

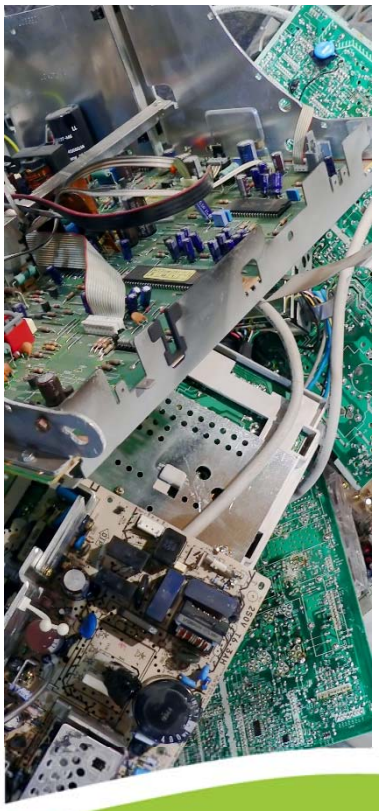


King County LinkUp Program
2017 Market Assessment

King County
Department of
Natural Resources and Parks
Solid Waste Division

Waste **Prevention** | *Resource* **Recovery** | *Waste* **Disposal**

www.kingcounty.gov/solidwaste

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FINAL

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Introduction

The King County LinkUp program (LinkUp) connects local businesses, public agencies, and other organizations to expand markets for selected recyclable and reusable materials. Each year, LinkUp evaluates and identifies focus materials as priorities for recycling and market development for the County.

The purpose of this guidance document is to:

- Summarize the available data and resources used to support initial selection of focus materials for the LinkUp program
- Assess and evaluate market potential for selected focus materials determined by Cascadia, LinkUp staff, and key stakeholders.

The document is organized into the following sections:

- **1. Initial Data Review,** which summarizes local waste characterization data and findings from past regional studies that can inform preliminary material selection.
- **2. Summary of Stakeholder Engagement,** which describes additional findings and key data points that arise from interviews and follow-up research.
- **3. Material-specific Market Assessments,** which assess preliminary focus materials along the planning criteria that have been reviewed by the stakeholders and finalized with LinkUp staff. Evaluation may be qualitative (low, medium, or high) or quantitative, depending on the availability of data.

1. Initial Data Review

This section summarizes local waste characterization data and market status for selected materials from recent material characterization studies and market assessments. It provides background on the status of materials locally and, when supplemented with stakeholder input, will be used to inform the preliminary selection of focus materials. More detailed information from this review can be found in Appendix B: Supplementary Data.

Waste Characterization Data

One way of gauging the need for improved markets for materials (one of the selection criteria) is to examine the prevalence of the material in local disposed waste streams. Waste characterization data from both King County and the City of Seattle can be used to:

- Identify those materials disposed in the largest quantities (by weight) and classify materials by their recyclability or recoverability.
- Analyze individual material capture rates if corresponding recycling data is available. Capture rates indicate how much of a given material is being collected for recycling and recovery.
- Assess trends over time, where data is available.

The following studies were available for review:

- King County's 2015 Waste Characterization Report[i]
- King County's 2007-2008 Construction and Demolition Waste Composition Study
- City of Seattle's 2012 Construction, Demolition, and Land Clearing Waste Composition Study[2,ii]

Commonly disposed materials in King County

Key findings from a review of the materials disposed of in the largest quantities by weight in King County are below. Designations of recyclability and their definitions – readily recyclable, limited recyclability, and not recyclable – match those used in the 2015 King County Waste Characterization Study.[iii]

- *Unpackaged food, clean wood,* and *packaged food* are among the largest disposed **readily recyclable** material types by weight, making up a nearly a quarter (24.6% or 239,000 tons) of the combined MSW and C&D tons in 2015. Readily recyclable means recycling technologies, programs, and markets are well developed, readily available, and currently utilized. These materials are accepted in most, if not all curbside collection programs in King County.
- *Film plastic* and *contaminated or treated wood* are the most commonly disposed materials of **limited recyclability** by weight. Over 130,000 tons of these materials were disposed of in King County in 2015. Limited recyclability means recycling technologies, programs, and markets exist, but they are either not well developed or not currently utilized.

[i] These studies have not yet been published online.
[ii] King County last completed a composition study of its C&D streams in 2007. To update this data, we obtained the disposed 2014 C&D tonnages from the County and applied the compositions from a representative substitute study, the 2012 City of Seattle C&D composition study to derive estimates of 2014 C&D disposed tonnages.
[iii] Not yet published online.

