MICHIGAN RECYCLING ECONOMIC IMPACT & RECYCLED COMMODITIES MARKET ASSESSMENT

DECEMBER 18, 2019

PREPARED BY:

RRS | recycle.com

COMMISSIONED BY:

EGLE MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY

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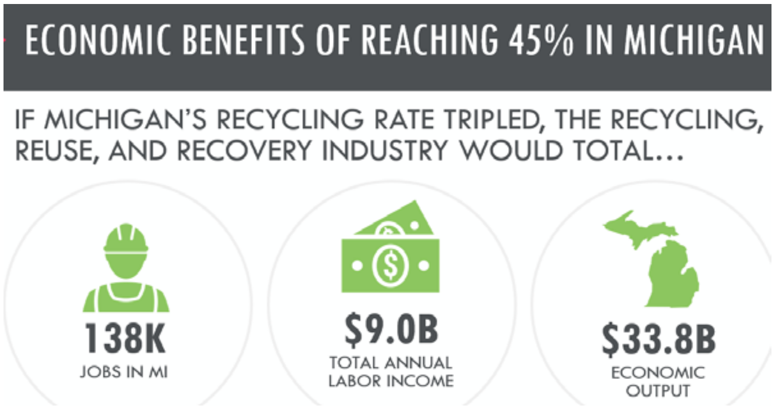
EXECUTIVE SUMMARY

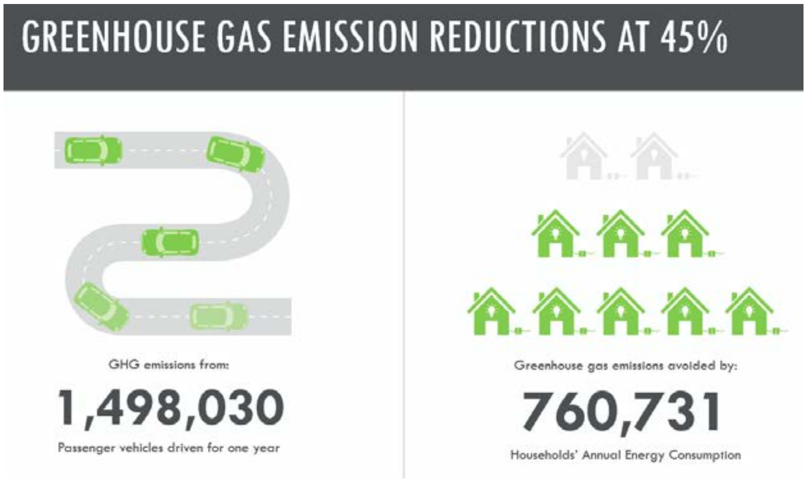
The analysis in this report covers the economic impact of increasing Michigan's recycling rate to 45% through capacity expansion in the recycling supply chain via improved recycling access and infrastructure investments to feed end markets both domestically and out-of-state. This report also provides an assessment of the current recycled commodities markets.

As part of this work, RRS updated all baseline research and analysis from the previous version of the recycling economic impact report, the Michigan Recycling Index (MRI) report, and the Michigan Waste Characterization Study. This update and analysis brings them into alignment recognizing the past few years of significant turbulence in the international recycling markets, acknowledges the negative as well as positive impacts on domestic markets broadly and Michigan specifically, and addresses challenges and growth opportunities. The assessment illustrates how Michigan's recycling-based economy is well-positioned for growth which will need to develop in close alignment with the goals to triple the state's recycling rate and benefit from the economic impact that it will foster.

Those end-markets, however, are entirely dependent on a strong recycling supply chain, so recognition is given to the impact on Michigan's economy with the needed improvements in recycling access, recycling infrastructure, and service provision in order to feed the markets and grow Michigan's Circular Recycling Economy.

The economic impact of tripling the recycling rate to 45% would support 138,000 new jobs in Michigan's Recycling, Reuse & Recovery (RRR) Industry, providing $9 billion in annual labor income and $33.8 billion in economic output. At a 45% recycling rate, the RRR industry would account for 3.3% of Michigan's total economic output, overtaking Michigan's transportation and tourism output. If all jobs that are directly, indirectly, or induced as a result of the recycling and recovery sectors were in the same city, it would be the third largest city in the state.

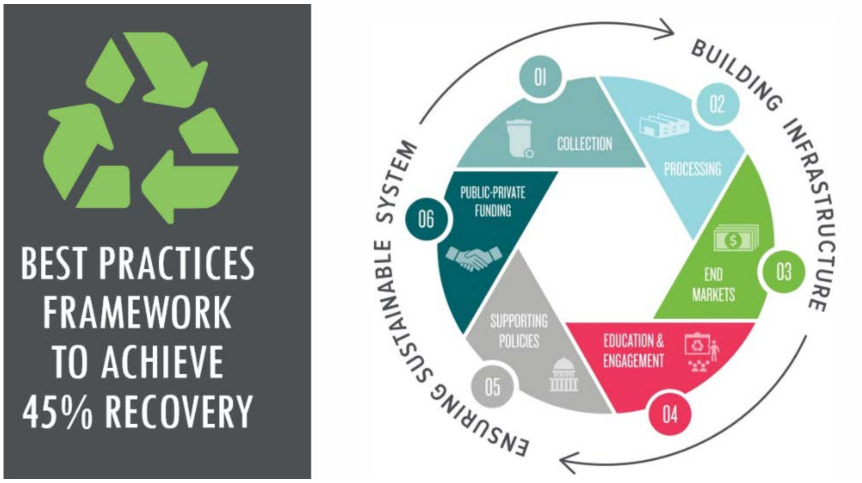




The benefits of a robust RRR Industry for Michigan are not just economic. Greenhouse gas reductions from tripling the recycling rate would eliminate emissions of an additional 7 million metric ton equivalent of carbon dioxide beyond current diversion practices - equivalent to taking nearly 1.5 million passenger vehicles off the road for one year or conserving the annual energy consumption of more than 760,000 households (approximately 20% of Michigan households).

As this study indicates, several things become clear: gaps in the supply chain are barriers to the development and expansion of markets and must be addressed if the recycling economy is to grow. There are also clear indications regarding which commodities require investments and incentives to expand their capacity in the state. The results of this study provide clear take-aways targets for market development, infrastructure and access grants to remove barriers, fill gaps, and connect end markets to the growing volume of recyclables in the state.

Robust end-markets for recycling require strong dependable recycling supply chains. The analysis in this report is presented in the context of a best practices framework that have been demonstrated to achieve high levels of recovery and support robust end markets. This framework demonstrates how collection, processing and end market infrastructure, supported by education and engagement, policies and public-private coordination can ensure a sustainable material recovery system.



Tripling the recycling rate to 45% will result in an additional 2.7 million tons recovered from the estimated 8.831 million ton of waste currently landfilled or incinerated. The following commodities lack robust end markets and will benefit from strategic and innovative solutions to increase demand-pull for these materials while also ensuring reliable supply:

- Mixed color glass – due to the high cost of transport, the development of both end market opportunities and glass processing capacity to improve the quality of glass for market within the state is vital. Roadbuilding, tile-making, landscaping aggregate and decorative applications are end-market examples.
- Mixed/non-bottle plastics – there are a wide variety of manufacturing and industrial uses that warrant vetted investment, including supply chain re-processors, plastic lumber and durable furniture, and automotive parts.
- Film/Flexible film plastics – from grocery sacks to marine shrink-wrap to agricultural film, there are a wide variety of film plastics that have end-market development needs, particularly post-consumer film. Bag-to-bag recycling represents one end-market opportunity that would benefit from minimum-content regulations.
- Compost – End-market opportunities in roadbuilding, coastal erosion control, agricultural/viticulture use, and more require investment to ensure demand for compost grows with the necessary increase in organics recovery.
- Hard-to-recycle materials such as Textiles and Carpets – there are many materials that need better end-markets and would benefit from investment to provide innovative solutions for recovery.

The following sectors of the state are lacking well-developed and comprehensive service provision:

- Commercial and Institutional – Recycling & Food Scrap collection
- Rural Residential – Recycling & Food Scrap recovery options

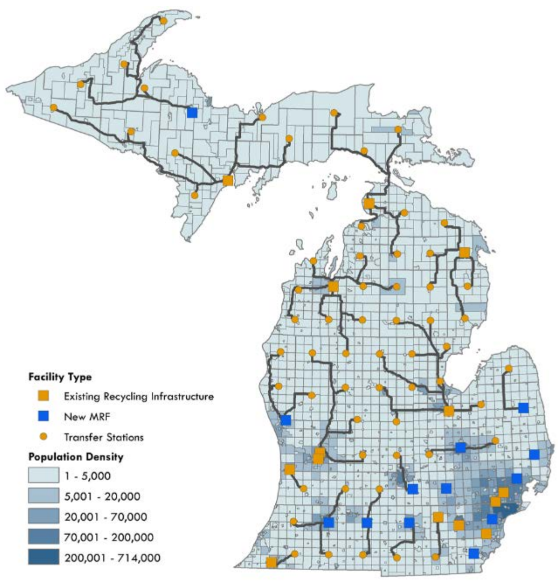
The following key infrastructure require investment and growth to develop capacity to meet growing demand:

- MRFs – Material Recovery Facilities, where recyclables are processed before being transported to end-markets: Existing MRFs will need to expand, upgrade equipment to increase through-put, and/or add shifts. New MRFs will be required in the coming years, particularly in high population areas and underserved regions of the state.

Equipment upgrades at existing MRFs can greatly increase throughput and is a cost-effective approach to increasing throughput in areas where there is a well-developed hub & spoke system already in play.

- Compost Facilities – The organics stream, consisting primarily of yard waste and food scraps, along with compostable food service packaging, comprises a critical element of the recoverable waste-stream. While the range of number, size, and technical sophistication are wide, this entire supply chain will need policy drivers, technical and financial support and end-market growth to ensure capacity along the entire supply chain.
- Super drop-offs/Convenience Centers/CHARMs (Centers for Hard to Recycle Materials): These staffed super drop-offs are needed in every region of the state, ideally in every county and large community. The ability for residents and businesses to conveniently drop off bulky and hard-to-recycle items is necessary to capture these materials for recovery. They can readily be co-located at transfer stations, recycle centers, compost facilities, DPW yards, or road commissions, or established as stand-alone centers.

The report includes an analysis of what an optimized collection and processing infrastructure could look like across the state as robust and efficient public-private partnerships are developed to serve both rural as well as urban areas. This "hub and spoke" network would link "spoke" areas across the state to both existing and new "hub" MRFs and composting operations that would provide the capacity and economies of scale to deliver clean material to end markets.



While key findings are shared throughout the report, critical recommendations are summarized at the end. These recommendations include a listing of policy drivers that can have significant impact on the recovery of materials and the encouragement of end markets to locate and grow in the state. The passage and implementation of Part 115 legislation will provide the guidance, planning, and funding necessary to support communities in their strategic planning, goal-setting and program development, which will in turn set the stage for a substantial boost to recovery options, opportunities and investment.

When it comes to end-market development, a more innovative funding model, based on the incubator/innovator approach to project development, including coaching, vetting, and seed funding, has clearly demonstrated in sectors such as energy, and more recently in the recycling arena, as being an effective alternative and/or addition to the more traditional grant-funding approach to market development projects, and provides the tools and process necessary to demonstrate real-world results.

The impact of past investments by the state via grant-funding have made significant strides over the past five years, increasing the recycling rate to 18.1% in 2018 from 15% in 2015 and improving access with cart-collection and drop site infrastructure in many communities. The investment opportunity now available will greatly accelerate the pace of improvement and this report will assist in determining how best to leverage those investments.

$$\frac{\text{TONS RECYCLED \& COMPOSTED}}{\text{TONS RECYCLED \& COMPOSTED} + \text{TONS DISPOSED}} = \text{RECYCLING RATE}$$

$$\frac{1{,}946{,}970 \text{ TONS}}{1{,}946{,}970 \text{ TONS} + 8{,}831{,}649 \text{ TONS}} = 18.1\%$$

The state of Michigan is ideally positioned to continue to demonstrate the economic and environmental benefits of investing in and growing Michigan's Recycling Circular Economy, reaping the benefits for residents and businesses for years to come. Focusing on all aspects of the recycling supply chain to close gaps and remove barriers will reap benefits in both attracting and expanding end-market opportunities in the state crucial to attaining recovery goals.

TRIPLING THE RECYCLING RATE

As part of the evaluation on the impact on markets related to recovery of recyclable material, RRS updated the waste characterization of landfilled municipal solid waste (MSW) generated in Michigan to estimate the quantity of recoverable material that is being landfilled by material type. Based on this characterization, an estimate was made by each material type of the potential recovery that would achieve a tripling of the recycling rate from the 15.3% estimated in 2014 to a 45% recovery rate. The quantity of material estimated to be recovered in 2015 was 1,535,195 tons, tripling this number would result in an additional 2.7 million tons of recovery from the estimated 8.831 million ton of waste currently landfilled or incinerated. As identified in the update to the MRI report, described in Appendix A, the reported quantity of material collected and processed from residential and commercial generators was 1.221 million tons of material, an increase of 81% above the estimated recovered material in 2014, or an additional 546,000 tons.

The estimation of the additional quantities of specific materials that would need to be recovered to reach the 2.7 million-ton target and recycled are based on the following preliminary recovery targets by material category.

	2015	2018
Population of Michigan	9,933,000	9,996,000
Per capita disposal	1,616	1,767
Per capita diversion	285	390
Per capita waste generation	1,901	2,157

While Michiganders **recycled** more, they also **disposed** of more, resulting in an **increase in waste generation** (lbs/person/year)

Table 1: Possible Target Recovery to Triple Recycling Rate

MATERIAL CATEGORY	PERCENT OF RECOVERY	ESTIMATED TONS
PAPER – HIGH/LOW GRADE -WHITE, MIXED OFFICE, OMG, BOXBOARD, PAPER BAGS, PHONEBOOKS	60%	408,140
ONP	60%	101,941
OCC	60%	300,799
CARTONS, ASEPTIC AND POLY-COATED	25%	3,055
COMPOSTABLE/ SOILED AND ALL OTHER PAPER	25%	181,960
PET BOTTLES AND CONTAINERS	50%	30,006
HDPE BOTTLES NATURAL & COLORED	50%	24,611
MIXED PLASTIC BOTTLES AND OTHER #3-7	25%	6,844
ALL OTHER PLASTICS AND PACKAGING, LDPE, POLYSTYRENE (FOAM), DURABLE AND RIGID CONTAINERS)	30%	292,129
ALUMINUM CANS	40%	6,015
FERROUS METALS (INCLUDES TIN/STEEL CANS, TIN)	50%	196,527
NON-FERROUS METALS, ALUMINUM (FOIL) AND OTHER METAL AND AEROSOL CANS	25%	32,070
GLASS – CONTAINERS	50%	58,215
ELECTRONICS – GENERAL, COMPUTER RELATED, AND CRT	10%	13,031
WHITE GOODS (APPLIANCES)	20%	2,484
TOTAL WOOD	40%	373,186
YARD WASTE	50%	119,342
FOOD	40%	533,285
OTHER TEXTILES, BATTERIES, CARPET	5%	23,901
TOTAL		2,707,541

These targets represent just one scenario of many that could be evaluated or targeted as goals and are not intended to represent a recommended target until further detailed evaluation of regional and county diversion potential is undertaken. The total tons disposed was distributed on a county basis based on the percentage of total population and the average per capita disposal quantity. The targeted quantities for each material that was estimated in Table 2 were allocated based on the population for each county to estimate targets for each Council of Government region.

*Table 2: Target Recovery by COG Region to Triple Recycling Rate (Tons)**

COG REGION	PAPER	PLASTIC	METAL	GLASS	ELECTRONICS	WOOD	YARD WASTE	FOOD	TEXTILES, (BATTERIES, TIRES, CARPET, LIGHT BULBS)	TOTAL
REGION 1	467,233	165,925	110,101	27,323	7,310	175,069	55,997	250,168	11,230	1,270,356
REGION 2	29,719	10,552	7,000	1,737	462	11,137	3,562	15,915	712	80,796
REGION 3	56,170	19,943	13,235	3,284	874	21,049	6,732	30,079	1,348	152,714
REGION 4	27,602	9,800	6,500	1,613	429	10,343	3,307	14,780	662	75,036
REGION 5	52,618	18,681	12,397	3,077	822	19,717	6,306	28,175	1,264	143,057
REGION 6	47,297	16,793	11,143	2,765	738	17,723	5,669	25,326	1,136	128,590
REGION 7	85,681	30,414	20,178	5,007	1,327	32,109	10,265	45,887	2,054	232,922
REGION 8	123,345	43,796	29,061	7,212	1,925	46,218	14,782	66,046	2,961	335,346
REGION 9	13,035	4,620	3,064	759	197	4,888	1,560	6,984	309	35,416
REGION 10	30,009	10,645	7,060	1,751	461	11,247	3,593	16,075	716	81,557
REGION 11	5,351	1,898	1,257	312	81	2,006	640	2,867	127	14,539
REGION 12	21,669	7,689	5,101	1,264	333	8,121	2,596	11,607	518	58,898
REGION 13	7,704	2,731	1,811	448	115	2,891	922	4,132	182	20,936
REGION 14	28,462	10,103	6,704	1,663	441	10,668	3,411	15,244	682	77,378
Total	**995,895**	**353,590**	**234,612**	**58,215**	**15,515**	**373,186**	**119,342**	**533,285**	**23,901**	**2,707,541**

INFRASTRUCUTRE DEVELOPMENT

The increase in the capture of materials to achieve a 45% recovery rate will require development of many new collection programs and facilities to process the additional material. This includes developing the equivalent of 12 to 18 new 50 Ton per Hour (TPH) Materials Recovery Facilities (MRFs) that could process 95,000 tons per shift. Additional MRFs may be needed if the scale (throughput) of the facilities is lower. Additional processing capacity will also be required to manage the increase in organics recovery, given that there is a substantial quantity of food waste and soiled fiber (e.g. tissues and napkins) that could be composted in other facilities, such as Anaerobic Digestion (AD).

MATERIALS RECOVERY FACILITIES

Historically, the throughput sweet spot for single stream MRFs has been 15 TPH or 30,000 tons per year or greater. Recent designs with a single sort line appear to perform well in the 15-35 TPH-size ranges and as high as 50 TPH. At throughputs below 35 TPH, higher capacity is obtained through increase in the size of separation equipment and increase in the number of separation stages rather than through parallel equipment. The primary advantage of this approach is that little additional staff is required to increase throughput. As a bonus, the additional separation stages also have the potential of providing better separation quality and automated production of additional fiber grades.

Most equipment designers choose to split the material sort after the OCC screen into two lines when processing 35 TPH or more rather than build huge components to handle it all as one sort. A number of facilities have been built to process more than 200,000 tons per year. Facilities sized to process 50 TPH usually justify optical sorters for PET and NHDPE and CHDPE. Most recent large facilities use optical sorters for most plastics. A number of facilities in this size range are also adding optical sorting for #3-7 plastics, cartons, and other poly coated fiber, polypropylene (PP), plastic films, and other types of plastic containers that would need to be manually sorted in smaller facilities. A few MRFs use optical sorters to post sort mixed fiber. These larger facilities are usually set up to receive transfer trailers and to serve a large regional area. In the Chicago area, for example, several large MRFs draw materials from five to seven states.

The separation technologies vary somewhat from one manufacturer to another, but with a few exceptions there is general agreement on the process sequence. The two areas where design sequences vary significantly are the place and method of glass removal and the place and method of small fiber recovery. In short, product quality is more dependent on operational decisions than on technology. This also applies to recyclables leaving the facility as residue or as out-throw in other products. Technology and scale do play a major role in improving efficiency of sorting operations.

COLLECTION

The collection of this material would require approximately 1,250 additional trucks and the associated routes to collect an additional 2.7 million tons of material. In addition, many transfer stations would be needed to move this material to regional MRFs and processing facilities to ensure that cost-effective processing is available. These networks of MRFs fed by transfer stations is often referred to as a “hub and spoke” system.

ORGANICS PROCESSING TECHNOLOGIES

Composting is the most cost-effective option for recycling food waste. While composting is a “natural” process, many technologies and engineered approaches are applied to processing food and other organic wastes (often referred to as SSO (source separated organics) into marketable compost. These range from low-tech windrowing to sophisticated, capital intensive digester operations. Each of these techniques is designed to create an environment for reduction and stabilization of organic materials but vary in their applicability to SSO recovery.

Four technologies are reviewed below; each has its own advantages and disadvantages pertaining to residentially generated SSO.

Table 3: Processing Types

TECHNOLOGY	TYPE	DESCRIPTION	TIME TO FINISHED PRODUCT	APPLICABILITY TO SSO
WINDROW	Outdoor open air	Organic material is mixed and formed into long trapezoidal rows. Material is periodically turned and mixed.	3-9 months	Food waste must be adequately mixed with yard debris and bulking agents (wood chips) to balance the carbon-to-nitrogen ratio (C:N) and follow "best practices" for odor prevention.
STATIC PILE	Outdoor open air	Air is pumped into large pile to speed decomposition.	1-2 years	As above, need to balance the carbon-to-nitrogen ratio (C:N) and follow "best practices" for odor prevention.
AERATED STATIC PILE	Outdoor, indoor, or in-vessel System	HHO is mixed with higher carbon-content materials and formed into long cylindrical rows and encased in a plastic bag "sleeve". Air is introduced into the bags.	4-6 months	Popular for animal manures and growing in application for additional high-nitrogen materials. As above, need to balance the carbon-to-nitrogen ratio (C:N) and follow "best practices" for odor prevention.
ANAEROBIC DIGESTION	Outdoor enclosed anaerobic	Organic material is typically mixed and warmed in a closed, airtight tank. Microorganisms break down or "digest" organic material without the presence of oxygen, typically for 6 weeks. Energy recovery from methane generation is common.	15-40 days	Household, industrial, institutional, and commercial organics (e.g. food waste) provide excellent nutrient sources in the digester. Not a solution for large amounts of yard waste.

Evaluating the best long-term technology options involves the consideration of:

- Feedstock volume,
- Biological engineering (aerobic versus anaerobic), and
- Access to end-markets.

Composting is an enterprise that has considerable economies of scales when it comes to capital investment. Indeed, some technology options such as anaerobic digestion require daily feedstock volumes of 100 tons. Conversely, windrow and static pile operations can be operated inexpensively with low technology while processing small incoming volumes.

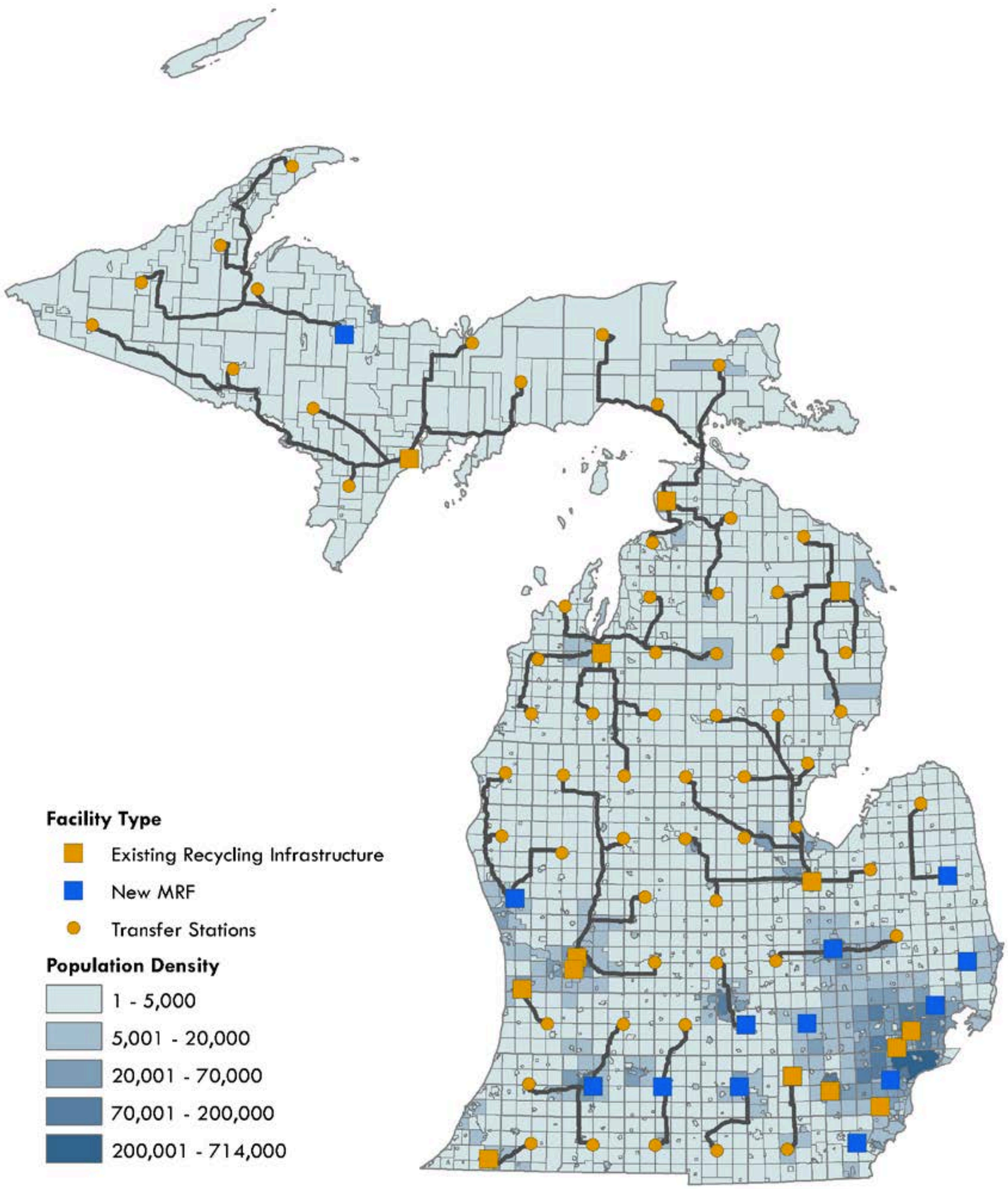
Hub and Spoke Processing Framework

Based on the needs to develop additional capacity in the State to process an additional 2.7 million tons of recoverable material RRS created a possible scenario for the new facility investments. This scenario is based on the estimated recovery of new material to achieve the 45% recovery goal. The baseline facility used for this analysis is 70,000 tons per year of throughput for both recycled materials and organic materials. If the quantity of material that could be potentially recovered in a region did not meet a minimum throughput volume then that region would either develop transfer capability and would move material to the next closest region, and the material would be added until minimum thresholds for a 70,000 ton processing facility was met, or continue the use of or upgrade an existing community MRF to meet its needs. This scenario assumes currently available facilities are handling the 1.9 million tons that are currently recovered but would not process these new additional tons, although some existing facilities could increase their capacity with facility upgrades that would increase overall throughput to meet the new demand. For compost siting, those communities that do not meet the 70,000 tpy threshold would expand or develop community-scale lower-tech compost facilities to meet their needs.

Table 4: Hub and Spoke Processing Scenario

COUNTY/COG	TOTAL RECYCLABLE	TOTAL ORGANICS	70K TONS/YR. MRF	70K TONS/YR. COMPOST SITE
REGION 1 SOUTHEAST COUNCIL OF GOVERNMENTS	789,122	481,234	10	6
REGION 2 PLANNING COMMISSION	50,182	30,614	1	-
REGION 3 SOUTHCENTRAL MICHIGAN PLANNING COUNCIL	94,854	57,860	1	1
REGION 4 SOUTHWEST MICHIGAN PLANNING COMMISSION	46,606	28,430	1	-
REGION 5 PLANNING & DEVELOPMENT COMMISSION	88,859	54,198	1	1
REGION 6 TRI-COUNTY REGIONAL PLANNING COMMISSION	79,872	48,718	1	-
REGION 7 EAST MICHIGAN COUNCIL OF GOVERNMENTS	144,661	88,261	2	1
REGION 8 WEST MICHIGAN REGIONAL PLANNING COMMISSION	208,300	127,046	3	2
REGION 9 NORTHEAST MICHIGAN COUNCIL OF GOVERNMENTS	21,984	13,432	-	-
REGION 10 NETWORKS NORTHWEST	50,642	30,915	1	-
REGION 11 EASTERN UPPER PENINSULA REGIONAL PLANNING & DEVELOPMENT COMMISSION	9,026	5,513	-	-
REGION 12 CENTRAL UPPER PENINSULA PLANNING & DEVELOPMENT REGIONAL COMMISSION	36,574	22,324	-	-
REGION 13 WESTERN UPPER PENINSULA PLANNING & DEVELOPMENT REGIONAL COMMISSION	12,991	7,945	-	-
REGION 14 WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION	48,055	29,323	1	-
TOTAL	1,681,728	1,025,813	22	11

Figure 1: Possible Scenario for Hub and Spoke Collection of Recoverable Materials



ECONOMIC VALUE OF RECYCLABLES TO MEET 45% RECOVERY GOAL

If the goal of the State were to increase the recycling rate to 45% for recyclable materials, then 30% of the currently landfilled material would need to be recovered. RRS calculated the economic impact of the current landfilled material being recovered began recovering an additional 30% of material from landfill disposal. Both the value of the material diverted from the landfill (recyclables and organics) and the landfill cost savings is calculated. It has been estimated that increasing Michigan's recycling rate from current levels to 45% would result in the addition of $3.3 to $13 million worth of valued recycled commodities to Michigan's economy annually, depending on the potential commodity value of material with values identified in known commodity price indexes. Guiding public and private investment to serve the public and private sector and maximize the value of material successfully diverted to recycling and composting is important to achieving goals that improve both Michigan's economy and environment.

