupled with the shortage is the new Electronic Log Devices that the U.S. enacted in January, which further restricted productive driver hours in the name of safety. Together these conditions are increasing costs and availability for reliable freight to move recovered materials. The short-term effect of these conditions is to price marginal markets out of both domestic and export opportunities.

These factors directly affect pricing for North American recovered materials. The factors have caused unexpected market movement and profit changes; for instance, recovered paper producer costs have

sharply risen with the need for more sorting and the higher freight; while, conversely, metal prices have spiked to record highs for all domestic scrap grades.

The recycling commodities market is in a very volatile state. Metals are near record high and have not been as affected by the ban but are affected by tariff actions. Dramatic price changes are the norm in this fractal space right now, and price conditions can quickly change. A trade war between China and USA could erupt, or some of the Bans lifted as part of a future agreement. Metal markets are still reacting to the tariffs, but big foreign producers, like Rusal Aluminum (Russia), are experiencing financial difficulty now that they are under a tariff.

Overseas producers, who relied on selling primary metal and finished manufacturing products (like coil and billet) to North America, may start emptying vast warehouses of metal, driving prices down. World demand and the world economy are still growing for consumer goods and recovered paper, yet prices are languishing under the above pressures. Major post-consumer polyolefin pricing (PET, HDPE, and PP) are rebounding domestically after initially dropping, despite being banned from China.

RRS further found several other notable conditions which directly affect commodities markets, including:

- Confusion and fragmentation occurring within all the bulk paper grades, Sorted Residential Paper and News (SRPN), Old Corrugated Cardboard (OCC), and Mixed Paper (MP); and, a divergence in price for higher quality, China-ready material of up to $100 per short ton.
- With poor financial conditions, the MRF community is concerned about processing low or negative value materials and some markets have reverted to disposal for some grades of material.

THE IMPACT OF CHINA'S "NATIONAL SWORD" POLICY

Even though China is consuming over 75 million tons of recovered paper, plastics, and metals from containers, far and away the largest consumer, its use of imports has declined by 10 million tons (from 33 to 22 million tons) as domestic capacity grew.[10] China's long-term intention has long-been to become

[10] Moore, Bill, "Global Recovered Paper Market Trends, International Molded Fiber Seminar", Vancouver, British Columbia, 13 April 2016

a 'circular economy' and rely on its own collection/recovery infrastructure over time; banishing "loathsome foreign waste" scrap and "smuggled garbage" completely, as part of a massive campaign of environmental improvement. This is the context for the State of Ohio to understand the current Chinese policies impacting the global recovered scrap industry.

China's National Sword regulatory and inspection policies, which began in February of 2017, and the WTO Trade ban on Foreign wastes (July 2017), and fully implemented March 1, 2018, continues to depress all MRF-derived material prices, and most of the recovered commodity market which makes up recycled commodities (apart from bottle grade plastics and UBC for the most part). Depending upon reporting source, 30-50% of all curbside materials from North America historically ended up in Chinese production with a downward trend in demand occurring before the ban.

The Chinese actions have severely depressed or disrupted commodity markets for mixed waste paper grades (SRPN and MP), mixed and lower grades of plastics, and has increased freight costs for all commodities, due to the loss of the reverse haulage and well-used freight lanes. Quality standards have also brought down OCC and metal pricing. The market is in a state of dramatic, high, downward volatility, despite the continuing high worldwide demand for almost all recovered materials in a good economy. With full implementation March 1, 2018, the world and China export market for bulk recycling commodities have experienced dramatic price decreases[11] and the lowest prices in nine years, even for the most sought-after materials.

The heavily enforced import ban paired with license restrictions mean that many millions of tons of materials will not be allowed into Chinese ports and will have to find new end markets. The resultant flood of lower quality paper and plastics into the rest of the available markets has pushed pricing down to zero (no value) on mixed commodities like #1-7 plastics and SRPN, and reduced OCC prices to nine-year lows. Paper Industry stalwart Bill Moore projected in October 2017, "If recyclers can't find new markets, or places to store the scrap they collect, some waste could end up in the landfill."[12] This

[11] For instance, one of several articles per day now, "China demand plunge drops OCC to 9-yr low, domestic off $5-30/ton, mixed being landfilled; white grades surge'', RISI 9 March 2018 Price alert

[12] Phillips, Erica E., "Trash Talk: Price of Recyclables Sinks After China Band U.S. Scrap", Wall Street Journal, 20 October 2017

practice is now being implemented in the U.S. Regulators in Oregon are allowing processors to landfill bales of mixed paper and plastic.[13]

Meanwhile, many other processors are stockpiling material and waiting for the market to open up. According to one interview, a single processor had over 10,000 tons of mixed paper stockpiled. This is leading certain states and communities to scale back their commingled programs, removing items such as shredded paper, cartons, glass (though unaffected by the ban), and most plastics other than bottles.[14] Even materials that are not outright banned but are coming from the domestic MRF ecosystem are not entering China due to the carried waste standard, which processors time and again insist cannot be met. Commodities such as OCC and UBC as of March are suddenly being discounted when entering secondary export markets in India and Southeast Asia.

There is also a fragmenting of traditionally reported grades of materials which impacts indices. For instance, for Old Corrugated Containers or OCC #12, wide premium gaps are being reported versus indices-reported OCC pricing for all markets. Double Sorted Cardboard (DS-OCC 12), Double-Lined Kraft (DLK 13), and non-standard grades such as "Select OCC", "OCC 11/12" and "OCC 11.5", are still being shipped to China, far above index-reported prices. Sorted Clean News (SCN), "Premium #8", "High-quality" Old News Paper (ONP) 8/9 are also continuing to ship to China at substantial premiums above indexed pricing, along with higher graphic grades like Old Magazine Grades (OMG) and Sorted Office Paper (SOP). Finally, if exported at all, MRF-generated OCC and SRPN are going to other Southeast Asian mills for re-sorting and shipping into China at a discount.

Bottle graded sorted plastics, such as PET, HDPE and PP typically wouldn't go to export and there is plenty of capacity in the U.S. to handle extra supply. This is the same for Aseptic and Gable Top Cartons (PS 52) and Steel Can Bundles. Aluminum Used Beverage Container (UBC) must use North American UBC kiln companies (i.e. Novelis, Constellum, Alcoa) with freight discounts off reported prices, to move material. The differences are not significant ($0.04-0.08 per ton, according to buyers). Aluminum, due to its value, enjoys continental movement compared to other materials.

[13] Oregon DEQ Recycling Stakeholder Meeting, Attended 15 February 2018

[14] IBID

In conclusion, this is a watershed moment in the global recycling industry. The recycling infrastructure in North America that developed around single stream residential programs was designed with the Chinese end market in mind and is systemically unable to meet the carried waste standard for any materials, including materials which are not banned, such as OCC and UBC. A shift in focus towards quality is needed along the entire recycling value chain. According to Bob Cappadonna of Casella Recycling LLC "(North American) recycling businesses will need to invest in machinery to more stringently sort the waste they collect. It also means households will have to do a better job of sorting items headed for recycling."[15]

Furthermore, it is important to see the bigger implications on China's role in the global economy. The rampant growth over the past two decades led to greater wealth and a growing middle class that resulted in significant environmental problems. At the same time the Chinese economy has reached a point of maturation where there are signs of shifting towards becoming more of a global consumer of manufactured goods and an internal producer of its own scrap. Moving forward, there should be an increasing demand for high-quality scrap from every buyer because of market oversupply, above and beyond Chinese requirements.

[15] Phillips, Erica E., "Trash Talk: Price of Recyclables Sinks After China Band U.S. Scrap", Wall Street Journal, 20 October 2017

RECYCLED COMMODITIES MARKET ASSESSMENT

This section provides the State of Ohio with an in-depth look at the market dynamics for each relevant grade of material encompassing recycled commodities that are recycled and currently need focus within the U.S. and Midwest marketplace related to quality and standards. This assessment includes comments on the state of the market for each grade, in addition to short and long-term viewpoints. In addition, the end markets that are available to producers in Ohio are identified for specific commodities. An assessment is also provided on the single most impactful issue affecting markets today – Chinese import policy and enforcement activities, including Operation Green Fence, National Sword, WTO Waste Import Ban and Operation Blue Sky.

Ongoing market impacts are described, including the effect that these policies have on the flow of recycled commodities generated through curbside programs, reliability of the recommended indices, and ability to develop reliable market forecasts. This information will allow the State of Ohio to better understand the market dynamics of recycled commodities and use the best possible pricing information, supplemented by continuous market research and engagement, to complete their required activities related to support of recycling programs and service contract support.

FIBERS

Old Corrugated Containers (OCC)

OCC has been and will remain the most widely recovered paper commodity in the world. It is also the largest North America export of recovered paper. There is very good demand worldwide. OCC world demand is not being met and some Chinese mills are paying as much as $450-550 per containerized ton as the world's largest consumer of recovered OCC. Due to China regulatory actions, this demand is not reflected in the price in North America or the Midwest. In fact, China's WTO ban and National Sword inspection policies have made OCC prices drop over 70% in 12 months, and over 75% of the half-million-ton shipments from North America per month have stopped, with full implementation of the Chinese Ban and quality standards on March 1, 2018.

This is creating immediate oversupply throughout North America. In addition, there are new announcements every day of fragmenting grades with higher quality thresholds and undefined specifications, which further changes prices. Today the fabric of the OCC market is chaotic and hard to

measure. Indexes are not predictive because surveys take time, and buyers report transactions with large deviations from stated pricing. In March 2018, the price dropped another 30%, and orders which are not discounted are the normal practice.

Growth in demand from a good North American and world economy, and the growth in export linerboard with the Chinese cutback in linerboard supply, will counter the current "panic" to some extent. For instance, research showed mill demand is surging and more mills are converting to linerboard. Cleaner OCC passing inspection from MRF sources seems achievable. China still needs 20 million tons of recovered OCC imports for its manufacturing base. These trends and China's needs should return prices close to $80-140 per ton range, in what should be a $200-300 per ton real demand market. It could take up to two years until stabilization occurs in the OCC markets.

Sorted Residential Papers and News (SRPN, ISRI Grade #56)

RRS believes that short term price declines for SRPN will continue. The trading market is in oversupply in North America. Markets in China are not available and other destinations do not have the infrastructure to absorb this material. In North America, especially material sources from MRFs, there is no demand unless ONP is hand sorted at much higher costs. RRS believes this trend will continue through 2018 and into 2019. A zero ($0.00) to negative price will be the norm.

Unlike OCC, SRPN has no economic demand driver to change conditions, and consumption has dropped in North America by over four million tons in ten years. SRPN is a slowly declining grade becoming associated with mixed paper. ISRI's move to this new grade in 2016 seemed prudent, making the MRF ONP-based grade descriptive of what the buyer was getting, due to the evolving ton. Now it is being treated as a banned material for export to China, the main consumer outside the U.S.

The lack of newsprint in MRF SRPN bales makes them less desirable for return to newsprint use. It costs too much to clean and there is no new investment in mill recycling processes in North America, though some virgin mills may be fired up because of newsprint demand with China's changing picture. Similarly, only the highest quality can be used in U.S. mills. The onset of mixed recycling collection twenty years ago is directly associated with higher mill costs: lower quality, shorter fiber, and less yield and more disposal due to contamination. The problem is "daily (printed) newspapers are a dying breed". Mills will continue to close as mechanical paper demand goes down. New unexpected costs associated with

freight (driver shortages, U.S. ELDs requirements and ocean shipping lanes) will further erode value for SRPN.

There is great confusion for this grade and it has experienced divergence into sub-grades. Some of these sub-grades are tracked, such as the retired ISRI grade of #8 ONP on Recyclingmarkets.net. The much stronger quality standards of older grades are preferred, and prices are at a premium, far the above indices. Any bale shipment meeting the Chinese 0.5 of 1% standard is coveted both there and in North American mills. There is a further Premium #8 broker grade, which in a few months, has become very popular and is sourced from dual stream and source separated sources. A higher #8/9 ONP is a combination of Premium #8 and Overissue ONP, again capturing a premium price. Prices for these 'premier' grades are much higher than the index.

Commodity: Sorted Clean News (SCN)

SCN is highly sought at remaining domestic mechanical paper recycle mills. High quality 'premium' fiber of almost any kind is commanding high prices and increased differentiation from the bulk grades with the loss of the Chinese Import market. RRS foresees continued volatility for SCN, trending towards continued price increases and differentiation from SRPN. The SCN grade designation assures buyers real post-consumer newsprint for deinking. It is, however, experiencing similar uncertainty in the market and within the indices as are all other RCP grades in this extraordinary period of change.