- Together, *disposable diapers* and *animal feces* make up over 80,000 tons of disposed material, or over 8 percent of overall waste by weight. These materials are considered **not recyclable** and were not found in C&D waste. Not recyclable means no local recycling technologies, programs, or markets exist.

Table 1 below shows all the materials that make up more than five percent of a studied substream – commercially hauled municipal solid waste (MSW), self-hauled MSW, and construction and demolition (C&D) waste – or materials for which more than 30,000 tons were disposed overall in King County.[iv]

Table 1: Percent composition by weight and overall tons for materials that are more than five percent of the disposed commercially collected, self-hauled, or C&D substream in King County, or for which more than 30,000 tons were disposed overall in 2015.

	Overall (MSW + C&D)		Commercially collected		Self-haul		C&D waste	
	%	tons	%	tons	%	tons	%	tons
Readily Recyclable								
Unpackaged Food	9.7%	94,703	15.1%	92,923	0.8%	1,780	-	-
Clean Wood	8.1%	78,263	2.7%	16,522	13.6%	31,688	24.2%	30,053
Packaged Food	6.8%	66,113	10.5%	64,418	0.7%	1,695	-	-
Compostable Paper	4.5%	43,370	6.8%	41,783	0.7%	1,587	-	-
Low Grade Recyclable Paper	3.5%	33,562	4.4%	26,931	2.1%	4,891	1.4%	1,740
Plain Corrugated Cardboard (OCC)	3.3%	32,114	3.8%	23,234	3.1%	7,151	1.4%	1,729
Yard Waste	3.2%	31,410	3.2%	19,713	4.6%	10,659	0.8%	1,038
Limited Recyclability								
Film Plastic	6.9%	66,773	9.0%	55,316	4.5%	10,574	0.7%	884
Contaminated/Treated Wood	6.8%	65,678	1.6%	9,872	13.1%	30,545	20.4%	25,262
Gypsum Wallboard	3.3%	32,169	0.7%	4,132	5.1%	11,825	13.1%	16,211
Not Recyclable								
Disposable Diapers	4.3%	41,863	6.6%	40,443	0.6%	1,420	-	-
Animal Feces	4.0%	38,785	6.0%	36,602	0.9%	2,183	-	-

[iv] Cascadia conducted a similar analysis for the City of Seattle waste characterization data (2012-2014, not shown) and found that the most prevalent materials by weight in Seattle's overall waste stream similar to the most prevalent materials in King County. These materials are listed below:

- Food and compostable/food-soiled paper
- Film plastic
- Clean and painted gypsum
- Clean and contaminated wood
- Diapers and animal feces

Review of Selected Regional Publications

This section summarizes key findings from selected regional publications to summarize market assessment activities that have previously been completed in the County and to provide background material that can inform preliminary selection of materials for LinkUp, in advance of future and more formal market assessment activities. We reviewed the following documents:

- LinkUp's 2012 Mini Market Assessments
- The King County 2015 Market Assessment for Recyclable Materials
- The 2015 Washington Commingled Recycling Workgroup Report

More detailed information from these documents is provided in Appendix B, and high level findings are summarized below.

- **Despite available regional processing capacity, food waste and compostable paper remain among the materials disposed of in the largest quantities by weight**. The 2015 market assessment report noted that processors may have to invest heavily in equipment and systems to effectively manage changing feedstocks, and some report that market prices and sales of compost products are not sufficient to cover increased processing costs.
  - Some of the material that is diverted from waste still ends up in the wrong stream. Processors report an ongoing presence of food-contaminated paper in commingled recycling.
- **Markets for gypsum remain strong**, and prices are stable. Processing facilities in King County are not yet operating at full capacity.
- **Diversion of plastic film materials continues to be a challenge**, particularly for non-industrial plastics.[v] End uses for non-industrial plastics were reported as limited to non-existent in the 2012 assessment. For recyclable film plastic, there are challenges with processing, especially since loose film can be problematic for material recovery facilities (MRFs). In general, take-back of recyclable film at retail locations is preferable to curbside collection.
  - Regional MRFs reported spending $700-$1,000 per ton[vi] to remove film from equipment, and that 20-30 percent of recycling center labor is spent addressing operational challenges from plastic film.
  - Despite challenges at the MRF with film plastics, major retailers report that polybag packaging is the dominant packaging material type and projected to increase.[vii]

[v] Non-industrial plastics are defined as all film used as food packaging or in another non-industrial capacity, such as produce bags, zip-lock bags, frozen vegetable bags, bread bags, and candy bar wrappers.

[vi] Moore & Associates reported an even higher per ton cost of plastic film to the MRF of $2,000 per ton at the 2016 Resource Recycling conference.

