

Ecology Study Focuses on Recoverable Material Quality, Yield Losses and Material Utilization

What happens to paper, bottles and cans, or food and yard waste after they are deposited in the recycling or organics collection bin? What about all the recycling collection at businesses, such as the baled cardboard and plastics in the back of retail stores, or material recovered at a construction site? Are the recovered materials actually recycled, composted, or used beneficially in some other way?

The Washington Department of Ecology recently completed a study to help answer these questions. This information will help people and organizations interested in recycling, composting, and other beneficial uses of recovered materials gain a clear picture of the overall success of the material recovery system, and it will help businesses and local governments in Washington make better decisions regarding their material recovery programs, especially policy and planning decisions involving mixed or “commingled” recycling collection.



Study purpose and background

The “Materials Recovery and Use Study”¹ investigates what happens to materials recovered from residences and businesses in Washington state that were intended for recycling, composting, reuse, burning for energy, or other beneficial uses.

For many years, Ecology, with the cooperation of businesses and local governments that track and report their recycling, composting, and other material recovery activities, has been measuring materials that are *collected* in Washington. However, we didn’t know how much was really recycled, composted, reused, burned for energy, or otherwise beneficially used.

¹ The study name was changed from “Recycling Destination and Use Study” to highlight the inclusion of a broader range of recovered materials, such as organics and construction and demolition debris.

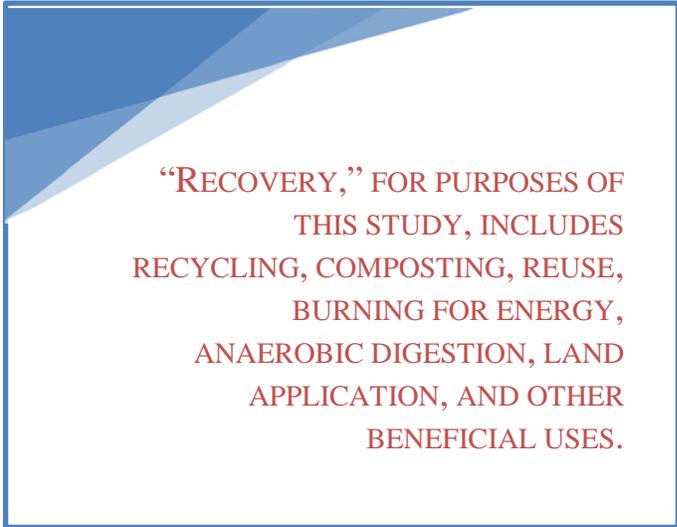
Ecology wanted the study to answer questions like:

- What percentage of materials collected for recycling are lost in the collection, sorting, and processing system, or ending up in landfills?
- How much material is lost due to contamination² in the collection system or cannot be recovered during sorting and processing?
- How much impact is the commingled recycling collection system having on material quality?
- How much material is ultimately recycled into new products, composted, or beneficially used?

Washington has measured materials recovered for recycling, composting, and other beneficial uses in homes and businesses since 1986. Over the years, the material recovery system has changed in many ways – most notably when “commingled,” all-in-one recycling collection carts were introduced in the early 2000s.

On a national scale, most recycling programs find higher participation rates and higher volumes of recyclables collected³ following the introduction of commingled collection. However, the transition to commingled recycling collection comes with a higher incidence of contamination and system loss as the materials are collected, sorted, and processed.⁴ These impacts from a commingled system occur in both residential and commercial collection programs.

It is important to note that, although commingled collection is important, it represents only about six percent of all materials recovered in Washington. Since materials collected in non-commingled systems represent such a large portion of the materials recovered, to get a clearer picture of the overall materials lost and utilized in the recovery system Ecology considered the entire collection and processing system in this study.



“RECOVERY,” FOR PURPOSES OF THIS STUDY, INCLUDES RECYCLING, COMPOSTING, REUSE, BURNING FOR ENERGY, ANAEROBIC DIGESTION, LAND APPLICATION, AND OTHER BENEFICIAL USES.

As commingled recycling collection programs increase in number, there is a need to quantify yield loss or “system loss” and the flow of recyclables to various markets in order to determine more accurate recycling and material recovery rates and to assess current uses of materials collected. In the Ecology study, we looked into the complex network of the current material sorting and processing system, starting at the point at which materials are collected, then on to facilities where the materials are sorted and baled, and finally to the facilities that transform those materials that have already been sorted, baled, or categorized, including mills, manufacturers, energy markets, and other destination markets.