Table 5: Value of Landfilled Material to Achieve 45% Recovery based on Commodity Value

POTENTIAL RECYCLED COMMODITY	TONS	PERCENT OF TOTAL	5 YEAR Average $/TON	5 YEAR VALUE	August 2019 VALUE
MIXED PAPER	408,140	27.9%	$9.07	$3,701,833	$32,406
SORTED RESIDENTIAL PAPERS AND NEWS (SRPN)	101,941	7.0%	$11.55	$1,177,419	$300,726
CORRUGATED CONTAINERS (OCC)	300,799	20.6%	$19.27	$5,796,397	$1,816,826
ASEPTIC CARTONS	3,055	0.2%	$0.04	$122	$31
GLASS 3 MIX	58,215	4.0%	$14.20	$826,653	-$175,809
ALUMINUM CANS (SORTED, BALED)	6,015	0.4%	$3.05	$18,346	$72,300
ALUMINUM (FOIL AND OTHER)	32,070	2.2%	$2.44	$14,677	$57,840
STEEL CANS (SORTED, DENSIFIED)	196,527	13.5%	$7.83	$1,538,806	$538,484
PET (BALED, PICKED UP)	30,006	2.1%	$5.06	$151,830	$233,747
NATURAL HDPE (BAILED, PICKED UP)	3,434	0.2%	$2.44	$8,379	$11,058
COLORED HDPE (BAILED, PICKED UP)	21,177	1.5%	$0.22	$4,659	$28,377
COMINGLED (#3-7, BALED, PICKED UP)	6,844	0.5%	-$2.54	-$17,384	$479
LDPE (INCLUDES SOME BAGS, FILM)	214,594	14.7%	$0.22	$47,211	$287,556
DURABLE AND RIGID CONTAINERS (HDPE RIGID (BALED) AND LDPE	77,535	5.3%	$0.22	$17,058	$103,896
TOTAL OF POTENTIAL RECYCLABLES	1,460,352	100%		$13,286,006	$3,307,918
TOTAL OTHER MATERIAL	1,247,189			$14,254,179	$14,241,535
TOTAL ALL MATERIAL	2,707,541			$27,540,184	$17,549,453
PERCENT RECOVERY	30.7%				

The value of currently landfilled but potentially recyclable material, based on a 5-Year Average Commodity Revenue for the Midwest, is approximately $13.28 million, which is 402% of the value based on the current August 2019 commodity value. As stated in the value of currently recycled material, the decline in value over the past 3-5 years is driven by the global decline in commodity demand driven in large part by the slowdown in the Chinese economy and the imposition of import bans under China's "Green Sword" regulations. The value of the avoided disposal cost for Potential Recyclables based on the average gate rate for disposal of $15/ton is approximately $40.6 million. Investments in domestic recycling-based manufacturing announced in 2018 and 2019 are anticipated to absorb this previously China bound material in the coming years, which will increase overall value above those shown via this forecast based on the look back 5-year average.

Jobs Created by Increasing Recycling to 45%

The job production estimates used in our analysis are summarized in Table 6. RRS utilized the estimate of the employment from the increase in recycling in a report developed by the Tellus Institute. Tellus reviewed a number of state and national studies conducted to estimate the level of economic activity and employment of the recycling industry. Two primary approaches have been used. The first is a "bottom-up" approach whereby the relevant business categories are identified and data on their direct activity is gathered from existing sources (e.g., U.S. Census Bureau's Economic Census and others) on the number of establishments, employment and payroll. The frequently cited U.S. Recycling Economic Information Study (2001) published by the National Recycling Coalition with U.S. EPA support used this approach. In 2009, the Northeast Recycling Council produced the Recycling Economic Information Study Update (REI Update) for five states in the Northeast, using a modified version of this methodology. The second is a "top-down" approach in which surveys are conducted of various recycling and reuse business sectors, defined by material, to collect data on tonnages managed and employment at each establishment. From this data, estimates of jobs per tonnage are derived for each of the relevant sectors. In the 1990s the Institute for Local Self Reliance (ILSR) used this approach to develop a set of job production estimates for recycling/reuse/processing business categories as well as for composting, landfilling and incineration. These job production estimates are still widely cited in assessments of job impacts of various solid waste management alternatives.

Unfortunately, neither approach provides a comprehensive data set that matches the EPA material categories and the categories of materials in the previous Michigan Waste Characterization study. Tellus developed a hybrid approach, relying on a combination of the key sources mentioned above. In order to conduct the economic impact analyses of tripling the recycling rate from the 2015 baseline of 15% to 45%, RRS used the estimates of jobs produced per 1,000 tons of MSW managed for each of the diversion management activities – collection, processing, manufacturing, and reuse/remanufacturing.

Materials collection generates relatively few jobs. Based on detailed data collected in 2010 by CM Consulting on behalf of the Container Recycling Institute, Tellus assumed that 1.67 jobs are created per 1,000 tons of material collected for recycling or composting and 0.56 jobs per ton for disposal. Note that the collection job production estimate for recyclables is expected to decline to 1.23 jobs per 1,000 tons by 2030 as single-stream recyclables collection continues to grow. These figures reflect the fact that job creation related to materials collection varies by material type (mixed waste versus mixed recyclables versus source-separated recyclables) and that less labor per ton collected is required for mixed waste loads (slated for disposal) than for recyclables/compostables collection. The assumption for processing of recyclables (two jobs per 1,000 tons) and organics (0.5 jobs per 1,000 tons) may also be somewhat conservative as the 2009 REI Update for five northeastern states estimated 2.73 jobs per 1,000 tons processed.

Job estimates derived from the REI Study for the various manufacturing sectors that use recyclable materials demonstrate the labor intensity of manufacturing. These job production estimates vary greatly by material/sector: from less than three jobs per 1,000 tons for wood and textiles, to about four jobs per 1,000 tons for paper as well as iron and steel manufacturing, to about 10 jobs per 1,000 tons for plastics and more than 17 jobs per 1,000 tons for nonferrous metals

Reuse and remanufacturing activity are particularly labor intensive with job production estimates of more than seven jobs per 1,000 tons for several material/product categories and around 20 jobs per 1,000 tons for metal products. Such high job production estimates for reuse and remanufacturing are consistent with the significant labor required for disassembly, inspection, repair/ refurbishment, reassembly and testing. The total number of jobs created is based on the tonnage data estimated by material category to achieve a 45% recovery rate.

Table 6: Job Production Estimates by Management Activity - MSW

SECTOR	EMPLOYMENT /1000 TONS	ESTIMATED JOBS
COLLECTION	1.23	3,330
PROCESSING	2	5,415
MANUFACTURING		
PAPER & PAPERBOARD	4.16	4,143
GLASS	7.85	457
FERROUS METALS	4.12	810
ALUMINUM	17.63	671
PLASTICS	10.3	3,642
TEXTILES	2.5	60
WOOD	2.8	1,045
YARD WASTE AND FOOD WASTE	0.4	261
OTHER	2.5	60

ECONOMIC ANALYSIS

Background

In 2016 RRS conducted a detailed end-use market analysis that consisted of interviews with MRF operators, a market survey, an economic analysis, and collaboration with the Recycling Partnership to develop recommendations to support end-use markets in Michigan and to move Michigan towards a sustainable materials management system. This study is intended as a follow on from the previous work, to assess changes to the baseline economic analysis from 2016 to 2019 and to investigate the economic impact of tripling

To conduct the economic analysis, RRS followed the published methodology incorporated by three statewide reports and one regional report. The four reports are:

- ENVIRON International Corporation for the Colorado Department of Public Health and Environment. Economic Study of Recycling in Colorado. November 17, 2014.
- SAIC for the Houston-Galveston Area Council. The Economic Contribution of the Recycling Industry to the Houston-Galveston Region. May 2013.
- Valentine, David, and Ann Ulmer. Missouri Recycling Economic Information Study MOREIS. Prepared by the University of Missouri Institute of Public Policy for the Environmental Improvement and Energy Resources Authority. January 20, 2005.
- The National Recycling Coalition in association with R.W. Beck, Inc. for the Florida Department of Environmental Protection. Florida Recycling Economic Information Study. June 2000.

Where appropriate, RRS' own data and metrics were integrated to verify and enhance the overall economic analysis and inform the development of recommendations. The IMPLAN modeling system allowed RRS to estimate the degree of recycling, remanufacturing, and reuse (RRR) activity that makes use of locally generated recovered materials to create jobs and provide economic benefits to local economies of employment in Michigan. Additionally, RRS used detailed Michigan waste characterization estimates to identify commodity specific additional tonnage recovery opportunities and added employment required to achieve the tripled diversion rate. To conduct this analysis, RRS used NAICS codes related to the RRR industries, estimates of the portion of each relevant NAICS sector dedicated to recycling, reuse, and recovery, and 2012 U.S. Business Census employment counts to generate inputs for the impact analysis for planning (IMPLAN). RRS then assessed the added economic value of triple the recycling rate including total added jobs, labor income, total value added, and total output to the Michigan economy.

Economic Analysis Overview

RRS' economic analysis found that if the Michigan recycling rate were to triple (15% to 45%) 47,800 jobs, $3.3 billion in labor income, $4.9 billion in total value added, and $11.6 billion in total output would be added to the Michigan economy. Overall, tripling the recycling rates contributes to just over a one percent increase in the portion of the state's economy represented by the RRR sector – from 2.2% of the total to 3.3%. In total, 137,903 jobs would be directly related to recycling, reuse, and recovery, so that if all the direct, indirect, and induced jobs created by the industry were in the same city, it would be the third largest city in the state. The direct economic output of the tripled RRR industry in the state is $19.6 billion and the total economic output (including indirect and induced effects) would be $33.8 billion, compared to the $12.9 billion and $22.2 billion of today respectively. Tripling the recycling rate results in roughly a 50% increase in all aspects – employment, labor income, total added value, and output – for the RRR sector.

Table 7: Direct, Indirect, Induced and Total Impacts of RRR in Michigan

TOTAL EMPLOYMENT, LABOR INCOME, TOTAL VALUE ADDED, AND OUTPUT FROM TRIPLING THE RECYCLING RATE				
IMPACT TYPE	**EMPLOYMENT**	**LABOR INCOME**	**TOTAL VALUE ADDED**	**OUTPUT**
DIRECT EFFECT	52,446	$4,272,603,554	$6,299,181,229	$19,579,793,334
INDIRECT EFFECT	40,572	$2,740,402,182	$4,219,108,533	$7,949,373,926
INDUCED EFFECT	44,885	$2,070,980,979	$3,595,345,945	$6,256,828,180
TOTAL EFFECT	**137,903**	**$9,083,986,715**	**$14,113,635,707**	**$33,785,995,440**

Figure 2: Economic Benefits of Recycling in Michigan

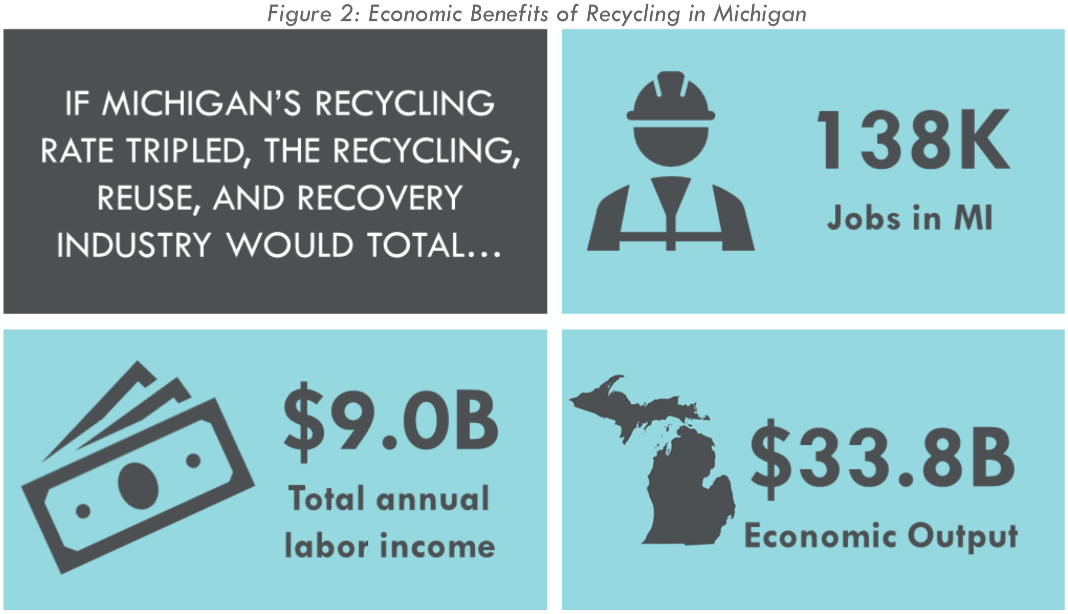


Figure 3: Summary Results of Direct, Indirect, Induced And Total Effects of Tripling the Recycling Rate in Michigan

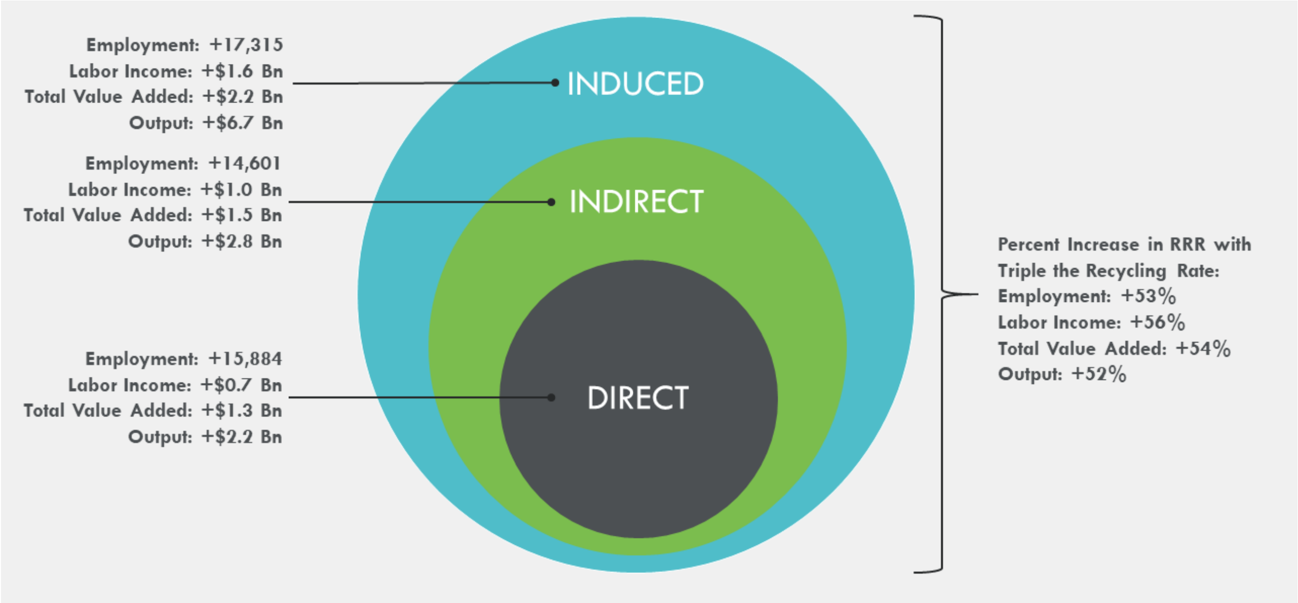


Table 8: Results of Direct, Indirect, Induced and Total Effects on the Michigan economy with a 15% recovery rate compared to a 45% recovery rate

	15% STATEWIDE RECYCLING RATE	45% STATEWIDE RECYCLING RATE	ADDED VALUE	PERCENT CHANGE
EMPLOYMENT	90,103	137,903	47,800	53%
LABOR INCOME	5,828,171,237	$9,083,986,715	$3,255,815,478	56%
VALUE ADDED	9,171,481,650	$14,113,635,707	$4,942,154,057	54%
OUTPUT	22,155,535,094	$33,785,995,440	$11,630,460,346	52%
PERCENT OF MI ECONOMY	2.2%	3.3%		1.1%

Methodology

In order to gather a complete picture of the RRR industry in Michigan, the economic study included the impacts of both supply and demand side activities in the state. On the supply side, the study included the impacts of all activities involved in collecting, processing, selling, and using recovered items in the state. On the demand side, the study included all activities up to the first point in which the materials are used or products have been completed. Following the methodology of the four previous reports listed above, the study excluded advocacy, education and other organizations or individuals that do not directly add value to the recovered items. The study also excluded waste to energy, incineration, refuse derived fuel and combustion activities.

RRS reviewed North American Classification System (NAICS)[1] information from the 2012 U.S. Economic Census as well as the NAICS codes and businesses identified in other state studies to identify the businesses involved in RRR in Michigan. The following business activities were considered in the research:

- Businesses and organizations involved in the collection and transportation of RRR materials, including both private and public sector collectors;
- Intermediate processing of recovered scrap materials or reused products and items, including activities such as sorting and cleaning as well as disassembling, consolidating, composting and densifying;
- Reclaiming materials used for manufacturing inputs;
- Manufacturing of products using recovered materials;
- Wholesale or retail establishments selling used, recovered or reclaimed materials; and
- Businesses supporting the industries above through research, consulting, equipment sales, engineering and brokering.

The complete list of NAICS codes, business classifications, and the NAICS description of the classifications included in the study can be found in Appendix E of this report. The table includes businesses directly involved in the RRR business (collection, processing, and recovery), businesses involved in reuse and remanufacture, and businesses involved in resale of RRR materials.

In 2016, RRS used secondary research to determine the number of employees directly engaged in RRR activities in the state and estimate what percentage of a sector's business activity is related to RRR for each of the NAICS codes, and those same percentages were reapplied in this 2019 model update. For instance, while there are multiple paper mills in the state, 100% of the activity at 100% of the paper mills is not directly related to RRR. In

[1] NAICS codes are the standard federal classification for business establishments in the United States and are used to publish statistical data on employment in the U.S.

fact, only a portion of the activities at the paper mills directly use recovered fiber as inputs in their process, thus the impact of paper mills on the state's economy needed to be discounted by the percentage of the business activity that is not related to RRR. When there was an option to choose from multiple data sources for the recycling factor, RRS staff chose the more conservative from the published reports so as to avoid overstating the impacts in the state. Table 9 displays the NAICS sectors, the associated IMPLAN sector,[2] the percent share of business activity related to the recycling industry used in the model, and the source of the data. The 2019 economic model update uses the same activity factors as shown in Table 9.

Table 9: Recycling Activity Factors and IMPLAN Sectors

TITLE OF 2012 NAICS CODE	IMPAN SECTOR	PERCENT OF BUSINESS ACTIVITY RRR	SOURCE
WOOD CONTAINER AND PALLET MANUFACTURING	142	56%	RRS expert interview
PULP MILLS	146	43%	NRC, 2000
PAPER MILLS	147	43%	NRC, 2000
ALL OTHER CONVERTED PAPER PRODUCT MANUFACTURING	153	100%	ENVIRON, 2014
ASPHALT PAVING MIXTURE AND BLOCK MANUFACTURING	157	100%	ENVIRON, 2014
FERTILIZER (MIXING ONLY) MANUFACTURING	171	13%	ENVIRON, 2014
CUSTOM COMPOUNDING OF PURCHASED RESINS	185	16%	Valentine, 2005
PLASTICS PACKAGING MATERIALS AND UNLAMINATED FILM AND SHEET MANUFACTURING	188	16%	Valentine, 2005
UNLAMINATED PLASTICS PROFILE SHAPE MANUFACTURING	189	16%	Valentine, 2005
PLASTICS PIPE AND PIPE FITTING MANUFACTURING	190	16%	Valentine, 2005
LAMINATED PLASTICS PLATE, SHEET (EXCEPT PACKAGING), AND SHAPE MANUFACTURING	191	16%	Valentine, 2005
POLYSTYRENE FOAM PRODUCT MANUFACTURING	192	16%	Valentine, 2005
URETHANE AND OTHER FOAM PRODUCT (EXCEPT POLYSTYRENE) MANUFACTURING	193	16%	Valentine, 2005
PLASTICS BOTTLE MANUFACTURING	194	16%	Valentine, 2005
OTHER PLASTICS PRODUCT MANUFACTURING	195	16%	Valentine, 2005
TIRES	196	100%	Valentine, 2005
RUBBER PLASTICS HOSES AND BELTING	197	50%	RRS expert interview
OTHER RUBBER PRODUCT MANUFACTURING	198	50%	RRS expert interview
GLASS CONTAINER MANUFACTURING	203	90%	ENVIRON, 2014

[2] The IMPLAN sector names do not always match up with the NAICS Codes, and more than one NAICS code could be grouped in an IMPLAN Sector based on similarities in the business activity.

TITLE OF 2012 NAICS CODE	IMPAN SECTOR	PERCENT OF BUSINESS ACTIVITY RRR	SOURCE
IRON AND STEEL MILLS AND FERROALLOY MANUFACTURING	217	95%	ENVIRON, 2014
SECONDARY SMELTING AND ALLOYING OF ALUMINUM	222	48%	ENVIRON, 2014
ALUMINUM SHEET, PLATE, AND FOIL MANUFACTURING	223	48%	ENVIRON, 2014
OTHER ALUMINUM ROLLING, DRAWING, AND EXTRUDING	224	48%	ENVIRON, 2014
COPPER ROLLING, DRAWING, EXTRUDING, AND ALLOYING	226	48%	ENVIRON, 2014
NONFERROUS METAL (EXCEPT COPPER AND ALUMINUM) ROLLING, DRAWING, EXTRUDING, AND ALLOYING	227	48%	ENVIRON, 2014
SECONDARY SMELTING, REFINING, AND ALLOYING OF NONFERROUS METAL (EXCEPT COPPER AND ALUMINUM)	228	95%	ENVIRON, 2014
NONFERROUS METAL FOUNDRIES	230	50%	NRC, 2000
MOTOR VEHICLE PARTS (USED) MERCHANT WHOLESALERS	395	97%	ENVIRON, 2014
INDUSTRIAL SUPPLIES MERCHANT WHOLESALERS	395	20%	RRS expert interview
RECYCLABLE MATERIAL MERCHANT WHOLESALERS	395	97%	ENVIRON, 2014
USED MERCHANDISE STORES	406	100%	ENVIRON, 2014
ALL OTHER PROFESSIONAL, SCIENTIFIC, AND TECHNICAL SERVICES	460	10%	RRS expert interview
SOLID WASTE COLLECTION	471	34%	RRS expert interview
OTHER NONHAZARDOUS WASTE TREATMENT AND DISPOSAL	471	67%	ENVIRON, 2014
HAZARDOUS WASTE COLLECTION	471	67%	ENVIRON, 2014
MATERIALS RECOVERY FACILITIES	471	100%	RRS expert interview
COMPUTER AND OFFICE MACHINE REPAIR AND MAINTENANCE	506	100%	ENVIRON, 2014

With the relevant NAICS codes and percent of business related to RRR identified, RRS utilized NAICS code specific employment data from the 2012 U.S. Economic Census to estimate total employment in the state related to RRR which was the key input to the IMPLAN model. The U.S. Economic Census is conducted every 5 years, with the most recent census having been completed in 2017. However, the results of the 2017 census will not be fully available until 2020 so the same employment data used in 2016 was also used in this study.

While the employment data used in the 2019 economic modeling was unchanged from 2016, IMPLAN has adjusted their Social Accounting Matrices (SAMs) recently, which track the flow of both market and non-market funds throughout economies in a given year. According to IMPLAN, “market flows occur between the producers of both industrial and institutional goods & services and the industrial and institutional purchasers of those goods & services. Serving as the perennial backbone of the tool's entire dataset. These improvements to the SAMs both ensure greater accuracy and make it easier to observe estimated commuting flows both into and out of economies. Additionally, some payments to governments have been reclassified in the new IMPLAN, like rents and royalties paid from Other Property Income (OPI) to governments rather than from Taxes on Production & Imports (TOPI). Such changes serve to align the new IMPLAN's SAMs with National Income and Product Accounts (NIPAs) from the Bureau of Economic Analysis (BEA) to improve the quality of both tax and impact results.” As a result of these changes, results from the 2016 study could not be replicated as a baseline. RRS therefore created a new baseline using the 2012 economic census.

IMPLAN modeled the following effects of RRR on Michigan’s economy for both the current recycling rate and a tripling of the recycling rate:

- **Direct economic impacts:** The dollar value of the economic activity available to circulate throughout the state economy. This includes not only the dollar value for the RRR industries, but also those in other industries that directly support RRR.
- **Indirect economic impacts:** These are the inter-industry impacts of the input-output analysis and cover the impacts that result from the spending and the increased demand by the RRR companies.
- **Induced impacts:** Include the impacts of household spending by the employees generated by the direct and indirect impacts.
- **Employment**: The annual average of monthly jobs in that industry (this is the same definition used by the U.S. Bureau of Labor Statistics and the U.S. Bureau of Economic Analysis at the national level). Thus, one job lasting 12 months is equal to two jobs lasting six months, which is equal to three jobs lasting four months each. A job can be either full-time or part-time.
- **Labor Income**: All forms of employment income, including Employee Compensation (wages and benefits) and Proprietor Income.
- **Total Value Added**: The difference between an industry’s or an establishment’s total output and the cost of its intermediate inputs. Total value-added equals gross output (sales or receipts and other operating income, plus inventory change) minus intermediate inputs (consumption of goods and services purchased from other industries or imported). Value added consists of compensation of employees, taxes on production and imports less subsidies, and gross operating surplus.
- **Output**: The value of industry production. These are annual production estimates for the year of the data set and are in producer prices. For manufacturers this would be sales plus/minus change in inventory. For service sectors production equals sales. For the retail and wholesale trade, output equals gross margin and not gross sales.

Economic Analysis Baseline

RRS evaluated the baseline economic impact of current recycling activities as a direct comparison to 2016 results, following the same methodology used in the previous Michigan work and other cited studies.

At present, the RRR industries account for 2.2% of total economic output of the state of Michigan. Approximately 35,131 thousand Michiganders directly work in recycling, reuse, and recovery and another 54,972 work in industries indirectly related to RRR or induced from the RRR industries. In total 90,103 jobs in the state are a direct, indirect, or induced result of the many recycling and recovery related sectors in the state, accounting for $5.8 billion in labor income, $9.2 billion in total value added, and $22.2 billion in economic output (Table 10).

Jobs directly related to Michigan's recycling industry include, for example, recycling collection truck drivers, MRF sorters, compost facility operators, and recycling commodity brokers that buy and sell recycled material. Recycling activities also create jobs in Michigan indirectly such as truck drivers that pick-up bales from MRFs and drive to secondary processors or end markets and engineering firms that develop all types of needed infrastructure spurred by recycling. Finally, a third piece of job creation brought on by the recycling industry is induced effects, for example, jobs in the food industry, supermarkets, banks, and other stores created near MRFs or end markets where workers may spend time and money.

Table 10: Direct, indirect and induced impacts of RRR in Michigan at Current Recycling Rate

IMPACT TYPE	EMPLOYMENT	LABOR INCOME	TOTAL VALUE ADDED	OUTPUT
DIRECT EFFECT	35,131	$2,717,310,190	$4,100,177,304	$12,928,673,635
INDIRECT EFFECT	25,971	$1,773,598,181	$2,749,540,398	$5,184,707,002
INDUCED EFFECT	29,002	$1,337,262,866	$2,321,763,948	$4,042,154,458
TOTAL EFFECT	**90,103**	**$5,828,171,237**	**$9,171,481,650**	**$22,155,535,094**

Breaking down the aggregate data, the table below shows the direct, indirect, induced, and total impact of each RRR related sector for employment, labor income, total value added, and out.

Table 11: Employment Effects of RRR Sector

SECTOR NUMBER	IMPLAN DESCRIPTION	DIRECT	INDIRECT	INDUCED	TOTAL
142	WOOD CONTAINER AND PALLET MANUFACTURING	994	342	453	1,789
146	PULP MILLS	26	57	38	121
147	PAPER MILLS	1,105	2,086	1,685	4,877
153	ALL OTHER CONVERTED PAPER PRODUCT MANUFACTURING	324	204	237	765
157	ASPHALT PAVING MIXTURE AND BLOCK MANUFACTURING	175	203	709	1,087
171	FERTILIZER MIXING	37	34	32	103
185	CUSTOM COMPOUNDING OF PURCHASED RESINS	128	92	109	328
188	PLASTICS PACKAGING MATERIALS AND UNLAMINATED FILM AND SHEET MANUFACTURING	292	193	231	716
189	UNLAMINATED PLASTICS PROFILE SHAPE MANUFACTURING	154	127	123	404
190	PLASTICS PIPE AND PIPE FITTING MANUFACTURING	168	112	126	406
191	LAMINATED PLASTICS PLATE, SHEET (EXCEPT PACKAGING), AND SHAPE MANUFACTURING	44	17	27	89
192	POLYSTYRENE FOAM PRODUCT MANUFACTURING	155	88	106	349
193	URETHANE AND OTHER FOAM PRODUCT (EXCEPT POLYSTYRENE) MANUFACTURING	324	182	215	720
194	PLASTICS BOTTLE MANUFACTURING	80	48	104	232
195	OTHER PLASTICS PRODUCT MANUFACTURING	5,321	2,807	3,562	11,690
196	TIRE MANUFACTURING	205	164	163	532
197	RUBBER AND PLASTICS HOSES AND BELTING MANUFACTURING	703	400	491	1,594

198	OTHER RUBBER PRODUCT MANUFACTURING	1,573	974	1,101	3,647
203	GLASS CONTAINER MANUFACTURING*	0	0	0	0
217	IRON AND STEEL MILLS AND FERROALLOY MANUFACTURING	5,249	9,859	9,130	24,239
222	SECONDARY SMELTING AND ALLOYING OF ALUMINUM	180	414	354	948
223	ALUMINUM SHEET, PLATE, AND FOIL MANUFACTURING	29	44	58	131
224	OTHER ALUMINUM ROLLING, DRAWING AND EXTRUDING	832	521	605	1,958
226	COPPER ROLLING, DRAWING, EXTRUDING AND ALLOYING	296	306	298	899
227	NONFERROUS METAL, EXCEPT COPPER AND ALUMINUM, SHAPING	57	29	40	126
228	SECONDARY PROCESSING OF OTHER NONFERROUS METALS	428	925	716	2,069
230	NONFERROUS METAL FOUNDRIES	1,805	782	1,272	3,859
395	WHOLESALE TRADE	4,925	2,515	3,669	11,109
406	RETAIL - MISCELLANEOUS STORE RETAILERS	5,535	580	987	7,101
460	MARKETING RESEARCH AND ALL OTHER MISCELLANEOUS PROFESSIONAL, SCIENTIFIC, AND TECHNICAL SERVICES	331	49	124	503
471	WASTE MANAGEMENT AND REMEDIATION SERVICES	2,835	1,635	1,798	6,267
506	ELECTRONIC AND PRECISION EQUIPMENT REPAIR AND MAINTENANCE	821	182	440	1,443
	TOTAL	**35,131**	**25,971**	**29,002**	**90,103**

*Since the 2012 business Census was conducted glass manufacturing operations in the state of Michigan have entirely closed so that there is no longer any employment in that industry in Michigan.

Table 12 displays the estimated labor income effects in IMPLAN RRR business sectors. The table does not include the labor income from the other IMPLAN sectors that are directly related to the RRR industry in Michigan.