[vii] Data presented by Amazon at the 2016 Washington State Recycling Association shipping packaging event in August 2016.

- **Some packaging products are not fully recyclable with today's infrastructure, technology, and market conditions**, creating challenges to downstream material recovery. Processors reported difficulty not only with films (flexible packaging), but also aseptic packaging, full-wrap plastic bottles, and compostable plastics that are difficult to distinguish from recyclable ones.
- **Consumers may not be aware of the reuse options for textiles and furniture**. For example, with textiles, the misconception is likely that clothing that cannot be worn should be disposed instead of donated. Campaigns such as ThreadCycle have been working to address this misconception and promote textile reuse by education the public and expanding available recycling drop-off options.
- **Diapers are a rapidly growing portion of disposed waste;** however, recycling options remain limited due to a lack of local processing capacity and high costs associated with available technology. Composting is a possibility, but separation of plastic from fiber material as well as concerns about potential pathogens are challenges; most municipal programs today do not accept diapers.[viii]

Market Status of Current LinkUp Focus Materials

TEXTILES

Clothing prices for consumers began to fall in 2000, spurring an increase in the consumption of inexpensive textiles in fabrics that often have little reuse/resale value. While clothing prices have stabilized in recent years, clothing prices for consumers remain relatively low compared to historical trends. In 2013, the Council for Textile Recycling estimated that over one-third (36%) of textiles collected for reuse/recycling are exported to overseas markets; about 20% is sold for reuse and 24% is repurposed and reused domestically; 16% is recycled/downcycle; and 4% is unusable and ends up as waste. Issues that impact the market value of recycled/reused textiles include increasing bans and/or regulation around imported textiles in overseas markets, as well as a lack of stable end markets and technology for recycling (as compared to re-use). Additionally, textile industry experts note that the value of material collected for textiles recycling and reuse is declining as more materials are made with polyester or poly-cotton blends. In particular, poly-cotton blends, and any blended fabrics, are not viable candidates for recycling through current closed loop recycling technologies.

Today, the only currently commercially viable closed-loop recycling solution for textiles is for polyester. Other organizations are working on technologies that improve sorting and grading of collected textiles or that can separate cotton from polyester during the recycling process.

[viii] The City of Seattle has a projected implementation date for composting of residential pet waste and diapers in 2020 (Source: Seattle Solid Waste Plan 2011 Revision).

Upcycling operations (such as fashion labels based on upcycled textiles) are catching on, but these are not widespread, scalable efforts at this time.

ASPHALT SHINGLES

An estimated 30,000 tons of asphalt shingle waste generated in King County are disposed each year. While some shingles are being recycled, local end markets for the material are not well-established. Asphalt shingles are processed into a ground product and successfully recycled in other states for road applications such as hot mix asphalt (HMA) pavement and cold patch. The Washington State Department of Transportation (WSDOT) general specifications now include standard provisions for the use of recycled asphalt shingles (RAS) in HMA for road construction. Since 2014, HMA including nearly 1,500 tons of RAS has been used on state roads in Washington. There remains growth potential for the recycled asphalt shingle market.

MATTRESSES

The main recyclable commodity from mattresses is polyurethane foams. The price for foam fluctuates based on demand; currently, demand for the material is low. Current consumer trends indicate a preference for hard surfaces, and the price of laminate surfaces have decreased. Foam from mattress recycling is primarily used for rebond (carpet padding). Mattress recyclers have been profitable in Oregon and California, but industry stakeholders note that businesses in those states have invested in both market development and necessary equipment to make recycling viable. Collecting large quantities of mattresses of an adequate quality is critical to financially sustainable mattress recycling (100,000 mattresses per year is an estimate for Seattle). In particular, collection of mattresses for recycling can be difficult, as materials are bulky and need to be stored until there is sufficient quantity to send to a processor.

Other components of mattresses that can be sold to existing commodity markets include plastic film, cotton, and scrap metal from springs, though there are challenges associated with each of these. In particular, wrapped pocket coils are a challenge for recyclers since it is labor-intensive to unwrap and separate the metal. Wrapped coil mattresses, however, are popular among customers (and consequently, retailers) who do not have to take into account post-consumer concerns; individuals in the mattress recycling industry note that this is an area where producer responsibility is needed.

CARPET

The 2015 King County Market Assessment for Recyclable Materials noted that carpet recycling infrastructure in the Northwest has shrunk; of the three local processors, only one processor remains in operation. However, this facility does not process carpet at full-scale and is not accepting new customers. Most processed plastic from post-consumer carpet is manufactured into engineered resin, while a subset is recycled into new carpet (fiber and backing). Current challenges for carpet recycling include low oil prices which make virgin plastics cheaper than recycled material as well as an increasing use by manufacturers of PET face fiber, which is not currently recyclable. In addition, carpet sales have declined as more consumers have selected other flooring options.