The newly defined (2018 ISRI) clean news grade and the overall market anxiety related to the China WTO ban have leaked into SCN short-term pricing after April 2017. Yet SCN and its precursor, Premium ONP #8 (which is now being made again and is also in high demand), which suffered from volatility over the last 13 months, has momentum and has been trending up in 2018. This is because it still has acceptance into China as a premium grade while also maintaining demand with domestic mills.

SRPN quality is a big problem in North America – brown unbleachable material and non-paper contaminants have increased, affecting yield, mill performance and disposal costs. SCN has none of these problems and can be an incentive to keep pulpers at higher levels of efficiency for the deinking process. With mixed grades of newsprint from curbside programs losing end-markets in China, SCN should benefit by fulfilling that space, which allows for increasing premiums over domestic pricing. The only risk would be if there is any trouble meeting the 0.05% carried waste standard. As a positively sorted grade this should be achievable.

The inevitable flood of SRPN into domestic markets could bring all newsprint pricing down domestically so the regions that do not have access to mills may have to accept a more modest and growing premium over a lower baseline and would be more susceptible to the downdraft of SRPN pricing should that continue to occur. The short supply of clean recycled newsprint will keep this grade buoyed as the trend of decreasing newsprint production is expected to continue and recycled newsprint mills worldwide, which rely on that material, have a challenging time getting a clean supply of overissue ONP and other fractured premium grades, i.e. Premium #8.[1] With no current trade restrictions, this will be a "first in line" material for export and domestic consumption. Volatility will remain in the market, which will include mills continuing to close and SRPN pricing declines.

Mixed Paper (MP ISRI Grade #54)

RRS sees harsh market conditions for Mixed Paper (MP), except in market regions that have regionally available mills that utilize this grade. The China WTO Ban of 2017, which was fully implemented in 2018, firmly bans this grade from import, though demand there is still high. China did utilize the bulk of North American recovered MP. Severe oversupply is growing and there is no currently supportable market. MP has lost 100% of its value, falling from a one-week spot market high of $125 per ton in late February 2017 to zero or a process fee charged by buyers. Only previously contracted tons or commercial "hard mix" bales have any value at all, while MRF tons have none.

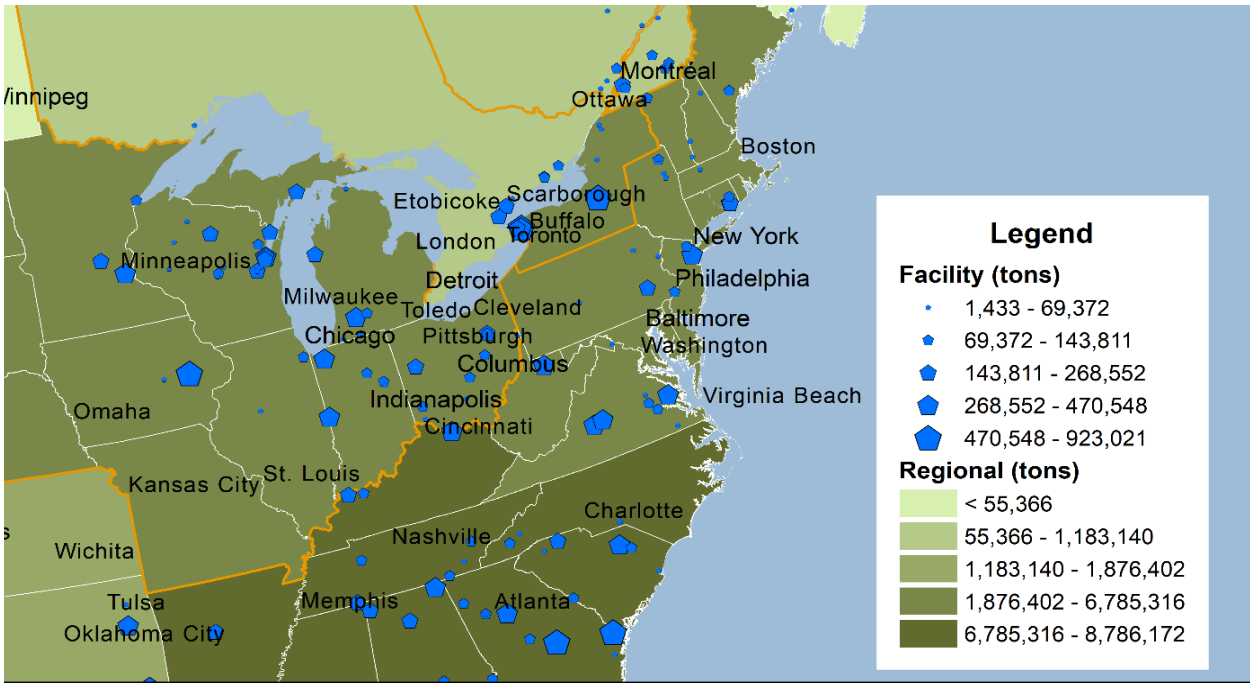
Mixed paper in current quantities in North America are a direct result of the spread of modern curbside Single Stream programs, the evolving ton, and Chinese demand. Design of sorting plants unfortunately keyed on MP as one of its growing outputs. As has been demonstrated, Single Stream commodities have an inelastic supply regardless of demand conditions (Timpane, 2016). ISRI Grade definitions changed with the use of the grade to the current standards. Domestic demand growth for Mixed Paper use is from cartonboard/boxboard where 20% or less is used and competes with SRPN.

The Midwest marketplace is the one region that can expect to see an increase in demand for MP. This is driven by the announcement that Pratt Industries Inc, one of the major U.S. recycling, paper and corrugated packaging companies and affiliate of the family owned Australian firm, Visy Industries, has plans to expand its U.S. operations. A new recycled corrugated case material mill - the fifth of its kind since the foundation of Pratt Industries in 1985 - is under development. The new Pratt Paper mill is being built in the town of Wapakoneta in the State of Ohio and will have a capacity of 400,000 tons of corrugated medium and linerboard made out of recycled fiber.

Pratt Industries put the new facility's demand for recovered paper at the equivalent of 465,000 tons, including 300,000 tons of mixed paper and 165,000 tons of old corrugated containers (OCC). Pratt Industries plans to meet all of its raw material needs through its corrugating and converting division Pratt Corrugated Holdings (PCH), which currently manufactures and sells 1.5 million tons of corrugated sheet and boxes and other specialty packaging. PCH is planning to purchase 90% of Pratt Paper's new recycled containerboard capacity in Ohio. The other 10% would be sold to third parties.

Figure 4 identifies the end markets for all recovered fiber including OCC, News, and Mixed Paper that are available to Ohio producers. Overall there are 62 mills that consume about 7.8 million tons of fiber, including 37 mills that are utilizing approximately 3.7 million tons of OCC, 56 mills that are utilizing approximately 3.7 million tons of Mixed Paper and 16 mills that are utilizing approximately 380,000 tons of Newsprint. A detailed list of facilities is available in Appendix VI.

Figure 4: Paper Mills Utilizing Recovered Paper



PLASTICS

Polyethylene Terephthalate (PET)

Post-consumer recovered Polyethylene Terephthalate (PET) relies on North American markets and is now restricted from export to China. Fortunately, North American capacity for post-consumer PET exceeds available supply. Relative to indicators like natural gas and oil, PET markets will probably see a slow, steady increase in bale pricing over the next year or two, as virgin material pricing is projected to remain at current, relatively high, levels. Supply is expected to remain stable. Though PET bale prices track closely to virgin resin pricing, and oil and natural gas, they are much more heavily influenced by supply and demand. The additional supply has helped to dampen the higher virgin resin prices that might have otherwise driven prices up.

The most significant regional difference in PET markets relates to the acceptability of mixed bales of PET bottles and thermoforms. The Association of Plastics Recyclers (APR) / ISRI bale specification identifies the acceptability of PET thermoforms as a buyer / seller issue to be agreed on a transactional basis. In regions where most PET bottles are collected at curbside, most PET markets will accept bales of mixed bottles and thermoforms, as long as the MRF uses optical sorting or otherwise has strong quality control measures in place to ensure that the thermoforms in PET bales are, in fact, PET. In regions where much of the PET bottle stream is from deposit systems, the management of PET thermoforms is more problematic. Given the ample supply of clean, high-quality bottles generated by deposit programs, PET reclaimers in those regions have little incentive to adapt systems to capture the more challenging PET thermoform stream.

The market is enjoying a respite from a very challenging period during which virgin PET prices were at record lows following a ramp up in new capacity, placing an effective cap on recycled PET prices and squeezing reclaimer margins. The bankruptcy of a major North American PET producer (M&G), and, to a lesser extent, the impact of Hurricane Harvey and newly-implemented import tariffs, resulted in a dramatic increase in virgin PET pricing in the fall of 2017, improving reclaimer margins and PET recycling system health. If virgin producers continue to exercise discipline in pricing, conditions should remain reasonably good, and current bale pricing should be supported.

Despite high virgin PET prices, bale prices are not expected to increase dramatically, due to the increased supply made available by the Chinese import restrictions or from the increase in

transportation costs resulting from the recent implementation of electronic monitoring and resulting shortage of trucking availability. Since PET bale prices are defined as Freight on Board (FOB) at the MRF, that increase in transportation adds to the effective cost of supply to the reclaimer.

The North American appetite for PET will likely remain strong. However, continued public outcry over ocean plastic may have the potential to dull consumption expansion and should be watched. All together these factors and how and when they play out makes a long-term outlook for recycled PET very challenging, and points towards periods of volatility over the long term.

High Density Polyethylene (HDPE)

RRS expects some decline in price as MRF-derived supply of #2 plastic resin bales and #1-7 mixed plastic resin bales increase. Overall, High Density Polyethylene (HDPE) markets are expected to remain relatively stable for the next couple of years, relative to oil and natural gas prices. Domestic recycling collection and reclamation capacity are not projected to change significantly, and virgin resin prices are expected to remain steady or will increase with fossil fuel inputs. New virgin polyethylene production capacity in North America is being absorbed into market growth and exports, and so far, has not led to oversupply or a drag to pricing. New direct natural gas to PE conversion technology with a much lower cost basis than PE from oil will make virgin much more competitive and keep prices tempered. RRS recommends monitoring virgin HDPE, and both oil and natural gas, as pricing factors that impact bale pricing, particularly of colored HDPE.

Like other plastics, bale pricing for HDPE is driven primarily by local supply and demand as well as by virgin resin pricing (which is driven by oil and natural gas pricing). Given that supply (i.e., recycling collection) has been relatively static for the last decade, demand is a more significant driver. Demand for HDPE is highly seasonal, with Spring / Fall pricing being substantially higher than Summer / Winter. This is because demand for the major end uses for recycled HDPE – pipe, flower pots, and cleaning products – all increase during the spring and fall.

The relationship of recycled HDPE prices to virgin is different for natural vs. colored HDPE. Markets for Natural HDPE are supported by minimum recycled content requirements in place under California's Rigid Plastic Packaging Container law, which bolsters demand and drives pricing of recycled natural HDPE to exceed that of virgin. Colored HDPE, on the other hand, competes more head on with virgin HDPE, and therefore the virgin HDPE pricing serves as an effective cap on recycled colored HDPE. As a

result, to forecast natural and colored HDPE pricing, the factors to monitor include the passage or repeal of mandatory minimum recycled content requirements, virgin resin pricing, and antecedent fossil fuel prices.

There is not a clear direction for markets in the long-term. Cheap fossil fuel (natural gas) feedstocks have led to a boost in virgin PE supply in North America and many in the recycling industry have been preparing for downward pricing impacts on recycled HDPE as a result. So far, the new virgin polyethylene production capacity coming on line in North America has not impacted pricing to full extent, due to production disruptions during the storms of 2016 and 2017. There still remains a growing demand in North America and abroad that has kept pace with supply increases

Polypropylene (PP)

High quality polypropylene (PP) bales have emerged as a consistent revenue source from this sorted grade of material. However, it is still difficult to track or forecast demand and pricing. The market is still clearly in a development phase and therefore volatile. It will be several years before PP will mature enough to enable accurate price tracking and forecasting.