² For this study, “contamination” refers to physical contaminants, and is defined as inappropriate materials that are placed in the recycling or organics collection bin that are not accepted in the program – these materials need to be sorted out and disposed as they impact the quality of the recovered material. Examples are garden hoses or ceramics in the recycling collection system, and plastic sandwich wrap or plastic utensils in the organics collection system.

³ Commingled Recycling Systems – Preventing Contamination at the Curb, MRF, and Mill ([https://yosemite.epa.gov/r10/HOMEPAE.NSF/Topics/ccrs/\\$FILE/11.+Marketing+White+Paper.pdf](https://yosemite.epa.gov/r10/HOMEPAE.NSF/Topics/ccrs/$FILE/11.+Marketing+White+Paper.pdf)).

⁴ Beyond the Curb – Tracking the Commingled Residential Recyclables from Southwest Washington (www.ecy.wa.gov/biblio/1007009.hytml).

How much material are we recovering?

Washington measures “recovery” to show how recycling, composting, and other beneficial use programs in the state are doing on capturing and utilizing materials (see Figure 1). Uses of recovered material include recycling, but also reuse, compost, fuel, and other beneficial uses. Landfilling and incineration are not considered material recovery. Both residential and commercial materials are included. Although curbside residential recycling is much more visible and familiar to most people, material recovery at businesses accounts for about 75 percent of overall recovery in Washington.

As of 2013, Washington state recovered 51 percent of recyclable materials. The national average was 34 percent in 2013.⁵



Figure 1: Recovered Materials in Washington state

Washington’s recovery rate is adjusted to account for incoming contamination and other material that become residuals⁶ from sorting commingled recyclables at material recovery facilities (MRFs), where materials are sorted and baled before being sent to mills or manufacturers to be made into new products.

Ecology adjusts the reported quantities of commingled material using a statewide average residual rate.⁷ This method of adjusting for lost or disposed materials at the MRF level helps gain a more accurate measure of what is actually recovered (versus disposed) from the initial collection and sorting facilities.

⁵ Advancing Sustainable Materials Management: Facts and Figures (<http://www.epa.gov/smm/advancing-sustainable-materials-management-facts-and-figures>), U.S. Environmental Protection Agency.

⁶ “Other residuals” are defined here as materials that conform to program specifications, however the sort line fails to separate them, they are not sorted into the appropriate outgoing material types, and are disposed as garbage. Examples include glass fines, material that has been compacted and is difficult to separate, such as aluminum cans and plastic bottles that get stuck together, and paper that has been contaminated with food due to compaction.

⁷ For 2009 and 2010, the residual rate applied to commingled recyclables collected was 5.8 percent; for 2011 and 2012, the residual rate applied to pre-sorted commingled recyclables collected was 14.5 percent; in 2013 the residual rate increased to 21.6 percent.

However, the adjustment does not account for *incomplete* sorting at the MRF level, such as flattened plastic bottles mixed in with paper bales. Likewise, this method does not account for other material losses at mills, recycling, processing, or manufacturing facilities where the sorted and baled material from the MRF goes for additional processing.

Study process

The two-phase study, completed by Ecology staff, began in spring of 2014 and was completed in fall of 2015. The study initially considered the following material groups:

- Core recyclables, including containers and paper.
- Organic materials, including food and yard debris.
- Construction and demolition debris.
- Other recoverable material, including electronic products, textiles, batteries, and tires.

Phase I

For Phase I of the project, Ecology surveyed and interviewed recyclers and facilities that were reported as receiving recoverable materials from other recyclers, called “destination facilities.”

- Survey recipients included 682 recyclers, MRFs, processors, and destination facilities that were either located in or handling material from Washington state during 2012.
- Survey recipients were asked to quantify contamination and residual rates for 34 materials.
- They were also asked to quantify what market the material was sold to or used for after processing or transformation at the survey recipient’s facility.
- Ecology received 341 usable responses (a 50 percent response rate).

The survey results revealed the complexities of tracking recoverable materials to their final destinations. Each level of collection, processing, and transport of materials to markets adds complexity to the system.