ORGANICS

The supply of organic feedstock for compost has been increasing as mandatory organics recycling ordinances have come into effect in the City of Seattle and as King County and member cities have worked to increase participation in organics programs. Processing capacity in the region is adequate to handle the current and the anticipated growth in organics; however, processors will need to invest in systems and equipment that can effectively manage changing feedstocks. Interviewees as part of the 2015 King County Market Assessment for Recyclable Materials noted that much of the existing infrastructure was designed to process yard trimmings, not anorganics mix that also includes food scraps, compostable paper, packaging, and contaminants. Market prices and sales for compost products in the region have been reported as stable, though there is some uncertainty as to whether market demand will continue to match anticipated increases in organics supply, unless it can increase agricultural markets in Western Washington and/or reach those in Central and Eastern Washington. New processing technologies—such as smaller on-site options by WisERG and Impact Bioenergy—are an emerging organics diversion option in King County, particularly for large commercial generators of food scraps such as grocery stores and food manufacturers. A review of permitting processes and regulatory requirements in the context of these alternative systems may be needed.

2. Summary of Stakeholder Engagement

STAKEHOLDER ENGAGEMENT PROCESS

Cascadia completed interviews with eleven stakeholders in October and November 2016 from King County and the City of Seattle. The stakeholders (named below; King County staff unless otherwise noted) were all recommended by the LinkUp project manager for interviews. Morgan John was invited to participate in the interview with Mathew Hobson, and Tom Watson declined to interview.

- Kris Beatty
- Kinley Deller
- Alex Erzen
- Liz Fikejs (Seattle Public Utilities)
- Jeff Gaisford
- Matthew Hobson
- Sego Jackson (Seattle Public Utilities)
- Morgan John
- Eric Johnson
- Jim Neely
- Lisa Sepanski
- Gabriella Uhlar-Heffner (Seattle Public Utilities)
- Tom Watson

Questions asked of stakeholders included:

- Which products/materials/commodities deserve market development attention in our region? Why?
- Which products/materials/commodities have the potential for a higher value use or rely on a single market (e.g., could use a more diverse market base)?
- Which products/materials/commodities are you currently focused on or looking to expand in the near future?
- What, if any associated infrastructure needs are there for these materials or for categories of materials?
- For each material identified, are there upstream opportunities (waste prevention, reuse, etc.) that someone, whether LinkUp or other, should consider pursuing?
- How are you integrating sustainable consumption (such as sustainable purchasing policies that minimize waste and pollution associated with materials used), upstream waste reduction, or circular economy concepts into your planning and programs? What related programs or initiatives should we include in our market assessment research?
- We are interested in your feedback on LinkUp's preliminary criteria for selecting priority materials for 2017 and beyond. Do these criteria resonate with you? Are there any key criteria missing?

BROAD THEMES

Broad themes expressed by interviewees included the following:

- Keeping materials local (rather than export) and building up domestic markets.
- Ensuring highest and best use of materials (e.g., concerns around tires going to tire-derived fuel).
- Promoting and maximizing reuse (Portland reuse network cited as an example).
- Leveraging existing partnerships and efforts where they exist for focus materials.

INPUT ON POTENTIAL FOCUS MATERIALS

The following materials were each brought up as products, materials, or commodities that deserve market development attention or have potential for a higher value use by multiple interviewees. Additional notes and more detail follow for each.

- Plastics
- Mattresses
- Textiles
- Compostable materials
- Other: tires, wood waste, electronics, and C&D (broadly)

The Linkup program has seen past successes working on market development for recycled asphalt shingles (RAS); this work helped establish the use of RAS in hot mix asphalt in state specifications for pavement, which some companies now use. However, other past areas of focus, such as carpet, have less potential under current market conditions. Despite promising developments in new processing options for carpet and growing extended producer responsibility, neither the LinkUp program manager nor interviewees saw much opportunity for influence over this material at this time.

Compostable materials

Noted in six[ix] interviews, particularly food waste

- Challenges with contamination (both pre- and post-processing)
- Still one-third of King County's waste stream and the largest remaining element of disposed MSW
- Food waste currently has local, national, and international attention, as well as opportunities in both King County and Seattle (synergistic opportunities, such as outreach campaigns that reach both regions)

[ix] Out of a total of 10 interviews including 12 participants.