PP is transitioning from one of the valuable elements in a mixed plastic bale to a commodity in its own right, being marketed as a sorted grade. Many facilities now optically sort it to a resin product (referred to as a PP bale) or hand sort it lower-grade product (referred to as Tubs and Lids - which also includes smaller percent combinations of HDPE, LDPE, and polystyrene). Some markets use “tubs and lids” to exclusively refer to polypropylene bales coming from MRFs. Recyclingmarkets.net (RMN) and the Association of Plastics Recyclers (APR) delineate between tubs and lids and polypropylene bottle bales.

Other significant factors are impacting PP, most notably the market for mixed plastics changing significantly due to Chinese import restrictions. MRFs, to the extent they can afford it, will try to separate out PP either as a tubs and lids or graded bale. This will increase recycled supply. Additionally, the collapsing plastics recovery facility (PRF) infrastructure in the U.S. is impacting secondary processing capacity, for instance, the recent closure of QRS in Baltimore, Maryland.

Domestic demand for PP is growing. Of the emerging grades of plastic, PP has consistent pricing to support separation if there is enough volume from the municipal collection stream. Markets have responded by demanding feedstock. There is significant interest from major end users in continued

growth, including strong demand from brands such as Unilever, Proctor & Gamble and Keurig Green Mountain.

Strong domestic market interest in PP is driving the development of a standalone PP grade, fed mostly by larger MRFs that can generate significant quantities of this low volume material as well as by plastics recovery facilities (PRFs) and innovative MRFs that are purchasing mixed plastics bales and mining them for PP content. Supply of this material is growing more quickly than demand in some cases, however, causing some volatility in the market. That volatility is underscored by virgin PP pricing which can swing very significantly in short periods of time.

It is noteworthy that there is confusion about the definition between PP bales and Tubs and Lids bales. Colloquially, many people refer to tubs and lids and polypropylene bales interchangeably, and this may be one reason why the indices are not reliable. Reported pricing may include reports for both material streams in the same grade. APR and RMN both delineate between tubs and lids and polypropylene bales in material definitions, although RMN only reports on the polypropylene.

Mixed Plastics and Film

RRS is not confident about the mixed recovered plastics markets. This market must stabilize to enable accurate price tracking and forecasting, especially post-consumer MRF film. All categories of post-consumer plastics were banned from China, resulting in an upheaval for exported materials, which in the case of plastics was mostly the lower mixed grades plus some bottle grades. MRFs have relied on these grades to make diversion goals and contractual recovery obligations.

With markets in oversupply, most mixed plastics have no market, or sellers are paying more than the cost of landfilling for further processing and recovery. Any recovery of the mixed and post-consumer film is marginal as a result of Chinese import restrictions. The only movement at all is highly local and due to domestic demand and specific quality characteristics from individual suppliers. As a result, collection of mixed plastics through curbside programs is challenged, with programs in the Western U.S. and Buffalo region sending mixed plastics to landfill and removing #3-#7 plastics from their list of acceptable comingled items.

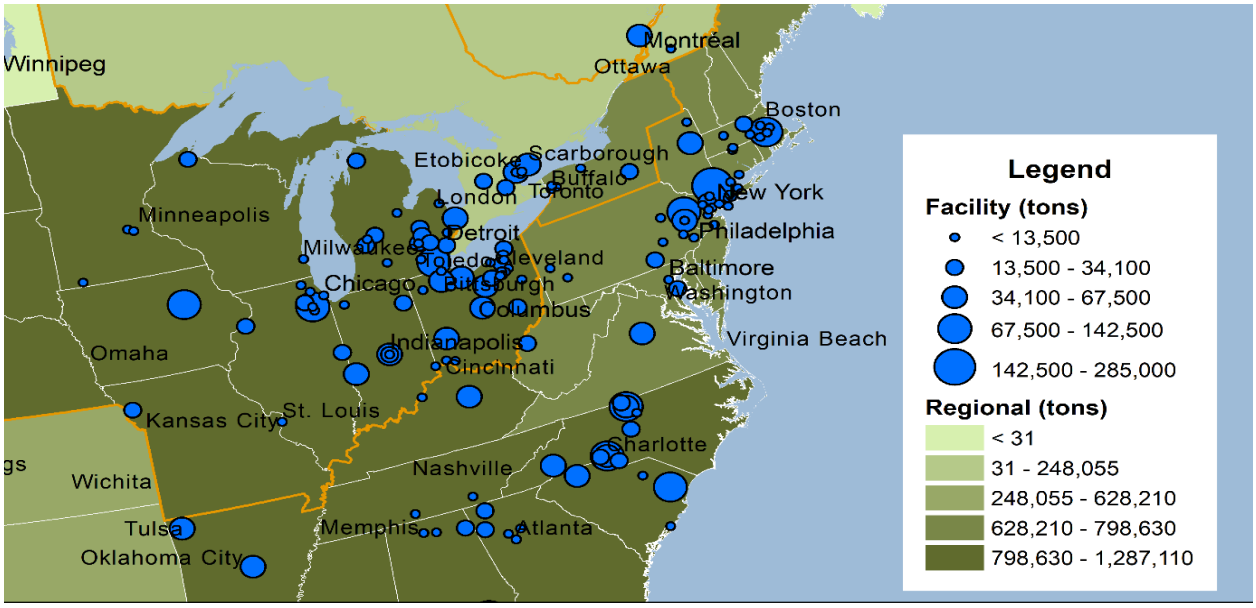
The Midwest is flooded with mixed plastics and film, and there are more processing options moving east for mixed plastics and film. Some higher value mixes in the Midwest go all the way to the Southeast U.S. for Mixed Bulky Rigids (MBR). Through the midterm, without the Chinese import draw conditions will

remain volatile. There is still some value to #4-#7, however it is dependent on geography, quantity and quality. Unless significant processing capacity is added in North America, current pricing trends will continue. This impact could be compounded for mixed grades as more MRFs transition to producing PP bales, removing the main value in the mixed plastic bales and leaving little reason to sort plastic further.

Compared to other North American markets, the Great Lakes markets are advantaged, along with Southeast U.S., for managing Mixed Grades. Markets for mixed plastics are robust in the Southeast U.S. One of the only North American markets for post-consumer film plastic is in Ontario, Canada. The value of #1 and #2 bottles historically kept market viability for #1-#7 and #3-#7, and those bales are still being produced in MRFs that are not equipped to sort out #1s and #2s. This was the primary reason they held any export value. #3-#7 bales sold better domestically but have not often been exported. Re-sorting of both grades for #1 and #2 allowed the grade to develop. #5 PP is now contributing to re-sort value, but not enough to overcome higher freight costs.

Figure 5 identifies the end markets for all plastics processors that are available to Ohio generators. Overall there are 129 plants that consume about 3.1 million tons of all grades of plastic including 18 facilities in the state that consume about 350,000 tons and an additional 33 facilities consuming 830,000 tons in the states bordering the State of Ohio, which are within reasonable and cost-effective haul distances from the state. A detailed list of plants is available in Appendix VII.

Figure 5: Recovered Plastics Processors and Reformers



METALS

Aluminum UBC Scrap, including "Taldon"- Baled and "Taldork" Briquetued UBC Scrap

The metal scrap world is over 3,000 years old and has been historically the most highly defined and valuably traded commodity. The price of a commodity is determined as a function of its market: well-established commodities have actively traded contract, spot, and derivative futures markets. Aluminum scrap has a well-functioning, well established world commodity market, with one of the longest reported daily prices for any scrap material. Aluminum is an orderly world market and aluminum scrap follows that market structure.

Escalation of trade war talk between China and the U.S. is focused on aluminum, and supply/demand balances for scrap, rely on these two consumers more than any other part of the world. Prices are just off historical highs for both UBC and the LME. Indicators and prices could dip if rhetoric heats up. Right now, the impacts are not known, and price is flat despite good demand.

One potential upside is consumption of Chinese aluminum mill products is sure to decrease in the short term in North America and this will drive scrap demand to be used here for manufacturing. This should positively stimulate the market when the impact from the Tariff actions becomes clear. Trade of UBC travels around the world between four continents with multiple players and freight costs do not restrict it because of its high value.

As late as January of 2018, MRF operators were continuing to enjoy high Aluminum UBC prices (less contamination deductions made at the mill). Cleaner quality UBC from buy back and deposit were getting premiums in some markets. Large scrap yards, like Sims and Commercial Metals, as well as consumers (Novelis, Constellium, and Alcoa) saw a rising world market and are building inventories, despite saber rattling from the U.S. and China over trade. Bales of cans generated were selling for about 72 cents per pound (delivered), up about 3 cents from December and close to the 2017 high at the end of February. American Metal Market has reported that since then the world aluminum price, and all aluminum scrap has been struggling to maintain the strong upward momentum and multi-year highs seen in the first few weeks of 2018 has been flat.

China slapped a 25% tariff on Aluminum scrap in 2018. Though UBC is not affected, it is bundled with other aluminum scrap grades in the market sentiment, as is the LME finished ingot pricing. Additional

recent Policy Tariff actions by the U.S. will have further impacts on the use of Aluminum UBC scrap and the production of can sheet in China. The U.S. tariff taxes affix 25% onto the price of imported steel and 10% onto imported finished aluminum.

MRF generated UBC is most affected and is likely to be sold at steeper discounts. Already, China stopped importing MRF UBC bales last November because of the high 0.5 of 1% quality standard. Most feel North American prices for aluminum will rise and will deviate from the very public world price, best reflected by the London Metal Exchange.

Steel Cans (Sorted, Baled)

Both hot rolled steel band (flat steel or "HRB") and hot rolled coil ("HRC") which is derived from steel band, are benchmark steel products. Both are made directly from steel scrap and there is a strong correlation between scrap pricing and these finished products. Both have risen from below $300 per short ton to over $700 per short ton at the beginning of February 2018 in the last two years, per numerous sources (i.e. Metal Miner 2018 February; NWI Times, NWI.com). No. 1 busheling, No. 1 heavy melting scrap, and shredded steel scrap are the benchmark grades of ferrous scrap and are reported regularly by American Metal Markets (AMM). No 2. Bundle, reported by AMM, is the closest related benchmark for steel can bundles and was the price to track before steel cans had their own grade.

Midwest trading is the source of the benchmark price used in the North American scrap industry. Steel cans trade off these grades and bale pricing rises with these prices. All benchmarks and steel cans have consistently risen in value over the last two years and are likewise expected to continue rising for the rest of the first half of this year.

Steel cans have seen consistently rising prices in the good economy. The World Steel Association anticipates an 8% increase in the price of steel in 2018. Demand and price are expected to grow through 2021 (Statista), provided regulatory or economic upheaval does not overtake it. Like other grades, ferrous scrap exports to China have decreased from a high in 2011 and are much less dependent upon this destination now. Actions by China or the U.S. should not deter pricing.

Figure 6 and 7 identify the end markets for all steel and aluminum plants that are available to generators in Ohio. Overall there are 9 aluminum plants that consume about 880,000 tons of all grades of non-ferrous metal, which are within reasonable and cost-effective haul distances from the State of Ohio. There are 101 steel plants that consume about 124.5 million tons of all grades of ferrous steel, which are

within reasonable and cost-effective haul distances from the state. A detailed list of plants is available in Appendix VIII and IX.