Table 12: Labor Income Effects of RRR Sectors (IMPLAN sector names do not always match NAICS Code descriptions)

SECTOR NUMBER	IMPLAN DESCRIPTION	DIRECT	INDIRECT	INDUCED	TOTAL
142	WOOD CONTAINER AND PALLET MANUFACTURING	$49,517,736	$21,457,568	$19,930,907	$90,906,211
146	PULP MILLS	$2,490,393	$3,498,018	$1,753,125	$7,741,536
147	PAPER MILLS	$123,188,731	$142,907,394	$77,783,299	$343,879,424
153	ALL OTHER CONVERTED PAPER PRODUCT MANUFACTURING	$23,039,021	$14,268,666	$10,948,100	$48,255,787
157	ASPHALT PAVING MIXTURE AND BLOCK MANUFACTURING	$105,605,889	$14,617,883	$32,600,749	$152,824,521
171	FERTILIZER MIXING	$2,677,428	$2,381,445	$1,456,532	$6,515,405

185	CUSTOM COMPOUNDING OF PURCHASED RESINS	$9,730,318	$7,407,936	$5,011,102	$22,149,355
188	PLASTICS PACKAGING MATERIALS AND UNLAMINATED FILM AND SHEET MANUFACTURING	$23,450,167	$13,338,466	$10,674,855	$47,463,488
189	UNLAMINATED PLASTICS PROFILE SHAPE MANUFACTURING	$11,020,765	$8,555,039	$5,681,088	$25,256,892
190	PLASTICS PIPE AND PIPE FITTING MANUFACTURING	$12,310,756	$7,799,177	$5,828,312	$25,938,246
191	LAMINATED PLASTICS PLATE, SHEET (EXCEPT PACKAGING), AND SHAPE MANUFACTURING	$3,078,649	$1,239,867	$1,254,301	$5,572,817
192	POLYSTYRENE FOAM PRODUCT MANUFACTURING	$11,082,284	$5,696,425	$4,875,532	$21,654,242
193	URETHANE AND OTHER FOAM PRODUCT (EXCEPT POLYSTYRENE) MANUFACTURING	$21,656,923	$12,486,365	$9,906,672	$44,049,960
194	PLASTICS BOTTLE MANUFACTURING	$12,986,385	$3,521,341	$4,802,183	$21,309,909
195	OTHER PLASTICS PRODUCT MANUFACTURING	$376,505,912	$189,634,490	$164,344,229	$730,484,631
196	TIRE MANUFACTURING	$17,082,807	$9,024,151	$7,535,093	$33,642,051
197	RUBBER AND PLASTICS HOSES AND BELTING MANUFACTURING	$51,720,565	$26,573,065	$22,641,923	$100,935,553
198	OTHER RUBBER PRODUCT MANUFACTURING	$112,992,146	$62,519,191	$50,786,126	$226,297,464
203	GLASS CONTAINER MANUFACTURING	$0	$0	$0	$0
217	IRON AND STEEL MILLS AND FERROALLOY MANUFACTURING	$618,233,762	$728,664,542	$421,467,571	$1,768,365,875
222	SECONDARY SMELTING AND ALLOYING OF ALUMINUM	$20,769,245	$29,055,879	$16,326,099	$66,151,223
223	ALUMINUM SHEET, PLATE, AND FOIL MANUFACTURING	$6,073,076	$3,012,672	$2,692,242	$11,777,990
224	OTHER ALUMINUM ROLLING, DRAWING AND EXTRUDING	$59,152,612	$35,491,222	$27,932,741	$122,576,575
226	COPPER ROLLING, DRAWING, EXTRUDING AND ALLOYING	$24,181,380	$21,437,521	$13,730,733	$59,349,634

227	NONFERROUS METAL, EXCEPT COPPER AND ALUMINUM, SHAPING	$4,467,104	$1,976,231	$1,858,936	$8,302,271
228	SECONDARY PROCESSING OF OTHER NONFERROUS METALS	$40,372,512	$64,055,968	$33,023,702	$137,452,183
230	NONFERROUS METAL FOUNDRIES	$148,656,453	$52,733,189	$58,694,159	$260,083,801
395	WHOLESALE TRADE	$432,862,877	$149,742,442	$169,273,984	$751,879,303
406	RETAIL - MISCELLANEOUS STORE RETAILERS	$125,304,542	$31,384,515	$45,499,981	$202,189,038
460	MARKETING RESEARCH AND ALL OTHER MISCELLANEOUS PROFESSIONAL, SCIENTIFIC, AND TECHNICAL SERVICES	$17,303,145	$2,655,956	$5,693,331	$25,652,431
471	WASTE MANAGEMENT AND REMEDIATION SERVICES	$190,288,506	$96,544,848	$82,974,104	$369,807,458
506	ELECTRONIC AND PRECISION EQUIPMENT REPAIR AND MAINTENANCE	$59,508,101	$9,916,708	$20,281,153	$89,705,962
	TOTAL	**$2,717,310,190**	**$1,773,598,181**	**$1,337,262,866**	**$5,828,171,237**

Table 13 displays the estimated "value added" effects in the IMPLAN RRR business sectors. The table excludes effects from the other IMPLAN sectors that are directly related to the RRR industry in Michigan.

Table 13: Value Added Effects of RRR Sectors (IMPLAN sector names do not always match NAICS Code descriptions)

SECTOR NUMBER	IMPLAN DESCRIPTION	DIRECT	INDIRECT	INDUCED	TOTAL
142	WOOD CONTAINER AND PALLET MANUFACTURING	$51,895,916	$30,808,107	$34,989,694	$117,693,717
146	PULP MILLS	$3,470,837	$5,055,091	$3,043,467	$11,569,395
147	PAPER MILLS	$218,699,723	$211,871,506	$135,026,695	$565,597,924
153	ALL OTHER CONVERTED PAPER PRODUCT MANUFACTURING	$29,017,802	$21,398,212	$19,003,334	$69,419,348
157	ASPHALT PAVING MIXTURE AND BLOCK MANUFACTURING	$119,697,052	$27,170,528	$56,714,449	$203,582,029
171	FERTILIZER MIXING	$3,652,591	$3,949,079	$2,529,688	$10,131,358
185	CUSTOM COMPOUNDING OF PURCHASED RESINS	$15,715,372	$11,266,073	$8,698,727	$35,680,172
188	PLASTICS PACKAGING MATERIALS AND	$35,536,823	$20,068,299	$18,535,206	$74,140,328

	UNLAMINATED FILM AND SHEET MANUFACTURING				
189	UNLAMINATED PLASTICS PROFILE SHAPE MANUFACTURING	$19,050,108	$12,667,825	$9,863,783	$41,581,716
190	PLASTICS PIPE AND PIPE FITTING MANUFACTURING	$21,732,477	$11,826,397	$10,121,703	$43,680,577
191	LAMINATED PLASTICS PLATE, SHEET (EXCEPT PACKAGING), AND SHAPE MANUFACTURING	$5,294,281	$1,940,996	$2,177,769	$9,413,046
192	POLYSTYRENE FOAM PRODUCT MANUFACTURING	$17,221,139	$8,441,032	$8,464,075	$34,126,247
193	URETHANE AND OTHER FOAM PRODUCT (EXCEPT POLYSTYRENE) MANUFACTURING	$32,041,058	$19,062,523	$17,201,274	$68,304,855
194	PLASTICS BOTTLE MANUFACTURING	$21,653,513	$5,577,717	$8,336,201	$35,567,431
195	OTHER PLASTICS PRODUCT MANUFACTURING	$450,040,905	$280,199,569	$285,356,096	$1,015,596,570
196	TIRE MANUFACTURING	$21,745,548	$13,330,593	$13,088,037	$48,164,178
197	RUBBER AND PLASTICS HOSES AND BELTING MANUFACTURING	$73,767,075	$38,868,278	$39,313,903	$151,949,256
198	OTHER RUBBER PRODUCT MANUFACTURING	$161,495,801	$90,490,577	$88,178,115	$340,164,493
203	GLASS CONTAINER MANUFACTURING	$0	$0	$0	$0
217	IRON AND STEEL MILLS AND FERROALLOY MANUFACTURING	$1,012,805,842	$1,164,727,476	$731,294,666	$2,908,827,983
222	SECONDARY SMELTING AND ALLOYING OF ALUMINUM	$31,719,667	$46,203,806	$28,319,912	$106,243,384
223	ALUMINUM SHEET, PLATE, AND FOIL MANUFACTURING	$7,007,192	$4,534,487	$4,677,347	$16,219,025
224	OTHER ALUMINUM ROLLING, DRAWING AND EXTRUDING	$63,838,907	$53,712,897	$48,486,052	$166,037,857
226	COPPER ROLLING, DRAWING, EXTRUDING AND ALLOYING	$39,215,752	$34,098,085	$23,832,741	$97,146,579
227	NONFERROUS METAL, EXCEPT COPPER AND ALUMINUM, SHAPING	$5,630,869	$2,985,287	$3,228,556	$11,844,712
228	SECONDARY PROCESSING OF OTHER NONFERROUS METALS	$116,180,854	$98,020,301	$57,300,335	$271,501,489

230	NONFERROUS METAL FOUNDRIES	$189,270,424	$75,575,249	$101,885,247	$366,730,919
395	WHOLESALE TRADE	$806,236,014	$232,920,199	$293,915,921	$1,333,072,134
406	RETAIL - MISCELLANEOUS STORE RETAILERS	$153,510,825	$56,144,057	$79,026,531	$288,681,412
460	MARKETING RESEARCH AND ALL OTHER MISCELLANEOUS PROFESSIONAL, SCIENTIFIC, AND TECHNICAL SERVICES	$15,237,463	$4,154,486	$9,895,448	$29,287,396
471	WASTE MANAGEMENT AND REMEDIATION SERVICES	$275,202,333	$145,867,737	$144,033,040	$565,103,110
506	ELECTRONIC AND PRECISION EQUIPMENT REPAIR AND MAINTENANCE	$82,593,143	$16,603,929	$35,225,939	$134,423,010
	Total	**$4,100,177,304**	**$2,749,540,398**	**$2,321,763,948**	**$9,171,481,650**

Finally, Table 14 displays the estimated total economic output of the RRR IMPLAN business sectors. The table does not include the effects from the other IMPLAN sectors that are directly related to the RRR industry in Michigan.

Table 14: Total Economic Output of RRR Sectors (IMPLAN Sector Names Do Not Always Match NAICS Code Descriptions)

SECTOR NUMBER	IMPLAN DESCRIPTION	DIRECT	INDIRECT	INDUCED	TOTAL
142	WOOD CONTAINER AND PALLET MANUFACTURING	$146,560,697	$64,741,121	$62,405,767	$273,707,585
146	PULP MILLS	$17,070,388	$9,765,107	$5,296,811	$32,132,306
147	PAPER MILLS	$875,230,906	$407,557,282	$235,012,138	$1,517,800,326
153	ALL OTHER CONVERTED PAPER PRODUCT MANUFACTURING	$102,169,683	$40,373,188	$33,077,821	$175,620,693
157	ASPHALT PAVING MIXTURE AND BLOCK MANUFACTURING	$208,867,857	$48,230,558	$98,518,871	$355,617,285
171	FERTILIZER MIXING	$20,353,001	$6,922,706	$4,401,086	$31,676,794
185	CUSTOM COMPOUNDING OF PURCHASED RESINS	$65,633,229	$23,133,641	$15,140,849	$103,907,719
188	PLASTICS PACKAGING MATERIALS AND UNLAMINATED FILM AND SHEET MANUFACTURING	$126,694,751	$41,345,881	$32,254,757	$200,295,389
189	UNLAMINATED PLASTICS PROFILE SHAPE MANUFACTURING	$63,807,052	$24,757,857	$17,165,698	$105,730,607
190	PLASTICS PIPE AND PIPE FITTING MANUFACTURING	$75,604,624	$24,338,699	$17,610,828	$117,554,152
191	LAMINATED PLASTICS PLATE, SHEET (EXCEPT PACKAGING), AND SHAPE MANUFACTURING	$13,458,155	$3,887,159	$3,789,934	$21,135,248

192	POLYSTYRENE FOAM PRODUCT MANUFACTURING	$52,953,737	$17,306,429	$14,731,543	$84,991,709
193	URETHANE AND OTHER FOAM PRODUCT (EXCEPT POLYSTYRENE) MANUFACTURING	$115,823,635	$37,573,802	$29,933,632	$183,331,070
194	PLASTICS BOTTLE MANUFACTURING	$45,765,752	$11,710,631	$14,509,839	$71,986,223
195	OTHER PLASTICS PRODUCT MANUFACTURING	$1,499,453,921	$555,434,586	$496,576,061	$2,551,464,568
196	TIRE MANUFACTURING	$78,356,561	$24,247,845	$22,768,289	$125,372,696
197	RUBBER AND PLASTICS HOSES AND BELTING MANUFACTURING	$204,769,072	$71,860,737	$68,413,997	$345,043,805
198	OTHER RUBBER PRODUCT MANUFACTURING	$488,545,401	$174,067,535	$153,452,778	$816,065,714
203	GLASS CONTAINER MANUFACTURING	$0	$0	$0	$0
217	IRON AND STEEL MILLS AND FERROALLOY MANUFACTURING	$4,797,319,914	$2,226,682,871	$1,272,950,688	$8,296,953,472
222	SECONDARY SMELTING AND ALLOYING OF ALUMINUM	$171,054,962	$87,459,935	$49,298,401	$307,813,298
223	ALUMINUM SHEET, PLATE, AND FOIL MANUFACTURING	$27,342,093	$8,800,671	$8,133,979	$44,276,743
224	OTHER ALUMINUM ROLLING, DRAWING AND EXTRUDING	$349,066,680	$108,096,221	$84,391,434	$541,554,335
226	COPPER ROLLING, DRAWING, EXTRUDING AND ALLOYING	$249,956,456	$60,376,644	$41,479,156	$351,812,256
227	NONFERROUS METAL, EXCEPT COPPER AND ALUMINUM, SHAPING	$23,546,577	$5,528,308	$5,616,982	$34,691,867
228	SECONDARY PROCESSING OF OTHER NONFERROUS METALS	$503,024,666	$182,682,568	$99,735,744	$785,442,978
230	NONFERROUS METAL FOUNDRIES	$441,613,839	$142,359,991	$177,338,402	$761,312,232
395	WHOLESALE TRADE	$1,185,700,023	$387,419,720	$511,472,054	$2,084,591,798
406	RETAIL - MISCELLANEOUS STORE RETAILERS	$240,656,507	$93,881,122	$137,484,018	$472,021,647
460	MARKETING RESEARCH AND ALL OTHER MISCELLANEOUS PROFESSIONAL, SCIENTIFIC, AND TECHNICAL SERVICES	$22,849,954	$6,861,750	$17,204,007	$46,915,710
471	WASTE MANAGEMENT AND REMEDIATION SERVICES	$594,436,647	$259,890,228	$250,706,709	$1,105,033,584
506	ELECTRONIC AND PRECISION EQUIPMENT REPAIR AND MAINTENANCE	$120,986,893	$27,412,210	$61,282,185	$209,681,288
	TOTAL	**$12,928,673,635**	**$5,184,707,002**	**$4,042,154,458**	**$22,155,535,094**

Economic Analysis from Tripling the Recycling Rate

RRS evaluated the impact on Michigan's economy if the recycling rate were tripled from 15% to 45%. At a 45% recycling rate in total, approximately 52,446 jobs in Michigan would be directly related to work in the recycling, reuse, and recovery industry and another 85,457 jobs would be created that are indirectly related to RRR or induced from the RRR industries. In total the Michigan economy would support 137,903 jobs that are directly, indirectly, or induced as a result of the recycling and recovery sectors, so that if all the jobs created by the industry were in the same city, it would be the third largest city in the state. The total labor income for a tripled recycling rate is $9.1 billion, total value added is $14.1 billion, and the total economic output is $33.8 billion. In all, these equate to 3.3% of the total Michigan economy, roughly a 1.1% increase in the economic share from a 15% recycling rate.

Table 15: Direct, indirect and induced impacts of RRR in Michigan if the recycling rate were tripled

IMPACT TYPE	EMPLOYMENT	LABOR INCOME	TOTAL VALUE ADDED	OUTPUT
DIRECT EFFECT	52,446	$4,272,603,554	$6,299,181,229	$19,579,793,334
INDIRECT EFFECT	40,572	$2,740,402,182	$4,219,108,533	$7,949,373,926
INDUCED EFFECT	44,885	$2,070,980,979	$3,595,345,945	$6,256,828,180
TOTAL EFFECT	**137,903**	**$9,083,986,715**	**$14,113,635,707**	**$33,785,995,440**

Breaking down the aggregate data, the below tables out the direct, indirect, induced, and total impact of each RRR related sector for employment, labor income, total value added, and out.

Table 16: Employment Effects of RRR Sector

SECTOR NUMBER	IMPLAN DESCRIPTION	DIRECT	INDIRECT	INDUCED	TOTAL
142	WOOD CONTAINER AND PALLET MANUFACTURING	1,925	729	1,023	3,677
146	PULP MILLS	84	184	123	391
147	PAPER MILLS	3,607	6,810	5,501	15,918
153	ALL OTHER CONVERTED PAPER PRODUCT MANUFACTURING	1,058	665	774	2,497
157	ASPHALT PAVING MIXTURE AND BLOCK MANUFACTURING	571	663	2,314	3,548
171	FERTILIZER MIXING	269	248	230	747
185	CUSTOM COMPOUNDING OF PURCHASED RESINS	191	137	162	490
188	PLASTICS PACKAGING MATERIALS AND UNLAMINATED FILM AND SHEET MANUFACTURING	434	287	344	1,065
189	UNLAMINATED PLASTICS PROFILE SHAPE MANUFACTURING	230	189	184	603
190	PLASTICS PIPE AND PIPE FITTING MANUFACTURING	250	167	188	605
191	LAMINATED PLASTICS PLATE, SHEET (EXCEPT PACKAGING), AND SHAPE MANUFACTURING	66	26	41	133
192	POLYSTYRENE FOAM PRODUCT MANUFACTURING	230	131	157	518
193	URETHANE AND OTHER FOAM PRODUCT (EXCEPT POLYSTYRENE) MANUFACTURING	482	270	319	1,072

194	PLASTICS BOTTLE MANUFACTURING	119	71	155	345
195	OTHER PLASTICS PRODUCT MANUFACTURING	7,910	4,173	5,295	17,378
196	TIRE MANUFACTURING	205	164	163	532
197	RUBBER AND PLASTICS HOSES AND BELTING MANUFACTURING	703	400	491	1,594
198	OTHER RUBBER PRODUCT MANUFACTURING	1,573	974	1,101	3,647
203	GLASS CONTAINER MANUFACTURING	0	0	0	0
217	IRON AND STEEL MILLS AND FERROALLOY MANUFACTURING	5,970	11,214	10,385	27,568
222	SECONDARY SMELTING AND ALLOYING OF ALUMINUM	283	651	556	1,490
223	ALUMINUM SHEET, PLATE, AND FOIL MANUFACTURING	45	68	91	203
224	OTHER ALUMINUM ROLLING, DRAWING AND EXTRUDING	1,310	821	953	3,083
226	COPPER ROLLING, DRAWING, EXTRUDING AND ALLOYING	296	306	298	899
227	NONFERROUS METAL, EXCEPT COPPER AND ALUMINUM, SHAPING	57	29	40	126
228	SECONDARY PROCESSING OF OTHER NONFERROUS METALS	428	925	716	2,069
230	NONFERROUS METAL FOUNDRIES	1,805	782	1,272	3,859
395	WHOLESALE TRADE	4,973	2,540	3,705	11,218
406	RETAIL - MISCELLANEOUS STORE RETAILERS	5,568	583	993	7,144
460	MARKETING RESEARCH AND ALL OTHER MISCELLANEOUS PROFESSIONAL, SCIENTIFIC, AND TECHNICAL SERVICES	337	50	126	513
471	WASTE MANAGEMENT AND REMEDIATION SERVICES	10,630	6,130	6,740	23,500
506	ELECTRONIC AND PRECISION EQUIPMENT REPAIR AND MAINTENANCE	837	186	448	1,471
	TOTAL	**52,446**	**40,572**	**44,885**	**137,903**

Table 17 displays the estimated labor income effects in IMPLAN RRR business sectors. The table does not include the labor income from the other IMPLAN sectors that are directly related to the RRR industry in Michigan.

Table 17: Labor Income Effects of RRR Sectors (IMPLAN sector names do not always match NAICS Code descriptions)

SECTOR NUMBER	IMPLAN DESCRIPTION	DIRECT	INDIRECT	INDUCED	TOTAL
142	WOOD CONTAINER AND PALLET MANUFACTURING	$113,955,924	$48,820,558	$47,153,370	$209,929,853
146	PULP MILLS	$8,045,883	$11,301,288	$5,663,944	$25,011,115
147	PAPER MILLS	$402,119,232	$466,485,946	$253,904,398	$1,122,509,577

153	ALL OTHER CONVERTED PAPER PRODUCT MANUFACTURING	$75,232,358	$46,593,360	$35,750,277	$157,575,995
157	ASPHALT PAVING MIXTURE AND BLOCK MANUFACTURING	$344,576,930	$47,696,064	$106,371,587	$498,644,581
171	FERTILIZER MIXING	$19,465,627	$17,313,751	$10,589,380	$47,368,758
185	CUSTOM COMPOUNDING OF PURCHASED RESINS	$14,519,458	$11,054,029	$7,477,503	$33,050,991
188	PLASTICS PACKAGING MATERIALS AND UNLAMINATED FILM AND SHEET MANUFACTURING	$34,854,016	$19,824,980	$15,866,051	$70,545,047
189	UNLAMINATED PLASTICS PROFILE SHAPE MANUFACTURING	$16,459,584	$12,777,006	$8,484,742	$37,721,333
190	PLASTICS PIPE AND PIPE FITTING MANUFACTURING	$18,319,578	$11,605,919	$8,673,083	$38,598,580
191	LAMINATED PLASTICS PLATE, SHEET (EXCEPT PACKAGING), AND SHAPE MANUFACTURING	$4,617,973	$1,859,801	$1,881,452	$8,359,226
192	POLYSTYRENE FOAM PRODUCT MANUFACTURING	$16,444,680	$8,452,760	$7,234,661	$32,132,101
193	URETHANE AND OTHER FOAM PRODUCT (EXCEPT POLYSTYRENE) MANUFACTURING	$32,218,014	$18,575,395	$14,737,704	$65,531,113
194	PLASTICS BOTTLE MANUFACTURING	$19,317,248	$5,237,994	$7,143,247	$31,698,489
195	OTHER PLASTICS PRODUCT MANUFACTURING	$559,699,636	$281,903,556	$244,307,996	$1,085,911,188
196	TIRE MANUFACTURING	$17,082,807	$9,024,151	$7,535,093	$33,642,051
197	RUBBER AND PLASTICS HOSES AND BELTING MANUFACTURING	$51,720,565	$26,573,065	$22,641,923	$100,935,553
198	OTHER RUBBER PRODUCT MANUFACTURING	$112,992,146	$62,519,191	$50,786,126	$226,297,464
203	GLASS CONTAINER MANUFACTURING	$0	$0	$0	$0
217	IRON AND STEEL MILLS AND FERROALLOY MANUFACTURING	$703,154,041	$828,753,537	$479,360,144	$2,011,267,722
222	SECONDARY SMELTING AND ALLOYING OF ALUMINUM	$32,653,868	$45,682,299	$25,668,255	$104,004,423
223	ALUMINUM SHEET, PLATE, AND FOIL MANUFACTURING	$9,423,738	$4,674,836	$4,177,616	$18,276,191
224	OTHER ALUMINUM ROLLING, DRAWING AND EXTRUDING	$93,136,925	$55,881,612	$43,980,638	$192,999,175
226	COPPER ROLLING, DRAWING, EXTRUDING AND ALLOYING	$24,181,380	$21,437,521	$13,730,733	$59,349,634
227	NONFERROUS METAL, EXCEPT COPPER AND ALUMINUM, SHAPING	$4,467,104	$1,976,231	$1,858,936	$8,302,271
228	SECONDARY PROCESSING OF OTHER NONFERROUS METALS	$40,372,512	$64,055,968	$33,023,702	$137,452,183
230	NONFERROUS METAL FOUNDRIES	$148,656,453	$52,733,189	$58,694,159	$260,083,801

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395	WHOLESALE TRADE	$437,081,642	$151,201,861	$170,923,761	$759,207,264
406	RETAIL - MISCELLANEOUS STORE RETAILERS	$126,051,615	$31,571,631	$45,771,255	$203,394,502
460	MARKETING RESEARCH AND ALL OTHER MISCELLANEOUS PROFESSIONAL, SCIENTIFIC, AND TECHNICAL SERVICES	$17,616,797	$2,704,100	$5,796,533	$26,117,430
471	WASTE MANAGEMENT AND REMEDIATION SERVICES	$713,497,997	$362,000,613	$311,116,305	$1,386,614,915
506	ELECTRONIC AND PRECISION EQUIPMENT REPAIR AND MAINTENANCE	$60,667,821	$10,109,969	$20,676,401	$91,454,190
	TOTAL	**$4,272,603,554**	**$2,740,402,182**	**$2,070,980,979**	**$9,083,986,715**

Table 18 displays the estimated "value added" effects in the IMPLAN RRR business sectors. The table excludes effects from the other IMPLAN sectors that are directly related to the RRR industry in Michigan.

Table 18: Value Added Effects of RRR Sectors (IMPLAN sector names do not always match NAICS Code descriptions)

SECTOR NUMBER	IMPLAN DESCRIPTION	DIRECT	INDIRECT	INDUCED	TOTAL
142	WOOD CONTAINER AND PALLET MANUFACTURING	$122,152,425	$70,053,030	$81,893,710	$274,099,165
146	PULP MILLS	$11,213,472	$16,331,833	$9,832,740	$37,378,045
147	PAPER MILLS	$713,891,312	$691,602,283	$440,761,347	$1,846,254,942
153	ALL OTHER CONVERTED PAPER PRODUCT MANUFACTURING	$94,755,662	$69,874,408	$62,054,096	$226,684,166
157	ASPHALT PAVING MIXTURE AND BLOCK MANUFACTURING	$390,554,381	$88,653,552	$185,051,144	$664,259,077
171	FERTILIZER MIXING	$26,555,323	$28,710,873	$18,391,513	$73,657,709
185	CUSTOM COMPOUNDING OF PURCHASED RESINS	$23,450,282	$16,811,094	$12,980,131	$53,241,507
188	PLASTICS PACKAGING MATERIALS AND UNLAMINATED FILM AND SHEET MANUFACTURING	$52,818,429	$29,827,541	$27,548,902	$110,194,871
189	UNLAMINATED PLASTICS PROFILE SHAPE MANUFACTURING	$28,451,460	$18,919,479	$14,731,624	$62,102,563
190	PLASTICS PIPE AND PIPE FITTING MANUFACTURING	$32,339,995	$17,598,805	$15,062,059	$65,000,858
191	LAMINATED PLASTICS PLATE, SHEET (EXCEPT PACKAGING), AND SHAPE MANUFACTURING	$7,941,421	$2,911,494	$3,266,653	$14,119,568
192	POLYSTYRENE FOAM PRODUCT MANUFACTURING	$25,553,949	$12,525,402	$12,559,596	$50,638,947
193	URETHANE AND OTHER FOAM PRODUCT (EXCEPT POLYSTYRENE) MANUFACTURING	$47,666,018	$28,358,445	$25,589,549	$101,614,013
194	PLASTICS BOTTLE MANUFACTURING	$32,209,600	$8,296,853	$12,400,100	$52,906,553

195	OTHER PLASTICS PRODUCT MANUFACTURING	$669,014,012	$416,534,221	$424,199,721	$1,509,747,955
196	TIRE MANUFACTURING	$21,745,548	$13,330,593	$13,088,037	$48,164,178
197	RUBBER AND PLASTICS HOSES AND BELTING MANUFACTURING	$73,767,075	$38,868,278	$39,313,903	$151,949,256
198	OTHER RUBBER PRODUCT MANUFACTURING	$161,495,801	$90,490,577	$88,178,115	$340,164,493
203	GLASS CONTAINER MANUFACTURING	$0	$0	$0	$0
217	IRON AND STEEL MILLS AND FERROALLOY MANUFACTURING	$1,151,924,343	$1,324,713,856	$831,744,933	$3,308,383,132
222	SECONDARY SMELTING AND ALLOYING OF ALUMINUM	$49,870,365	$72,642,650	$44,525,195	$167,038,210
223	ALUMINUM SHEET, PLATE, AND FOIL MANUFACTURING	$10,873,228	$7,036,273	$7,257,952	$25,167,453
224	OTHER ALUMINUM ROLLING, DRAWING AND EXTRUDING	$100,515,587	$84,571,990	$76,342,222	$261,429,799
226	COPPER ROLLING, DRAWING, EXTRUDING AND ALLOYING	$39,215,752	$34,098,085	$23,832,741	$97,146,579
227	NONFERROUS METAL, EXCEPT COPPER AND ALUMINUM, SHAPING	$5,630,869	$2,985,287	$3,228,556	$11,844,712
228	SECONDARY PROCESSING OF OTHER NONFERROUS METALS	$116,180,854	$98,020,301	$57,300,335	$271,501,489
230	NONFERROUS METAL FOUNDRIES	$189,270,424	$75,575,249	$101,885,247	$366,730,919
395	WHOLESALE TRADE	$814,093,746	$235,190,285	$296,780,482	$1,346,064,513
406	RETAIL - MISCELLANEOUS STORE RETAILERS	$154,426,066	$56,478,791	$79,497,692	$290,402,548
460	MARKETING RESEARCH AND ALL OTHER MISCELLANEOUS PROFESSIONAL, SCIENTIFIC, AND TECHNICAL SERVICES	$15,513,670	$4,229,793	$10,074,822	$29,818,286
471	WASTE MANAGEMENT AND REMEDIATION SERVICES	$1,031,887,406	$546,939,699	$540,060,393	$2,118,887,497
506	ELECTRONIC AND PRECISION EQUIPMENT REPAIR AND MAINTENANCE	$84,202,753	$16,927,513	$35,912,437	$137,042,703
	TOTAL	**$6,299,181,229**	**$4,219,108,533**	**$3,595,345,945**	**$14,113,635,707**

Finally, Table 19 displays the estimated total economic output of the RRR IMPLAN business sectors. The table does not include the effects from the other IMPLAN sectors that are directly related to the RRR industry in Michigan.