- Some interest in anaerobic digestion for food waste processing, as well as smaller-scale operations and on-site processing (Wise-Erg, Impact Bioenergy)
  - Permitting for processors has been a challenge. Current permitting requirements are based on the needs of larger-scale projects (e.g., centralized collection and processing), not small-scale distributed systems.
  - One interviewee noted that compost markets seem saturated, and that apple maggot concerns have limited demand; alternative processing/conversion technologies for organics are of interest.
  - One interviewee noted that food scrap/compostable material diversion in the residential sector is currently fine, but the challenge and opportunities for improvement are for commercial generators.
- One area of future work is understanding the barriers to commercial food scrap diversion in King County
- Need for better labeling of compostability in products (which also helps the quality of recycling streams).
- Organizations/people working on this already include:
  - Federal government agencies, such as EPA and USDA
  - WRAP UK
  - Industry associations, such as the Biodegradable Plastics Institute (BPI) and the Food Packaging Institute (FPI).
  - NRDC
  - Harvard Law Clinic
  - Municipalities such as San Francisco, Alameda County, and StopWaste
  - City of Seattle (small-scale AD pilots with Fremont Brewing and Impact Bioenergy), City of Tacoma (commercial food scrap collection routes; digestion at the wastewater treatment plant)
  - Oregon DEQ
- Infrastructure needs:
  - Scales and tracking tools (e.g., LeanPath) to help with prevention
  - Improved recovery infrastructure (food containers for transport, refrigeration, etc.) and accompanying staffing.
  - On contamination, may be new technology to apply (but challenge is often financing)
  - Technology funding
  - For anaerobic digestion:
    - Pre-processing technology to pull organics out of mixed waste
    - Small-scale processing options; one interviewee noted that it is costly for centralized regional food scrap digestion.

Mattresses

Noted in six interviews

- Consider a product stewardship approach; currently it is cheaper to dispose of mattresses than it is to recycle them.
- Limited markets; only one recycler active in the region and would benefit from more.
  - Tacoma is piloting mattress collection at its transfer stations
  - Seattle is considering mattress collection at transfer stations as well.
- Polyurethane foam component of mattresses a particular challenge.
  - Current market for the foam is only carpet underlay, but use is declining.
- King County to implement a fee-based collection at some transfer stations in 2018.
- Organizations/people working on this already include:
  - Look to California
  - Spring Back
  - British Columbia, Canada has a report (may be dated) on the true cost of handling and recycling mattresses.
- Infrastructure needs:
  - Need additional local processing for mattresses
  - Need markets for foam and cotton material

Plastics

Noted in five interviews, with a particular emphasis on film plastics

- A lot generated, but not a lot captured. Push for more use of recycled content in products, consider local plastic producers who could potentially use more recycled content as feedstock.
- Plastics Recovery Facility (PRF) as an area of interest, particularly for local opportunities and higher uses for #3-7 plastics (rather than bale and export)
  - Oregon has done a study to see if there is enough plastic volume to support a PRF; this study would be a good resource.
- Consider encouraging local governments to require recycled content in purchasing contracts (e.g., waste/recycling collection carts)
- Flex packaging/film plastics
  - Shifts in packaging from cardboard to flex packaging – this has financial impacts on MRFs that businesses and producers don't necessarily understand. Flex packaging use is projected to continue to increase in the future.[x]
  - Contamination in existing film collection, needs more oversight

[x] Online retail is one of the drivers of this increase. As reported in a 2016 Washington State Recyclers Association's event on shipping packaging, approximately 60% of packaging used by Amazon is currently flexible packaging (polybags) and is projected to increase in the future.

  - Current efforts have not been effective at connecting product designers with processors to ensure recyclability of new packaging; consider a potential partnership with industry organizations, trade groups, or others to work with MRFs.
  - C&D ban on shingles and plastic film to start in January 2017, but one interviewee notes that markets are not ready for these materials yet.
- Organizations/people working on this include:
  - Seattle working with the Wrap Recycling Action Program (WRAP); Washington is participating in 2017
  - NW Commingled Workgroup
  - Oregon is pursuing a statewide program to address film that is supposed to launch in 2017.
  - American Chemistry Council/American Plastics Council
  - Sustainable Packaging Coalition
  - B.C., Canada
- Infrastructure needs:
  - PRF and a film washing facility
  - Local processing opportunities for Styrofoam (there is a market in CA for densified polystyrene)

Textiles

Noted in four interviews

- Opportunities for higher and better use through upcycling
- Opportunities for additional collection at transfer stations (non-reusable textiles)
- Are there local processors for insulation and other markets for textiles?
- Organizations/people working on this already include:
  - Ellen MacArthur Foundation
  - WRAP UK and various European Clothing Action Plan (ECAP) representatives
  - Closed Loop Fund
  - Potentially Oregon DEQ
  - Others identified in the 2016 LinkUp global markets research

Other materials: tires, wood waste, electronics, and C&D (broadly)

Tires and wood waste mentioned in three interviews; electronics and C&D (broadly) in two interviews.