The Phase I survey results were not able to be used to quantify the movement and loss rates on an aggregate basis with sufficient accuracy. Quantifying this information was beyond our resources to accomplish. However, we were able to use the survey results to inform and help guide material recovery technical assistance and planning efforts. It also led us into Phase II of this study with a stronger knowledge base of the movement and system loss at the various levels.

Phase II

For Phase II of the project, Ecology completed a literature review of about 50 studies, from sources including local, state and federal governments, trade associations, industry, and consultants.

Due to a limited availability of information and resources to complete the study, we narrowed the focus from the original intended scope, looking at the complete universe of materials, to look only at issues surrounding the various collection methods and material categories. We used the findings to estimate loss and utilization rates for Washington’s recoverable materials. We also examined final uses of recoverable material with the intent of quantifying those uses where possible.

How much recovered material in Washington is actually used to make new products or otherwise beneficially used?

From this study, we were able to estimate a range of system loss and utilization rates for the various recovered materials.⁸ Loss and use rates from the literature review were applied to the 2012 material recovery data collected from facility annual reports to provide estimated ranges of how much of each material is either used in new products or otherwise beneficially used, or is lost to the recovery system and ends up in landfills.

A study from the Container Recycling Institute showed that commingled systems produce 25 percent system loss on average for all steps in the process (MRF, processor, mill, and end user).⁹ The losses from a system where all recoverable materials are collected separately from each other (sometimes called source-separated systems) are much lower, at about 5 percent.

In a commingled recycling collection system, only about 75 to 80 percent of the materials collected make it back into new products. Some 20 to 25 percent of the materials are lost to the system and end up disposed in landfills, burned in incinerators, or burned in industrial boilers for energy recovery.



In the average single-stream collection program, if you collect 100 tons of recyclables at the curb, on average, 75 tons will actually be recycled into new products, and most of the rest will be landfilled.

Susan V. Collins, CRI, 2012

Considering the entire material collection and processing system in Washington state gives us a clearer picture of the overall materials lost to the recovery system. This is especially true since a large portion of recoverable material collection in Washington is not commingled and, therefore, the system losses are not such a large issue. In a source separated recovery system, where all materials are kept separate from each other at the point of collection, a far greater amount of material collected is made into new products or used beneficially – somewhere between 90 and 99 percent, depending on the material, the level of contamination and the sorting and processing accuracy.

⁸ For the recoverable material collection systems assessed in this study, an exact accounting of all the material types and their final uses is unfeasible with current agency resource levels and available data.

⁹ Understanding economic and environmental impacts of single-stream collection systems, Container Recycling Institute, <http://www.container-recycling.org/assets/pdfs/reports/2009-SingleStream.pdf> (2009).

The key to gauging the overall impact of system loss on our material recovery rates is that commingled is only about six percent of the total material (eight percent of municipal solid waste) collected for recovery in Washington.

In Figure 2, the orange section represents the system losses from commingled collection, and the red section represents the losses from other types of collection. Adding these sections up shows that we lose about eight percent of the total material collected for recovery. In other words, we use about 92 percent of the materials collected for recovery as resources, either to make new products or reuse them in some other beneficial way.

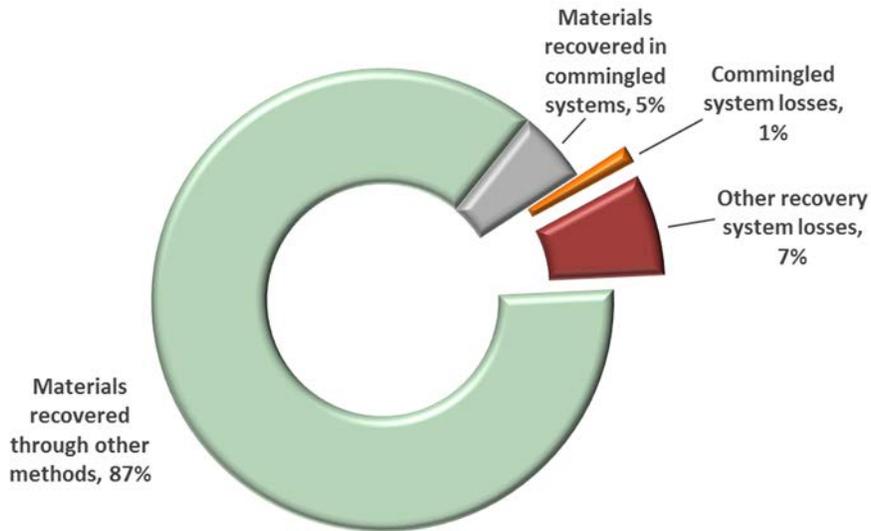


Figure 2: Recoverable material collected, utilized & disposed in Washington (2012)