Figure 6: Recovered Steel Plants

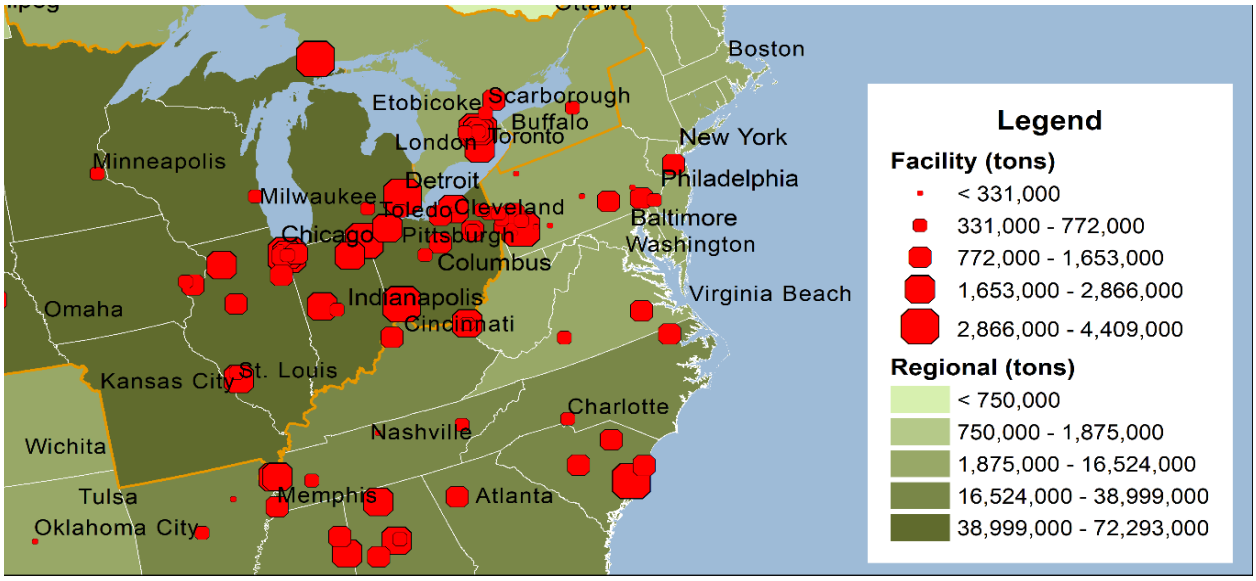
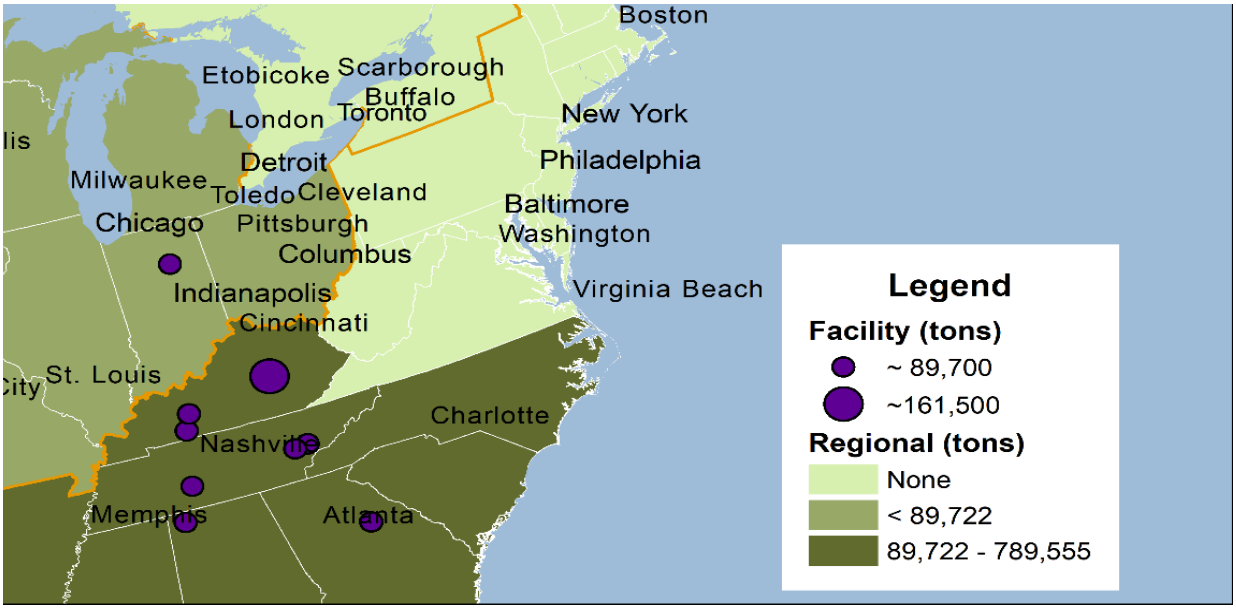


Figure 7: Recovered Aluminum Plants



GLASS

Material Recovery Facility-derived 3-Color Mixed Container Glass ("MRF Glass")

Note on this Section: *RRS is the Managing Consultant for the Glass Recycling Coalition and the Recycling Consultant for the Glass Packaging Institute. In addition, RRS has done major market surveys of supply, demand and price in North America for several large members of the supply chain as a private consultation on market entries and viabilities. Finally, RRS has frequent on-going conversations with several glass processing companies and attends Glass Workshops throughout North America.*

Since the beginning of this century glass bottles are losing annual container market and have shut down several American facilities, the latest being in Milford, Connecticut. This is a tight value chain that lives on high volume package units with low-margins, contained costs, and glass bottles must compete with more cost-efficient packages. Glass bottle furnace facilities are built to support beverage and food operations and are often isolated in geographies. Fiberglass facilities open with economic expansion and close with economic downturn, tightly tied to the construction economy. Any net expansion in glass bottle and fiberglass consumption is not expected and the furnace footprint in North America is stable to declining.

Recyclingmarkets.net is the original market index with the most surveyed members for 3-mix glass and has improved survey methods over the years. The final price negotiated by buyers for 3-mix uses the index price as a base. 3-mix pricing has decreased over time. As a continental average over four years pricing has moved from negative $3 per ton to negative $20 per ton. RRS expects further drops, especially if glass continues to lose market share or the economy falters.

Glass composition, fines content, and moisture content is tested at secondary processors.[16] Fines, contamination and moisture are deducted from the index price on a percentage basis. This is a new ISRI specification and there is an illustration of the inverse relationship between price and these factors within the specification. RRS is concerned about low participation with that index. RRS recommends watching that pricing, but only as a check price.

[16] ISRI Scrap Circular 2017, p. 25 Matrix.

Unprocessed Color-sorted Glass Bottles and Jars - Flint (Clear), Amber (Brown), Emerald (Green)

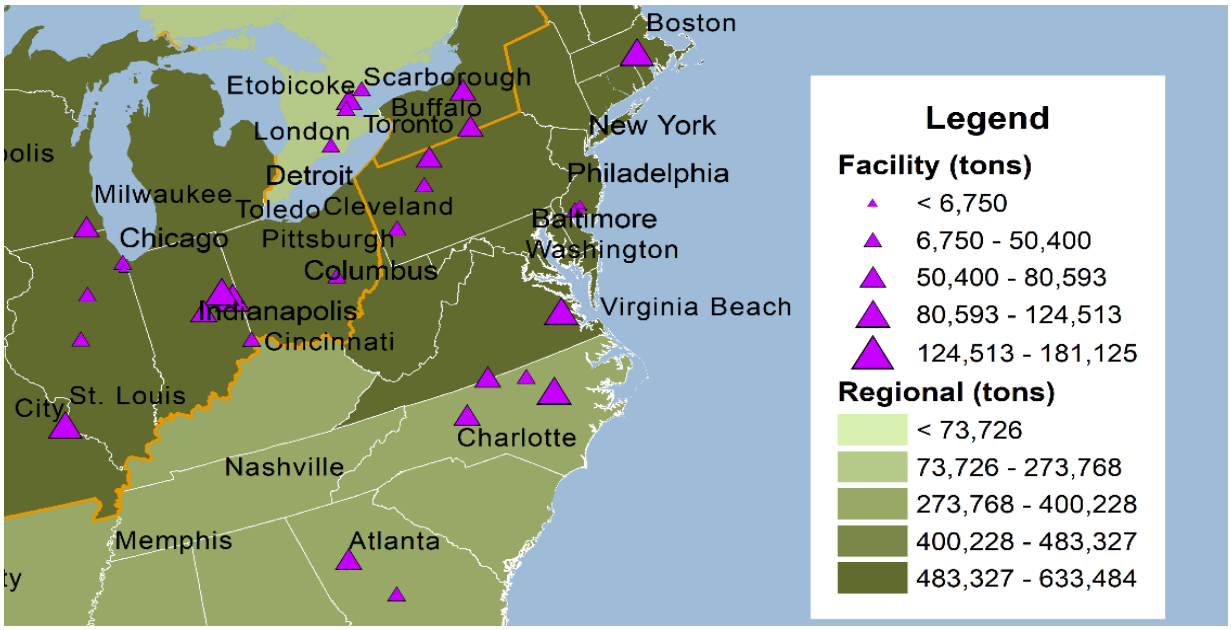
Clean unprocessed color-sorted glass will be supported where a furnace is located nearby. Prices have not changed in 30 years. In 1988, at the Owens Illinois Glass plant in Williamsburg, Virginia, pricing for Flint Glass was $40T, for Amber was $30T, and for Green $10T, close to today's prices. Unprocessed color-sorted glass usually still needs to go through final beneficiation to remove ceramics, metals, and other harmful inputs to the batch, and there is not that much value spread in the manufacturing process to pay much more than $40 per ton. Since there is little competition in beneficiating, RRS' opinion is that there will be further very slow price drop, but clean glass will maintain good market position when processors are located near corresponding furnaces that can use colored product.

With energy prices decreasing due to the natural gas revolution, the attractiveness of cullet as an input is limited, given lingering quality concerns after beneficiation. RRS also believes source separated supplies will grow with the new China ban and the re-emphasis of removing glass from curbside convenience to a more quality, higher value sort.

Use of cullet varies widely by geographical market availability. The Ohio market has a well-developed beneficiation plant infrastructure. Rumpke Recycling in Ohio partnered with the Ohio Department of Natural Resources and Owens- Illinois to build enhanced technology to process glass. Rumpke first opened its Dayton glass processing facility in 2002 in an effort to process the broken, mixed color glass screened from the single stream sorting process. The new system creates a product suitable for the glass container industry. State-of-the-art optical scanning will make the recycling of glass containers used by consumers as well as bars and restaurants easier and more economical. While a significant portion of the material processed at Rumpke Recycling will be prepared for use in container manufacturing, long-standing glass recycling partner Johns Manville, a fiberglass manufacturing firm with a production facility in Defiance, Ohio, will continue to use 50% of the processed glass as a raw material.

Figure 8 identifies the end markets for all 3-mix glass cullet that are available to Ohio producers of recovered glass. Overall there are 28 plants that consume about 1.5 million tons of cullet including an Owens-Illinois (O-I) plant in Zanesville, Ohio, an O-I plant in Lapel, Indiana and two O-I plants in Pennsylvania that are within reasonable and cost-effective haul distances from Ohio. There are also two Ardagh plants in Pennsylvania and one Ardagh plant in Indiana. A detailed list of plants is available in Appendix X.

FIGURE 8: GLASS CULLET PLANTS



APPENDICES

Appendix I: End Market Commodity Types

Grade	Material
Plastics	PET (Baled, ¢/lb., picked up)
Plastics	PET Curbside Grade B in CA (Baled, ¢/lb., picked up)
Plastics	Natural HDPE (Baled, ¢/lb., picked up)
Plastics	Colored HDPE (Baled, ¢/lb., picked up)
Plastics	Commingled (#1-7, Baled, ¢/lb., picked up)
Plastics	Commingled (#3-7, Baled, ¢/lb., picked up)
Plastics	HDPE Rigid (Baled, ¢/lb., picked up)
Plastics	Mixed Bulky Rigid (Baled, ¢/lb., picked up)
Plastics	FILM - Grade A (Sorted, 800+lb Bales, ¢/lb., picked up)
Plastics	FILM - Grade B (Sorted, 800+lb Bales, ¢/lb., picked up)
Plastics	FILM - Grade C (Sorted, 800+lb Bales, ¢/lb., picked up)
Plastics	LLDPE-Stretch Film (Refer to FILM grades A, B, C)
Plastics	PP Post Consumer (Baled, ¢/lb., picked up)
Plastics	Polystyrene EPS (Baled, ¢/lb., picked up)
Metals	
Metals	Aluminum Cans (Sorted, Baled, ¢lb., picked up)
Metals	Aluminum Cans (Loose, ¢/lb., dropped off at RC)
Metals	Steel Cans (Sorted, Baled, $/Gross ton, picked up)
Metals	Steel Cans (Sorted, Densified, $/Gross ton, dropped off at RC)
Metals	Steel Cans (Sorted, Loose, $/Gross ton, dropped off at RC)
Metals	White Goods (Loose, $/ton, picked up)
Glass	
Glass	Flint ($/ton del.)
Glass	Amber ($/ton del.)
Glass	Green ($/ton del.)
Glass	3 Mix ($/ton del. as Recyclable or Disposable)
Paper	
PS 54	Mixed Paper (MP)
PS 56	Sorted Residential Papers (SRNP)
PS 58	Sorted Clean News (SCN)
PS 4	Boxboard Cuttings
PS 10	Magazines
PS 11	Corrugated Containers
PS 13	New Double-Lined Corrugated Cuttings
PS 24	White News Blanks
PS 28	Coated Soft White Shavings
PS 30	Hard White Shavings
PS 31	Hard White Envelope Cuttings
PS 37	Sorted Office Paper
PS 40	Sorted White Ledger
PS 43	Coated Book Stock
PS 44	Coated Groundwood Sections
PS 47	Unprinted Bleached Board
PS 52	Aseptic Cartons
PS 1	Soft Mixed Paper (Refer to PS 54 - View for Historical)
PS 6	News (Refer to PS 56 - View for Historical)
PS 7	De-ink Quality News (Refer to PS 56 - View for Historical)
PS 8	Special De-ink Quality news (Refer to PS 56 - View for Historical)

Appendix II: Detailed Statewide Waste Composition

This table provides a detailed profile of the statewide disposed waste stream based on the Medium Residential and Commercial scenario. For each material category, the estimated disposed tons, and mean percent are shown.