- Concern with tires and wood waste that conversion to fuel is not highest and best use; interest in identifying other viable options.
- For **tires**, product stewardship to fund clean-up efforts may be of interest. Interviewees noted limited markets and the need to charge money to recycle tires.

- For **wood waste**, promote of use of salvage (e.g., salvaged lumber warehouse, decorative uses, frames and lumber), but additional materials and new markets for clean wood need to be explored as well.
  - Promote design for disassembly; potentially add to building code in long-term
  - Need solutions for dirty wood – are there processing options that can accept both dirty and clean wood?
- For **electronics**, need better markets for small items not covered in eCycle. New products on market all the time (e.g., 3D printing), creating new waste. Are there opportunities to influence design of new products locally?
- Some interviewees also noted **C&D materials** broadly, noting materials such as shingles and drywall where King County has taken action in the past. Interviewees indicated that they did not want to see these efforts dropped.
  - For example, New West Gypsum has requested more material; wants help increasing supply of local recycled feedstock
  - Packaging waste a large component of C&D waste; addressing packaging may help
  - Legislation such as C&D bans and requirements for use of recycled content may be opportunities to reduce waste.
  - C&D ban on shingles and plastic film to start in January 2017, but one interviewee notes that markets are not ready for these materials yet.

INPUT ON SELECTION CRITERIA

Selection criteria for evaluating potential LinkUp focus materials identified by interviewed stakeholders include the following:

- Weight-based and volume-based selection
- Criteria related to social responsibility, such as:
  - System integrity (e.g., responsible recycling)
  - Environmental justice (look to Minal, OR DEQ for examples)
  - Social benefit by addressing the item (e.g., bulky items to surplus warehouse for disadvantaged people, case workers)
  - Toxicity of material, concerns about worker & environmental safety
- Ability of LinkUp to influence/feasibility of influencing the material market
  - E.g., existence of partnerships and some infrastructure
  - Current momentum, such as local, regional, national, and global environment for action, and/or government and private brand stated interest and investment.
  - Opportunities for partnership with other jurisdictions and other market players.
  - Are there local markets? If not, where are there proven markets or pilot projects?

- Greenhouse gases associated with the material
  - Emissions-based criteria are in-line with updates to King County's Environmental Purchasing Policy in 2017, which includes reducing climate impact and lowering the greenhouse gas footprint.
- Existing priority level in King County
  - Is there an existing materials ban from landfill?
  - Is the material one of focus in the King County comprehensive plan?

3. Material-specific Market Assessments

Cascadia developed an evaluation framework to identify up to six potential priority materials for the LinkUp program. Stakeholder feedback was incorporated into both the development of the framework and to review the final outputs. Through this process, Cascadia identified the following six potential priority materials for further assessment: **food and food-soiled paper, film plastic, #3-7 plastics, electronics, clean wood**, and **gypsum**. This section describes the process for identifying these materials, research methodologies, and final material-specific assessments.

Material Selection Criteria

To identify up to six preliminary focus materials for the program, Cascadia developed a materials evaluation matrix in collaboration with LinkUp's program manager. This matrix provides a framework for a preliminary assessment of potential focus materials for the program. We do not intend that the matrix alone define priority materials for the program; rather, it provides a structure that better enables some initial comparison of the available data. Final program priority decisions should take into account both qualitative and quantitative market conditions.

The materials included in this matrix were selected through a process that involved analysis of waste composition data in Seattle and King County and engagement with internal stakeholders with the King County Solid Waste Division and with Seattle Public Utilities—an organization that King County partners with frequently in its infrastructure and market development efforts. Following stakeholder engagement, we worked with the LinkUp program manager to define more specific categories for several broad material groups, resulting in the 14 candidate materials. The table below shows the initial priority rankings of materials that resulted from the matrix. Evaluated materials are listed in order from high to low score, where a high score indicates higher potential program priority. Bolded materials indicate the materials selected for further research. Mattresses and textiles, though among the top-scorers, were not selected for further research because these are already current areas of investment for the LinkUp program.