Table 19: Total Economic Output of RRR Sectors (IMPLAN Sector Names Do Not Always Match NAICS Code Descriptions)

SECTOR NUMBER	IMPLAN DESCRIPTION	DIRECT	INDIRECT	INDUCED	TOTAL
142	WOOD CONTAINER AND PALLET MANUFACTURING	$320,439,021	$138,169,607	$142,479,299	$601,087,927
146	PULP MILLS	$55,150,485	$31,548,806	$17,112,774	$103,812,065
147	PAPER MILLS	$2,856,975,454	$1,330,370,242	$767,139,170	$4,954,484,867

153	ALL OTHER CONVERTED PAPER PRODUCT MANUFACTURING	$333,628,163	$131,835,906	$108,013,379	$573,477,447
157	ASPHALT PAVING MIXTURE AND BLOCK MANUFACTURING	$681,505,978	$157,369,420	$321,453,001	$1,160,328,399
171	FERTILIZER MIXING	$147,971,818	$50,329,947	$31,997,087	$230,298,852
185	CUSTOM COMPOUNDING OF PURCHASED RESINS	$97,937,083	$34,519,731	$22,592,986	$155,049,800
188	PLASTICS PACKAGING MATERIALS AND UNLAMINATED FILM AND SHEET MANUFACTURING	$188,306,582	$61,452,439	$47,940,289	$297,699,310
189	UNLAMINATED PLASTICS PROFILE SHAPE MANUFACTURING	$95,296,247	$36,976,020	$25,637,082	$157,909,349
190	PLASTICS PIPE AND PIPE FITTING MANUFACTURING	$112,506,882	$36,218,303	$26,206,589	$174,931,773
191	LAMINATED PLASTICS PLATE, SHEET (EXCEPT PACKAGING), AND SHAPE MANUFACTURING	$20,187,232	$5,830,739	$5,684,901	$31,702,872
192	POLYSTYRENE FOAM PRODUCT MANUFACTURING	$78,576,513	$25,680,507	$21,859,709	$126,116,729
193	URETHANE AND OTHER FOAM PRODUCT (EXCEPT POLYSTYRENE) MANUFACTURING	$172,305,532	$55,896,829	$44,530,898	$272,733,259
194	PLASTICS BOTTLE MANUFACTURING	$68,076,557	$17,419,564	$21,583,385	$107,079,506
195	OTHER PLASTICS PRODUCT MANUFACTURING	$2,229,032,234	$825,688,324	$738,191,438	$3,792,911,996
196	TIRE MANUFACTURING	$78,356,561	$24,247,845	$22,768,289	$125,372,696
197	RUBBER AND PLASTICS HOSES AND BELTING MANUFACTURING	$204,769,072	$71,860,737	$68,413,997	$345,043,805
198	OTHER RUBBER PRODUCT MANUFACTURING	$488,545,401	$174,067,535	$153,452,778	$816,065,714
203	GLASS CONTAINER MANUFACTURING	$0	$0	$0	$0
217	IRON AND STEEL MILLS AND FERROALLOY MANUFACTURING	$5,456,277,364	$2,532,538,910	$1,447,802,5 54	$9,436,618,828
222	SECONDARY SMELTING AND ALLOYING OF ALUMINUM	$268,936,412	$137,506,453	$77,508,042	$483,950,907
223	ALUMINUM SHEET, PLATE, AND FOIL MANUFACTURING	$42,427,386	$13,656,213	$12,621,691	$68,705,290
224	OTHER ALUMINUM ROLLING, DRAWING AND EXTRUDING	$549,612,200	$170,199,579	$132,875,936	$852,687,715

226	COPPER ROLLING, DRAWING, EXTRUDING AND ALLOYING	$249,956,456	$60,376,644	$41,479,156	$351,812,256
227	NONFERROUS METAL, EXCEPT COPPER AND ALUMINUM, SHAPING	$23,546,577	$5,528,308	$5,616,982	$34,691,867
228	SECONDARY PROCESSING OF OTHER NONFERROUS METALS	$503,024,666	$182,682,568	$99,735,744	$785,442,978
230	NONFERROUS METAL FOUNDRIES	$441,613,839	$142,359,991	$177,338,402	$761,312,232
395	WHOLESALE TRADE	$1,197,256,085	$391,195,587	$516,456,959	$2,104,908,631
406	RETAIL - MISCELLANEOUS STORE RETAILERS	$242,091,316	$94,440,847	$138,303,706	$474,835,868
460	MARKETING RESEARCH AND ALL OTHER MISCELLANEOUS PROFESSIONAL, SCIENTIFIC, AND TECHNICAL SERVICES	$23,264,153	$6,986,132	$17,515,862	$47,766,146
471	WASTE MANAGEMENT AND REMEDIATION SERVICES	$2,228,875,328	$974,473,764	$940,039,619	$4,143,388,711
506	ELECTRONIC AND PRECISION EQUIPMENT REPAIR AND MAINTENANCE	$123,344,738	$27,946,431	$62,476,478	$213,767,647
	TOTAL	**$19,579,793,334**	**$7,949,373,926**	**$6,256,828,180**	**$33,785,995,440**

Comparisons to Other Industries

To put these RRR impacts into perspective, they were compared to the total economic activity in the state. The RRR industry accounts for 1.6% of the total employment in Michigan and 2.2% of the state's total economic output. A tripling of the recycling rate would increase the RRR industry impact to 2.4% of the total employment and 3.3% of the total economic output, a 0.8% and 1.1% increase respectively. Figure 4 compares the total economic output impacts of RRR at the current 15% recycling rate and if the recovery rate were increased to 45%

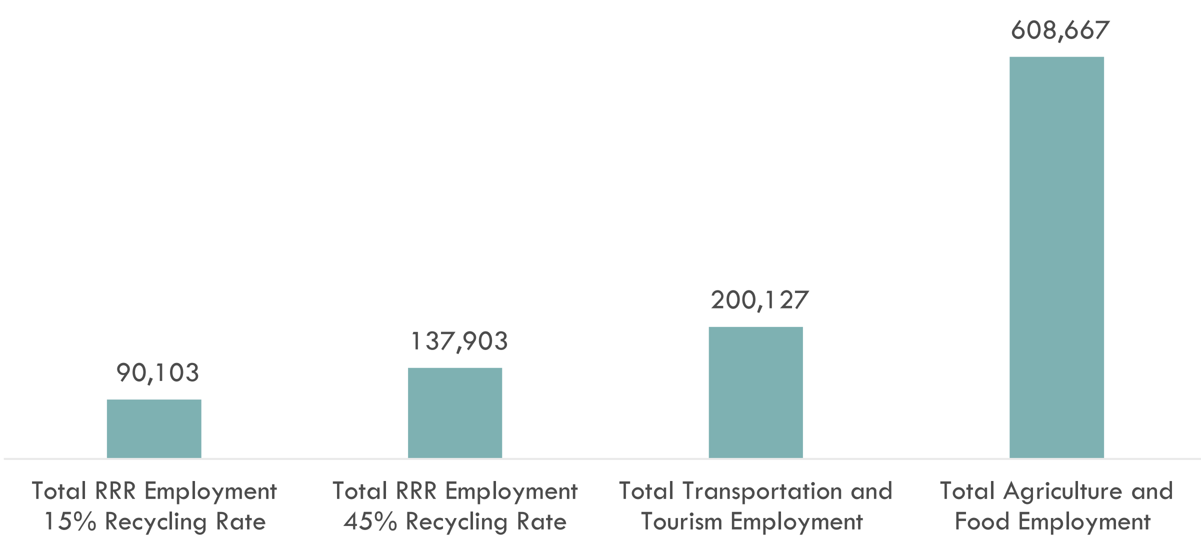
Figure 4: Total Economic Output at fir 15% Recovery

The RRR employment and total output was compared to employment and total output of the agricultural and food sectors (farming, food manufacturing, grocers, eateries) and the transportation and tourism sectors (air, train, and water transportation, casino, hotel, museums, etc.) in Michigan[3]. Both of those sectors are in the top 10 sectors for the state of Michigan, and according to IMPLAN model results agriculture and food account for 11% of total employment and 6% of total output in Michigan, and transportation accounts for 4% of total employment and tourism accounts for 2% of total output. If the recycling rate were tripled, the RRR industry would account for 3.3% of total output for the state of Michigan, overtaking the transportation and tourism output.

Table 20: Total Employment and Output for RRR, Transportation and Tourism, and Agriculture and Food Sectors in Michigan

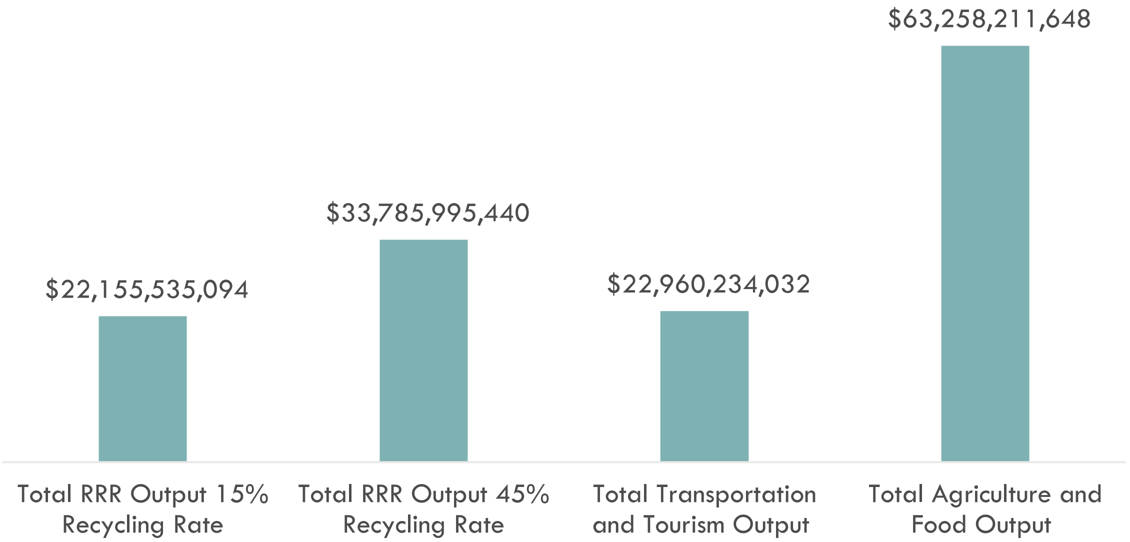
	TOTAL EMPLOYMENT	TOTAL OUTPUT
TOTAL RRR EMPLOYMENT 15% RECYCLING RATE	90,103	$ 22,155,535,094
TOTAL RRR EMPLOYMENT 45% RECYCLING RATE	137,903	$ 33,785,995,440
TOTAL TRANSPORTATION AND TOURISM EMPLOYMENT	200,127	$ 22,960,234,032
TOTAL AGRICULTURE AND FOOD EMPLOYMENT	608,667	$ 63,258,211,648

Table 21: Total Employment for the RRR, Transportation and Tourism, and Agriculture and Food Sectors in Michigan



[3] See appendix E for full list of sectors included in agriculture and food sectors and transportation and tourism sectors and IMPLAN employment and Total Output estimates. It is difficult to make a clear distinction between agricultural production and food manufacturing within the NAICS data available through IMPLAN.

Table 22: Total Output for the RRR, Transportation and Tourism, and Agriculture and Food Sectors in Michigan



THE MICHIGAN COMMODITIES MARKETPLACE

In order to understand the recycling marketplace from the perspective of those interviewed, RRS updated previously identified strengths and weaknesses of the Michigan recycling marketplace.

Strengths

BOTTLE BILL

Many of the experts we spoke with cited Michigan's bottle bill as a strength of the state's marketplace because it provides clean, local materials for processing.

MANDATORY REPORTING

The passage of SB507 legislation in March of 2016 requires reporting of recycling tonnages as a new strength of the Michigan marketplace because it provides data about recycling in the state. The State has published two annual reports that aggregates data on waste diversion and recycling collection for seven commonly recycled materials: paper, plastic, glass, ferrous and nonferrous metals, textiles, and single stream recyclables. This data provides a better picture of the recovery rate and the recyclable materials than was previously available in the State. The aggregation of the data, however, makes it difficult to understand the dynamics of the recovery infrastructure for both the collection and processing infrastructure and the development of end markets. There are several approaches that should be evaluated that would make the data more useful for planning purposes. These approaches include: 1) the data needs to be available on a regional level; 2) data should be broken out by residential and commercial sectors; 3) data should be aggregated by more specific commodity types i.e. PET, HDPE, and 4) efforts need to be made to account for and remove exempt construction & demolition debris from the MSW total, in order to better reflect a more accurate recovery rate.

COLLABORATION

Another strength is the ability of processors to network and develop relationships with end markets in the Michigan materials marketplace. This ability to develop relationships with other players in Michigan is a strength that not everyone in the state may be taking advantage of currently, but it is an action that EGLE could encourage and support.

FUNDING

With passage of the Renew Environmental Fund by the legislature in the fall of 2018, the State of Michigan now has an annual allocation of $15M that is intended to provide support for the development of programming and infrastructure to increase recycling.

YARD WASTE BAN

Michigan's yard waste ban, Public Act 264, in effect since 1995 has been a positive policy driver to divert yard waste from landfills creating a growing composting industry in the state.

Weaknesses

SINGLE STREAM

While one of Michigan's strengths is the cleanliness of the material available through the bottle deposit system, one of Michigan's weaknesses is the dirtiness of the state's single stream materials. Contaminants in single stream materials include shredded paper, general trash, food waste, batteries, porcelain, ceramic and Pyrex. Glass from single stream sources is so contaminated and with a negative value that some programs are removing it from their accepted materials list. MRFs that process dual-stream materials have weathered the market down-turn more effectively and had no problems moving all recyclables collected during this downturn.

LACK OF INFRASTRUCTURE

There are large parts of the state without processing infrastructure or with infrastructure in need of upgrade, expansion, or increased automation to improve both throughput and quality of materials. Providing facilitation among businesses and a hub and spoke structure for these areas may prove helpful.

LOW TIP FEES

Disposal costs in Michigan, impacted by excess landfill capacity, has resulted in extremely low tip fees at the landfill, which results in recycling programs competing with, not other recyclers, but landfills.

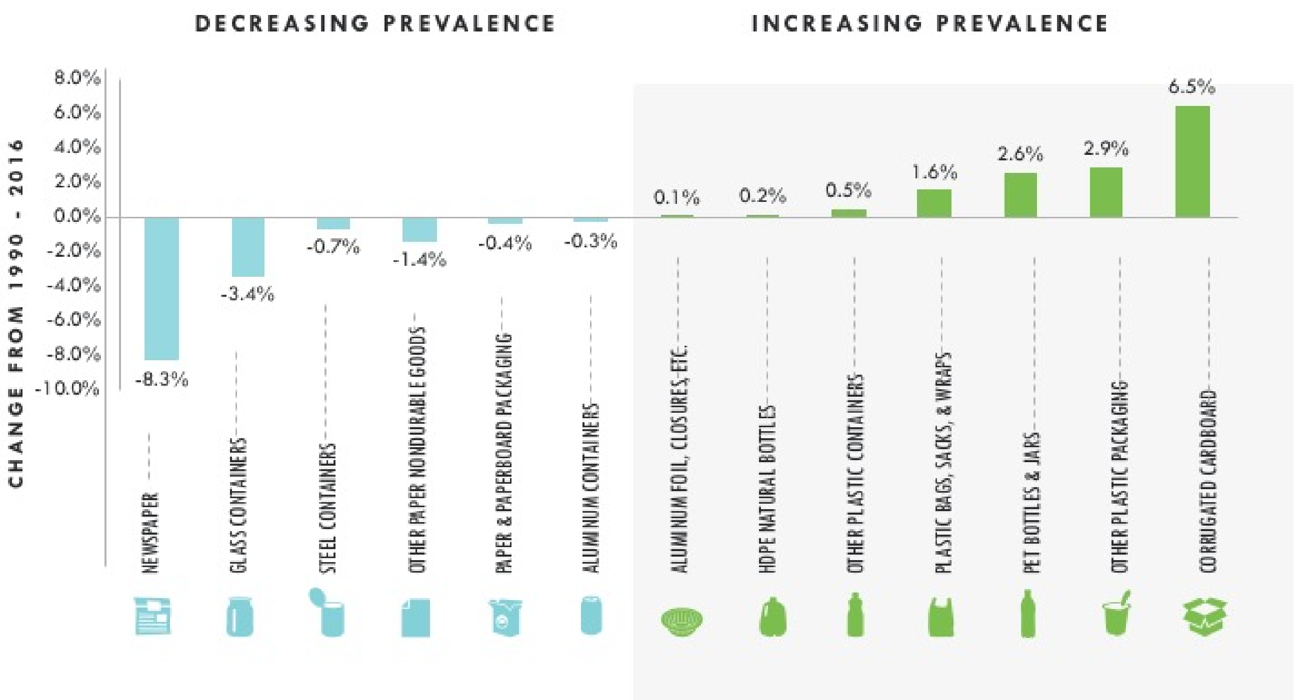
LACK OF DATA

The quality of recycling data is still a weakness in Michigan. There is a lack of data describing curbside performance, so it is difficult to set a strategy on how to improve recycling in Michigan. Data collection is paramount to increasing volumes collected and improving education efforts. Auditing of recycling carts to determine the composition of what households are putting in their carts is related to the issue of high contamination of recyclables when people put non-recyclable materials in the collection carts or bins (wish-cycling). Data that is only available in aggregated form over large regions of the state makes it difficult to analyze and target supply chain system gaps and recommend region-specific remedies.

The Future of Recycling

A major consideration that complicates the development of a processing facilities and the improvement in the amount of contamination in commodities marketed from MRFs 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 has played a major role in changing the composition of our recycling stream by reducing the absolute volume of newspaper and office paper.

Figure 5: 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).

To achieve higher diversion of materials will require the development of additional sorting abilities and marketing capacity in the region. The number of products produced is a choice of the operator, based on trade-offs among several factors including, marketability, price, cost of production and environmental values. For example, white office paper can be extracted from a mixed residential sort as part of Sorted Residential Papers and News (SRPN), part of a mixed paper grade, part of sorted office paper (SOP), or sorted white ledger (SWL). MRF operators can usually select how the fiber in the feedstock gets divided into end products.

Another factor in selecting what products to produce is the evolution of the consuming fiber mills. While recent single stream MRFs are now able to produce very clean SRPN, mills have also adapted to work well with a wider range of feedstock. Few mills can afford to refuse SRPN and few if any offer a premium price based on origin. Some mills will pay a premium based on long-term consistent high quality, regardless of the MRF technology.

RECYCLED COMMODITIES MARKET ASSESSMENT

This section will provide the State of Michigan 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 Michigan 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 Michigan 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.

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.[4] China's long-term intention has long-been to become 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 Michigan 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 wastepaper 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[5] 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

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[4] Moore, Bill, "Global Recovered Paper Market Trends, International Molded Fiber Seminar", Vancouver, British Columbia, 13 April 2016
[5] 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

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."[6] This practice is now being implemented in the U.S. Regulators in Oregon are allowing processors to landfill bales of mixed paper and plastic.[7]

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.[8] 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.

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."[9]

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

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

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

[8] IBID

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

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.

Commodity Markets
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% related to the Chinese commodity quality controls, and orders which are not discounted are now 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 several 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 2019 and into 2020. 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 with 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)

While RRS sees harsh market conditions for Mixed Paper (MP) nationally, the Midwest benefits from having 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. Low to negative pricing is expected for the next 12-18 months.

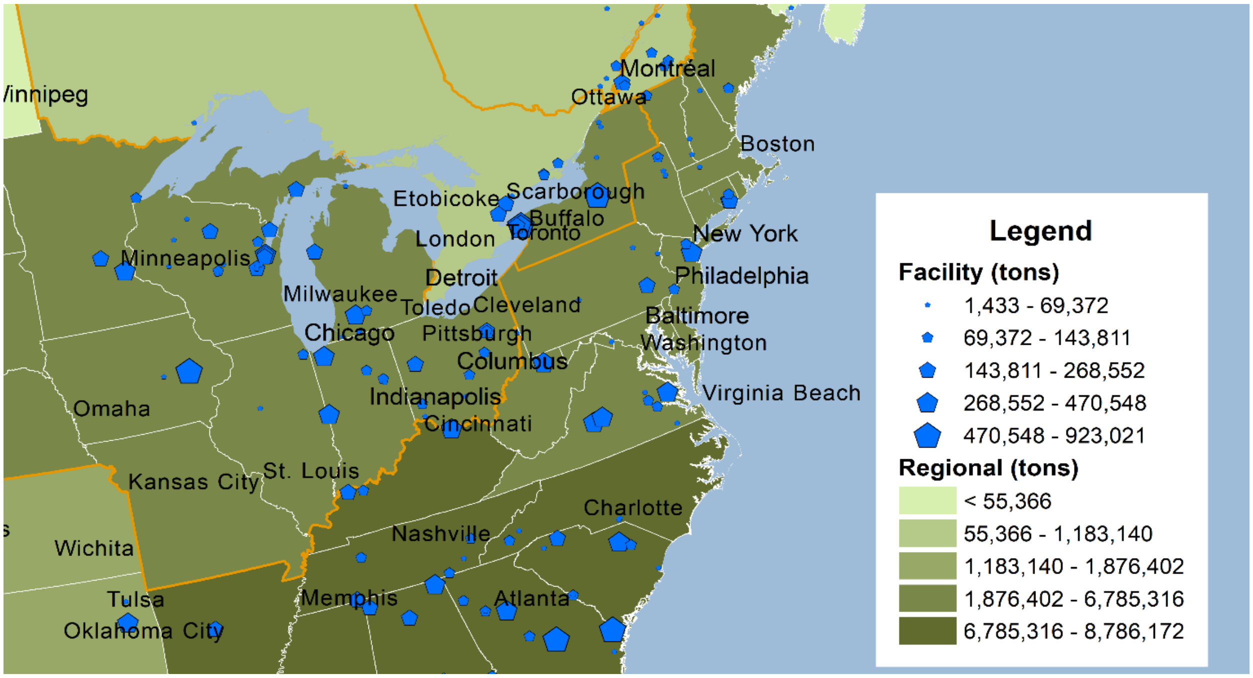
Mixed paper in current quantities in North America are a direct result of the spread of modern curbside Single Stream programs, the evolving ton, and Chinese demand. Design of sorting plants unfortunately keyed on MP as one of its growing outputs. As has been demonstrated, Single Stream commodities have 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 carton board/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, OH will have a capacity of 400,000 tons of corrugated medium and linerboard made from 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 Michigan. The other 10% would be sold to third parties. This new facility will have a major impact on the ability of Michigan processors and brokers to market fiber.

Figure 6 identifies the end markets for all recovered fiber including OCC, News, and Mixed Paper that are available to Michigan 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 I.

Figure 6: 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)

While HDPE enjoys relative stability compared to other plastic resins, RRS expects the potential for some decline in price, particularly of colored HDPE 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, flowerpots, 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. A recent spike in natural HDPE is likely the result of a large increase in brand recycled-content commitments. 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. There remains a growing demand in North America and abroad that has kept pace with supply increases. Michigan benefits from being home to Clean Tech, TABB and Plastipak, a supply chain for HDPE bottles and jugs for use in detergent bottles. Their strong demand for volume draws recyclables from throughout the Midwest.

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. There is also a move by EFS (Ontario and PN) to expand capacity for mixed plastics bales primarily to sort for PP in response to demand.

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. A number of plastics processors are expanding capacity in anticipation of the demand-pull from the brands committing to increasing PCR content.

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.

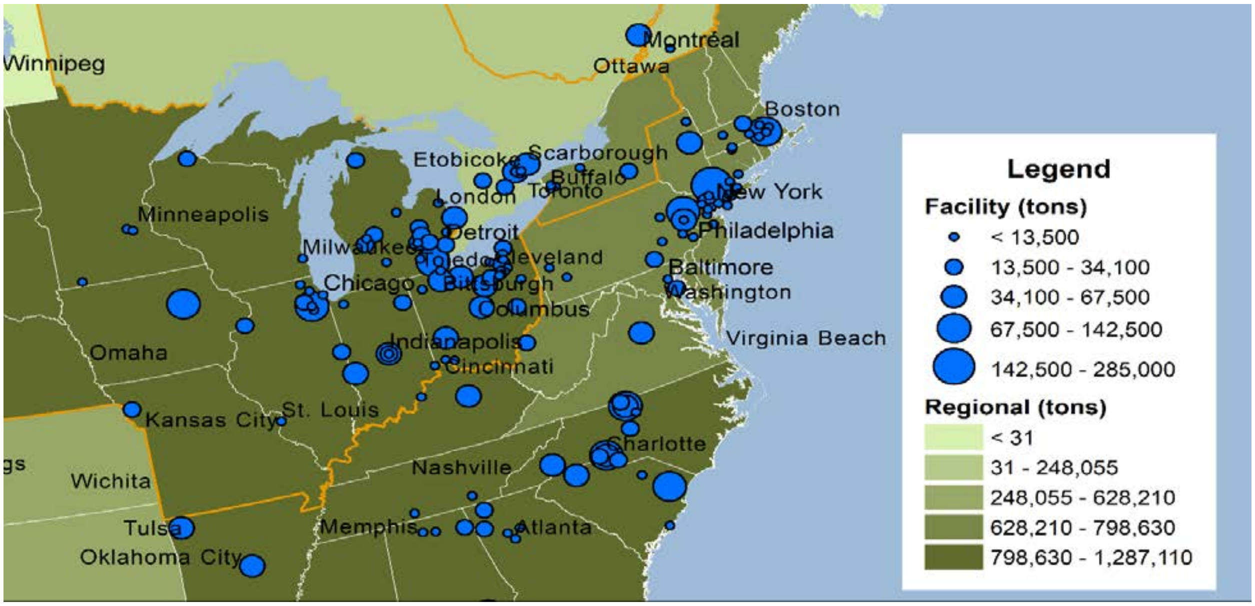
With markets in oversupply, most mixed plastics have no market, or sellers are paying more than the cost of landfilling for further processing and recovery. Any recovery of the mixed and post-consumer film is marginal as a result of Chinese import restrictions. The only movement at all is highly local 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 7 identifies the end markets for all plastics processors that are available to Michigan 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 Michigan, which are within reasonable and cost-effective haul distances from the state. A detailed list of plants is available in Appendix II.

Figure 7: 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.

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 53 cents per pound (delivered), down about 9 cents from January 2019 and much lower than the recent high of 77.5 cents per pound in July 2018. American Metal Market has reported that since then the world aluminum price, and all aluminum scrap has been struggling to maintain the upward momentum and multi-year highs seen in 2018 has been falling. Scrap processors are generally gloomy regarding the outlook for aluminum scrap markets at least through the end of 2019. Most sources mention an overall lack of domestic spot market orders as the biggest issue facing the aluminum sector as of mid-August 2019.

China slapped a 25% tariff on Aluminum scrap in 2018. The U.S. tariff taxes affix 25% onto the price of imported steel and 10% onto imported finished aluminum. Though UBC is not affected, it is bundled with other aluminum scrap grades in the market sentiment, as is the LME finished ingot pricing. Aluminum scrap markets continue to feel the effects of an imbalance between supply and demand. An imbalance between supply and demand has characterized the domestic aluminum scrap sector for more than a year, compressing margins for scrap dealers. Additionally, global trade lanes out of the U.S. have shifted in response to China's scrap import restrictions and that country's trade war with the U.S. that seems to have no end in sight. 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.

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. The soft domestic market has made some export markets more competitive on certain grades of aluminum scrap.

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. 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. Steel Cans that are densified have seen a dramatic drop in delivered price (average) drop to $95 per ton in July 2019 from a high of $180 per ton in April 2018.

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 prices again trended downward across the board, with U.S. HRC, HDG, CRC and plate declining. Plate posted the largest decline of the steel forms. In terms of production, U.S. steel production remains elevated over 2018 levels; through the first approximately nine months of the year, U.S. steel production was up 3% on a year-over-year basis. However, the steel sector's capacity utilization rate has inched downward, falling to 80.4% for the year through Oct. 5.

Steel cans have seen consistently falling prices in the good economy primarily due to the impact of tariffs and import/export quotas. Demand and price are expected to begin to increase through 2021 (Statista), provided regulatory actions (tariffs) are resolved 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 8 and 9 identify the end markets for all steel and aluminum plants that are available to generators in Michigan. 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 Michigan. 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 III and IV.

Figure 8: Recovered Steel Plants

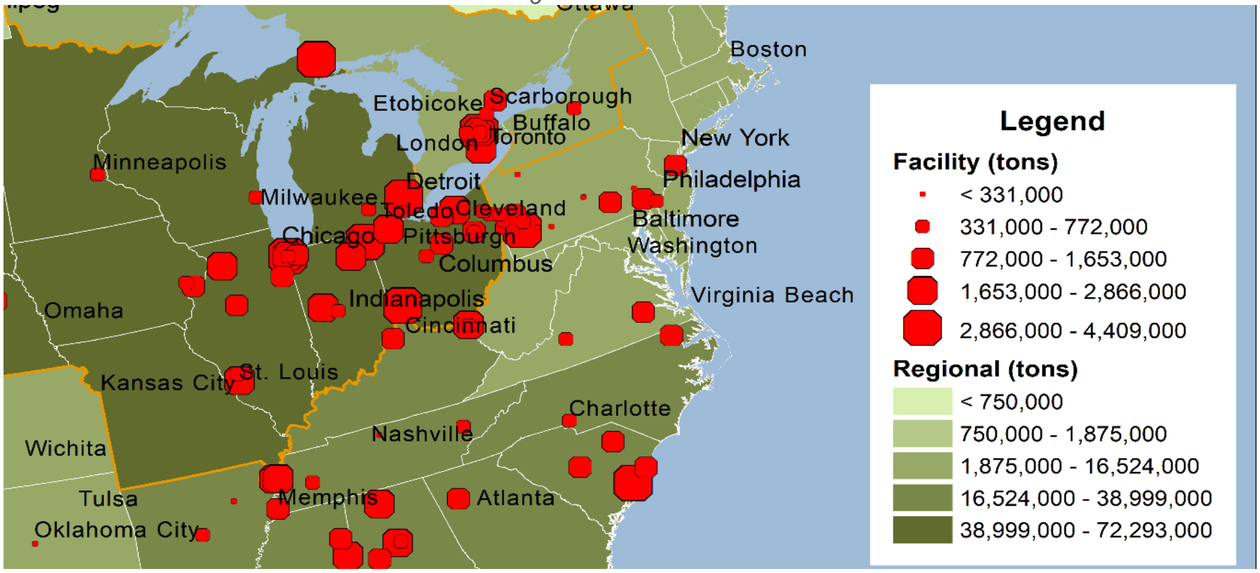
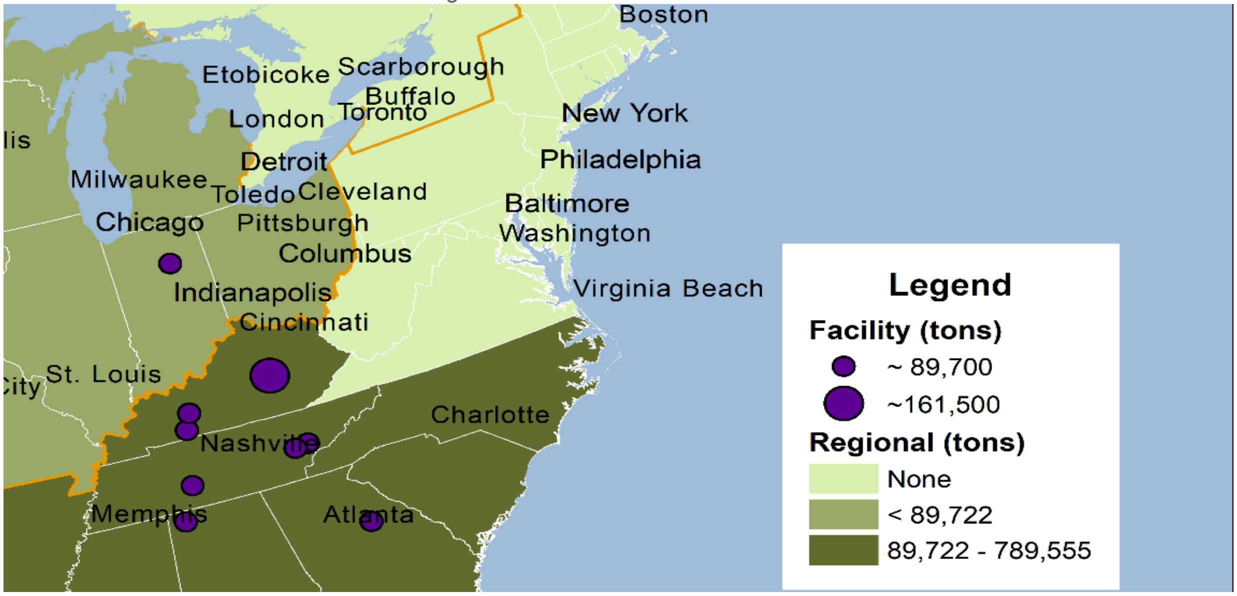


Figure 9: Recovered Aluminum Plants



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.