Material Type	%	Tons		Material Type	%	Tons
High Grade	1.03%	99,076		Glass	1.23%	118,251
Mixed/ unspecified Office	0.40%	38,352		Flat/plate	0.10%	9,588
White Ledger	0.23%	22,372		Other Glass	0.67%	63,920
ONP	1.73%	166,191		**Glass Subtotal**	**2.00%**	**191,759**
Magazines and Catalogs (OMG)	1.00%	95,880		Brown goods and electronics	0.67%	63,920
Paper Bags	0.13%	12,784		Computer-related includes monitors	0.40%	38,352
Phonebooks and Directories	0.13%	12,784		Video display and CRT	0.57%	54,332
OCC	4.87%	466,614		White goods (appliances)	0.37%	35,156
Paperboard/ Boxboard	0.23%	22,372		Other electronics	0.50%	47,940
Polycrates Paper	0.07%	6,392		**Electronics Subtotal**	**2.50%**	**239,699**
Compostable/soiled	4.33%	415,478		Wood - general	2.47%	236,503
Other Recyclable Paper	2.60%	249,287		Untreated Wood	4.27%	409,086
all other paper	4.53%	434,654		Treated Wood	0.30%	28,764
Paper subtotal	**21.30%**	**2,042,234**		Lumber	4.83%	463,418
PET bottles	0.63%	60,724		**Wood Subtotal**	**11.87%**	**1,137,770**
PET containers non-bottles	0.03%	3,196		Yard waste <6"	0.40%	38,352
HDPE Bottles Natural	0.07%	6,392		Yard waste >6"	0.03%	3,196
HDPE Bottles not specified/Colored	0.37%	35,156		Branches and Stumps	0.33%	31,960
LDPE (includes some bags, film)	4.00%	383,518		Pruning and Trimmings	1.63%	156,603
Expanded Polystyrene (foam)	0.67%	63,920		Leaves and grass	3.67%	351,558
Plastic bottles and #3-7 (general)	0.17%	15,980		Food	13.07%	1,252,826
Durable and Rigid containers	2.43%	233,307		Compostable organics	0.03%	3,196
All other Plastics	3.27%	313,206		Other R/C Organics	4.73%	453,830
Plastic subtotal	**11.63%**	**1,115,399**		**Organic Subtotal**	**23.90%**	**2,291,521**
Aluminum cans	0.20%	19,176		Tires	0.27%	25,568
Aluminum (foil and other)	0.17%	15,980		Carpet	3.03%	290,835
Tin/Steel Cans	0.47%	44,744		Textiles	2.90%	278,051
Tin cans	0.17%	15,980		**Other Materials Subtotal**	**6.20%**	**594,453**
Ferrous metals (includes tin)	2.40%	230,111		**NON- RECYCLABLE MATERIAL**	**15.67%**	**1,502,113**
Non-ferrous metals	0.30%	28,764				
Other Metal	1.23%	118,251		**TOTAL**	**100.0%**	**9,587,953**
Metal subtotal	**4.93%**	**473,006**				

Appendix III: List of Reviewed Waste Characterization Studies

Low-Diversion Profile

- Pennsylvania Department of Environmental Protection, *Statewide Municipal Waste Composition Study,* 2003. http://www.dep.state.pa.us/dep/deputate/airwaste/wm/recycle/Waste_Comp/Study.htm
- Illinois Department of Commerce and Economic Opportunity/Illinois Recycling Association, *Illinois Commodity/Waste Generation and Characterization Study,* 2009. http://www.illinoisrecycles.org/pdffiles/ICWCGSReport052209.pdf
- Georgia Department of Community Affairs, *Georgia Statewide Waste Characterization Study: Final Report,* 2005. http://www.dca.state.ga.us/development/EnvironmentalManagement/publications/GeorgiaMSWCharacterizationStudy.pdf
- Indiana Department of Environmental Management, *Municipal Solid Waste Characterization Study for Indiana*, May 2012 *www.in.gov/idem/recycle/files/msw_characterizarion_study.pdf*
- U.S. EPA, *Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Detailed Tables and Figures for 2008, 2010, 2012, 2014.* http://www.epa.gov/wastes/nonhaz/municipal/pubs/msw2014data.pdf
- Ada County Solid Waste, Boise, Idaho. *Ada County Waste Stream Analysis 2014*. https://adacounty.id.gov/Portals/Landfill/Documents/Waste-Stream-Analysis-2014.pdf?ver=2016-02-04-095456-053.
- Solid Waste Division, Prince William County, Virginia. *Waste Composition Study Summary of 2013-2014 Results.* http://gbbinc.com/gbbwp2013/wp-content/uploads/2013/10/PWC-Waste-Characterization-Final-Report.pdf

Medium -Diversion Profile

- Wisconsin Department of Natural Resources, *Statewide Waste Characterization Study,* 2003, 2009. https://dnr.wi.gov/topic/Recycling/documents/WI_WCS_Final_Report_June-30-2010.pdf
- Connecticut Department of Environmental Protection, *Connecticut Statewide Solid Waste Composition and Characterization Study,* 2010, 2015. http://www.ct.gov/deep/lib/deep/waste_management_and_disposal/Solid_Waste_Management_Plan/CMMS_Final_2015_MSW_Characterization_Study.pdf

- California Integrated Waste Management Board, *California 2008, 2010, 2014 Statewide Waste Characterization Study,* 2009. http://www.calrecycle.ca.gov/Publications/Documents/1546/20151546.pdf
- Department of Sanitation – NYC, NY. *The New York City 2013 Residential Waste Characterization Study* http://www1.nyc.gov/assets/dsny/docs/2013-Waste-Characterization-Study.pdf
- City of Durham, NC. *Waste Characterization Study, 2015 http://cityordinances.durhamnc.gov/OnBaseAgendaOnline/Documents/ViewDocument/WS-Published%20Attachment%20-%2011457%20-%20PRESENTATION%20-%20PRESENTATION-%20WASTE%20CHARECTERIZAT.pdf?meetingId=156&documentType=Agenda&itemId=2405&publishId=9304&isSection=false*.
- Minnesota Pollution Control Agency, Minnesota. *2013 Statewide Waste Characterization.* https://www.pca.state.mn.U.S./sites/default/files/w-sw1-60.pdf
- Connecticut Department of Energy and Environmental Protection, *2015 Statewide Waste Characterization Study.* http://www.ct.gov/deep/lib/deep/waste_management_and_disposal/Solid_Waste_Management_Plan/CMMS_Final_2015_MSW_Characterization_Study.pdf
- Department of Commerce and Economic Opportunity, Illinois and Illinois Recycling Association. *Illinois Commodity/Waste Generation and Characterization Study Update 2015.* https://www.illinois.gov/dceo/whyillinois/TargetIndustries/Energy/Recycling/Documents/2015%20Waste%20Characterization%20Update%20FINAL.pdf#search=Illinois%20Commodity%2F%20Waste%20Generation%20and%20Characterization%20Study%20Update
- Rhode Island Resource Recovery Corporation, Rhode Island. *Rhode Island Solid Waste Characterization Study – Final Report 2015*.

High-Diversion Profile

- Thurston County, WA Department of Water and Waste Management, *Solid Waste System Assessment,* 2007, 2013-14. https://fortress.wa.gov/ecy/publications/documents/1007023.pdf
- Snohomish County, WA Department of Public Works, *Snohomish County Waste Composition Study,* 2009. http://www.co.snohomish.wa.us/documents/Departments/Public_Works/SolidWaste/Information/Brochures/WasteComp2009Final.pdf

- Clark County, WA, *Clark County 2008 Waste Stream Analysis,* 2008, 2012. https://www.clark.wa.gov/sites/default/files/dept/files/public-health/SWEO/SWMP/AppendixI-10-14-14.pdf
- Seattle, WA Public Utilities, *Residential Waste Stream Composition Study,* 2006, 2010, 2014; *Construction & Demolition Waste Composition Study,* 2007, 2011, 2015; *Commercial and Self-Haul Waste Streams Composition Study,* 2008, 2012, 2016. https://www.seattle.gov/util/cs/groups/public/@spu/@garbage/documents/webcontent/01_014338.pdf
- San Francisco Department of the Environment, *Waste Characterization Study,* 2006. http://www.sfenvironment.org/downloads/library/wastecharacterizationstudy.pdf
- Palo Alto, CA, *Palo Alto Waste Composition Study,* 2006, 2017. https://www.cityofpaloalto.org/civicax/filebank/documents/63577
- California Integrated Waste Management Board, see above
- Delaware Solid Waste Authority (DSWA), Delaware. *Statewide Waste Characterization Study FY 2016 – Final Report*. http://dswa.com/wp-content/uploads/2017/02/Final-Report-DSWA-Waste-Characterization-FY-2016-January-2017.pdf
- Department of Natural Resources and Parks, Solid Waste Division, King County, Washington. King County Waste Monitoring Program, *2015 king County Waste Characterization and Customer Survey Report*. https://your.kingcounty.gov/solidwaste/about/documents/waste-characterization-study-2015.pdf
- Department of Ecology, State of Washington. *2015-2016 Washington Statewide Waste Characterization Study*. https://fortress.wa.gov/ecy/publications/SummaryPages/1607032.html
- Mecklenburg County, North Carolina. *Solid Waste Characterization Study - Fall 2015.* http://charmeck.org/mecklenburg/county/LUESA/SolidWaste/ManagementPlan/Documents/Mecklenburg%20County%20Waste%20Characterization%20Study%20(2015).pdf
- Larimer County, CO. *2016 Waste Composition and Characterization Analysis*. www.co.larimer.co.us/solidwaste/publications/WasteSort.pdf
- Austin Resource Recovery – Austin, TX. *City-Serviced Residential Waste Characterization Study, 2015*. https://www.austintexas.gov/sites/default/files/files/Final_Report_-_Austin_City-Serviced_Waste_Characterization_Study_2015-04-14.pdf

- City of Palo Alto, CA. 2013 Waste Characterization Report. http://www.cityofpaloalto.org/civicax/filebank/documents/33681.