Overall Ranking	Materials
High	**1. Food and food-soiled paper*** **2. Clean wood** 3. Textiles* **4. Film plastic**
Medium	**5. Electronics (covered by E-Cycle)** **6. #3-7 plastics** 7. Mattresses* **8. Clean (new) gypsum** 9. Electronics (not covered by E-Cycle) 10. Asphalt Shingles* 11. Carpet
Low	12. Treated wood 13. Painted (demo) gypsum 14. Tires

**Indicates materials for which the LinkUp program is currently offering market support*

Evaluation criteria used to assess each of the materials were developed from the initial data review and King County and Seattle stakeholder engagement. Criteria included:

- Disposed tons (C&D and MSW)
- Disposed volume
- GHG emissions avoided if not landfilled and if recycled
- Ability to influence
- Market strength
- Priority in the County Comprehensive Plan

Cascadia solicited feedback on the process and findings for the preliminary scoring as well as the detailed matrix (Appendix C) from the stakeholders interviewed in late 2016.

RESEARCH PROCESS

Desktop research

Cascadia conducted desktop research to obtain information on collection, processing, and end markets for specific materials. Key sources of information included the following reports:

- LinkUp's 2012 Mini Market Assessments
- The King County 2015 Market Assessment for Recyclable Materials
- The 2015 Washington Commingled Recycling Workgroup Report

Other reports incorporated into our research included plastics market reports published by More Recycling[xi] and planning documents produced by other government agencies such as CalRecycle, Massachusetts Department of Environmental Protection, and the Oregon Department of Environmental Quality. External Stakeholder Interviews

Cascadia completed interviews with 15 stakeholders between April and September 2017 who represented experts on specific potential priority materials with knowledge beyond the scope of King County and Seattle Public Utilities activities. The stakeholders were identified through desktop research and from internal stakeholder recommendations. Interviewee lists can be found at the end of each mini-market assessment. Cascadia also incorporated data from the internal stakeholder interviews that took place in late 2016 into the final market assessments.

Questions asked of stakeholders varied by topic, but broadly focused on understanding regional processing capacity, domestic markets for processed materials, and any Northwest-specific barriers across the material value chain.

Mini-Market Assessments

Market research for the mini-market assessments took place from late 2016 to mid-2017. Due to the dynamic nature of recycling markets and uncertainty in policy developments (such as China's announcement of its national SWORD campaign in 2017), market changes that took place while these reports were being drafted may not be fully captured.

For the purposes of this assessment, **diversion** describes all processes that prevent material from being disposed of in a landfill. Examples of diversion that are not recycling include:

- Energy recovery from burning wood waste
- Use of gypsum as a soil amendment
- Pyrolysis of plastics to fuel

[xi] More Recycling is a research and consulting firm that specializes in plastics recycling markets; the company conducted the research for and authored the latest reports on U.S. post-consumer recycling for film, rigid plastics, and plastic bottles on behalf of the Association of Plastic Recyclers.

#3-7 RIGID PLASTICS

#3-7 rigid plastics describes hard plastic containers made of materials other than PET (#1) or HDPE (#2) plastic. These plastics can take the form of tubs, jars, jugs, or bottles, but this material category excludes bags, which are a film (non-rigid material). Other examples of #3-7 rigid plastics include bulky rigid plastics, such as laundry baskets, plastic crates, and 5-gallon buckets.

Material supply

In 2015, residents, businesses, and construction and demolition (C&D)-sector generators in King County and Seattle disposed of an estimated 3,300 tons of #3-7 rigid plastics, approximately two-tenths of one percent of the overall waste stream by weight. Though a small portion of the waste stream by weight, this material is highly voluminous. Using standard density factors from the U.S. Environmental Protection Agency for mixed plastics, the disposed quantity is estimated to be equivalent to 254,300 cubic yards of material.[1]

The volume and variety of plastic packaging types in the waste stream continues to increase. This not only increases challenges to recyclers to sort, separate, and process this material, but also to local jurisdictions who have had to make decisions as to what types of material to allow in their collection programs.

Collection

Collection infrastructure for #3-7 rigid plastics for both residential and commercial generators is adequate. Most residential curbside recycling programs throughout King County and Seattle accept #3-7 rigid plastics. In general, regional recycling programs do not use the resin identification code in public education, focusing instead on the shape of the material (e.g., bottles, tubs, jars, jugs, and cups). Some residential curbside programs, such as those in Bellevue, Burien, Mercer Island, and Shoreline also accept bulky rigid plastics (e.g., laundry baskets, plastic crates, and 5-gallon buckets).[2] Commercial recycling programs across King County and Seattle also accept #3-7 rigid plastics.