System loss/utilization by collection method

The ranges of system loss and utilization rates that we found for each type of recoverable material collection system in the study are shown in the following table (Table 1). Loss rates range from 1 to 31 percent and utilization rates range from 69 to 99 percent, depending on the collection system.

Collection System for Recoverable Material	Material Loss Rates	Material Utilization Rates
Commingled / Single Stream (Mixed Recyclables)	16.6-31.0%	69.0-83.4%
Dual Stream (Commingled with glass on the side)	2.0-6.0%	94.0-98.0%
Source Separated Materials ¹⁰	1.0-4.3%	95.7-99.0%
Commingled Construction & Demolition Materials	18.7-26.0%	74.0-81.3%
All Collection Systems	3.8-11.5%	88.5-96.2%

Table 1: Material loss and utilization rates by material recovery collection system

¹⁰ Materials are kept separate from each other; common for large-scale commercial recovery and residential drop off locations such as drop boxes or buyback centers.

For recoverable materials separated by material type, or “source separated” materials, the range of loss rates were very low, at 1.0 to 4.3 percent. For materials collected in a “dual stream” system, where most of the materials are commingled, but glass is collected separately, the range of loss rates were also fairly low, at 2.0 to 6.0 percent. For fully commingled materials including glass, the range of loss rates were higher, at 16.6 to 31.0 percent.

Applying the loss rates by collection type to the recoverable material collected in Washington by collection method, we estimate the rate of loss to be between 3.8 and 11.5 percent overall.

The utilization rates, or the amount of material that is being used to make new products or otherwise used beneficially, are determined by subtracting the lost materials from the total amount of material collected. Utilization rates range from 70 to 99 percent, depending on collection method. Overall, the utilization rate for Washington’s recoverable material is estimated to be between 88.5 and 96.2 percent.

System loss/utilization by material type

The ranges of system loss and utilization rates that we found for each recoverable material in the study are shown in the following table (Table 2). Loss rates range from 1.5 to 45 percent and utilization rates range from 55 to 98.5 percent, depending on the material type.

Recoverable Material	Material Loss Rates	Material Utilization Rates
Metals	4.2-14.3%	85.7-95.8%
Paper	7.4-19.1%	80.9-92.6%
Plastics	18.0-29.3%	70.7-82.0%
Construction & Demolition Debris	3.3-26.0%	74.0-96.7%
Organics	1.5-3.7%	96.3-98.5%
Glass ¹¹	10.0-45.0%	55.0%-90.0%

Table 2: Material loss and utilization rates by recoverable material type

The estimated ranges of loss and utilization rates for materials can depend on the type of collection system, as demonstrated previously. The loss and utilization rates may also be affected by typical contaminants unique to the material (such as food residuals in plastic containers), processing efficiency that can vary by material or facility type, regional access to markets for the material itself, contaminants (known as “out-throws”), the level of education and outreach provided by the service provider or government entity, and the commitment of the users.

It is important to mention that for certain materials, such as organics, even a small amount of contamination might make a finished product unmarketable, such as bits of plastic in compost. Thus, a seemingly low contamination or loss rate can make a material useless for the intended market.¹²

¹¹ The wide range of loss and utilization rates for glass depends largely on whether glass is commingled with other materials or not. Loss rates drop sharply for glass when it is collected separately.

¹² For purposes of this study, material that is collected for recycling, however is unmarketable and is either disposed or remains unsold for the study period is considered a system loss.