Additional Studies Consulted

- Delaware Solid Waste Authority, *Statewide Waste Characterization Study*, 2007. http://www.dswa.com/pdfs/reports/Statewide%20Waste%20Characterization%20Study%202006-2007.pdf
- Iowa Department of Natural Resources, *2017 Iowa Statewide Waste Characterization Study, Final Report*, September 2011, 2017. http://www.iowadnr.gov/About-DNR/DNR-News-Releases/ArticleID/1674/DNR-releases-2017-Iowa-Statewide-Waste-Characterization-Study-food-waste-and-plastics-top-the-list
- Missouri Department of Natural Resources, *2016-2017 Missouri Waste Composition Study*, 2016-17. *https://dnr.mo.gov/env/swmp/docs/20162017wastesortcharreport.pdf*
- Nebraska Department of Environmental Quality, *Waste Characterization Study*, 2009. http://www.deq.state.ne.us/Publica.nsf/23e5e39594c064ee852564ae004fa010/e3b876e52f86f1a6862575c900733cca/$FILE/Waste%20Study%20Portfolio.pdf
- Oregon Department of Environmental Quality, *Oregon Waste Composition Study*, 2006; *Oregon Solid Waste Characterization and Composition,* 2002. http://www.deq.state.or.us/lq/sw/disposal/2005study.htm http://www.deq.state.or.us/lq/sw/disposal/wastecompositionstudy.htm
- Vermont Department of Environmental Conservation, *Vermont Waste Composition Study*, 2002. http://www.cswd.net/pdf/VT_WCS.pdf
- Metro Vancouver, BC. *2013 Waste Composition Monitoring Program.*

Appendix IV: Comprehensive Characterization Categories

	Residential and Commercial			Residential							
Material Type	Low Diversion - Residential and Commercial	Medium Diversion - Residential and Commercial	High Diversion - Residential and Commercial	Low Diversion - National Residential	Medium Diversion - National Residential	High Diversion - National Residential	National Residential	National Commercial	National Residential and Commercial	GL Residential	GL Residential and Commercial
High Grade - general with White and Colored Ledger	0.35%	1.27%	0.48%	0.25%	1.17%	0.20%	1.11%	1.35%	1.32%	1.12%	1.43%
Mixed/ unspecified Office	2.37%	0.40%	0.23%	1.10%	0.57%	0.85%	0.26%	1.13%	0.66%	0.82%	0.67%
Low Grade - general (OMG), Boxboard, Paper Bags, Phonebooks, and other recyclable	7.63%	4.10%	5.22%	7.85%	6.00%	0.95%	6.10%	6.32%	5.27%	9.50%	5.72%
ONP	4.02%	1.73%	1.64%	4.70%	2.83%	1.87%	3.39%	2.05%	2.87%	4.17%	3.33%
OCC	10.12%	4.87%	2.68%	5.45%	2.60%	2.19%	3.65%	9.80%	6.09%	4.55%	9.09%
Cartons, Aseptics and Poly-coated	0.17%	0.07%	0.28%	0.25%	0.03%	0.17%	0.15%	0.21%	0.23%	0.22%	0.18%
Compostable/ soiled and all other paper	8.03%	8.87%	7.90%	7.70%	10.40%	12.62%	9.73%	8.63%	9.11%	7.71%	7.11%
Paper Subtotal	**32.69%**	**21.30%**	**18.43%**	**27.30%**	**23.60%**	**18.85%**	**24.39%**	**29.50%**	**25.54%**	**28.09%**	**27.52%**
PET bottles and containers	1.12%	0.67%	0.65%	1.30%	0.83%	1.10%	1.30%	0.99%	1.15%	1.31%	1.29%
HDPE Bottles Natural & Colored	0.99%	0.43%	0.54%	1.10%	0.73%	0.75%	0.80%	0.99%	0.88%	0.87%	1.52%
Plastic bottles and #3-7 (general)	0.42%	0.17%	0.70%	0.65%	0.40%	0.76%	0.96%	0.60%	0.64%	0.79%	0.51%
All other Plastics and Packaging, LDPE, Polystyrene, Durable /Rigid containers and PP tubs)	11.35%	10.37%	10.88%	9.70%	9.13%	9.49%	9.54%	11.87%	10.17%	10.09%	10.72%
Plastic Subtotal	13.88%	11.63%	12.77%	12.75%	11.10%	12.09%	12.60%	14.45%	12.85%	13.06%	14.04%
Aluminum cans	0.54%	0.20%	0.30%	0.55%	0.30%	0.37%	0.53%	0.36%	0.48%	0.51%	0.48%
Ferrous metals (includes Tin/Steel Cans)	3.75%	3.03%	2.30%	3.90%	2.67%	2.64%	2.63%	2.91%	3.03%	2.93%	3.92%
Non-ferrous metals, Aluminum (foil) and Other Metal and Aerosol Cans	1.04%	1.70%	2.20%	1.20%	1.60%	1.86%	1.46%	1.71%	1.82%	1.45%	1.37%
Metal Subtotal	5.33%	4.93%	4.80%	5.65%	4.57%	4.87%	4.62%	4.98%	5.33%	4.89%	5.77%
Glass - general including containers	2.91%	1.23%	1.93%	3.55%	1.70%	2.22%	2.76%	1.63%	2.46%	3.15%	2.43%
Other Glass	0.37%	0.77%	0.61%	0.40%	0.73%	0.58%	0.54%	0.51%	0.69%	0.98%	0.45%
Glass Subtotal	3.28%	2.00%	2.54%	3.95%	2.43%	2.80%	3.30%	2.14%	3.15%	4.14%	2.88%
Electronics - general, computer, and CRT	2.23%	2.13%	0.30%	2.15%	2.07%	0.37%	1.29%	1.17%	1.07%	2.07%	1.76%

White goods (appliances)	0.00%	0.37%	0.40%	0.00%	0.43%	0.00%	0.25%	0.08%	0.27%	0.20%	0.24%
Electronics Subtotal	2.23%	2.50%	0.70%	2.15%	2.50%	0.37%	1.54%	1.26%	1.35%	2.27%	2.00%
Total Wood	8.67%	11.87%	7.61%	6.35%	6.27%	3.77%	3.90%	7.46%	7.25%	7.49%	9.81%
Yard waste - general	3.12%	5.70%	2.55%	4.90%	7.87%	4.58%	4.71%	2.05%	3.60%	4.17%	4.10%
Food	12.46%	13.07%	26.58%	13.40%	17.50%	23.61%	20.69%	15.90%	16.92%	16.03%	13.29%
Other R/C Organics, Branches and Stumps	5.20%	5.13%	7.23%	7.55%	8.00%	4.35%	6.09%	3.01%	3.53%	8.55%	3.53%
Organic Subtotal	20.79%	23.90%	36.35%	25.85%	33.37%	32.54%	31.48%	20.97%	24.05%	28.75%	20.92%
Other Textiles, Tires, Carpet, Light Bulbs	6.23%	6.20%	4.56%	7.65%	7.70%	3.45%	5.88%	4.50%	5.14%	7.03%	5.73%
OTHER NON- RECYCLABLE MATERIAL	6.90%	15.67%	12.24%	8.35%	8.47%	21.28%	12.28%	14.75%	15.34%	4.29%	11.34%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.000%	100.000%	100.0%	100.0%	100.0%

Appendix V: Consolidation of Characterization Categories

High Grade - general	High Grade - general with White and Colored Ledger
White Office	
White Ledger	
Colored Ledger	
Mixed/ unspecified Office	Mixed/ unspecified Office
Low Grade - general	Low Grade - general OMG, Boxboard, Paper Bags, Phonebooks other recyclable
Paperboard/ Boxboard	
Magazines and Catalogs (OMG)	
Paper Bags	
Phonebooks and Directories	
Other Recyclable Paper	
Hard Bound Books	
OCC	OCC
ONP	ONP
Aseptic	Cartons, Aseptic and Poly-coated
Cartons	
Poly-coated Paper	
Compostable/soiled	Compostable/ soiled and all other paper
all other paper	
PET bottles	PET bottles and containers
PET containers non-bottles	
HDPE Bottles Natural	HDPE Bottles Natural & Colored
HDPE Bottles not specified/Colored	
LDPE (includes some bags, film)	All other Plastics and Packaging, LDPE, Polystyrene (foam), Durable and Rigid containers and PP tubs)
Expanded Polystyrene (foam)	
Durable and Rigid containers	
Plastic Packaging	
All other Plastics	
Other Plastic Films	
PP (includes tubs)	Plastic bottles and #3-7 (general)
Plastic bottles and #3-7 (general)	
Vinyl (PVA)	
Aluminum cans	Aluminum cans
Tin/Steel Cans	Ferrous metals (includes Tin/Steel Cans, tin)
Tin cans	
Ferrous metals (includes tin)	
Steel Cans/Packaging	
Aerosol Cans	
Other Metal	
Aluminum (foil and other)	

	Non-ferrous metals, Aluminum (foil) and Other Metal and Aerosol Cans
Non-ferrous metals	
Glass - general	Glass - general including containers
Container	
Flat/plate	Other Glass
Other Glass	
Brown goods and electronics - general	Electronics - general, computer related, and CRT
Computer-related includes monitors	
Video display and CRT devices	
Other electronics	
White goods (appliances)	White goods (appliances)
Wood - general	Total Wood
Untreated Wood	
Treated Wood	
Painted	
Unpainted	
Clean engineered	
Pallets and crates	
Lumber	
Contaminated	
Furniture	
Yard waste <6"	Yard waste - general
Yard waste >6"	
Yard waste and other Compostable	
Yard waste - general	
Branches	
Stumps	
Prunings and Trimmings	
Leaves and grass	
Food	Food
Other Compostable organics	Other Organics,
Other R/C Organics and Branches and Stumps >6"	
Porcelain toilets	Textiles, (Batteries, Tires, Carpet, Light Bulbs)
Batteries	
Tires	
Used Oil	
Carpet	
Textiles	
Light bulbs - general	
Fluorescent blubs	
Non- Recyclable Material	Other Non- Recyclable Material

Appendix VI: Paper Mills Utilizing Recovered Paper

Company Name	Facility Name	City	State	Estimated Tons per Year	Estimated OCC Tons per Year	Estimated Newsprint Tons per Year	Estimated Mixed Paper Tons per Year
American Eagle Paper	American Eagle Paper - Tyrone	Tyrone	PA	57,505	0	0	42,071
Appleton Coated LLC	Appleton Coated LLC - Combined Locks	Combined Locks	WI	22,968	0	0	22,968
Caraustar	Caraustar - Cincinnati	Cincinnati	OH	62,925	55,303	0	7,622
Cascades	Cascades - Ransom	Ransom	PA	67,212	0	0	67,212
Cascades	Cascades - Eau Claire	Eau Claire	WI	62,020	0	0	62,020
Clearwater Paper	Clearwater Paper - Ladysmith	Ladysmith	WI	57,093	0	0	57,093
Corenso	Corenso - Wisconsin Rapids	Wisconsin Rapids	WI	85,726	85,726	0	0
Domtar	Domtar - Nekoosa	Nekoosa	WI	15,808	0	0	15,808
FiberCorr	FiberCorr - Massillon	Massillon	OH	82,723	62,101	0	20,622
Flambeau River Papers	Flambeau River Papers - Park Falls	Park Falls	WI	34,977	0	0	34,977
Fox River Fiber	Fox River Fiber - De Pere	De Pere	WI	173,820	0	0	173,820
French Paper	French Paper - Niles	Niles	MI	1,433	0	0	1,433
FutureMark Paper	FutureMark Paper - Alsip	Alsip	IL	95,433	0	14,209	81,224
FutureMark Paper	FutureMark Paper - Manistique	Manistique	MI	152,213	24,256	0	127,957
Georgia-Pacific	Georgia-Pacific - Big Island	Big Island	VA	377,235	324,289	0	52,946
Georgia-Pacific	Georgia-Pacific - Green Bay	Green Bay	WI	470,548	0	0	470,548
Glatfelter	Glatfelter - Chillicothe	Chillicothe	OH	14,861	0	0	14,861
Graphic Packaging International	Graphic Packaging International - Battle Creek	Battle Creek	MI	127,425	40,077	23,776	63,572
Graphic Packaging International	Graphic Packaging International - Kalamazoo	Kalamazoo	MI	348,166	147,756	64,656	135,754
Graphic Packaging International	Graphic Packaging International - Middletown	Middletown	OH	123,887	3,635	16,230	104,022
Great Lakes Tissue	Great Lakes Tissue - Cheboygan	Cheboygan	MI	24,548	0	0	24,548
Green Bay Packaging	Green Bay Packaging - Green Bay	Green Bay	WI	217,444	201,895	0	15,549
Greif	Greif - Massillon	Massillon	OH	204,495	204,495	0	0
Greif	Greif - Amherst	Amherst	VA	279,306	279,306	0	0
Hartford City Paper	Hartford City Paper - Hartford City	Hartford City	IN	123,580	111,204	0	12,377
Hood Container Corporation	Hood Container Corporation - Waverly	Waverly	TN	135,641	135,641	0	0
International Paper	International Paper - Cayuga	Cayuga	IN	347,326	275,291	45,835	26,200
Interstate Resources	Interstate Resources - Reading	Reading	PA	162,390	153,637	0	8,753