Glass has become an issue for recycling operations around the country, and although Michigan's bottle deposit system blunts the impact of the challenges of glass recycling, by providing Michigan with a glass stream that is cleaner than what is found in some non-bottle bill states, Michigan is not entirely immune. In Michigan, the roles are reversed for glass. The deposit system is working well, the material that comes out of the deposit system is in high demand and has no difficulty finding a home, but on the other hand there is no home in the state for the curbside collected glass. Even though glass processors are paying what they consider to be a high price, the MRFs do not make money on glass so they are not incentivized to clean it up to standards that are acceptable to glass processors.

Several structural problems in the collection and processing system have been identified for glass; modern single stream MRFs were designed to remove glass from other commodities, not necessarily to recover glass without contamination. A glass breaker is designed to break glass and the screens are two inches, all materials sized smaller fall through those holes and end up in the glass stream. The glass stream then has to be cleaned of contaminants to meet the glass market's specifications. There is no standard specification for pre-mixed glass sorted from a MRF and the experts interviewed felt that the companies that process glass have not done a sufficient job of policing what they receive in relation to their ability to remove contamination until recently. In many cases, glass recyclers have insufficient equipment to remove contaminants, and adding more cleaning capacity would require spending additional money to meet demand.

Across the country, these shortcomings are being addressed in different ways. Some regions have had success with supply chain partnerships to reprocess MRF glass to market specifications – the Momentum glass recycling facility in the Denver Colorado metro area is one such example, where Rocky Mountain Bottling (part of the Miller Coors supply chain) partnered with Momentum and local MRFs to successfully move MRF glass into new glass beer bottles through an advanced technology separation and cleaning system. A similar operation exists in the Kansas City metro area – Ripple Glass – that fills a supply chain gap by taking MRF glass and drop-off glass through advanced cleaning and processing equipment for use in fiberglass insulation. For both of these systems, as well as other areas, glass drop-off recycling infrastructure is also being set up to bring cleaner glass into the recycling marketplace.

However, despite the encouraging advancements in some regions, 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.[10] 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.

UNPROCESSED COLOR-SORTED GLASS BOTTLES AND JARS - FLINT (CLEAR), AMBER (BROWN), EMERALD (GREEN)

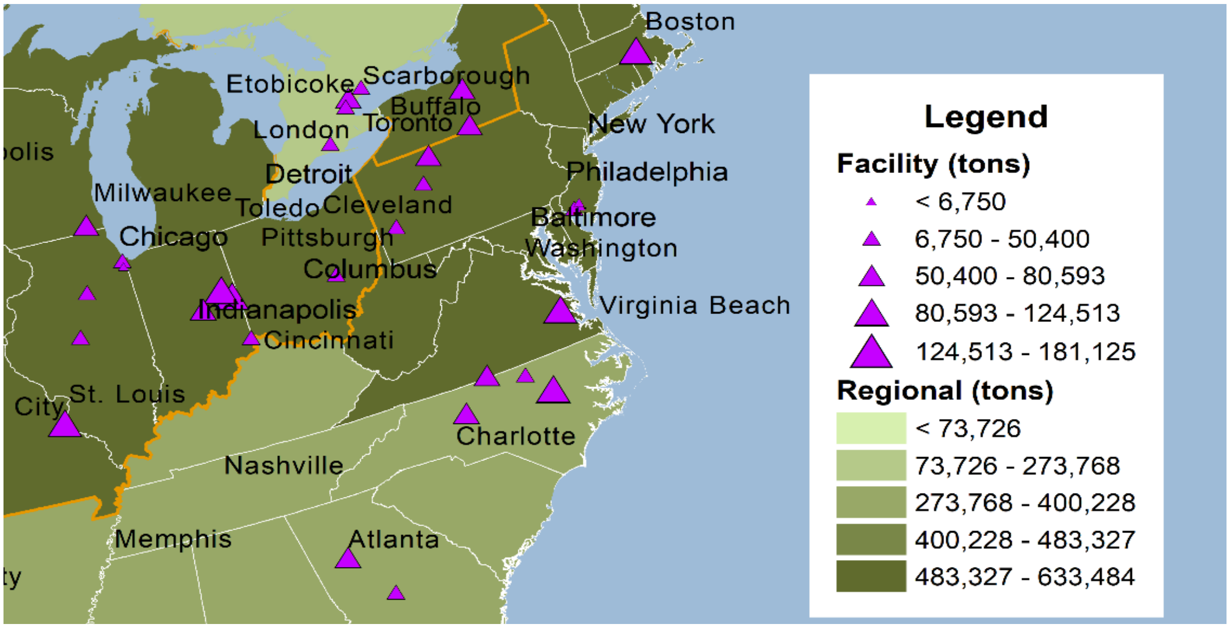
Clean unprocessed color-sorted glass will be supported where a furnace is located nearby. Prices have not changed in 30 years. In 1988, at the Owens Illinois Glass plant in Williamsburg, Virginia, pricing for Flint Glass was $40T, for Amber was $30T, and for Green $10T, close to today's prices. Unprocessed 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. Figure 10 identifies the end markets for all 3-mix glass cullet that are available to Michigan producers of recovered glass. Due to consolidation in the industry, there are no longer any glass manufacturers remaining in the state. 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 Michigan. 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 10: Glass Cullet Plants

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


Boston
Etobicoke
Scarborough
Buffalo
London
Toronto
New York
olis
Detroit
Philadelphia
Milwaukee
Toledo
Cleveland
Baltimore
Chicago
Pittsburgh
Washington
Columbus
Indianapolis
Virginia Beach
Cincinnati
St. Louis
City
Charlotte
Nashville
Memphis
Atlanta
ty
Legend
Facility (tons)
< 6,750
6,750 - 50,400
50,400 - 80,593
80,593 - 124,513
124,513 - 181,125
Regional (tons)
< 73,726
73,726 - 273,768
273,768 - 400,228
400,228 - 483,327
483,327 - 633,484

RECYCLING RATE FOR 2018

In addition to curbside and drop-off collection programs, direct research was conducted to measure materials collected through take-back programs for e-waste, organics, beverage container deposits, textiles, waste and batteries. Recycled MSW is discarded material that is returned to the economic mainstream through the production of new products, excluding material that is used for energy production (EPA 2013). MRFs and other processors of recovered materials are now using the State of Michigan Reporting system.

Take-Back Programs

A variety of materials diverted from disposal are collected through take-back programs. Examples include electronic waste, textiles and beverage containers that are included in the state's 10-cent bottle deposit system. RRS reviewed information from a number of these take-back program operators on an individual basis.

E-WASTE

EGLE provided a report on the total tonnage of electronic waste reported as recycled by the recyclers that are registered with the state's electronics program in the 2018 program year, covering October 2017 through September 2018.

TEXTILES

Textile data is now reported in the State of Michigan reporting program.

PAINT

Data was provided by ePaint Recycling (epaintrecycling.com), representing the total amount of paint that was collected from Michigan communities in 2016 through the ePaint program.

BATTERIES

RRS collected information from the Association of Battery Recyclers for an industry-leading calculation methodology for measuring lead acid battery recycling. The resultant extrapolation provided what was determined to be an aggressive scenario, especially when benchmarked against an alternative approach following a US EPA protocol. RRS utilized a blended approach for the baseline calculation and utilized these reference approaches for aggressive and conservative scenarios in the sensitivity analysis. Data obtained on recycled batteries was from Call2Recycle, the primary take-back program for rechargeable batteries and mobile phones operated by US manufacturers of rechargeable batteries.

CONTAINER DEPOSITS

Michigan container deposit data is recorded in unredeemed deposit revenue and must be converted to material tonnage accordingly. Using data on the volume of 2018 container deposit returns provided by the Michigan Department of Treasury, RRS determined the number and material composition of total deposits redeemed, then projected the total tonnage with average container weights for each material (metal, glass and plastic) commonly used. See methodology section of the report for details.

The number of containers recovered through the container deposit program was calculated using the total value of redeemed deposits and percentage composition by material provided by the Michigan Department of Treasury.

Total tonnage was then calculated using average container weights calculated by Franklin Associates for the California BEAR Report.

Table 23: Container Deposit Measurement

MATERIAL	CONTAINER WEIGHT (LBS)	% OF STREAM	# OF CONTAINERS	WEIGHT (LBS)	WEIGHT (TONS)
GLASS	0.4366	13%	458,151,406	200,028,904	100,014
PET	0.0749	23%	810,575,564	60,712,110	30,356
ALUMINUM	0.0302	64%	2,255,514,614	68,098,396	34,049
TOTAL			**3,524,241,584**	**328,839,409**	**164,420**

Quantity Disposed

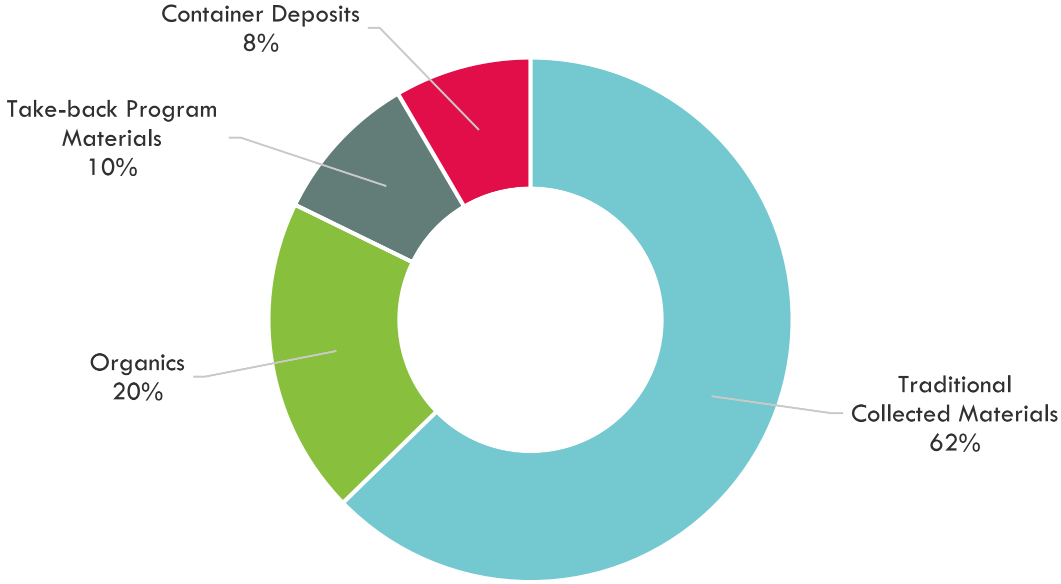
Disposal tonnage of 7,867,367 tons was calculated from annual fiscal report of solid waste landfilled in Michigan (23,840,367 cubic yards (CY) using 3 CY/ton of waste), as well as from reported data from two incinerators in the state, Kent and the Greater Detroit Resource Recovery Authority. Landfill disposal quantities were adjusted to avoid double-counting incinerator ash, then added to the total incoming quantities of incinerated materials less the recovered metal quantities (2,922,067 CY or 964,282 tons), yielding a total disposed tonnage of 8,831,649 tons.

Disposed MSW is reported to the EGLE in cubic yards and reported material quantities are converted to tons using both generic and material-specific conversion factors. These conversions may have a significant impact on disposal data accuracy. For this calculation, reported MSW volumes were converted using the EGLE's methodology of 3 CY/ton of waste. It is worth noting that the EPA calculates using a 3.3 CY/ton conversion factor; if Michigan were to use that conversion factor, disposal tonnages would decrease to 8,116,834. Additionally, there is reason to believe that reported landfill tonnages may include substantial fractions of materials that fall outside of the classification of MSW, in effect inflating reported quantities of disposed MSW and lowering the calculated recycling rate. EGLE should investigate the impact that material that should be classified as industrial waste (IW) or C&D wastes are not included in the data for disposed municipal and commercial waste (MCW).

Part 175, Recycling Reporting, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended, requires recycling establishments to report on a portion of the materials that should be counted to calculate a statewide recycling rate. This is a summary of what was reported into the system during fiscal year (FY) 2018, the second year of the program. The law focuses on waste diversion and recycling collection data for seven commonly recycled materials: paper, plastic, glass, ferrous and nonferrous metals, textiles, and single stream recyclables. In addition to recycling establishments who are required to report, additional facility types can also opt in to report voluntarily into the program. At the end of the second year (November 2018), 104 separate entities had identified themselves as recycling establishments by registering in the online Michigan Recycling Reporting module. In FY 2018, 76 percent (79 out of 104) of the registered facilities reported their recycling data through the system.

The data reported for 2018 from the first two years of the program show an increase in recycling of almost all materials reported as recycled from 2017 to 2018. A total of 553,105 tons of materials were reported as recycled in 2017, compared to 1,220,748 tons in 2018 in seven categories: Plastic, Paper, Glass, Single Stream, Textiles, Nonferrous Metals and Ferrous Metals. This is an increase of 120 percent from 2017. RRS used this data and included the reported data for organics recovery and estimated recovery from takeback programs, container deposit recovery, and metal recovery from incineration.

Figure 11: Material Recycled By Category in 2018



Traditional household recyclables collected from commercial and residential sources comprise 62% of the recycling stream, while 20% of the total is composed of organics including yard waste. The container deposit program accounts for 8%, and other materials that are collected through a variety of take-back programs such as lead-acid batteries, appliances, tires, e-waste, and textiles comprise the remaining 10% of the recycling stream.

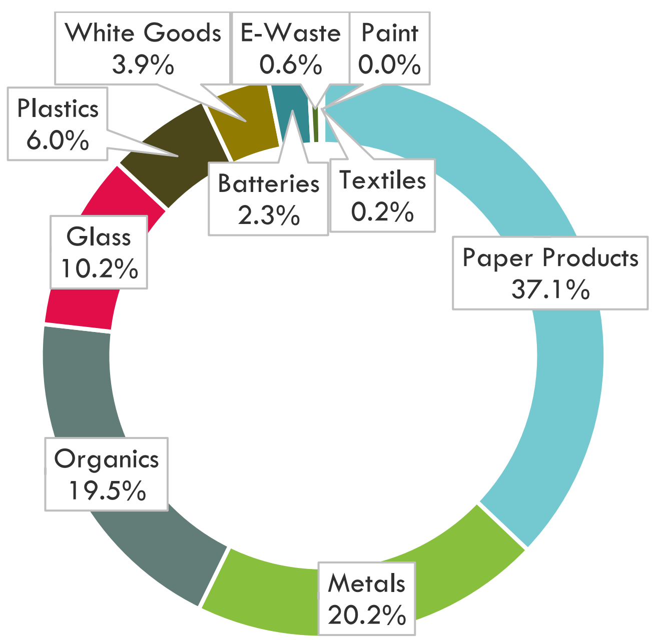
$$\frac{\text{TONS RECYCLED \& COMPOSTED}}{\text{TONS RECYCLED \& COMPOSTED} + \text{TONS DISPOSED}} = \text{RECYCLING RATE} \qquad \frac{1{,}946{,}970 \text{ TONS}}{1{,}946{,}970 \text{ TONS} + 8{,}831{,}649 \text{ TONS}} = 18.1\%$$

In 2014, community-specific and facility data was submitted to the MRI project team, then directly applied to the specific communities which it represented. Due to the voluntary nature of information sharing for all stakeholders, a sophisticated model was built to leverage the data that was provided and enable extrapolations to be made to account for data gaps. The study published in 2015 found Michigan to have an estimated recycling rate of 15% in 2014, with a possible range of 12.9-18.7%. However, due to the access to better data and modeling, the 15% baseline was an overestimation. The 15% included tires, which this 2018 update does not, and an overestimation on textiles. A revision to the 2014 rate that does not include tires and lowers the textile recovery results in a rate of 14.25% recovery rate in 2014.

Based on the recovery of materials reported to the State of Michigan and the calculated capture of materials from organics recovery, take back programs and the container deposit program the current recycling rate in the State of Michigan is 18.1%. This includes an increase of 81% (546,000 tons) in the recovery of traditional collected curbside and commercial materials from the quantity estimated in 2014. This increase is due in large part to the increased access, infrastructure, programming, and education and outreach made possible by grants provided by the state since 2015, which includes $635,500 in funding to 14 projects including infrastructure and education, $450,000 in grants supporting the addition of curbside carts in nine communities in 2016, $241,800 to fund four projects in food waste reduction and diversion, $534,242 in state grants funding 29 projects in infrastructure and education in 2017, and $575,000 in grant funding to two communities for curbside carts. All of these communities leveraged additional investment of public and private funds by the grant recipients and their project partners.

With better reporting and modeling tools, this is an increase from a revised baseline of 14.25% in 2015 of over 27%. While this increase may be due in small part to the new reporting system capturing better data on recovery of materials, this increase is primarily the result of communities converting to carts for curbside recycling collection, funded in part by DEQ grants, to increase the convenience and capacity of collection. As stated above, if the total waste disposed was converted using the EPA estimated conversion rate then the disposal tonnages would decrease to 8,116,834 and the recycling rate would increase to 19.35%

Figure 12: Materials Recycled in 2018



METHODOLOGY

To meet the state's objectives of determining the diversion rate for municipal solid waste (MSW) and profiling access to recycling opportunities throughout Michigan, the MRI collected data from a variety of Michigan organizations, businesses, and programs that recycle or compost material from the municipal waste stream. The MRI survey process followed the recommended survey guidelines established by the US EPA for measuring recycling rates, and submitted data was applied directly to the respondent communities. Additionally, data received was used as the basis for an extrapolation of recycling activity to gap communities which have analogous and relevant demographic characteristics that are likely to be reflected through recycling performance. The types of data collected, and the data collection methods are described below.

Material Flows

The update to the MRI report considered MSW in Michigan to be divided into three primary streams: disposal, recycling, and compost, as described below:

DISPOSED MATERIAL

Disposed material from Michigan is either sent to a Michigan landfill, sent to a Michigan incinerator, or shipped out of state. The first two categories are quantified through the EGLE's reports of solid waste landfilled in Michigan as well as and public reports on the quantity of solid waste disposed at Michigan incinerators. Michigan is believed to be a net importer of solid waste, so the third category is relatively small. In determining the total quantity of disposed material, incinerator ash was excluded from the total landfilled volume, as this waste was accounted for pre-incineration via the data from Michigan incinerators.

RECYCLED MATERIAL

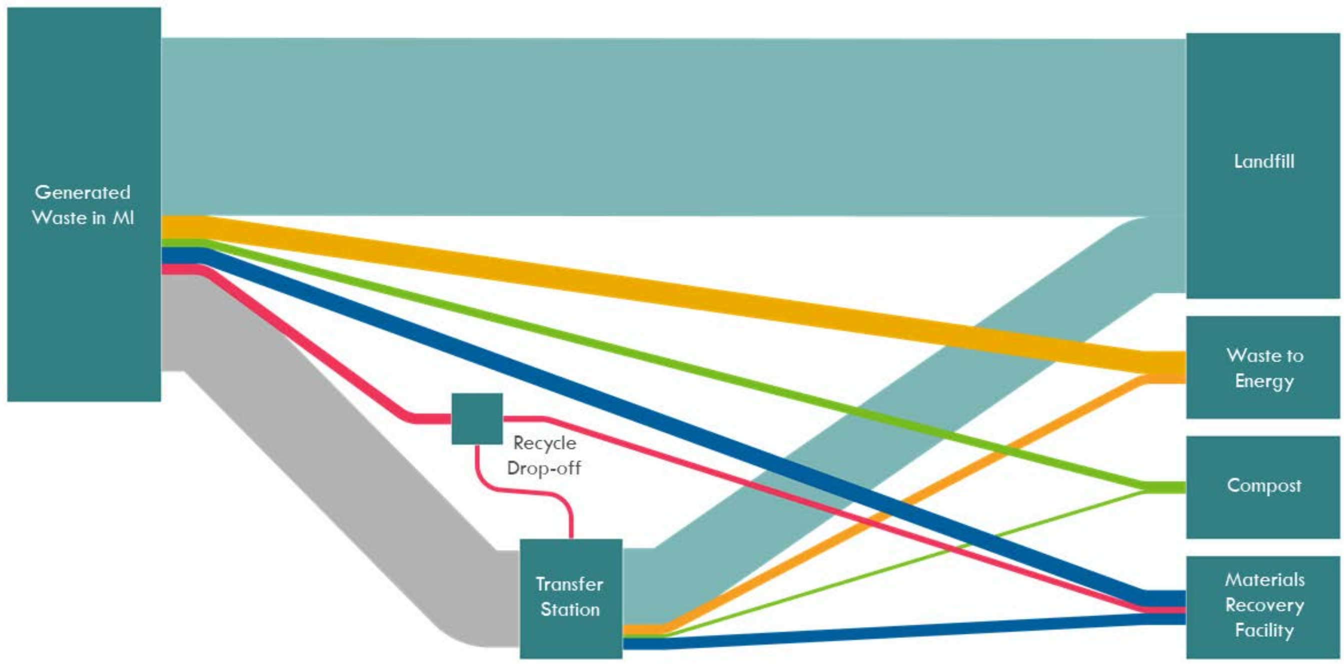
Recycled material from Michigan is processed in three ways: it may be sorted at a Michigan MRF, sorted at an out-of-state MRF, or sold to brokers and/or end users without further sorting. The study measured material collected by communities and counties. These MRFs included single, dual and multi-stream MRFs and operations that are baling source-separated materials. The MRI assessed material that may have been sorted at out-of-state MRFs through a review of communities within the largest 6 counties.

The figure below depicts the flow of materials through the Michigan waste system using previously reported data provided. Figure 13 illustrates the pathways from generation of the waste material to the point of disposal. This figure approximates the proportion of materials entering each of the separate pathways.

Once designated recyclables are collected in Michigan and sorted by area MRFs, they are sold to brokers and re-processors in and around Michigan. The markets that use the materials collected from residential recycling programs, commercial recycling programs and industrial recycling systems in Michigan are a diverse set of organizations that span across the state and larger region. Secondary processors and end markets in Michigan exist in each of the major commodity categories, specifically paper; PET, HDPE, and polypropylene plastics; glass; and metals.

Figure 13 also shows an estimate of the proportion of recyclable materials as they move from Michigan through a variety of end markets, both in and outside of Michigan. The proportions shown in this figure are based on educated assumptions, and the reality of the marketplace is more complex than what is shown here.

Figure 13



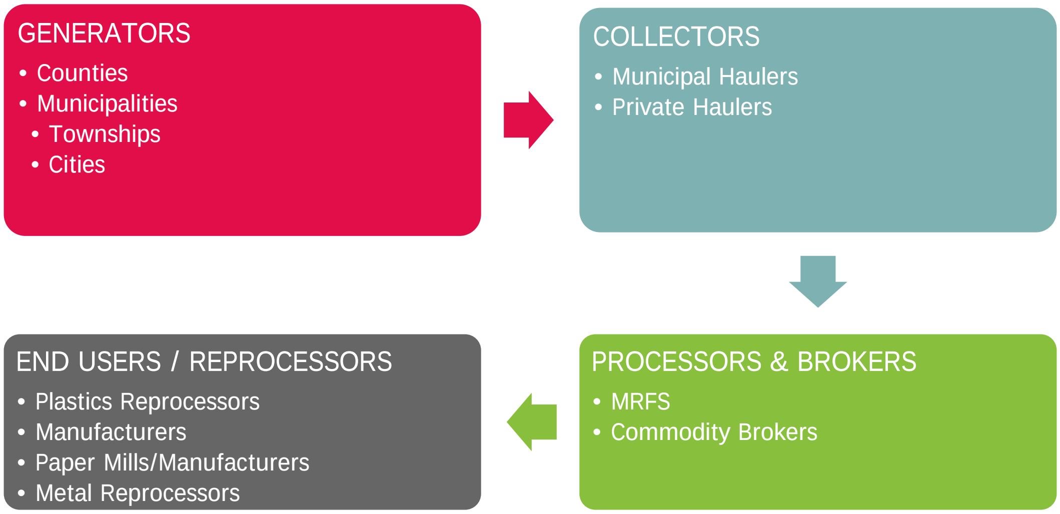
COMPOSTED MATERIAL

Composted material from Michigan is processed into finished mulch and compost either at Michigan compost facilities or out-of-state compost facilities. For this analysis RRS collected data from the EGLE's annual report required for licensed compost facilities. Only large-scale commercial composters were considered for MSW diversion; onsite, backyard composting was not part of the update as it is excluded from the EPA's definition of MSW.

Supply Chain for Recycled Material: Stages of Diversion

Material diverted from disposal moves through several stages before being reprocessed into new items. The MRI study considered four primary stages, while noting intermediate steps between them. These stages of the diversion process are:

Figure 14: Simplified Material Flow Diagram



GENERATION
Material that has reached the end of its useful life is discarded into the recycling or compost stream by households and businesses.

COLLECTION
Diverted materials are transported from the home or workplace to a central location.

SORTING OR PROCESSING
Diverted materials are sorted by type and prepared for future reuse, usually baled for shipment.

RE-PROCESSING OR REMANUFACTURING
Sorted materials are broken down into feedstock for the production of new products.

Material Definitions

MUNICIPAL SOLID WASTE
Municipal Solid Waste is defined by the US EPA as "discards from residential and commercial sources that does not contain regulated hazardous wastes." (EPA, State Measurement Program Template, 2013) The EPA has provided a detailed description of materials that are considered MSW and those that are not, 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.

RECYCLING
Recycling is defined by the US 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." (EPA, State Measurement Program Template, 2013) Similar detail by material identifying the activities that are and are not considered recycling is excerpted from "Measuring Recycling: A Guide for State and Local Governments" and appended to this document. Key activities that are not considered recycling 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 C&D debris.

Effectively, the EPA definition of MSW was used in this methodology and is based on the historical management of municipal solid waste. 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. The currently reported quantity of C&D material disposed in the state is 1,867,011 tons.

Participation in Recycling Programs

Participation in recycling programs is the key component that links access to recycling opportunities with the goal of diversion. However, recycling programs typically have very limited data on participation as it can be costly and time-consuming to track. In this study, data was collected on the following measurements of program participation:

- The **curbside participation** rate is defined in this study as the percent of households with curbside services who set out their materials for collection over the course of the year. To measure curbside participation, communities may have haulers note how many stops they make on each collection route through on-truck GPS and service event tracking technology; use data from RFID-enabled carts or conduct periodic set-out studies or spot checks. The MRI surveys asked communities to either provide any data they had on curbside participation, or provide an estimate based on their knowledge of the program.

- **Drop-off participation** can be measured in two ways, first by the number of households who made at least one visit to a drop-off location over the course of the year, and second, by the total number of visits made to drop-off locations. MRI asked for both measurements in the surveys of community and county programs, and asked respondents to provide actual data or an estimate if data was unavailable. Note that in many cases, drop-offs are not staffed so there was no feasible way for the number of visits to be measured.

An additional dimension of participation in recycling programs refers to the quantity of material that participants recycle. A recycling program may improve their performance either by increasing the proportion of residents who recycle at all, or by increasing the quantity set out by existing recyclers. To assess the quantity recycled per participating household, this study collected data on the annual volume of material collected through recycling programs offered by counties, communities, and haulers.

The Recycling Rate

In 2018, the State of Michigan achieved a total statewide MSW recycling rate of 18.1%. Of the total amount of material recycled, only 62% is composed of 'traditional' recyclable materials collected from commercial and residential sources. 20% of the total is composted organics, mostly yard waste. The container deposit program accounts for 8%, and other source separated streams (such as lead-acid batteries, white goods, tires, e-waste, and textiles) make up the remaining 10%.

Data on the amount of commercial material currently recycled still has a large degree of uncertainty and likely significant areas for growth. Some increases in the recycling rate may be accomplished through additional data gathering, while others will require new policy, programming, infrastructure and focus.

There is some concern that the state landfill reports include industrial and construction and demolition material, primarily wood, in the MSW totals. This can have a significant effect on the recycling rate.

There is no single solution that can be implemented to achieve the state goal of 45% recovery. In order to achieve it, a multi-pronged approach will need to be undertaken.

- Improve data gathering on the amount of material recycled
- Evaluate data collection for amount of material disposed
- Expand access to convenient curbside and comprehensive drop-off for all single family and multifamily homes
- Expand access to commercial recycling and increase participation through that access

- Expand access to public area recycling and increase participation through that access
- Expand food scrap and other organics recovery, collection, and compost end-markets

Recommendations

- Commercial recycling represents a large relatively untapped opportunity to increase recovery rates, and current recovery needs to be better tracked and documented in reported data. Improvements in commercial recycling access, infrastructure, and participation can be considered one of the 'low hanging fruits' available to invest in to make additional strides in recovery rates.
- Organics recovery, particularly yard waste and food waste collection and composting from both residential and commercial sectors represents a significant opportunity to increase recovery rates as well as many other environmental benefits. Investment in access, infrastructure, participation incentives and end market development will be crucial to reach recovery rate goals.
- Super Drop-offs, or 'Convenience Centers' are vastly underrepresented in the state. Increasing convenient access and infrastructure would greatly increase the recovery of a wide array of recyclables, including scrap metal, untreated wood, mattresses, electronics, paints, motor oil, anti-freeze, batteries, oversized marketable plastics, marine shrink-wrap, plant plastics, and many others that represent significant opportunities to improve recycling rates.