Conclusions & next steps

By applying system loss and utilization rates to our overall recovery rate (previously referred to as the “diversion rate”), we estimate a relatively small impact – about two percentage points.¹³

As a result, the adjusted recovery rate for 2012 would be about 52 percent (adjusted from 54 percent) if we apply loss rates from this study. In terms of tons, that equals about 600,000 tons of material disposed that was intended to be recovered due to contamination, residuals, out-throws, and other types of unintended and inadvertent losses in the material recovery system. That means that, of the 7.9 million tons of material reported as collected for recovery in 2012, approximately 7.3 million tons of material were actually recovered for recycling, composting, and other beneficial uses in Washington.

Material quality and loss is an important issue for everyone involved in building and maintaining a stronger material recovery system. These issues impact the economics and overall success of recovery programs at all levels. Washington has a strong material recovery system – we hope to bring attention to this issue so that we can help reduce negative impacts to the system, allowing it to remain strong and grow into the future.

What is Ecology doing?

In order to account for incoming contamination in commingled collection systems, Ecology has been calculating and reporting on an adjusted collection rate with the annual recovery rate reports since 2009.¹⁴

The adjusted rates are calculated based on the material collected and processed by regulated facilities that submit required reports, and sampling information from county studies. Using results from this study to adjust recovery rates in the future would require an updated study with a significant investment of resources, which there are no plans for at this time.

To continue to provide a consistent and comparable measure to past years, other state and national rates, Ecology will continue to report the adjusted collection rate, and we will use the information from this study on system loss and utilization rates to inform policy decisions at the state level, as well as using this information to inform local governments and the private sector.

Ecology is continuing the commingled improvements project, “Improving Commingled Recycling in Washington,” a stakeholder effort including developing best practices around acceptable program materials and public outreach for recycling programs. Project efforts are showing results in material recovery programs around the state. See the reports and best management practices on Ecology’s website (<http://www.ecy.wa.gov/programs/swfa/commingled/results.html>).

The amount of non-compostable contaminants collected with compostable food and yard debris is on the rise. To reverse this trend, state and local government employees, composters, packaging manufacturers, and haulers are working together to create best management practices that will help reduce the amount of non-compostable contaminants entering food and yard debris collection programs.

¹³ The disposed amounts are not impacted in this equation because disposed residuals that originate from Washington are currently reported on facility reports for Washington and Oregon landfills, and material disposed outside the country is not counted as a part of this study.

¹⁴ “Recovery” in this report is referred to as “Recycling and Diversion”. Solid Waste in Washington State – 22nd Annual Status Report: <http://www.ecy.wa.gov/programs/swfa/solidwastedata/report.html>.

Suggestions for local government, agencies, and businesses when evaluating material recovery programs

- ❖ Know what's really being recovered and the economics of material quality for incoming and outgoing materials.
- ❖ Require contamination rates standards from MRFs or haulers when entering into contracts.
- ❖ Consider more efficient collection options like dual stream or modified single stream.
- ❖ Encourage material cleanliness for all recoverable material through education and outreach.

Sources (limited list)

- *Understanding economic and environmental impacts of single-stream collection systems.* Container Recycling Institute. www.container-recycling.org/assets/pdfs/reports/2009-SingleStream.pdf.
- *Composition of Commingled Recyclables Before and After Processing.* Oregon Department of Environmental Quality. www.deq.state.or.us/lq/pubs
- *2006 Material Recovery Facility (MRF) Assessment.* King County Solid Waste Division. your.kingcounty.gov/solidwaste/about/documents/MRF_assessment.pdf.
- *Beyond the Curb - Tracking the Commingled Residential Recyclables from Southwest WA.* Department of Ecology. Pub. # 10-07-009. fortress.wa.gov/ecy/publications/UIPages/Home.aspx.
- *Recycling Rates of Metals.* United Nations Environmental Programme. www.unep.org/resourcepanel/Portals/24102/PDFs/Metals_Recycling_Rates_110412-1.pdf.
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- *Getting a Return from Residue.* Institute of Scrap Recycling Industries. www.isri.org/news-publications/scrap-magazine/all-scrap-articles/.
- *Used Electronic Products: An Examination of U.S. Exports.* U.S. International Trade Commission. www.usitc.gov/publications/332/pub4379.pdf.

More information

Commingled Improvements Project: <http://www.ecy.wa.gov/programs/swfa/commingled/>.

Beyond Waste and Toxics Progress Report: <http://www.ecy.wa.gov/wasteplan/progressReport.html>.

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