Kimberly-Clark	Kimberly-Clark - Loudon	Loudon	TN	89,112	0	0	89,112
Neenah Paper	Neenah Paper - Appleton	Appleton	WI	3,995	0	0	3,995
Neenah Paper	Neenah Paper - Neenah	Neenah	WI	4,477	0	0	4,477
Neenah Paper	Neenah Paper - Stevens Point	Stevens Point	WI	12,310	0	0	12,310
Newark	Newark - Baltimore	Baltimore	OH	109,491	81,748	0	27,743
Ox Paperboard	Ox Paperboard - Pekin	Pekin	IL	44,020	14,832	5,972	23,216
Ox Paperboard	Ox Paperboard - Constantine	Constantine	MI	52,915	36,877	0	16,038
Ox Paperboard	Ox Paperboard - Halltown	Halltown	WV	40,421	28,167	0	12,253
PaperWorks Industries	PaperWorks Industries - Wabash	Wabash	IN	134,201	31,963	31,312	70,926
PaperWorks Industries	PaperWorks Industries - Philadelphia	Philadelphia	PA	126,978	41,472	43,719	41,787
PCA	PCA - Filer City	Filer City	MI	179,967	171,494	0	8,473
PCA	PCA - Counce	Counce	TN	178,889	170,467	0	8,421
PCA	PCA - Tomahawk	Tomahawk	WI	177,323	152,122	0	25,201
Pratt Paper	Pratt Paper - Valparaiso	Valparaiso	IN	335,658	0	0	335,658
Pratt Paper	Pratt Paper - Wapakoneta	Wapakoneta	OH	209,378	62,051	0	147,327
Resolute Forest Products	Resolute Forest Products - Menominee	Menominee	MI	230,157	0	0	230,157
Resolute Forest Products	Resolute Forest Products - Calhoun	Calhoun	TN	34,641	0	25,982	8,659
Resolute Forest Products	Resolute Forest Products - Fairmont	Fairmont	WV	290,345	0	0	290,345
RockTenn	RockTenn - Eaton	Eaton	IN	56,892	26,030	8,564	22,299
RockTenn	RockTenn - Battle Creek	Battle Creek	MI	125,473	31,073	25,687	68,713
RockTenn	RockTenn - Cincinnati	Cincinnati	OH	44,746	29,720	0	15,026
RockTenn	RockTenn - Coshocton	Coshocton	OH	99,858	99,858	0	0
RockTenn	RockTenn - Delaware Water Gap	Delaware Water Gap	PA	59,566	0	3,186	56,380
RockTenn	RockTenn - Chattanooga	Chattanooga	TN	117,741	64,390	13,794	39,557
RockTenn	RockTenn - Hopewell	Hopewell	VA	71,858	71,858	0	0
RockTenn	RockTenn - West Point	West Point	VA	324,838	304,299	0	20,540
SCA	SCA - Menasha	Menasha	WI	223,612	104,477	0	119,135
Sonoco Products	Sonoco Products - Richmond	Richmond	VA	76,898	65,147	0	11,752
ST Paper	ST Paper - Franklin	Franklin	VA	62,972	0	0	62,972
ST Paper	ST Paper - Oconto Falls	Oconto Falls	WI	76,703	0	0	76,703
Valley Converting Co.	Valley Converting Co. - Toronto	Toronto	OH	19,768	2,973	3,006	13,790
Wausau Paper	Wausau Paper - Middletown	Middletown	OH	117,135	16,309	0	100,825
White Birch Paper	White Birch Paper - Ashland	Ashland	VA	62,426	0	46,820	15,606
White Pigeon Paper	White Pigeon Paper - White Pigeon	White Pigeon	MI	62,274	13,147	6,573	42,553

Appendix VII: Plants Utilizing Recovered Plastics

Company Name	Facility Name	City	State	Estimated Tons per Year
3R Recycling Solutions Inc.	3R Recycling Solutions Inc. - Avon	Avon	MA	1,850
Aaron Industries Corp.	Aaron Industries Corp. - Leominster	Leominster	MA	20,000
ACI Plastics Inc.	ACI Plastics Inc. - Flint	Flint	MI	28,500
Adams Plastics LP	Adams Plastics LP - Rolling Meadows	Rolling Meadows	IL	2,500
Adirondack Plastics & Recycling Inc.	Adirondack Plastics & Recycling Inc. - Argyle	Argyle	NY	8,300
Advanced Environmental Recycling Technologies Inc.(P)b	Advanced Environmental Recycling Technologies Inc.(P)b - Springdale	Springdale	AR	50,000
Alloy Exchange Inc.	Alloy Exchange Inc. - Rockford	Rockford	MI	5,100
Angleboard Blue Ridge Division	Angleboard Blue Ridge Division - Eden	Eden	NC	21,000
Antek Madison Plastics Recycling Corp.	Antek Madison Plastics Recycling Corp. - Scarborough	Scarborough	ON	38,500
Appertain Corp.	Appertain Corp. - Pulaski	Pulaski	TN	3,900
Arrotin Plastic Materials Inc.	Arrotin Plastic Materials Inc. - Fort Wayne	Fort Wayne	IN	30,000
Arthur Products LLC	Arthur Products LLC - Enfield	Enfield	CT	900
B. Schoenberg & Co. Inc.	B. Schoenberg & Co. Inc. - Yorktown	Yorktown	NY	202,500
Bach Polymers	Bach Polymers - Annapolis	Annapolis	MD	30,000
Bata Plastics Inc.	Bata Plastics Inc. - Grand Rapids	Grand Rapids	MI	22,700
Bedford Technology LLC	Bedford Technology LLC - Worthington	Worthington	MN	10,000
Blackrock Plastics LLC	Blackrock Plastics LLC - Charleston	Charleston	SC	3,750
Bosgen Inc.	Bosgen Inc. - Wellesley	Wellesley	MA	900
Bromley Plastics Corp.	Bromley Plastics Corp. - Fletcher	Fletcher	NC	40,400
Buckeye Polymers Inc.	Buckeye Polymers Inc. - Lodi	Lodi	OH	20,000
Butler-MacDonald Inc.	Butler-MacDonald Inc. - Indianapolis	Indianapolis	IN	17,250
C4 Polymers Inc.	C4 Polymers Inc. - Chagrin Falls	Chagrin Falls	OH	10,150
Canusa Hershman Recycling LLC	Canusa Hershman Recycling LLC - Branford	Branford	CT	3,900
Champion Polymer Recycling	Champion Polymer Recycling - Winchester	Winchester	KY	55,000
Choice Plastics Inc.	Choice Plastics Inc. - Mound	Mound	MN	8,800
Clean Tech Inc.	Clean Tech Inc. - Dundee	Dundee	MI	125,000
CM Polymers Inc.	CM Polymers Inc. - Montvale	Montvale	NJ	900
CTC Plastics	CTC Plastics - Dayton	Dayton	OH	40,000
Custom Polymers Inc.	Custom Polymers Inc. - Charlotte	Charlotte	NC	125,400

Custom Resins Inc.	Custom Resins Inc. - Wayne	Wayne	NJ	17,500
Cycle-Tex Inc.	Cycle-Tex Inc. - Dalton	Dalton	GA	33,500
Delta Plastics of the South LLC	Delta Plastics of the South LLC - Little Rock	Little Rock	AR	62,500
Deltco Plastics Inc.	Deltco Plastics Inc. - Ashland	Ashland	WI	15,675
Destiny Plastics Inc.	Destiny Plastics Inc. - Deckerville	Deckerville	MI	9,500
Domino Plastics Co. Inc.	Domino Plastics Co. Inc. - Port Jefferson	Port Jefferson	NY	2,500
Eastern Recycling Services LLC	Eastern Recycling Services LLC - Baltimore	Baltimore	MD	225
East-Terra Supply LLC	East-Terra Supply LLC - Indianapolis	Indianapolis	IN	9,600
EFS-Plastics Inc.	EFS-Plastics Inc. - Listowel	Listowel	ON	33,000
Engineered Recycling Co. LLC	Engineered Recycling Co. LLC - Charlotte	Charlotte	NC	47,500
Envision Plastics LLC	Envision Plastics LLC - Reidsville	Reidsville	NC	87,500
Evergreen Plastics Inc.	Evergreen Plastics Inc. - Clyde	Clyde	OH	55,000
Exxel Polymers Inc.	Exxel Polymers Inc. - Bromont	Bromont	ON	11,375
Faith Group Co. Inc.	Faith Group Co. Inc. - Manalapan	Manalapan	NJ	6,200
Franklin Plastics	Franklin Plastics - Battle Creek	Battle Creek	MI	6,100
General Mill Supply Co.	General Mill Supply Co. - Wixom	Wixom	MI	14,400
Gianco Environmental Services	Gianco Environmental Services - Melville	Melville	NY	375
Good Works Reprocessing LLC	Good Works Reprocessing LLC - Easton	Easton	PA	65,500
GP Harmon Recycling LLC	GP Harmon Recycling LLC - Jericho	Jericho	NY	7,500
Grace Plastics Inc.	Grace Plastics Inc. - Batavia	Batavia	OH	2,125
Graham Recycling Co.	Graham Recycling Co. - York	York	PA	20,000
Green Earth Plastic Recycling Inc.	Green Earth Plastic Recycling Inc. - Joliet	Joliet	IL	5,400
Green Line Polymers	Green Line Polymers - Waterloo	Waterloo	IA	142,500
Green Processing Co. Inc.	Green Processing Co. Inc. - Windsor	Windsor	ON	19,150
Greystone Logistics Inc.(P)	Greystone Logistics Inc.(P) - Bettendorf	Bettendorf	IA	22,500
H. Sattler Plastics Co. Inc.	H. Sattler Plastics Co. Inc. - Chicago	Chicago	IL	4,900
Industrial Materials Recycling LLC	Industrial Materials Recycling LLC - Buffalo	Buffalo	NY	4,095
Industrial Resin Recycling Inc.	Industrial Resin Recycling Inc. - Howell	Howell	MI	32,400
Industrial Resources Co.	Industrial Resources Co. - McHenry	McHenry	IL	250
In-plas Recycling Inc.	In-plas Recycling Inc. - Lawrenceburg	Lawrenceburg	IN	12,000
iSustain Inc.	iSustain Inc. - Soddy Daisy	Soddy Daisy	TN	10,050
Jadcore LLC	Jadcore LLC - Terre Haute	Terre Haute	IN	48,000
Jerico Plastic Industries Inc.	Jerico Plastic Industries Inc. - Minerva	Minerva	OH	3,600
K&B Plastic Industries Inc.	K&B Plastic Industries Inc. - Blodgett Mills	Blodgett Mills	NY	17,100

Kal-Trading Inc.	Kal-Trading Inc. - Mississauga	Mississauga	ON	12,500
KJ Plastics Inc.	KJ Plastics Inc. - Green Lane	Green Lane	PA	7,500
Klöckner Pentaplast Group	Klöckner Pentaplast Group - Gordonsville	Gordonsville	VA	36,000
L&P Plastics Co.	L&P Plastics Co. - Harrison City	Harrison City	PA	1,000
Lion Extruding Corp.	Lion Extruding Corp. - Newark	Newark	NJ	5,250
Marglen Industries Inc.	Marglen Industries Inc. - Rome	Rome	GA	33,000
Marsh Plastics Inc.	Marsh Plastics Inc. - Amherst	Amherst	NY	1,250
Material Recovery Inc.	Material Recovery Inc. - Milwaukee	Milwaukee	WI	5,000
McDunnough Inc.	McDunnough Inc. - Fenton	Fenton	MI	25,150
Mega Recycling LLC	Mega Recycling LLC - Romeoville	Romeoville	IL	1,875
Mervis Industries Inc.	Mervis Industries Inc. - Danville	Danville	IL	14,000
Midland Compounding & Consulting Inc.	Midland Compounding & Consulting Inc. - Midland	Midland	MI	2,000
Midwest Recycling Co. Inc.	Midwest Recycling Co. Inc. - Chicago	Chicago	IL	5,000
Nam Polymers Inc.	Nam Polymers Inc. - Etobicoke	Etobicoke	ON	9,000
Nexcycle Plastics Inc.	Nexcycle Plastics Inc. - Brampton	Brampton	ON	46,000
Next Specialty Resins Inc.	Next Specialty Resins Inc. - Toledo	Toledo	OH	10,000
Norwich Plastics Inc.	Norwich Plastics Inc. - Cambridge	Cambridge	ON	17,500
Nu-Tech Polymers Co. Inc.	Nu-Tech Polymers Co. Inc. - Cincinnati	Cincinnati	OH	12,500
O.K. Industries Inc.	O.K. Industries Inc. - Fostoria	Fostoria	OH	6,750
Palmer Plastics Inc.	Palmer Plastics Inc. - Easton	Easton	PA	12,000
Parc Corp.	Parc Corp. - Romeoville	Romeoville	IL	90,000
PET Processors LLC	PET Processors LLC - Painesville	Painesville	OH	25,000
Petoskey Plastics Inc.	Petoskey Plastics Inc. - Petoskey	Petoskey	MI	15,000
PFA Recycling Inc.	PFA Recycling Inc. - Chesterfield	Chesterfield	MI	7,200
PGA Inc.	PGA Inc. - Freeland	Freeland	PA	6,350
Phoenix Technologies International LLC	Phoenix Technologies International LLC - Bowling Green	Bowling Green	OH	37,500
Plast-Ex International Inc.	Plast-Ex International Inc. - Brampton	Brampton	ON	6,000
Plastic Compounders Inc.	Plastic Compounders Inc. - Cambridge	Cambridge	OH	15,000
Plastic Materials Inc.	Plastic Materials Inc. - Macedonia	Macedonia	OH	27,000
Plastic Recycling Inc.	Plastic Recycling Inc. - Indianapolis	Indianapolis	IN	36,800
Plastic Revolutions Inc.	Plastic Revolutions Inc. - Reidsville	Reidsville	NC	42,000
Plastics Group of America	Plastics Group of America - Woonsocket	Woonsocket	RI	11,250
Polychem USA Inc.	Polychem USA Inc. - Foxboro	Foxboro	MA	80,000