ADDITIONAL DATA

Table 24: Michigan Disposal of MSW

	CUBIC YDS	TONS
TOTAL LANDFILLED LESS INCINERATOR ASH	23,840,505	7,867,367
TOTAL INCINERATED LESS RECOVERED METALS	2,922,067	964,282
TOTAL DISPOSAL	**26,762,572**	**8,831,649**

Table 25: Recovery by Material Category

MATERIAL	PERCENT	TONS COLLECTED (TONS)
PAPER PRODUCTS	37.10%	722,328
METALS	20.16%	392,520
ORGANICS	19.53%	380,221
GLASS*	10.18%	198,163
PLASTICS	6.00%	116,769
WHITE GOODS	3.89%	75,747
BATTERIES	2.32%	45,182
E-WASTE	0.62%	12,011
TEXTILES	0.20%	3,805
PAINT	0.01%	225
TOTAL		**1,946,970**

** 100,014 Tons are from Container Deposit Programs See Table 23: Container Deposit Measurement*

EPA Scope of Materials Included in Standard Recycling Rate

MATERIAL[1]	WHAT IS MSW	WHAT IS NOT MSW[2]
Food Scraps	Uneaten food and food preparation wastes from residences and commercial establishments (restaurants, supermarkets, and produce stands), institutional sources (school cafeterias), and industrial sources (employee lunchrooms).	Food processing waste from agricultural and industrial operations.
Glass Containers	Containers; packaging; and glass found in appliances, furniture, and consumer electronics.	Glass from transportation equipment (automobiles) and construction and demolition (C&D) debris (windows).
Lead-Acid Batteries	Batteries from automobiles, trucks, and motorcycles.	Batteries from aircraft, military vehicles, boats, and heavy-duty trucks and tractors.
Tin/Steel Cans and Other Ferrous Metals	Tin-coated steel cans; strapping; and ferrous metals from appliances (refrigerators), consumer electronics, and furniture.	Ferrous metals from C&D debris and transportation equipment.
Aluminum Cans and Other Nonferrous Metals	Aluminum cans; nonferrous metals from appliances, furniture, and consumer electronics; and other aluminum items (foil and lids from bimetal cans).	Nonferrous metals from industrial applications and C&D debris (aluminum siding, wiring, and piping).
Paper	Old corrugated containers; old magazines; old newspapers; office papers; telephone directories; and other paper products including books, third-class mail, commercial printing, paper towels, and paper plates and cups.	Paper manufacturing waste (mill broke) and converting scrap not recovered for recycling.
Plastic	Containers; packaging; bags and wraps; and plastics found in appliances, furniture, and sporting and recreational equipment.	Plastics from transportation equipment.
Textiles	Fiber from apparel, furniture, linens (sheets and towels), carpets[3] and rugs, and footwear.	Textile waste generated during manufacturing processes (mill scrap) and C&D projects.
Tires	Tires from automobiles and trucks.	Tires from motorcycles[4], buses, and heavy farm and construction equipment.
Wood	Pallets; crates; barrels; and wood found in furniture and consumer electronics.	Wood from C&D debris (lumber and tree stumps[5]) and industrial process waste (shavings and sawdust).
Yard Trimmings	Grass, leaves, brush and branches, and tree stumps.[5]	Yard trimmings from C&D debris.
Other	Household hazardous waste (HHW)[6], oil filters, fluorescent tubes[7], mattresses, and consumer electronics.	Abatement debris, agricultural waste, combustion ash, C&D debris, industrial process waste, medical waste, mining waste, municipal sewage and industrial sludges, natural disaster debris[8], used motor oil, oil and gas waste, and preconsumer waste.

CHARACTERIZATION OF DISPOSED WASTE UPDATE

A major part of this approach is to update the waste characterization study of landfilled material and development of a county by county forecast of key recyclable materials (excluding tires) that can be generated as outputs from primary and secondary recycling facilities as industrial feedstock for Michigan and Great Lakes Regional recycling based economic development. The recycling feedstock focuses on the following types of targeted materials – paper of all grades, rigid plastic containers and packaging, glass containers, aluminum containers, film and flexible plastic packaging, Styrofoam containers and packaging, output from composting and anaerobic digestion facilities, and relevant outputs from the Michigan Materials Marketplace project that is already underway.

Development of Landfill Characterization for Michigan

To inform sound policy and program design, implementation and program analyses for both the public sector and private sector in Michigan, 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. 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 commodities, providing guidance to state agencies and local governments, and aid in fulfilling the responsibilities required under the Governor's Initiative.

The development of a waste characterization for the State of Michigan 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 27 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.

Each study was evaluated for inclusion in the tool to ensure compatibility with the existing studies. Based on the unique features of the waste characterization studies, RRS performed a statistical analysis of those studies to quantify the effects of each of a range of unique factors. For example, the waste characterization for states with landfill bans (or strong policy promoting the diversion of organics) was compared with those without such bans 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 Michigan.

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 PET replacing PVC or 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). Another consideration that complicates the use of waste characterizations studies for the development of a waste characterization for the State of Michigan 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.

METHODOLOGY

The studies were reviewed and evaluated for thoroughness and accuracy, date conducted, and relevance to the material types under consideration. Each study was assigned to a low, medium, or high diversion profile based on the characteristics of the states or communities represented in each study and the per capita amount of landfilled material. By averaging across several studies, generic profiles for low, medium, and high diversion states and communities were developed. Each profile 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.

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 bottle deposit systems and states with yard waste bans. Several studies also included a breakdown between Residential and Institutional, and Commercial, and Industrial (ICI) categories. RRS strongly believes that when a state is classified by its diversion rate, a credible estimation can be made of the percentage of materials that are recyclable and the value of that material relative to the State of Michigan.

The final step was to combine the 80 categories of material that were identified in the characterization states into a classification system that typifies broader categories consistent with market specifications. The estimate of landfilled material was calculated by multiplying the quantity of total landfilled material by the average percent of material types selected as representative of Michigan. The reported disposal data identifies that 23,840,505 cubic yards, or 7,867,367 tons (at 3 CY per ton), of material generated in-state were disposed in 2018. An additional 964,282 tons (not including recovered metals) were incinerated for a total of material landfilled and incinerated of 8,831,649 tons. The Detroit Incinerator, however, was shut down in 2019, which incinerated approximately 789,933 tons (not including recovered metals). Approximately 48,300 tons of metal was recovered from incinerators in the State.

Another key issue is the allocation of waste that is generated by the industrial, commercial and institutional (ICI) sectors versus the residential sector. RRS evaluated waste characterization studies from five states that included separate characterizations for commercial and residential waste disposal.

*Table 26: Distribution of Residential and ICI of Statewide Disposed Municipal Waste**

GENERATOR SECTOR	AVERAGE WEIGHTED PERCENT OF RESIDENTIAL AND ICI	MICHIGAN (TONS)
RESIDENTIAL	46.9%	4,143,737
ICI	53.1%	4,687,912
RES AND ICI	100.0%	8,831,649

* Includes Incinerated Materials but not recovered metals

Table 27 provides a consolidated profile of the statewide disposed waste stream. In addition, the current recovery of material as developed in the Michigan Recycling Index project was included for comparative purposes. The scenario that was adjusted for Bottle Bill's is the recommended framework for the State of Michigan Waste Characterization.

Table 27: Consolidated Characterization Profile of Statewide Disposed Waste

MATERIAL TYPE	CURRENT DIVERSION TONS	MEDIUM DIVERSION TONS	MEDIUM DIVERSION PERCENT	FINAL ADJUSTED TONS	FINAL ADJUSTED PERCENTAGE
HIGH GRADE – WHITE & COLORED	7,734	111,868	1.27%	**120,994**	1.42%
MIXED/ UNSPECIFIED OFFICE	52,300	35,327	0.40%	**59,834**	0.70%
LOW GRADE – (OMG), BOXBOARD, PAPER BAGS, PHONEBOOKS, OTHER	307,907	362,098	4.10%	**474,039**	5.58%
ONP	88,836	153,082	1.73%	**163,606**	1.92%
OCC	223,711	429,807	4.87%	**482,650**	5.68%
CARTONS, ASEPTICS AND POLY-COATED	41,840	5,888	0.07%	**11,923**	0.14%
COMPOSTABLE/ SOILED	-	783,073	8.87%	**700,791**	8.24%
PAPER SUBTOTAL	**722,328**	**1,881,141**	**21.30%**	**2,013,837**	**23.69%**
PET BOTTLES AND CONTAINERS	9,425	58,878	0.67%	**57,847**	0.68%
HDPE BOTTLES NATURAL & COLORED	8,331	38,270	0.43%	**47,470**	0.56%
PLASTIC BOTTLES AND #3-7	3,534	14,719	0.17%	**26,495**	0.31%
OTHER PLASTICS AND PACKAGING, LDPE, POLYSTYRENE (FOAM), DURABLE & RIGID CONTAINERS AND PP TUBS)	95,479	915,548	10.37%	**937,480**	11.03%
PLASTIC SUBTOTAL	**116,769**	**1,027,415**	**11.63%**	**1,069,292**	**12.58%**
ALUMINUM CANS	39,743	17,663	0.20%	**14,572**	0.17%
FERROUS METALS (TIN/STEEL CANS, TIN)	276,236	267,893	3.03%	**378,436**	4.45%
NON-FERROUS METALS, FOIL AND OTHER METAL AND AEROSOL CANS	76,541	150,138	1.70%	**123,643**	1.45%
METAL SUBTOTAL	**392,520**	**435,695**	**4.93%**	**516,651**	**6.08%**
GLASS – INCLUDING CONTAINERS	175,630	108,924	1.23%	**112,162**	1.32%
OTHER GLASS	22,532	67,709	0.77%	**40,184**	0.47%
GLASS SUBTOTAL	**198,163**	**176,633**	**2.00%**	**152,346**	**1.79%**
ELECTRONICS – GENERAL, COMPUTER RELATED, CRT	12,011	188,409	2.13%	**125,851**	1.48%
WHITE GOODS (APPLIANCES)	75,747	32,383	0.37%	**12,144**	0.14%
ELECTRONICS SUBTOTAL	**87,757**	**220,791**	**2.50%**	**137,995**	**1.62%**
TOTAL WOOD		**1,048,022**	**11.87%**	**898,179**	**10.57%**
YARD WASTE – GENERAL	228,133	503,404	5.70%	**572,953**	2.70%
FOOD	57,033	1,154,002	13.07%	**1,283,459**	15.10%
OTHER ORGANICS, BRANCHES AND STUMPS	95,055	453,358	5.13%	**297,406**	3.50%
YARD WASTE AND ORGANIC SUBTOTAL	**380,221**	**2,110,764**	**23.90%**	**2,153,818**	**21.30%**
TEXTILES, BATTERIES, TIRES, CARPET, LIGHT BULBS	**49,212**	**547,562**	**6.20%**	**461,213**	**5.42%**
OTHER NON- RECYCLABLE MATERIALS		**1,383,625**	**15.67%**	**1,428,318**	**16.95%**
TOTAL	**1,946,970**	**8,831,649**	**100.00%**	**8,831,649**	**100.00%**

**Numbers may not total due to rounding errors*

Key Findings

The key findings demonstrate significant progress since this data was last analyzed in 2015. The increase in tons recovered, the recycling rate, and the quality of the data available are all indicative of progress towards the state's recovery goals.

In particular, the increase in the number of communities with weekly curbside cart collection, made possible in part by state grant funding, as well as numerous infrastructure investments and education and outreach efforts, all contribute to an environment in Michigan where recycling can be successful. The addition of four recycling specialists focusing on outreach, technical assistance, and collaboration efforts has helped raise the level of awareness in communities, as well as provide them with a resource at the state level that can be responsive to their concerns. The recent approval of the Renew Michigan funding will provide a significant boost in these and other areas, that if well aligned with identified gaps, will go a long way towards continuing to grow Michigan's end-market capacity, processing capabilities, and access options that will connect the dots in Michigan's supply chain and substantially grow Michigan's recycling rate.

- Recycling Rate
  - An aggressive multi-pronged strategy will be required to achieve a recycling rate of 45%.
  - While Michigan does not have data-reporting in place to accurately capture the breakdown of residential to commercial generation, it is estimated that 53% of the material generated in Michigan is by the commercial sector. This has significant implications for efforts moving forward to increase recovery.
  - The current annual average quantity of material recyclables per household (single family) is 360 lbs. per household (single family). If all multi-family residences are included, then 341 lbs. per household are recovered.
  - Residential recycling improvements alone will not be enough to achieve the 45% goal.
    - If all households in every city in Michigan with a population greater than 25,000 recycled at the same proportion as reported curbside programs (i.e. 433 lbs. recyclables per household annually), the state recycling rate would increase to 19.9%.
    - If all households in the state (including single family and multi-family) recycled at the same proportion as reported curbside programs (i.e. 433 lbs. recyclables per household annually), the state recycling rate would increase to 20.5%.
    - If all households in the state (including single family and multi-family) recycled at the expected level of a high-participation curbside programs (i.e. generating 550 lbs. recyclables per household annually), the state recycling rate would increase to 21%.
    - If all single-family households in the state recycled at the level of a high-recovery rate curbside programs at 800 lbs. recoverable (recyclables and food waste) per household annually, the state recycling rate would increase to approximately 30%.
- The quantity of material estimated to be recovered in 2015 was 1,535,195 tons. Tripling the recycling rate from the 15% estimated in 2015 to a 45% recovery rate would result in an additional 2.6-2.7 million tons of recovery from the estimated 8.831 million ton of waste currently landfilled or incinerated.
  - As identified in the update to the MRI section, the reported quantity of material collected and processed in 2018 from residential and commercial generators was 1.221 million tons of material, an increase of 81% above the estimated recovered material in 2015 or an additional 546,000 tons.
- Reported Disposal Data

- The reported disposal data identifies that 23,840,505 cubic yards, or 7,867,367 tons (at 3 CY per ton), of material generated in-state were disposed in 2018. An additional 964,282 tons (not including recovered metals) were incinerated for a total of material landfilled and incinerated of 8,831,649 tons. The Detroit Incinerator, however, was shut down in 2019, which incinerated approximately 789,933 tons (not including recovered metals). Approximately 48,300 tons of metal was recovered from incinerators in the State.
- Based on regional data of the percentage of waste that is generated by the commercial (53.1%) and residential (46.9%) sectors respectively, the commercial sector disposes approximately 4,176,063 tons and the residential sector disposes 3,691,304 tons.

*Table 28: Distribution of Residential and ICI of Statewide Disposed Municipal Waste**

GENERATOR SECTOR	AVERAGE WEIGHTED PERCENT OF RESIDENTIAL AND ICI	MICHIGAN (TONS)
RESIDENTIAL	46.9%	4,143,737
ICI	53.1%	4,687,912
RES AND ICI	100.0%	8,831,649
RES AND ICI (WITHOUT INCINERATED MATERIAL)	100.0%	7,867,367

* Converted ay 3 CY per Ton

- If the landfill tonnage were converted from cubic yards using the US EPA conversion ratio of 3.3 cubic yards per ton instead of 3 cubic yards per ton as calculated by EGLE, then only 8,116,434 tons of material was disposed in landfills and the baseline recycling rate would be 19.35%.

- Economic Value of Recycling
  - RRS' economic analysis found that if the Michigan recycling rate were to triple (15% to 45%) 47,800 jobs, $3.3 billion in labor income, $4.9 billion in total value added, and $11.6 billion in total output would be added to the Michigan economy. Overall, tripling the recycling rates contributes to just over a one percent increase in the portion of the state's economy represented by the RRR sector – from 2.2% of the total to 3.3%.
  - In total, 137,903 jobs would be directly related to recycling, reuse, and recovery, so that if all the direct jobs created by the industry were in the same city, it would be the third largest city in the state.
  - The direct economic output of the tripled RRR industry in the state is $19.6 billion and the total economic output (including indirect and induced effects) would be $33.8, compared to the $12.9 billion and $22.2 billion of today respectively. Tripling the recycling rate results in roughly a 50% increase in all aspects – employment, labor income, total added value, and output – for the RRR sector.

RECOMMENDATIONS

Collection and Processing

Collection and processing infrastructure for recycling and organics needs significant investment and improvement in order to more efficiently and comprehensively provide services throughout the state. While some of this can achieved with policy tools and incentives, better contract arrangements, and competitive grant funding, state seed funding could also be directed towards increasing the funding available to small and mid-size local governments across the state, to help them create jobs in the recycling economy. Programs like that of Emmet County can serve as a model to others in how to develop a sustainable long-term business plan for recycling programs. Directing funding towards rural and suburban areas can help to create a greater number of recycling centers throughout the state.

- Collection infrastructure and transportation are weaknesses in Michigan's recycling end markets; RRS continues to endorse the recommendation that the state offer a set of incentives to encourage private investments in recycling, including tax credits, low interest bonds and loans, or other financial mechanisms. This may require changes to the current solid waste planning approach to ensure that regional collaboration and planning is a key component of future efforts to develop cost effective programs to recover and process recyclable materials.
- Commercial recycling represents a large relatively untapped opportunity to increase recovery rates, and current recovery needs to be better tracked and documented in reported data. Improvements in commercial recycling access and infrastructure can be considered one of the 'low hanging fruits' available to invest in to make additional strides in recovery rates.
- Organics recovery, particularly yard waste and food waste collection and composting from both residential and commercial sectors represents a significant opportunity to increase recovery rates as well as many other environmental benefits. Investment in access, infrastructure, and end market development will be crucial to reach recovery rate goals.
- Super Drop-offs are vastly underrepresented in the state. Increasing convenient access and infrastructure would greatly increase the recovery of a wide array of recyclables, including scrap metal, untreated wood, mattresses, electronics, paints, motor oil, anti-freeze, batteries, oversized marketable plastics, marine shrink-wrap, plant plastics, FOGs and many others that represent significant opportunities to improve recycling rates.
- Curbside recycling collection expanded to all single-family household (up to 8-unit buildings) in all communities that have a population greater than 25,000 people.
- Hub and spoke is necessary to consolidate material acceptance across regions with insufficient generation to support large scale cost-effective materials processing. This may require changes to the current solid waste planning approach to ensure that regional collaboration and planning is a key component of future efforts.
- A glass specification could be included in local government contracts with MRFs that would specify the amount of contamination in glass and the amount of undersized glass that would come out of the MRF.
- Local governments to include in contracts a requirement to receive quantity and quality reports generated by the MRF's markets.
- A more comprehensive network of drop-off centers needs to be developed in areas where cost effective curbside services are not available.
- Expand Film Collection
  - Determine methods to effectively capture film at the MRF.
  - Expand grocery store film and agricultural plastic collection programs.

- To achieve a higher recycling rate, the mechanics and the MRF systems will evolve and expand to increase recovery, which will include more optical and robotic sorting.
- Increasing the efficiency and net costs of processing can be addressed in part by developing larger scale facilities that process material through 2 shift operations to lower the capital costs per ton.
- Encourage regionalization of processing facilities, with both policy and funding incentives.
- Encourage public and private investment in state recycling by leveraging new financial mechanisms
  - EGLE and its partner state organizations (e.g. Michigan Economic Development Corporation) can encourage private investment in building recycling and organics processing infrastructure in Michigan from partners with an interest in strengthening the supply chain.
  - State government is well-positioned to provide seed funding (along with other incentives) to leverage the necessary private and public sector investments in MRF capacity, organics processing capacity, hub and spoke collection and processing networks, moving from bins to carts, drop-off and convenience centers and other investments that will maximize both the capture rate for recyclables and organics and the quality of those materials.

Develop a Substantive and Continual Education and Outreach Program

Outreach and education campaigns that increase participation and reduce contamination are as important to successful recycling program as infrastructure development. Education is never one and done but requires regular interactions with residents, businesses, and community leaders to ensure continued success. Finally, there is no one entity that education relies upon or one size fits all approach. EGLE, local governments, non-profits, service providers, and recycling agencies all play a role in long term education that spurs behavioral changes.

- Education programs should provide information on a frequent basis, at least quarterly, so that residents and businesses know what can and can't be put in the recycling bin.
- Identification of the responsible service provider or agency for education is a key part of success. If the private sector isn't held to standard of education, then local or regional government agencies will need adequate resources for comprehensive continual education programs.
- To increase participation and reduce contamination, Michigan leaders must make a lasting, substantial and consistent investment in education and outreach that engages residents, front line staff, elected officials, and business and industry. This education and outreach program should have two main areas of focus: 1) developing and disseminating education and outreach tools that drive behavior change, not just ways to build awareness; and 2) supporting Michigan's communities in managing contamination in recycling streams to avoid conflicts with MRF contracts.
- EGLE should devote staff time to working one-on-one with local governments and with MRFs and haulers to help them strengthen education and outreach programs. EGLE should also focus on providing education to other agencies that work directly with recycling businesses, for example, MEDC, so that those agencies can be effective educators and communicators about recycling. EGLE staff should provide advice and suggestions on speaking to elected officials, messaging, designing outreach materials, and other education and outreach tasks.
- EGLE's website should be updated to include a page dedicated to sharing resources from Michigan local governments and businesses who have successful recycling campaigns or materials. This could

include recycling brochures and case studies, allowing Michigan local governments and businesses to learn from each other.
- The education and outreach program should be a collaborative public private partnership with state agencies, Michigan NGOs and trade associations (like the Michigan Recycling Coalition, SWANA, ISRI and others) as well as national NGOs and trade associations (like The Recycling Partnership, Keep America Beautiful, the Carton Council and others) and private industry (retail, grocer, food service, brands and others).

State Agencies and Regulatory Programs

While EGLE and other state agencies may never collect or process recyclable or compostable materials, they play a key role in ensuring the success of these programs through data collection, setting statewide goals and policies, assisting local municipalities in regional and individual goals, encouraging innovation in recycling and composting, and ensuring state staff are trained in waste management leading practices so they are equipped to address community needs.

- Review the legislative requirement for solid waste and recycling planning at the County level. Evaluate and authorize regional planning that will facilitate achieving higher recycling rates that are based on the appropriate waste sheds and movement of recycled material unrestricted by county-based approaches to planning. Set goals and objectives that solid waste regions and districts must reach, including access to recycling.
- With baseline data now available and the recycling measurement data system now in place, the state should continue working towards the goal to increase recovery/recycling rate to 45%. EGLE should also work to integrate incremental goal setting across the state – including at the local government level. For example, EGLE could set goals for diverting organic materials from landfills and targets for number of communities with convenient access to recycling. EGLE recycling specialists could offer assistance to local governments in developing their own set of recycling goals that incorporate these statewide performance targets.
- The state should consider designating "Recycling Market Development Zones" to incubate innovation in recycling, organics processing, donation and reuse/source reduction initiatives that are targeted at materials that make up municipal solid waste. Michigan should also provide incentives to attract circular economy and recycling infrastructure businesses to the state.
- EGLE should consider goals for diversion for specific material streams – something between recycling and landfilling, for example, glass used as alternative daily cover (ADC).
- Keep the bottle deposit law in place and expand the bottle bill with a focus on glass containers.
- Provide Staff Training on Recycling and Organics Management Best Practices
  - In order to carry out any of the subsequent recommendations for success, the State of Michigan, with assistance from EGLE, must first invest in the education and training of their staff, specifically their Recycling Specialists. Educating recycling specialists, and in turn others in Michigan, about the importance of both raising awareness and driving behavior changes related to lowering contamination rates, will be critical to the success of Michigan recycling. Recycling Specialists must have superior knowledge of recycling trends in other states, the latest recycling processing and manufacturing technologies, and exposure to best management practices in place in communities across the country.
  - Develop an action plan for Recycling Specialists to learn from their peers in other state agencies as well as from The Recycling Partnership's State Leaders Group. This action plan should include

sending the Recycling Specialists on trips to other states employing BMPs to learn and to bring that knowledge back to the State of Michigan.

Data

Data collection is a key component to knowing how waste flows across the state and measuring progress towards diversion goals. EGLE should work to improve and increases data on recycling and composting in the state, including the development of diversion metrics for both commercial and residential recovery. When considering data collection, the state should track residential, commercial, and C&D quantities separately and generally improve commercial recycling tracking.

Having regularly tracked metrics in place allows for:

- Benchmarking Michigan's progress against previous years and other states.
- The private sector to better understand where recyclable commodities are generated in the state for the purpose of siting new processing and manufacturing facilities.
- Local governments to track their own progress against that of their peers and use that information to show elected officials how they are doing or whether past investments in recycling programs have produced results.

End Markets

END-USE MARKET DEVELOPMENT

- Development of end markets for specific commodities in Michigan for materials where foreign import restrictions have been imposed, as well as the development of programs and technologies that can reduce the level of contamination to meet market specifications. These solutions will begin to resolve current issues in recycling markets for materials that were primarily exported in the past.
- The State should focus on a communication program that encourages products made in Michigan with recycled content. Case studies should be developed that illustrate how a commodity flows through the system and into what new product.
- The State should provide information on Michigan capacity, quantities of material Michigan generates, and identify areas of opportunity, like how to recycle specific materials like agricultural plastic.
- The State should implement policies and regulations that incentivize recycling, such as a solid waste surcharge on top of the tipping fee, tax credits for recycling equipment, or material bans.
- Solid waste districts could serve as a clearinghouse on the recyclability of products and provide a clear message on education.
- Increase the use of recycled materials content standards to incentivize recycling and end-market development
- Attract forward thinking companies to invest and locate in Michigan with a focus on utilizing the recycled commodity materials generated in the state.
- Consider innovative incubator-type approaches to developing, vetting, and funding promising end-market solutions.

CONTINUE TO ASSESS THE STATE OF END-USE MARKETS AT REGULAR INTERVALS

- We recommend that EGLE conduct a comprehensive census of manufacturers who currently or could potentially consume recyclable feedstocks and maintain a regular survey to identify current and potential consumers of recyclable feedstocks in Michigan and the region.

- Valuable information can be gleaned from regular communication with the experts we have assembled for this review and can also help to support the networks needed to ensure Michigan's recycling system is strong. EGLE should continue to conduct an annual survey or other formal interaction (workshop, capital day, investment conference with current and potential end-use markets. Gathering and sharing data from end-use markets on a regular basis will assist EGLE in tracking progress towards goals as well as to identify new areas of opportunity or challenges that the Department may provide support.

COLLABORATE WITH ECONOMIC DEVELOPMENT AGENCIES TO CONNECT STAKEHOLDERS

- Support economic development agencies in understanding recycling and providing recycling data. For instance, Michigan might be a great place to make recycled glass counters, but there is a lack of data to prove the theory.
- Representatives of Michigan end markets contacted in this study emphasized the need to find ways for communities, processors and manufacturers to work together when possible. One way to catalyze such collaborations is to empower regional economic development agencies to make connections between communities that create a supply of materials, facilities that sort materials, and processors and manufacturers that use recycled commodities. Ideally, economic development agencies will be able to foster relationships between MRFs looking to sell materials and brokers or manufacturers looking to purchase materials.
- Economic development agencies may be able to establish hub and spoke systems by identifying partners who are interested in being a hub or spoke and making connections between the two. Creating these types of relationships will build regionalization within the recycling industry and thereby strengthen Michigan's end markets.
- We recommend that EGLE work with regional economic development agencies, including local chambers of commerce and local economic development corporations, to help them attract businesses that can use materials generated in Michigan. EGLE can encourage this by providing economic development agencies with information on the basics of recycling, the system of recycling markets, and the positive economic impacts of recycling.
- The Michigan Economic Development Corporation (MEDC) should be a full partner, along with the EGLE, in the development and execution of a comprehensive census of manufacturers who currently or could potentially consume recyclable feedstocks and maintain a regular survey to identify current and potential consumers of recyclable feedstocks.

LEVERAGE NATIONAL BRANDS, ASSOCIATIONS AND AGENCIES SEEKING SUSTAINABLE MATERIALS MANAGEMENT

- The EGLE should inventory and identify a potential role in Michigan for the many initiatives currently progressing throughout the country. The EGLE should consider active participation and funding of events and projects that might foster increased investment and activity by these groups, as well as routinizing access for Michigan stakeholders to national resources through technical support, partner agreements, matching funds and in kind supports. These groups will also provide a cost-effective means for access to training, best practices, and topical experts for the professional training and development of the Recycling Specialists.

ENHANCE END-MARKET CAPACITY AND TARGET MATERIALS TECHNICAL ISSUES AND UNDEVELOPED END MARKET CAPACITY

- It is recommended that that during the current down recycling market, the State of Michigan should research and set goals for attracting, over the next five years, secondary processing facilities for materials that are more challenging to recycle and/or need stronger supply chains to reach end markets – including mixed plastics, glass and e-waste.
- The Michigan Legislature, with assistance from EGLE, should develop a process within the university system that would consider how materials research and potential substitution (recyclable for virgin), technology transfer, and basic research into materials handling and supply chain are currently adapted to incorporate recovery market needs. Recommendations about how best to integrate and prioritize recovery markets should be prepared, vetted and supported by the EGLE and the Legislature, to ensure that our university assets are being fully leveraged.
- The State should collect data and evaluate and target specific commodities by Value Proposition. The following table matrix provides a framework and a range of possible recovery for targeting specific commodities for recovery.

Table 29: High Volume and Good Market Value

MATERIAL TYPE	CURRENT ANNUAL VOLUME ESTIMATE (TONS)	RANGE POTENTIAL OF ADDITIONAL RECYCLED MATERIAL (ANNUAL TONS)	PRIMARY SOURCES (RESIDENTIAL, COMMERCIAL, INSTITUTIONAL)	KEY VALUE CHAIN GAPS COLLECTION TO END-MARKET, REGULATORY AND POLICY	TOOLBOX OF SOLUTIONS TO ADDRESS THOSE GAPS
CARDBOARD	223,711	270,700 to 330,900	All Sources	Collection access for residential (rural and multi-family), smaller commercial; un-necessary exclusions (e.g. pizza boxes); processing capacity shortfall, links to end markets, supporting policies	Improved end-markets and pricing, minimum access standards, expanded MRF capacity (including hub & spoke), disposal bans, minimum recycled content standards
COMPOSTABLE ORGANICS (FOOD WASTE, SOILED PAPER)	380,221	671,100 to 998,000	All Sources	Collection access for residential (residential and commercial), commercial requirements for food waste; processing capacity shortfall, Compost and Other (AD), supporting regulatory framework for sites	Improved end-markets and pricing, minimum access standards, expanded Composting and Alternative Processing (e.g. Anaerobic Digestion) capacity, disposal bans, Collection Requirements for commercial food waste
FERROUS SCRAP METAL	276,236	176,900 to 216,200	All Sources	Collection access for residential (rural and multi-family), commercial; processing capacity shortfall, links to end markets, supporting regulatory framework for sites	Improved end-markets and pricing, minimum access standards, expanded MRF capacity (including hub & spoke), disposal bans
ALUMINUM CANS AND CONTAINERS	39,743	5,700 to 6,300	All Sources	Collection access for residential (rural and multi-family), commercial; processing capacity shortfall, yield loss in MRFs (20+% loss is typical), links to end markets, supporting regulatory framework for sites	Improved end-markets and pricing, increasing yield in MRF through additional eddy current separator capacity. minimum access standards, expanded MRF capacity (including hub & spoke), disposal bans

PET PLASTICS	57,155	27,000 to 33,000	All Sources	Collection access for residential (rural and multi-family), commercial; processing capacity shortfall, links to end markets, supporting regulatory framework for sites	Improved end-markets and pricing, minimum access standards, expanded MRF capacity (including hub & spoke), disposal bans
HDPE PLASTICS	50,521	22,150 to 27,100	All Sources	Collection access for residential (rural and multi-family), commercial; processing capacity shortfall, links to end markets, supporting regulatory framework for sites	Improved end-markets and pricing, minimum access standards, expanded MRF capacity (including hub & spoke), disposal bans
WOOD	Not Reported (NR)	298,500 to 448,000	Residential and Commercial Demolition	Requirements for recovery from Construction and Demolition, Link to Green Building requirements	Improved end-markets and pricing, disposal bans, Recovery Requirements for C&D

Table 30: Lower Volume Higher Value Recyclables

MATERIAL TYPE	CURRENT ANNUAL VOLUME ESTIMATE	RANGE POTENTIAL OF ADDITIONAL RECYCLED MATERIAL (ANNUAL TONS)	PRIMARY SOURCES (RESIDENTIAL, COMMERCIAL, INSTITUTIONAL)	KEY VALUE CHAIN GAPS COLLECTION TO END-MARKET, REGULATORY AND POLICY	TOOLBOX OF SOLUTIONS TO ADDRESS THOSE GAPS
POLY COATED PAPER CUPS AND CARTONS	3,612	2,900 to 3,200	All Sources	Collection access for residential (rural and multi-family), commercial; processing capacity shortfall, links to end markets, supporting regulatory framework for sites	Improved end-markets and pricing, minimum access standards, expanded MRF capacity (including hub & spoke)
NON-FERROUS SHEET AND FOIL	76,541	30,500 to 33,700	All Sources	Collection access for residential (rural and multi-family), commercial; processing capacity shortfall, links to end markets, supporting regulatory framework for sites	Improved end-markets and pricing, minimum access standards, expanded MRF capacity (including hub & spoke)
ELECTRONICS	87,757	9,800 to 16,300	All Sources	Enhanced Take-Back Programs in cooperation with Brands and Retailers	Improved end-markets and pricing, Producer Take-back Requirements

Table 31: Lower Value

MATERIAL TYPE	CURRENT ANNUAL VOLUME ESTIMATE	RANGE POTENTIAL OF ADDITIONAL RECYCLED MATERIAL (ANNUAL TONS)	PRIMARY SOURCES (RESIDENTIAL, COMMERCIAL, INSTITUTIONAL)	KEY VALUE CHAIN GAPS COLLECTION TO END-MARKET, REGULATORY AND POLICY	TOOLBOX OF SOLUTIONS TO ADDRESS THOSE GAPS
CONTAINER GLASS	175,630	49,500 to 67,000	All Sources	Collection access for residential (rural and multi-family) and commercial; processing beneficiation shortfall (work with container deposit processors), Identify viable end market alternatives, supporting regulatory framework for siting	Improved end-markets and pricing, minimum access standards, expanded MRF capacity (including hub & spoke), improved glass separation at MRFs, one or more glass reprocessing hub and spoke networks, bottle bill expansion
#3 THROUGH #7 PLASTICS	6,727	6,200 to 7,500	All Sources	Collection access for residential and commercial; processing capacity shortfall, improved end markets viability and capacity, supporting regulatory framework for sites	Improved end-markets and pricing, minimum access standards, expanded MRF capacity (including hub & spoke), upgraded MRF capabilities, added plastics reprocessing capacity
MIXED PAPER	495,005	453,900 to 586,600	All Sources	Collection access for residential (rural and multi-family), commercial; processing capacity shortfall, links to end markets, supporting regulatory framework for sites	Improved end-markets and pricing, minimum access standards, expanded MRF capacity (including hub & spoke)

ALL OTHER PLASTICS AND PACKAGING, LDPE, POLYSTYRENE (FOAM), DURABLE AND RIGID CONTAINERS/ PRODUCTS AND PP TUBS	2,367	233,700 to 350,500	Residential	Collection access for residential and commercial; processing capacity upgrades to sort complex materials (packaging, LDPE, films), links to end markets, supporting regulatory framework for sites	Improved end-markets and pricing, minimum access standards, expanded MRF capacity (including hub & spoke), upgraded MRF capabilities, expanded takeback networks and super drop-offs
OTHER GLASS	22,532	12,300 to 20,500	All Sources	Take-back requirements, end market development for coated plate and other glass, access state-wide at enhanced Drop-off Convenience Centers	Improved end-markets and pricing, recycling requirements, take-back requirements
TEXTILES	49,212	98,500 to 164,000	Residential	Take-back requirements, Education programs for enhanced recovery, access state-wide at enhanced Drop-off Convenience Centers	Reporting Requirements for textile collection programs, Improved end-markets and pricing, recycling requirements, take-back requirements

Table 32: Other Recoverable Material

MATERIAL TYPE	CURRENT ANNUAL VOLUME ESTIMATE	RANGE POTENTIAL OF ADDITIONAL RECYCLED MATERIAL (ANNUAL TONS)	PRIMARY SOURCES (RESIDENTIAL, COMMERCIAL, INSTITUTIONAL)	KEY VALUE CHAIN GAPS COLLECTION TO END-MARKET, REGULATORY AND POLICY	TOOLBOX OF SOLUTIONS TO ADDRESS THOSE GAPS
MATTRESSES	NR	Not Estimated	All Sources	Take-back requirements, Education programs for enhanced recovery, access state-wide at enhanced Drop-off Convenience Centers	Reporting Requirements for mattress collection programs, Improved end-markets and pricing, recycling requirements, take-back requirements
LATEX PAINT, OIL PAINT	NR	Not Estimated	Residential	Take-back requirements, Education programs for enhanced recovery, access state-wide at enhanced Drop-off Convenience Centers	Reporting Requirements for paint collection programs, Improved end-markets and pricing, recycling requirements, take-back requirements
HHW		Not Estimated	Residential	Collection access for residential (rural and multi-family) at enhanced Drop-off Convenience Centers	Reporting Requirements for HHW collection programs, Improved end-markets and pricing, recycling requirements, take-back requirements
BATTERIES	NR	Not Estimated	Residential	Collection access for residential (rural and multi-family) at enhanced Drop-off Convenience Centers	Reporting Requirements for battery collection programs, Improved end-markets and pricing, recycling requirements, take-back requirements

PHARMACEUTICALS	NR	Not Estimated	Residential	Take-back requirements, Education programs for enhanced recovery	Reporting Requirements for meds collection programs, Improved end-markets and pricing, recycling requirements, take-back requirements
FATS, OIL, GREASES (FOG)	NR	Not Estimated	Commercial	Enhanced Education and Enforcement of local health/sewer discharge regulations, supporting regulatory framework for sites such as collection requirements under Public Health and Wastewater discharge programs, enhanced drop-off	Reporting Requirements for FOGs collection programs, recycling requirements

APPENDICES

APPENDIX A: UPDATE TO THE MICHIGAN RECYCLING INDEX

Introduction

In June 2019, the Michigan Department of Environment, Great Lakes, and Energy (EGLE) engaged RRS to update the Michigan Recycling Index (MRI). The project's task was to measure access to recycling throughout Michigan, evaluate participation in recycling, and calculate the rate of recycling for municipal solid waste (MSW).

To achieve this goal, RRS reviewed information that is available in the EGLE reporting system, with different types of data proving more readily available than others. To account for data gaps for materials not reported in the State system, such as White Goods, RRS utilized the previously developed extrapolation model to make reasonable projections for those materials. In addition to a base recycling rate calculation, conservative and aggressive scenarios were examined for each material category to reflect levels of certainty and are expressed as a range. The result of the project update to the 2015 estimate provides a better understanding of Michigan's recycling systems, the progress made to date, and recommendations that may be used to support state leadership and funding in this arena, attract public and private sector investments, increase the availability of low cost, environmentally beneficial feedstock to manufacturers, and improve program performance at all levels.

Rate of Recycling

- Michigan achieved an estimated MSW recycling rate of 18.1% in 2018.
- Container deposits account for 8.4% of recycled MSW in Michigan, or 1.7% of total MSW.
- 62.6% of MSW recycled is made up of 'traditional' recyclable materials collected from commercial and residential sources, while 19.5% of the total is composted organics, and other source separated streams (such as lead-acid batteries, white goods, tires, e-waste, and textiles) make up the remaining 9.5%.

Key Findings

- Recycling Rate
    - An aggressive multi-pronged strategy will be required to achieve a recycling rate of 45%.
    - Assuming that 53% of the material generated in Michigan is by the commercial sector, data available on the generation and recovery of material from this sector needs to be improved and better understood so that commercial recycling can increase as required to reach 45%
    - The current annual average quantity of material recycled per household (single family) is 360 lbs. per household (single family). If all multi-family residences are included, then 341 lbs. per household are recovered.
    - Residential recycling improvements alone will not be enough to achieve the 45% goal.
        - If all households, in every city in Michigan, with a population greater than 25,000, recycled at the same proportion as reported curbside programs (i.e. 433 lbs. recyclables per household annually), the state recycling rate would increase to 19.9%.
        - If all households in the state (including single family and multi-family) recycled at the same proportion as reported curbside programs (i.e. 433 lbs. recyclables per household annually), the state recycling rate would increase to 20.5%.

        - If all households in the state (including single family and multi-family) recycled at the expected level of a high-participation curbside programs (i.e. recovering 550 lbs. recyclables per household annually), the state recycling rate would increase to 21%.
        - If all single-family households in the state recycled at the level of a high-recovery rate curbside program at 800 lbs. (recyclables and food waste) per household annually, the state recycling rate would increase to approximately 30%.
- The quantity of material estimated to be recovered in 2015 was 1,535,195 tons. Tripling of the recycling rate from the 15% estimated in 2015 to a 45% recovery rate would result in an additional 2.6-2.7 million tons of recovery from the estimated 8.831 million ton of waste currently landfilled or incinerated.
    - As identified in the update to the MRI section, the reported quantity of material collected and processed in 2018 from residential and commercial generators was 1.221 million tons of material, an increase of 81% above the estimated recovered material in 2015 or an additional 546,000 tons.

PER CAPITA DISPOSAL, DIVERSION, & WASTE GENERATION IN MICHIGAN

	2015	2018
Population of Michigan	9,933,000	9,996,000
Per capita disposal	1,616	1,767
Per capita diversion	285	390
Per capita waste generation	1,901	2,157

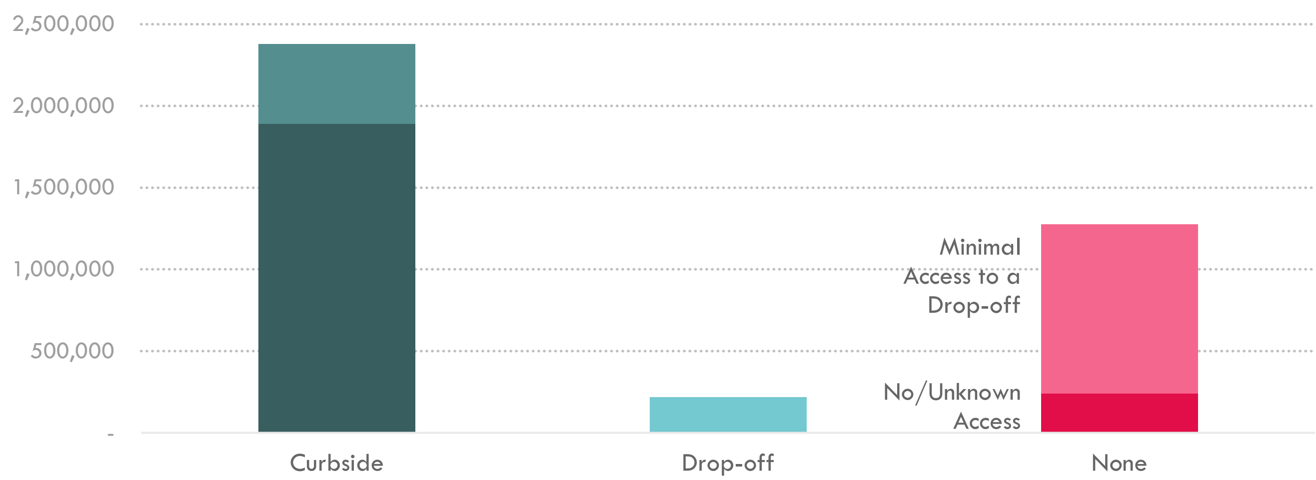
While Michiganders **recycled** more, they also **disposed** of more, resulting in an **increase in waste generation** (lbs/person/year)

APPENDIX B: STATE OF RECYCLING IN MICHIGAN

Access

The Michigan Recycling Index evaluated over 1,700 communities representing at least 95% of the state's population to determine the level of access to recycling and composting services statewide in 2015. These services are provided in a variety of ways, including curbside pickup provided by communities, curbside pickup available through subscriptions with private waste haulers, and drop-off locations for recycled materials. The study found that two-thirds (67%) of Michigan households have access to some form of convenient recycling – either municipal or subscription curbside recycling, or convenient drop-off locations (defined by EGLE as one location for every 10,000 residents of a county). Curbside recycling provided by municipalities is available to 49% of Michigan households, while another 13% have curbside services available via subscription. Drop-off stations are found in a vast majority of Michigan counties and support 94% of the state's households, but these facilities only reach the 10,000 residents per drop-off threshold for 7% of Michiganders. The MRI project also measured access to compost drop-off and curbside collection services, concluding that at least 43% of Michigan households have access to composting services for materials like yard waste and leaves.

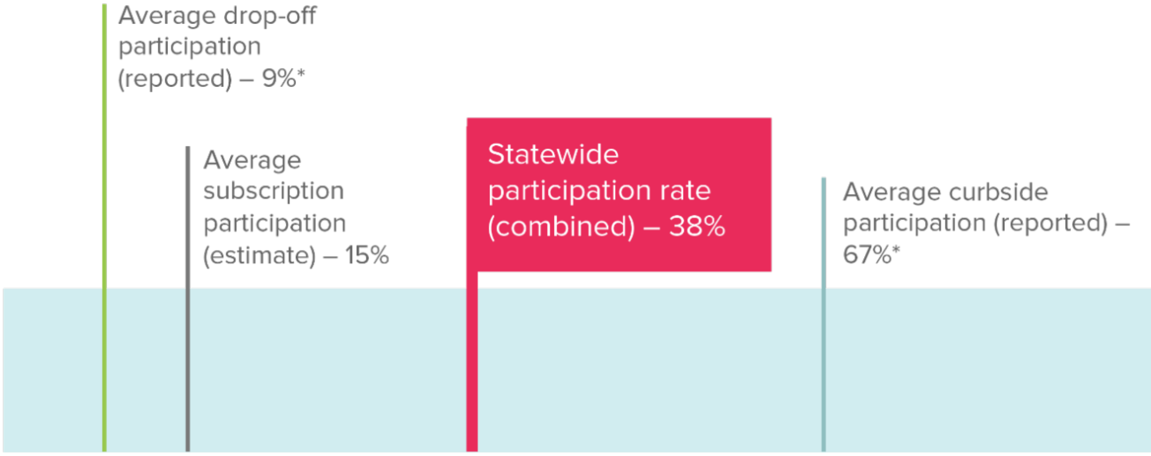
Figure 15: Households with Access to Convenient Recycling



Participation

Although data on participation is limited due to this information being challenging for recycling programs to collect, the MRI found a wide range of participation in recycling programs, from less than 1% of households participating to over 90%. This wide range held true for both curbside and drop-off recycling, but outside of the extremes on either end, curbside programs tended to have much greater participation. The average participation rate for drop-off, weighted by program size, was just 9%, compared to 67% for curbside.

Figure 16: Range of Program Participation Rates



Municipal Solid Waste Definitions

MUNICIPAL SOLID WASTE

The US EPA defines Municipal Solid Waste (MSW) as "discards from residential and commercial sources that does not contain regulated hazardous wastes." (EPA, State Measurement Program Template, 2013) The EPA has provided a detailed description of materials that are considered MSW and those that are not, 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.

RECYCLING

Recycling is defined by the US 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." (EPA, State Measurement Program Template, 2013) Similar detail identifying the activities that are and are not considered recycling is excerpted from "Measuring Recycling: A Guide for State and Local Governments" and appended to this document. Key activities that are not considered recycling 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 C&D debris.

Effectively, the EPA definition of MSW was used in this methodology and is based on the historical management of municipal solid waste. 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.

MICHIGAN DEFINITION OF SOLID WASTE

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. This study is limited to analysis of the statutory definition of municipal solid waste (MSW or solid waste), which is defined by Michigan law as “garbage, rubbish, ashes, incinerator ash, incinerator residue, street cleanings, municipal and industrial sludges, solid commercial waste, solid industrial waste, and animal waste” as per Act 451 of 1994, Part 115, Solid Waste Management. 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.

The definition of MSW in Michigan excludes the following materials from the definition of Solid Waste:

a) Human body waste.
b) Medical waste.
c) Organic waste generated in the production of livestock and poultry.
d) Liquid waste.
e) Ferrous or nonferrous scrap directed to a scrap metal processor or to a reuser of ferrous or nonferrous products.
f) Slag or slag products directed to a slag processor or to a reuser of slag or slag products.
g) Sludges and ashes managed as recycled or non-detrimental materials appropriate for agricultural or silvicultural use pursuant to a plan approved by the department.
h) The following materials that are used as animal feed, or are applied on, or are composted and applied on, farmland or forestland for an agricultural or silvicultural purpose at an agronomic rate consistent with GAAMPS.
i) Materials approved for emergency disposal by the department.
j) Source separated materials.
k) Site separated material.
l) Coal ash, when used under specified circumstances
m) Inert material.
n) Soil that is washed or otherwise removed from sugar beets, has not more than 35% moisture content, and is registered as a soil conditioner.
o) Soil that is relocated under section 20120c.
p) Diverted waste that is managed through a waste diversion center.
q) Beneficial use by-products.
r) Coal bottom ash, if substantially free of fly ash or economizer ash, when used as cold weather road abrasive.
s) Stamp sands when used as cold weather road abrasive in the Upper Peninsula by specified agencies:
t) Any material that is reclaimed or reused in the process that generated it.
u) Any secondary material that, as specified in or determined pursuant to 40 CFR part 241, is not a solid waste when combusted.
v) Other wastes regulated by statute.

Appendix I: 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
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 - 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 - 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
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
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
PAPERWORKS INDUSTRIES	PaperWorks Industries - Wabash	Wabash	IN	134,201	31,963	31,312	70,926
PCA	PCA - Filer City	Filer City	MI	179,967	171,494	0	8,473
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
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
SCA	SCA - Menasha	Menasha	WI	223,612	104,477	0	119,135

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 PIGEON PAPER	White Pigeon Paper - White Pigeon	White Pigeon	MI	62,274	13,147	6,573	42,553

Appendix II: Plants Utilizing Recovered Plastics

COMPANY NAME	FACILITY NAME	CITY	STATE	ESTIMATED TONS PER YEAR
ACI PLASTICS INC.	ACI Plastics Inc. - Flint	Flint	MI	28,500
ADAMS PLASTICS LP	Adams Plastics LP - Rolling Meadows	Rolling Meadows	IL	2,500
ALLOY EXCHANGE INC.	Alloy Exchange Inc. - Rockford	Rockford	MI	5,100
ANTEK MADISON PLASTICS RECYCLING CORP.	Antek Madison Plastics Recycling Corp. - Scarborough	Scarborough	ON	38,500
ARROTIN PLASTIC MATERIALS INC.	Arrotin Plastic Materials Inc. - Fort Wayne	Fort Wayne	IN	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
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
CHOICE PLASTICS INC.	Choice Plastics Inc. - Mound	Mound	MN	8,800
CLEAN TECH INC.	Clean Tech Inc. - Dundee	Dundee	MI	125,000
CTC PLASTICS	CTC Plastics - Dayton	Dayton	OH	40,000
DELTCO PLASTICS INC.	Deltco Plastics Inc. - Ashland	Ashland	WI	15,675
DESTINY PLASTICS INC.	Destiny Plastics Inc. - Deckerville	Deckerville	MI	9,500
EAST-TERRA SUPPLY LLC	East-Terra Supply LLC - Indianapolis	Indianapolis	IN	9,600
EFS-PLASTICS INC.	EFS-Plastics Inc. - Listowel	Listowel	ON	33,000
EVERGREEN PLASTICS INC.	Evergreen Plastics Inc. - Clyde	Clyde	OH	55,000
EXXEL POLYMERS INC.	Exxel Polymers Inc. - Bromont	Bromont	ON	11,375
FRANKLIN PLASTICS	Franklin Plastics - Battle Creek	Battle Creek	MI	6,100
GENERAL MILL SUPPLY CO.	General Mill Supply Co. - Wixom	Wixom	MI	14,400
GRACE PLASTICS INC.	Grace Plastics Inc. - Batavia	Batavia	OH	2,125
GREEN EARTH PLASTIC RECYCLING INC.	Green Earth Plastic Recycling Inc. - Joliet	Joliet	IL	5,400
GREEN PROCESSING CO. INC.	Green Processing Co. Inc. - Windsor	Windsor	ON	19,150
H. SATTLER PLASTICS CO. INC.	H. Sattler Plastics Co. Inc. - Chicago	Chicago	IL	4,900
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
KAL-TRADING INC.	Kal-Trading Inc. - Mississauga	Mississauga	ON	12,500

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
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
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
PRIME TIME PLASTICS LTD.	Prime Time Plastics Ltd. - Rocky River	Rocky River	OH	5,250
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
SBC SOLUTIONS GROUP	SBC Solutions Group - Centerburg	Centerburg	OH	40,000
SCRAP MASTERS INC.	Scrap Masters Inc. - Manchester	Manchester	MI	9,050
UNITED PLASTICS INC.	United Plastics Inc. - Flint	Flint	MI	32,400
UPCYCLE POLYMERS LLC	UpCycle Polymers LLC - Howell	Howell	MI	600
WERLOR INC.	Werlor Inc. - Defiance	Defiance	OH	2,500
WEST MICHIGAN COMPOUNDING LLC	West Michigan Compounding LLC - Greenville	Greenville	MI	30,000
WINCO PLASTICS	Winco Plastics - North Aurora	North Aurora	IL	22,500

Appendix III: 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 startup 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 IV: 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

APPENDIX C: ACCESS TO RECYCLING IN MICHIGAN

Overview and Definitions

Waste diversion begins when residents are given the opportunity to send their waste products, packaging, and other materials to a recycling or compost facility, rather than a landfill. These opportunities can come in the form of curbside collection or drop-off facilities available to residents. Access to recycling and composting are defined in terms of the availability of these services in a local area, as described below:

CURBSIDE ACCESS

Curbside access to composting or recycling means that residents of a given community either have curbside collection services provided to them by municipal employees or a private hauler under contract with their municipality, or they have the opportunity to subscribe to curbside collection services made available by private haulers in their area. While municipally collected or contracted services typically have significantly higher participation rates than subscription services, both are counted as curbside access because residents under both systems have the opportunity to participate if they choose to do so.

Where offered, curbside collection is typically available to residents living in single-family homes and small multi-family buildings (four units or fewer). Residents in larger multi-family buildings and complexes may have access to curbside recycling or similar services through the commercial waste hauler contracted by the apartment owner. Studies quantifying access to recycling in the US have noted that access to recycling for multi-family residents is notoriously difficult to measure. For the purposes of this study, unless a community provided or mandated recycling services to all multi-family residents, it was assumed that only residents living in buildings of four units or smaller have access to the curbside recycling programs in a community. Residents of larger multi-family complexes were assumed to have access only to the drop-off recycling programs available to the general public.

When it comes to subscription curbside services, there is a wide variation in how subscription curbside recycling is offered in Michigan. In some regions it is common for haulers offering subscription waste collection services to provide recycling collection at no additional cost, while in other areas recycling is available with an additional fee. In addition, some haulers may provide free recycle bins, while others charge the subscriber for the bin. Recycling carts are available through subscription in some areas, typically for a monthly fee, but some haulers provide them at no additional cost. The variation in fee structure and service availability in subscription areas has implications for resident participation in recycling programs and is worthy of further study.

Quality of curbside recycling access is also a factor in assuring high participation. Frequency of curbside recycling service is a key component of quality access with weekly considered a best practice to assure high participation. Less frequent rates of service (e.g. once per month) are uncommon.

Provision of a large rolling curb-cart for recycling is a second key component in quality curbside recycling access. The State of Michigan has been working to increase access to recycling, in cooperation with organizations such as the Recycling Partnership, to provide grants to communities for the procurement of recycling curb carts and to enhance curbside collection programs. Significant investments in the past five years by the state through its grant programs and technical support have increased the number of communities with carts at the curb, increasing the capacity of recyclables collected curbside.

DROP-OFF ACCESS

Drop-off access to composting or recycling refers to the availability of a collection facility for these materials open to residents in a local area, either free of charge or for a nominal fee. Drop-off access, rather than being a simple "yes or no" metric, is evaluated on a variable scale based on a drop-off location's proximity to residents, size, hours, materials accepted, etc. For the purpose of this study, the MRI evaluated Michigan communities based on two levels of access to drop-offs.

- A minimal level of drop-off access is defined as having at least one drop-off facility in a given county that is open to the public.
- A convenient level of drop-off access is defined as having at least one drop-off location for every 10,000 persons in any given county.

COMBINATION ACCESS

A combination of curbside and drop-off access provides many advantages to residents of a municipality, allowing residents to divert waste on a day-to-day basis through convenient curbside services, while maintaining the availability of drop-offs for larger volumes of material, special events, missed pick-ups, etc. Drop-off recycling opportunities are also important for residents in multi-family housing that is not served by a municipal curbside program, as noted above. Therefore, the MRI also evaluated the availability of a combination of both types of access in Michigan counties.

Access to recycling and composting services has improved but still varies significantly across Michigan's regions. Targeted updates to the 2015 MRI study to account for grant-funded infrastructure improvements, including carts to communities and drop site infrastructure in rural areas, are included in the updated Table 2, which demonstrates that curbside services continue to be more accessible in the denser and more urbanized regions such as Southeast Michigan. However, several rural areas excelled at providing extensive convenient drop-off networks, bringing their overall access rate up among the highest state-wide. Table 2, below, summarizes access in each of Michigan's 14 economic development regions. Note that these are broad generalizations based on combining access across each region.

Appendix XI: Access by Michigan Region

NUMBER OF HOUSEHOLDS (%)				
	ACCESS TO CURBSIDE RECYCLING	ACCESS TO CURBSIDE COMPOSTING	ACCESS TO CURBSIDE OR CONVENIENT DROP-OFF RECYCLING	ACCESS TO CURBSIDE OR DROP-OFF COMPOSTING
REGION 1: SEMCOG	79%	51%	79%	59%
REGION 2: R2PC	35%	6%	35%	7%
REGION 3: SCMPC	44%	10%	55%	39%
REGION 4: SWMPC	23%	0%	23%	0%
REGION 5: GLSPDC	73%	25%	73%	25%
REGION 6: TCRPC	59%	31%	72%	53%
REGION 7: EMCOG	50%	31%	59%	40%
REGION 8: WMRPC	54%	20%	59%	25%
REGION 9: NEMCOG	8%	8%	81%	8%
REGION 10: NETWORKS NW	22%	13%	67%	43%
REGION 11: EUPRPDC	25%	0%	66%	0%

REGION 12: CUPPAD	17%	7%	27%	19%
REGION 13: WUPPDR	0%	0%	16%	9%
REGION 14: WMSRDC	35%	20%	35%	22%
TOTAL	**61%**	**34%**	**67%**	**43%**

APPENDIX D: GREENHOUSE GAS REPORT

Many people believe that throwing food scraps and paper products into a landfill is harmless because they biodegrade. However, most people are surprised to learn that when these materials break down in a landfill, they become powerful contributors to greenhouse gas emissions. Compostable materials such as food scraps and paper decompose anaerobically (without oxygen) in a landfill, producing methane (CH_4) which has 23-71 times greater heat trapping capabilities than carbon dioxide. In fact, landfills accounted for approximately 16.4 percent of total U.S. anthropogenic methane (CH_4) emissions in 2017, the third largest contribution of any CH_4 source in the United States[11].

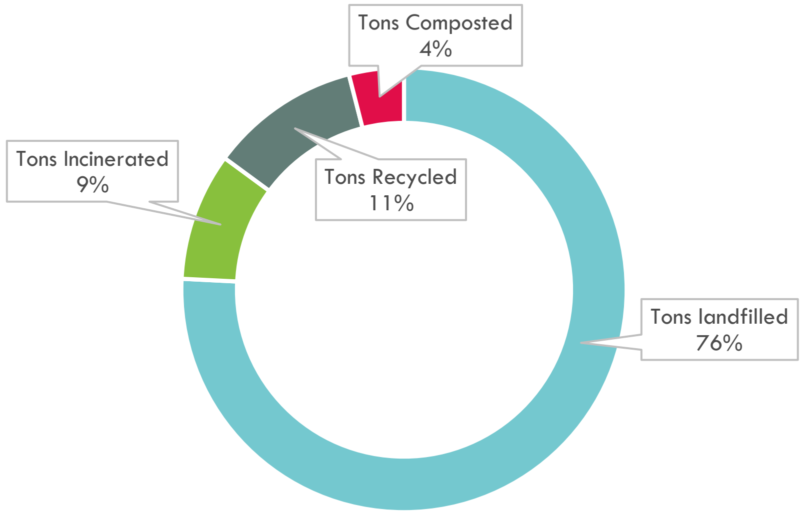
Gases that trap heat in the atmosphere are called greenhouse gases. The main greenhouse gases are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_20), and fluorinated gases. Each gas's effect on the climate depends on how much is in the atmosphere, how long they stay in the atmosphere, and how strongly they impact the atmosphere. Disposal and treatment of materials results in greenhouse gas emissions from collection, transport, landfill disposal, manufacture, etc.

The most common way to measure climate impact of waste management is to state the impact in carbon equivalents. Since waste reduction results in the reduction of several types of greenhouse gases, the conversion to a standard carbon equivalent (CO_2E) measurement allow for a total quantification of the impact. It also provides a standard language for people to compare these actions to others such as transportation and energy conservation efforts. A carbon equivalent CO_2E is simply the amount of CO_2 that would have the same global warming potential as the waste reduction impacts, when measured over a specified timescale. The international reporting standard for CO_2 emissions is metric tons, so carbon dioxide amounts may be reported as $MTCO_2E$, metric tons of carbon equivalent.

In 2015 Michigan landfilled 7,186,565 tons and incinerated 881,953 tons of MSW from the residential and commercial sector. In addition, the state recycled and composted 1,414,029 tons of material diverted from the residential and commercial waste streams as well as recovered metals from incinerator ash. If Michigan maximized recycling and reuse and applied the principles of circular economy, it can contribute to reduction of greenhouse gas emissions. Altering waste management practices to avoid landfilling waste can reduce greenhouse gas emissions, keep dollars in the local economy, create new green jobs, and improve the community quality of life. When you take into account the full lifecycle of the products, we use every day and the increased energy needed to make replacement products from virgin, raw materials, the actual impact of all this waste grows significantly. Michigan has already made progress towards greater waste diversion, increasing the recycling rate from 15% to 18% from 2015 to 2018. More than 532,000 additional tons were recycled or composted in 2018 than three years prior.

[11] "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2017". USEPA. EPA 430-R-19-001.

Appendix XII: Breakdown of Michigan waste stream



To better understand the greenhouse gas (GHG) impacts of waste management activities and identify emission reduction opportunities, RRS quantified the current and potential GHG impacts of material management if the recycling rate were tripled from the 2015 rate of 15% to 45%.

WARM MODEL OVERVIEW

While there are many models emerging to calculate greenhouse gas reductions, the most recognized and standard model is the EPA's WARM model. Produced by US EPA, the Waste Reduction Model (WARM) was designed to help solid waste planners, municipal leaders, and other stakeholder organizations track and report greenhouse gas emissions reductions. It is a database tool that helps decision makers predict the strategies that most reduce GHG emissions. The WARM model calculates GHG emission across six waste management modalities (source reduction, recycling, composting, anaerobic digestion, combustion, and landfilling). Modeling different combinations of waste management practices sees which approach leads to the least GHG entering the atmosphere.