PolyReps Inc.	PolyReps Inc. - Monroe	Monroe	NC	19,000
Prime Time Plastics Ltd.	Prime Time Plastics Ltd. - Rocky River	Rocky River	OH	5,250
Pro Pel Plastech Inc.	Pro Pel Plastech Inc. - South Deerfield	South Deerfield	MA	12,250
RBW Technologies	RBW Technologies - Evans City	Evans City	PA	5,500
Recycle Inc. East	Recycle Inc. East - South Plainfield	South Plainfield	NJ	6,500
Recycled Materials Inc.	Recycled Materials Inc. - Atlanta	Atlanta	GA	4,700
Recycling Solutions Inc.	Recycling Solutions Inc. - Chicago	Chicago	IL	2,500
Return Polymers Inc.	Return Polymers Inc. - Ashland	Ashland	OH	40,000
ReVital Polymers	1271 Lougar Ave	Sarnia	ON	55,000
Rez-Tech Corp.	Rez-Tech Corp. - Kent	Kent	OH	95
Rochester Recycling LLC	Rochester Recycling LLC - Rochester	Rochester	NY	4,500
SBC Solutions Group	SBC Solutions Group - Centerburg	Centerburg	OH	40,000
Scrap Masters Inc.	Scrap Masters Inc. - Manchester	Manchester	MI	9,050
Seaview Plastic Recycling Inc.	Seaview Plastic Recycling Inc. - Bridgeport	Bridgeport	CT	3,700
Shuman Plastics Inc.	Shuman Plastics Inc. - Depew	Depew	NY	6,250
Sonoco Recycling LLC	Sonoco Recycling LLC - Hartsville	Hartsville	SC	30
St. Joseph Plastics	St. Joseph Plastics - St. Joseph	St. Joseph	MO	20,000
Star Plastics Inc.	Star Plastics Inc. - Ravenswood	Ravenswood	WV	25,000
Syncot Plastics Inc.	Syncot Plastics Inc. - Belmont	Belmont	NC	15,000
TKO Polymers Group	TKO Polymers Group - Atlanta	Atlanta	GA	3,250
Trigon Plastics LLC	Trigon Plastics LLC - Newmanstown	Newmanstown	PA	12,000
Ultra-Poly Corp.	Ultra-Poly Corp. - Portland	Portland	PA	100,000
UltrePET LLC	UltrePET LLC - Albany	Albany	NY	50,000
United Plastics Inc.	United Plastics Inc. - Flint	Flint	MI	32,400
Universal Composites Inc.	Universal Composites Inc. - Port Jefferson	Port Jefferson	NY	1,815
UpCycle Polymers LLC	UpCycle Polymers LLC - Howell	Howell	MI	600
US Plastics Recovery	US Plastics Recovery - Duluth	Duluth	GA	13,500
Wellman Advanced Materials	Wellman Advanced Materials - Johnsonville	Johnsonville	SC	90,000
Wellmark LLC	Wellmark LLC - Asheboro	Asheboro	NC	23,750
Werlor Inc.	Werlor Inc. - Defiance	Defiance	OH	2,500
West Michigan Compounding LLC	West Michigan Compounding LLC - Greenville	Greenville	MI	30,000
William Barnet & Son LLC	William Barnet & Son LLC - Spartanburg	Spartanburg	SC	37,500
Winco Plastics	Winco Plastics - North Aurora	North Aurora	IL	22,500

Appendix VIII: Plants Utilizing Recovered Steel

Company Name	Facility Name	City	State	Estimated Tons per Year
AK Steel Corp	AK Steel Corp - Ashland	Ashland	KY	2,546,000
AK Steel Corp	AK Steel Corp - Mansfield	Mansfield	OH	882,000
AK Steel Corp	AK Steel Corp - Middletown	Middletown	OH	2,899,000
AK Steel Corp	AK Steel Corp - Butler	Butler	PA	1,543,000
Allegheny Technologies Inc	Allegheny Ludlum - Brackenridge Works	Brackenridge	PA	551,000
Allegheny Technologies Inc	Allegheny Ludlum - Latrobe Works	Latrobe	PA	20,000
Allegheny Technologies Inc	Allegheny Ludlum - Midland Works	Midland	PA	551,000
Alton Steel	Alton Steel	Alton	IL	772,000
ArcelorMittal North America	ArcelorMittal - Riverdale	Riverdale	IL	1,102,000
ArcelorMittal North America	ArcelorMittal - Burns Harbor	East Chicago	IN	6,173,000
ArcelorMittal North America	ArcelorMittal - Indiana Harbor Bar	East Chicago	IN	507,000
ArcelorMittal North America	ArcelorMittal - Indiana Harbor Bar #2	East Chicago	IN	2,205,000
ArcelorMittal North America	ArcelorMittal - Indiana Harbor Bar #3	East Chicago	IN	2,976,000
ArcelorMittal North America	ArcelorMittal - Indiana Harbor Bar #4	East Chicago	IN	3,638,000
ArcelorMittal North America	ArcelorMittal - Bayou Steel	La Place	LA	794,000
ArcelorMittal North America	ArcelorMittal - Cleveland East	Cleveland	OH	2,535,000
ArcelorMittal North America	ArcelorMittal - Cleveland West	Cleveland	OH	2,094,000
ArcelorMittal North America	ArcelorMittal - Coatesville	Coatesville	PA	970,000
ArcelorMittal North America	ArcelorMittal - Steelton	Steelton	PA	1,213,000
ArcelorMittal North America	ArcelorMittal - Georgetown	Georgetown	SC	1,102,000
Arkansas Steel Associates (Yamato/Sumitomo)	Arkansas Steel Associates (Yamato/Sumitomo)	Newport	AR	165,000
Benteler Steel/Tube (projected start up 2018)	Benteler Steel/Tube (projected start up 2018)	Caddo-Bossier	LA	440,000
Bluescope Steel North America	Bluescope Steel North America	Delta	OH	2,183,000
Carpenter Steel	Carpenter Latrobe Specialty Steel	Latrobe	PA	61,000
Steel Dynamics, Inc.	Steel Dynamics Columbia City Site Structural & Rail Div.	Columbia City	IN	2,480,000
Steel Dynamics, Inc.	Steel Dynamics Pittsboro Site Engineered Bar Products Div.	Pittsboro	IN	728,000
The Timken Co.	The Timken Co. - Faircrest	Canton	OH	871,000
The Timken Co.	The Timken Co. - Harrison	Canton	OH	683,000

ThyssenKrupp Stainless USA	ThyssenKrupp Stainless USA	Calvert	AL	1,102,000
TMK - Ipsco Koppel	TMK - Ipsco Koppel	Koppel	PA	496,000
Union Electric Steel Corp. - Harmon Creek Plant	Union Electric Steel Corp. - Harmon Creek Plant	Burgettstown	PA	35,000
United States Steel Corporation	US Steel - Fairfield Works	Fairfield	AL	2,400,000
United States Steel Corporation	US Steel - Granite City Works	Granite City	IL	2,866,000
United States Steel Corporation	US Steel - Gary Works (No. 1BOP & Q-BOP)	Gary	IN	8,102,000
United States Steel Corporation	US Steel - Great Lakes Works	Ecorse	MI	3,527,000
United States Steel Corporation	US Steel - Mon Valley Works	Braddock	PA	2,899,000
Universal Stainless & Alloy Products	Universal Stainless & Alloy Products	Bridgeville	PA	149,000
V&M Star Steel CO.	V&M Star Steel CO.	Youngstown	OH	694,000
Valbruna Slater Stainless Inc. (Subs. of Acciaierie Valbruna)	Valbruna Slater Stainless Inc. (Subs. Of Acciaierie Valbruna)	Ft. Wayne	IN	61,000
Warren Steel Holdings	Warren Steel Holdings	Warren	OH	441,000
Whemco Steel Castings, Inc	Whemco Steel Castings, Inc	Midland	PA	65,000

Appendix IX: Plants Utilizing Recovered Aluminum

Company Name	Facility Name	City	State	Estimated Tons per Year
Alcoa Inc.	Alcoa Inc. - Alcoa	Alcoa	TN	89,722
Constellium Aluminum	Constellium Aluminum - Muscle Shoals	Muscle Shoals	AL	89,722
G&S Metal Consultants Inc.	G&S Metal Consultants Inc. - Wabash	Wabash	IN	89,722
Logan Aluminum (a joint venture of Novelis and Tri-Arrows Aluminum)	Logan Aluminum - Russellville	Russellville	KY	89,722
Novelis Corp.	Novelis Corp. - Greensboro	Greensboro	GA	89,722
Novelis Corp.	Novelis Corp. - Berea	Berea	KY	161,500
Real Alloy	Real Alloy - Morgantown	Morgantown	KY	89,722
Real Alloy	Real Alloy - Loudon	Loudon	TN	89,722
Tennessee Aluminum Processors	Tennessee Aluminum Processors - Mount Pleasant	Mount Pleasant	TN	89,722

Appendix X: Plants Utilizing 3-Mix Cullet Glass

Company Name	Facility Name	City	State	Estimated Tons per Year
Anchor	Anchor - Warner Robins	Warner-Robins	GA	37,800
Anchor	Anchor - Lawrenceburg	Lawrenceburg	IN	23,625
Anchor	Anchor - Elmira	Elmira	NY	63,000
Ardagh	Ardagh - Dolton	Dolton	IL	33,863
Ardagh	Ardagh - Lincoln	Lincoln	IL	47,250
Ardagh	Ardagh - Dunkirk	Dunkirk	IN	85,050
Ardagh	Ardagh - Winchester	Winchester	IN	94,500
Ardagh	Ardagh - Milford	Milford	MA	94,500
Ardagh	Ardagh - Pevely	Pevely	MO	99,000
Ardagh	Ardagh - Henderson	Henderson	NC	36,000
Ardagh	Ardagh - Wilson	Wilson	NC	110,250
Ardagh	Ardagh - Bridgeton	Bridgeton	NJ	50,400
Ardagh	Ardagh - Port Allegany	Port Allegany	PA	80,388
Ardagh	Ardagh - Burlington	Burlington	WI	75,600
Gerresheimer	Gerresheimer - Chicago Heights	Chicago Heights	IL	3,375
Gerresheimer	Gerresheimer - Millville	Millville	NJ	6,750
Gerresheimer	Gerresheimer - Vineland	Vineland	NJ	6,750
Kelmann Bottles	Kelmann Bottles - Glenshaw	Glenshaw	PA	24,300
O-I	O-I - Atlanta	Atlanta	GA	66,825
O-I	O-I - Streator	Streator	IL	29,292
O-I	O-I - Lapel	Lapel	IN	58,099
O-I	O-I - Winston-Salem	Lexington	NC	80,593
O-I	O-I - Auburn	Auburn	NY	63,394
O-I	O-I - Zanesville	Zanesville	OH	27,588
O-I	O-I - Crenshaw	Brockport	PA	37,765
O-I	O-I - Brockway	Brockport	PA	42,053
O-I	O-I - Danville	Ringgold	VA	76,186
O-I	O-I - Toano	Toano	VA	87,998