WARM factors both upstream and downstream GHG costs into its equations, consistent with life-cycle approach to measuring environmental impacts. (See Appendix A for additional WARM background, limitations, and proxies.) This is why source reduction is a powerful strategy because it does away with upstream environmental costs entirely. Not every management practice is effective for every material, and different materials are associated with higher or lower GHG emissions. To take these differences into account WARM algorithms included data on 54 distinct waste materials.

RRS used the WARM model to calculate a material-specific comparison of baseline waste management practices in 2015 to a tripled recovery rate waste management scenario to determine greatest GHG benefits.

MEASUREMENT

The WARM tool generates GHG emissions in terms of three metrics. This report shows the metric tons of carbon dioxide equivalent ($MTCO_2E$), which describes the global-warming potential of all common greenhouse gases as an equivalent of carbon dioxide. Negative values indicate GHG savings and positive values indicate increasing emissions. In 2015, compared to landfilling the material, recycling and organics service programs reduced emission by over 3.3 million $MTCO_2E$, as shown in Table 1. Emissions were further reduced in 2018 to 4.6 $MTCO_2E$ as a result of greater diversion activity. The diversion rate increased from 15% in 2015 to 18% in 2018.

Appendix XIII: Estimated GHG Emission Reductions from 2015 Diversion Rate and 2018 Diversion Rate

MATERIAL	2015 CURRENT DIVERSION ($MTCO_2E$)	2018 DIVERSION ($MTCO_2E$)
Paper Products	(1,786,334)	(2,503,101)
Metals	(1,554,686)	(2,106,789)
Organics*	162,336	155,218
Glass	(33,954)	(50,064)
Plastics	(62,032)	(99,592)
White Goods	Included in Metals	Included in Metals
Batteries	(11,001)	(15,877)
E-Waste	(6,545)	(9,206)
Textiles	(7,679)	(10,687)
$MTCO_2E$ Emissions	**(3,299,895)**	**(4,640,099)**

Organics: Assumes 95% of organics diverted from disposal in 2015 was yard waste and the remaining 5% is food waste. In 2018, 91% of organics diverted from disposal was yard waste and 9% was food waste.

With more than 80% of the material being landfilled or incinerated in Michigan, there is significant opportunity to divert more material. RRS modeled an alternative system scenario with triple the recycling rate to demonstrate levels of GHG savings from increased diversion. The magnitude of the reduction in GHG emissions per material depends on both the quantity of material diverted and the material itself. Each material has a different GHG emission reduction potential based on how readily it degrades the landfill, how far it travels to market, and other factors. The alternative system scenario RRS developed set conservative targets applying best management practices across material streams currently demonstrating under-performing recovery rates. The outcome is tangible realistic recovery goal estimations as shown in Table 2. By implementing additional best practices, Michigan's residents and businesses can increase material diversion and reduce GHG emissions. Table 2 lists current diversion tonnages for underperforming targeted materials, potential recovered tonnages, and modeled diversion tonnages needed to get Michigan to 45% diversion. These tonnages were used in WARM to model the potential GHG emissions of these additional diverted materials.

Appendix XIV: Estimated Recovered Tons

MATERIAL	2015 DIVERSION (tons)	2018 DIVERSION (tons)	TRIPLE RECYCLING RATE RECOVERY TONNAGE (tons)	CHANGE IN GHG EMISSIONS FROM 15% to 45% DIVERSION RATE
Paper Products	524,606	722,328	1,529,107	(3,635,151)
Metals	285,076	392,520	830,932	(2,798,184)
Organics	276,144	380,221	804,895	(294,183)
Glass	143,920	198,163	419,493	(81,864)
Plastics	84,806	116,769	247,189	(192,803)
White Goods	55,013	75,747	160,349	Included in Mixed Metals
Batteries	32,815	45,182	95,647	(24,774)
E-Waste	8,723	12,011	25,426	(13,518)
Textiles	2,763	3,805	8,055	(15,246)
Total	**1,413,866**	**1,946,746**	**4,121,093**	**(7,055,723)**

Additional GHG emissions could be avoided if materials are reduced at the source before entering the waste stream to be managed. ReFED[12] reports consumer education measured in the United Kingdom and elsewhere demonstrate reduced impacts on consumer food waste. Love Food Hate Waste is a national consumer awareness campaign launched by Waste and Resources Action Programme (WRAP). After six months of launching this campaign in six Boroughs of West London Waste Authority, a 14% avoidable food waste reduction was tracked.[13] While there is minimal tracking in the U.S regarding consumer education campaigns, King County, WA and Honolulu County, HI implemented pilot programs testing messages and tools to reduce food waste. Those respective campaigns measured 28% and 19.6% reduction[14]. Applying the minimal measured impact of 14% to Michigan's food scrap generation could reduce 165,943 tons of food scraps from the waste stream and net GHG emission savings of 697,000 $MTCO_2E$. Table 4.7 shows the source reduction of food scraps modeled in WARM.

Appendix XV: Estimated Source Reduced Tons

Material	POTENTIAL AND MODELED REDUCTION (tons)	CHANGE IN GHG EMISSIONS ($MTCO_2E$)
Food Scraps	**165,943**	**(697,281)**

Tripling the recycling rate would avoid emissions of an additional 7 million metric ton equivalent of carbon dioxide than current diversion practices. That is equivalent to taking nearly 1.5 million passenger vehicles off the road for one year or conserving the annual energy consumption of more than 760,000 households (approximately 20% of

12 https://www.refed.com/solutions/consumer-education-campaigns/
13 "The Impact of Love Food Hate Waste".
http://www.wrap.org.uk/sites/files/wrap/West%20London%20LFHW%20Impact%20case%20study_0.pdf
14 "Toolkit Implementation Guide for the Food: Too Good to Waste Pilot". July 2013. West Coast Climate and Materials Management Forum.
https://westcoastclimateforum.com/sites/westcoastclimateforum/files/related_documents/02_ToolKit_Implementation_Guide_for_the_Good_Too_Good_to_Waste_Pilot.pdf

Michigan households). In total, a 45% recycling rate in Michigan results in 10.3 million metric ton equivalent of carbon dioxide avoided emissions over landfilling or incineration.

GHG emissions from:

1,498,030

Passenger vehicles driven for one year

Greenhouse gas emissions avoided by:

760,731

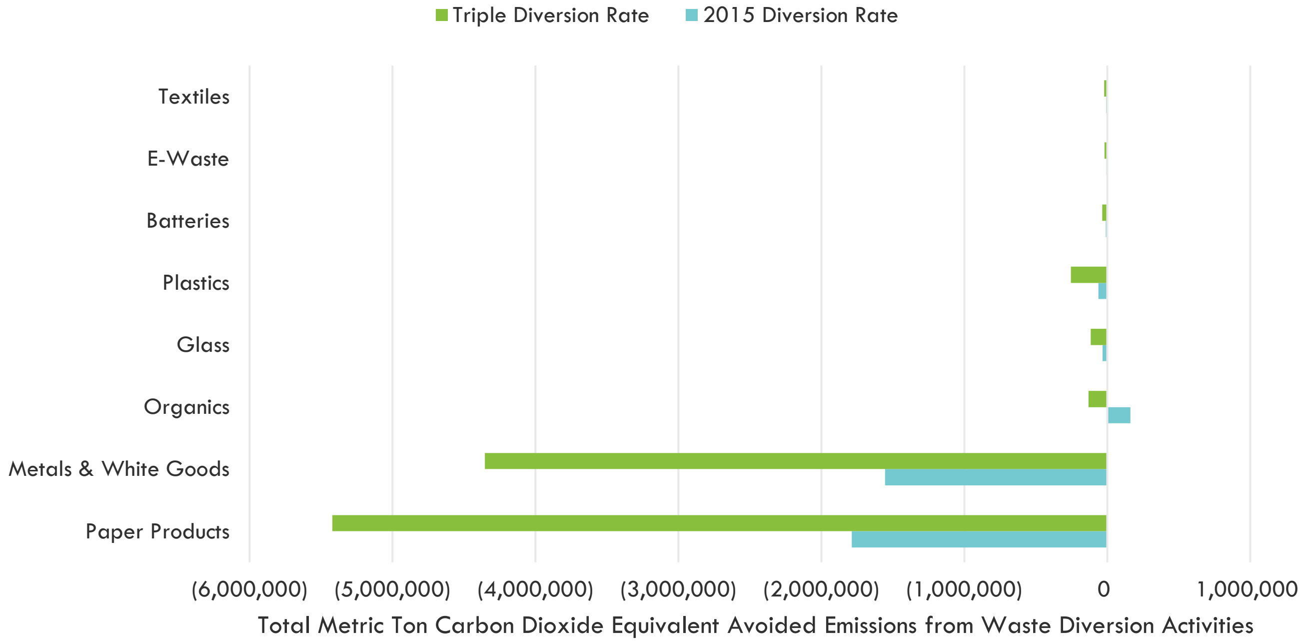
Households' Annual Energy Consumption

Appendix XVI: Estimated GHG Emission Reductions Potential from Triple the Recycling Rate

	TRIPLE THE RECYCLING RATE ($MTCO_2E$)
Paper Products	(5,421,485)
Metals & White Goods	(4,352,870)
Organics	(131,847)
Glass	(115,818)
Plastics	(254,835)
Batteries	(35,775)
E-Waste	(20,063)
Textiles	(22,925)
MTCO2E Emissions	**(10,355,618)**

Appendix XVII compares the current GHG emissions to the potential for the estimated recovered tonnage. One of the greatest opportunities for GHG savings is alternative strategies for mixed paper, mixed metals, and organics. Increasing food waste recovery changes organics from a GHG emitter (positive emissions) to a GHG reducer (negative emissions).

Appendix XVII: Total Metric Ton Carbon Dioxide Equivalent Avoided Emissions from Waste Diversion Activities in 2015 and Triple the Recycling Rate



CONCLUSIONS

GHG accounting allows for a consistent approach to calculating and reporting impacts to reduce GHG emissions. The magnitude of the reduction in GHG emissions per material depends on both the quantity of material diverted and the material itself. Each material has a different GHG emission reduction potential based on how readily it degrades the landfill, how far it travels to market, and other factors. In 2015, Michigan's waste management system avoided more than 3,299,895 $MTCO_2E$. Looking toward the future and aiming to further reduce GHG emissions, tripling the diversion rate avoids more than 10,355,618 $MTCO_2E$, equivalent to removing nearly 1.5 million passenger cars from Michigan's roads each year. By concentrating on enhancing the source reduction, recycling and composting practices, GHG emission reductions can be achieved.

U.S. EPA WARM MODEL

BACKGROUND

EPA determined that the best way to conduct such a comparative analysis is a streamlined application of a life-cycle assessment (LCA). A full LCA is an analytical framework for understanding the material inputs, energy inputs and environmental releases associated with manufacturing, using, transporting and disposing of a given material. A full LCA generally consists of four parts: (1) goal definition and scoping; (2) an inventory of the materials and energy used during all stages in the life of a product or process, and an inventory of environmental releases throughout the product life cycle; (3) an impact assessment that examines potential and actual human health effects related to the use of resources and environmental releases; and (4) an assessment of the change that is needed to bring about environmental improvements in the product or processes.

WARM does not provide a full LCA, as EPA wanted the tool to be transparent, easy to access and use, and focused on providing decision-makers with information on climate change impacts, namely GHG and energy implications. WARM's streamlined LCA is limited to an inventory of GHG emissions and sinks and energy impacts. This study did not assess human health impacts, or air, water or other environmental impacts that do not have a direct bearing on climate change. WARM also simplifies the calculation of emissions from points in the life cycle that occur before a material reaches end of life.

The streamlined LCA used in WARM depends on accurately assessing the GHG and energy implications of relevant life-cycle stages. The GHG implications associated with materials differ depending on raw material extraction requirements and how the materials are manufactured and disposed of at end of life. WARM evaluates the GHG emissions associated with materials management based on analysis of three main factors: (1) GHG emissions throughout the life cycle of the material (including the chosen end-of-life management option); (2) the extent to which carbon sinks are affected by manufacturing, recycling and disposing of the material; and (3) the extent to which the management option recovers energy that can be used to replace electric utility energy, thus reducing electric utility emissions.

The life cycle of a material or product includes the following primary life-cycle stages: (1) extraction and processing of raw materials; (2) manufacture of products; (3) transportation of materials and products to markets; (4) use by consumers; and (5) end-of-life management. GHGs are emitted from (1) the pre-consumer stages of raw materials acquisition and manufacturing, and (2) the post-consumer stage of end-of-life management.

WARM does not include emissions from the use phase of a product's life, since use does not have an effect on the waste management emissions of a product. Since the design and results of WARM include the difference between the baseline and the alternative waste management scenarios that show the GHG savings from different treatment options, emissions from the use phase are the same in both the baseline and alternative scenarios; therefore, emissions from the use phase are excluded and all tables and analyses in this report use a "waste generation" reference point.

Materials management decisions can reduce GHGs by affecting one or more of the following:

- Energy consumption (specifically combustion of fossil fuels) and the resulting GHG emissions associated with material extraction, manufacturing, transporting, using, and end-of-life management of the material or product.

- Non-energy-related manufacturing emissions, such as the carbon dioxide (CO2) released when limestone used in steel manufacturing is converted to lime, or the perfluorocarbons (PFCs) generated during the aluminum smelting process.
- Methane (CH4) emissions from decomposition of organic materials in landfills.
- CO2 and nitrous oxide (N2O) emissions from waste combustion.
- Carbon sequestration and storage, which refer to natural or manmade processes that remove carbon from the atmosphere and store it for long periods or permanently.

WARM assesses the GHG emission implications of recycling from the point of waste generation (i.e., starting at the point when the material is collected for recycling) through the point where the recycled material or product has been manufactured into a new product for use. This includes all of the GHG emissions associated with collecting, transporting, processing and recycling or manufacturing the recycled material into a new product for use. To account for the emissions associated with virgin manufacture, WARM calculates a "recycled input credit" by assuming that the recycled material avoids—or offsets—the upstream GHG emissions associated with producing the same amount of material from virgin inputs.

The net GHG emission reductions from recycling of each material are expressed for recycling in absolute terms and are not values relative to another waste management option, although they must be used comparatively, as all WARM emission factors must be. They are expressed in terms of short tons of waste input (i.e., tons of waste prior to processing) and result in the GHG Reductions from using recycled Inputs Instead of virgin Inputs. The recycling results are reported in terms of GHG emissions per short ton of material collected for recycling. Thus, the emission factors incorporate assumptions on loss of material through collection, sorting and remanufacturing. There is uncertainty in the loss rates: some materials recovery facilities and manufacturing processes may recover or use recycled materials more or less efficiently than as estimated here.

The net GHG emission are based on the current management strategy currently utilized by SWALCO, which includes: 1) recycling; 2) landfill disposal; and 3) composting and also take into consideration source reduction, energy impacts and forest carbon storage. The net emissions for each material category is based on the estimate for individual material classifications included in the WARM and the results show either positive net GHG emission or negative net GHG emissions (reductions) summed for all management strategies for a specific material type.

The WARM model was last updated May 2019 and recognizes 50 material types.

LIMITATIONS

Although, WARM is the most widely peer-reviewed and accepted model, it is considered to have several flaws. The WARM Model is useful for comparing internal scenarios for different approaches to a comprehensive waste management approach. It is less useful for examining the fate of individual waste streams (e.g. OCC, organics etc.). In addition, the system boundaries for organics are drawn to include processing, but no presumption about end-market use is made. This means that in the case of a comparison between thermal combustion of organics for electricity generation and composting, credit would be given for low carbon power generation but not for carbon sequestration or displacement of conventional fertilizer use, both of which are well-documented benefits for composting. This disproportionately and unfairly favors incineration of organics and yard wastes. In addition, there is also no consideration to the emission of other criteria pollutants that accompany the incineration of MSW.

The West Coast Climate and Materials Management Forum is an EPA-convened collaboration of state, local, and tribal governments that develop ways to institutionalize sustainable materials management practices. The purpose is to identify and share effective greenhouse gas emission reduction strategies that also improve the way communities' source, use, and recover materials. The goal is to demonstrate effective ways for communities to reduce greenhouse gas emissions throughout the life cycle of materials. The Forum evaluated EPA's WARM tool and stated that although it remains one of the best options available for state and local governments to estimate the emissions reduction potential of prevention, recycling, and composting (relative to incineration and landfilling), WARM is not without limitations. Some of the key limitations identified when using the model include:

- WARM currently has no capacity to calculate reuse separate from source reduction. The source reduction management option assumes materials not manufactured.
- WARM focuses on materials, not products, which leaves out some significant pieces of the solid waste stream.
- In addition, WARM users face the challenge of reconciling their own materials category definitions with those the model employs – WARM's assumed composition of "mixed recyclables" or "mixed plastics" for example may vary from your community's mixture. WARM's categories for mixed paper and corrugated cardboard remain ambiguous since there are many materials with different emissions impacts that would fall into these categories in varying ratios.
- The lack of "upstream" (or production-related) emissions for food limits WARM's utility for evaluating food scrap prevention projects.
- The current new version of WARM includes a more comprehensive analysis of composting yard and food scrap than it has in the past. First, the calculation of landfill emissions from organics is based on a first-order decay rate to better measure when emissions are generated. Previous versions of the model only calculated the lifetime methane yield. In addition, landfill gas capture systems is modeled with a time element, assuming systems are phased in at landfills. With these two new elements, the model is able to estimate the amount of methane being generated at a particular time and the amount of methane being captured at that time. This new calculation methodology most affects food scrap and grass. The emission factors for branches, which degrade at a very slow rate, changed very little. The new emission factor takes into account the higher soil carbon sequestration capacity for compost-improved soil as well as the GHG emissions involved in composting machinery and transportation. However, the updated model still does not include an emission factor for other compostable materials, like non-recyclable paper. WARM also does not include GHG emissions or emissions reductions associated with other co-benefits associated with the use of compost, such as water conservation and changes in fertilizer use. WARM also does not differentiate between the potential for varying emissions from compost sites themselves as a function of technology (e.g., anaerobic vs. aerobic composting, or centralized vs. home composting).
- Currently, WARM is not intended as an inventory or accounting tool. It is not sufficiently precise and it is not easily connected to other inventory protocols.
- WARM does not currently break emissions and emissions reductions into the years in which they actually occur. Rather, WARM rolls all future emissions and emissions reductions into a single number.

DATA INPUTS

WARM version 14 recognizes 54 material categories. Proxies were used for these materials and pathways not in the WARM model. A proxy is a material not in WARM but similar to a material in WARM. Material physical properties do not necessarily indicate that life-cycle energy use and greenhouse gas emissions are the same. Where possible RRS used USEPA's list of acceptable proxies. For proxies not on the acceptable list, RRS consulted with USEPA about the suitability of a proxy and aggregated material types into WARM material types. The below table lists the material and WARM proxy materials used in the model.

Appendix XVIII: WARM Model Inputs

MATERIAL	PERCENT	WARM MODEL CATEGORY	TRIPLE RATE	2015	2015 COMBUSTED*	2015 LANDFILLED
Paper Products	37%	Mixed Paper	1,529,107	524,606	110,375	894,126
Metals	20%	Mixed Metals	830,932	285,076	59,979	485,876
Organic**	20%	Food and Yard Waste	804,895	276,144	58,100	470,652
Glass	10%	Glass	419,493	143,920	30,280	245,293
Plastics	6%	Mixed Plastics	247,189	84,806	17,843	144,541
White Goods	4%	Mixed Metals	160,349	55,013	11,574	93,762
Batteries	2%	Electronic Peripherals	95,647	32,815	0	62,833
E-Waste	1%	Mixed Electronics	25,426	8,723	0	16,703
Textiles	0.2%	Mixed Recyclables	8,055	2,763	581	4,710
Paint	0.01%	No WARM model category	476	163	34	279
TOTAL	100%		**4,121,570**	**1,414,029**	**288,768**	**2,418,774**

*In 2015, approximately 11% of total disposal in Michigan was incinerated. This ratio was applied to all estimated quantities of disposed recyclables.

**See Appendix XIX for organics breakdown

Appendix XIX: WARM Model Organics Detail Inputs

	WARM MODEL CATEGORY	TRIPLE RATE	2015	AMOUNT COMBUSTED	AMOUNT LF
Yard Waste	Yard Trimmings	330,772	262,336	4,139	33,525
Food Waste	Food Waste	474,123	13,807	53,961	437,127
Total	Total	**804,895**	**276,144**	**58,100**	**470,652**

APPENDIX E: NAICS CODES

NAICS Codes Used in The Economic Analysis

Table XI below shows the complete list of NAICS codes, business classifications, and the NAICS description of the classifications included in the study. The table includes businesses directly involved in the RRR business, (collection, processing, and recovery), businesses involved in reuse and remanufacture, and businesses involved in resale of RRR materials.

Appendix XI: NAICS CLASSIFICATIONS

2012 NAICS CODE	CLASSIFICATION	DESCRIPTION
321920	Wood container and pallet manufacturing	This industry comprises establishments primarily engaged in manufacturing wood pallets, wood box shook, wood boxes, other wood containers, and wood parts for pallets and containers.
322110	Pulp mills	This industry comprises establishments primarily engaged in manufacturing pulp without manufacturing paper or paperboard. The pulp is made by separating the cellulose fibers from the other impurities in wood or other materials, such as used or recycled rags, linters, scrap paper, and straw.
32212	Paper mills	This industry comprises establishments primarily engaged in manufacturing paper from pulp. These establishments may manufacture or purchase pulp. In addition, the establishments may convert the paper they make. The activity of making paper classifies an establishment into this industry regardless of the output.
322299	All other converted paper product manufacturing	This U.S. industry comprises establishments primarily engaged in converting paper or paperboard into products (except containers, bags, coated and treated paper, stationery products, and sanitary paper products) or converting pulp into pulp products, such as egg cartons, food trays, and other food containers from molded pulp
324121	Asphalt paving mixture and block manufacturing	This U.S. industry comprises establishments primarily engaged in manufacturing asphalt and tar paving mixtures and blocks from purchased asphaltic materials.
325314	Fertilizer (mixing only) manufacturing	This U.S. industry comprises establishments primarily engaged in mixing ingredients made elsewhere into fertilizers.
325991	Custom compounding of purchased resins	This U.S. industry comprises establishments primarily engaged in (1) custom mixing and blending plastics resins made elsewhere or (2) reformulating plastics resins from recycled plastics products.
326121	Unlaminated plastics profile shape manufacturing	This U.S. industry comprises establishments primarily engaged in converting plastics resins into no rigid plastics profile shapes

2012 NAICS CODE	CLASSIFICATION	DESCRIPTION
		(except film, sheet, and bags), such as rod, tube, and sausage casings.
326122	Plastics pipe and pipe fitting manufacturing	This U.S. industry comprises establishments primarily engaged in converting plastics resins into rigid plastics pipes and pipe fittings.
326130	Laminated plastics plate, sheet (except packaging), and shape manufacturing	This industry comprises establishments primarily engaged in laminating plastics profile shapes such as plate, sheet (except packaging), and rod. The lamination process generally involves bonding or impregnating profiles with plastics resins and compressing them under heat.
326140	Polystyrene foam product manufacturing	This industry comprises establishments primarily engaged in manufacturing polystyrene foam products.
326150	Urethane and other foam product (except polystyrene) manufacturing	This industry comprises establishments primarily engaged in manufacturing plastics foam products (except polystyrene).
326160	Plastics bottle manufacturing	This industry comprises establishments primarily engaged in manufacturing plastics bottles.
32619	Other plastics product manufacturing	This industry comprises establishments primarily engaged in manufacturing plastics plumbing fixtures and other plastics products (except film, sheet, bags, profile shapes, pipes, pipe fittings, laminates, foam products, and bottles
32621	Tires	This industry comprises establishments primarily engaged in manufacturing tires and inner tubes from natural and synthetic rubber and retreading or rebuilding tires.
326220	Rubber plastics hoses and belting	This industry comprises establishments primarily engaged in manufacturing rubber hose and/or plastics (reinforced) hose and belting from natural and synthetic rubber and/or plastics resins. Establishments manufacturing garden hoses from purchased hose are included in this industry.
32629	Other rubber product manufacturing	This industry comprises establishments primarily engaged in manufacturing rubber products (except tires, hoses, and belting) from natural and synthetic rubber.
327213	Glass container manufacturing	This U.S. industry comprises establishments primarily engaged in manufacturing glass packaging containers.

2012 NAICS CODE	CLASSIFICATION	DESCRIPTION
331110	Iron and steel mills and ferroalloy manufacturing	This industry comprises establishments primarily engaged in one or more of the following: (1) direct reduction of iron ore; (2) manufacturing pig iron in molten or solid form; (3) converting pig iron into steel; (4) making steel; (5) making steel and manufacturing shapes (e.g., bar, plate, rod, sheet, strip, wire); (6) making steel and forming pipe and tube; and (7) manufacturing electrometallurgical ferroalloys. Ferroalloys add critical elements, such as silicon and manganese for carbon steel and chromium, vanadium, tungsten, titanium, and molybdenum for low- and high-alloy metals. Ferroalloys include iron-rich alloys and more pure forms of elements added during the steel manufacturing process that alter or improve the characteristics of the metal being made.
331314	Secondary smelting and alloying of aluminum	This U.S. industry comprises establishments primarily engaged in (1) recovering aluminum and aluminum alloys from scrap and/or dross (i.e., secondary smelting) and making billet or ingot (except by rolling) and/or (2) manufacturing alloys, powder, paste, or flake from purchased aluminum.
331315	Aluminum sheet, plate, and foil manufacturing	This U.S. industry comprises establishments primarily engaged in (1) flat rolling or continuous casting sheet, plate, foil and welded tube from purchased aluminum; and/or (2) recovering aluminum from scrap and flat rolling or continuous casting sheet, plate, foil, and welded tube in integrated mills.
331318	Other aluminum rolling, drawing, and extruding	This U.S. industry comprises establishments primarily engaged in (1) rolling, drawing, or extruding shapes (except flat rolled sheet, plate, foil, and welded tube) from purchased aluminum and/or (2) recovering aluminum from scrap and rolling, drawing, or extruding shapes (except flat rolled sheet, plate, foil, and welded tube) in integrated mills.
331420	Copper rolling, drawing, extruding, and alloying	This industry comprises establishments primarily engaged in one or more of the following: (1) recovering copper or copper alloys from scraps; (2) alloying purchased copper; (3) rolling, drawing, or extruding shapes, (e.g., bar, plate, sheet, strip, tube, wire) from purchased copper; and (4) recovering copper or copper alloys from scrap and rolling, drawing, or extruding shapes (e.g., bar, plate, sheet, strip, tube, wire).
331491	Nonferrous metal (except copper and aluminum) rolling, drawing, extruding, and alloying	This U.S. industry comprises establishments primarily engaged in (1) rolling, drawing, or extruding shapes (e.g., bar, plate, sheet, strip, tube) from purchased nonferrous metals) and/or (2) recovering nonferrous metals from scrap and rolling, drawing, and/or extruding shapes (e.g., bar, plate, sheet, strip, tube) in integrated mills.

2012 NAICS CODE	CLASSIFICATION	DESCRIPTION
331492	Secondary smelting, refining, and alloying of nonferrous metal (except copper and aluminum)	This U.S. industry comprises establishments primarily engaged in (1) alloying purchased nonferrous metals and/or (2) recovering nonferrous metals from scrap. Establishments in this industry make primary forms (e.g., bar, billet, bloom, cake, ingot, slab, slug, wire) using smelting or refining processes.
33152	Nonferrous metal foundries	This U.S. industry comprises establishments primarily engaged in introducing molten nonferrous metal, under high pressure, into molds or dies to make nonferrous metal die-castings. Establishments in this industry purchase nonferrous metals made in other establishments.
423140	Motor vehicle parts (used) merchant wholesalers	This industry comprises establishments primarily engaged in the merchant wholesale distribution of used motor vehicle parts (except used tires and tubes) and establishments primarily engaged in dismantling motor vehicles for the purpose of selling the parts.
423840	Industrial supplies merchant wholesalers	This industry comprises establishments primarily engaged in the merchant wholesale distribution of supplies for machinery and equipment generally used in manufacturing, oil well, and warehousing activities.
423930	Recyclable material merchant wholesalers	This industry comprises establishments primarily engaged in the merchant wholesale distribution of automotive scrap, industrial scrap, and other recyclable materials. Included in this industry are auto wreckers primarily engaged in dismantling motor vehicles for the purpose of wholesaling scrap.
453310	Used merchandise stores	This industry comprises establishments primarily engaged in retailing used merchandise, antiques, and secondhand goods (except motor vehicles, such as automobiles, RVs, motorcycles, and boats; motor vehicle parts; tires; and mobile homes).
541990	All other professional, scientific, and technical services	This industry comprises establishments primarily engaged in the provision of professional, scientific, or technical services (except legal services; accounting, tax preparation, bookkeeping, and related services; architectural, engineering, and related services; specialized design services; computer systems design and related services; management, scientific, and technical consulting services; scientific research and development services; advertising, public relations and related services; market research and public opinion polling; photographic services; translation and interpretation services; and veterinary services).
562111	Solid waste collection	This U.S. industry comprises establishments primarily engaged in one or more of the following: (1) collecting and/or hauling nonhazardous solid waste (i.e., garbage) within a local area; (2)

2012 NAICS CODE	CLASSIFICATION	DESCRIPTION
		operating nonhazardous solid waste transfer stations; and (3) collecting and/or hauling mixed recyclable materials within a local area.
562219	Other nonhazardous waste treatment and disposal	This U.S. industry comprises establishments primarily engaged in (1) operating nonhazardous waste treatment and disposal facilities (except landfills, combustors, incinerators and sewer systems or sewage treatment facilities) or (2) the combined activity of collecting and/or hauling of nonhazardous waste materials within a local area and operating waste treatment or disposal facilities (except landfills, combustors, incinerators and sewer systems, or sewage treatment facilities). Compost dumps are included in this industry.
562112	Hazardous waste collection	This U.S. industry comprises establishments primarily engaged in collecting and/or hauling hazardous waste within a local area and/or operating hazardous waste transfer stations. Hazardous waste collection establishments may be responsible for the identification, treatment, packaging, and labeling of waste for the purposes of transport.
56292	Materials recovery facilities	This industry comprises establishments primarily engaged in (1) operating facilities for separating and sorting recyclable materials from nonhazardous waste streams (i.e., garbage) and/or (2) operating facilities where commingled recyclable materials, such as paper, plastics, used beverage cans, and metals, are sorted into distinct categories.
811212	Computer and office machine repair and maintenance	This U.S. industry comprises establishments primarily engaged in repairing and maintaining computers and office machines without retailing new computers and office machines, such as photocopying machines; computer terminals, storage devices, and printers; and CD-ROM drives.

APPENDIX F: REFERENCES

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