The type of recyclable plastic materials accepted in curbside programs varies across neighboring jurisdictions in King County. For example, some jurisdictions accept plastic cups, while others accept only plastic bottles. Variance in recyclable materials where one works, lives, or goes to school can create public confusion, resulting in higher contaminant plastic types in the recycling. In King County, approximately one out of every six pounds of plastic collected (16 percent) are non-conforming, meaning they are not considered an accepted material in the local recycling program.[2]

Processing

In general, primary processing infrastructure and capacity for #3-7 rigid plastics is adequate. In Northwest Washington, plastics are separated from other materials using a mix of hand and machine-sorting technologies. #1 and #2 plastics (PET and HDPE) are sorted into separate bales, while the remaining plastics (#3-7) go to mixed plastic bales.[2] Mixed plastic bales in Washington are exported.

Facilities that process #3-7 plastics from commingled recycling from King County include:[3]

- Recology CleanScapes' materials recovery facility (Seattle)
- Republic Services' 3rd and Lander facility (Seattle)
- Waste Management's Cascade Recycling Center (Woodinville)
- Waste Management's JMK Fibers (Tacoma, WA)

Other recycling companies in the area that recover #3-7 rigid plastics from commingled recycling to sell to export markets include Pioneer Recycling in Tacoma and SeaDruNar in Seattle. Due to more stringent quality standards from China's recent National Sword policy, smaller facilities like Pioneer Recycling and SeaDruNar are accumulating plastic that they cannot currently sell.[4]

Processing challenges for mixed plastics include the following:

- Non-conforming plastic materials such as plastic trays are difficult to sort and contaminate other recyclables.
- Potentially limited processing capacity for new plastic and packaging types. One processor interviewed in King County's 2015 Market Assessment for Recyclable Materials noted the expansion of accepted recyclable materials lists in local jurisdictions can complicate processing and contaminate other recyclables. In addition, the materials added to the accepted recycling list do not necessarily have strong end markets.5
- Contamination from lookalike material such as compostable plastics or plastics with degradable additives; these materials are difficult to sort and separate.

The Northwest currently lacks processing infrastructure for washing dirty plastics or sorting plastics from mixed #3-7 rigid bales. Merlin Plastics, a reclaimer in British Columbia, Canada has washing capabilities, but the company reported in 2014 that it does not need additional plastic from the United States.[7] Another plastics processor, Denton Plastics, processes post-industrial plastics into pellets that can be used to make new products (the company does not accept mixed plastic bales), but it was not confirmed whether they purchase any post-industrial plastics from generators in King County.

Local processors did not report selling mixed plastic bales to domestic secondary processors. However, there are domestic secondary processing facilities for #3-7 rigid plastics, such as plastics recovery facilities (PRFs) or secondary material recovery facilities (MRFs). Examples of these facilities include the QRS PRF in Baltimore, PRFs in Canada, and Titus (a secondary MRF) in Southern California.[6] At PRFs, plastic material is further sorted, washed, and then ground into flake or re-melted into pellets to make new products. Secondary MRFs, such as Titus in Southern California are another processing option for mixed rigid plastics. These facilities take residuals from primary MRFs to further separate out fiber, metals, and other materials. Ideally, they accept material for less than the landfilling cost.[6]

Seattle Public Utilities and members of the Northwest Commingled Recycling Workgroup are exploring the potential of building plastics processing capacity in the form of a PRF in the Northwest, which would allow additional separation of mixed plastic bales containing #3-7 plastics and potentially expand domestic markets for the material. These organizations are in the information-gathering stage, and the work remains in preliminary stages. In 2014, Oregon Department of Environmental Quality and Oregon Metro evaluated the minimum feedstock needed to make the economics of a PRF in the region work. They found that a viable small-scale facility would need at least 15,000 tons per year of material, and a PRF that incorporated reclamation steps such as washing and pelletizing would need to process 50,000 tons per year.[7]

An emerging processing option for polystyrene (#6 plastic) in development by Agilyx, is to use post-consumer polystyrene to produce the styrene monomer, a precursor plastics material. The process accepts all forms of polystyrene products (such as cups and plastic plant pots), including expanded polystyrene (EPS). The company anticipates production at this new facility beginning in the second quarter of 2017 and will likely increase local markets for polystyrene (#6 plastic) in the future.[8] If this technology does expand such that there is capacity to process polystyrene material from King County, infrastructure for separate collection of #6 plastic or infrastructure to sort #6 plastic from mixed bales will be needed to produce suitable feedstock.

End uses for processed material and existing markets

Markets for #3-7 rigid plastics are weak and reliant on export. Local processors noted in an email survey that demand for this material is low. Market prices for #3-7 plastics varies by type of resin. Market conditions are affected by the price of oil (which affects the cost of producing plastic from virgin material and transportation costs) and strength of the U.S. dollar (which affects import/export dynamics) import/export.

Domestic markets for mixed resin bales remains limited due to current market conditions; in 2015, export buyers purchased 64 percent of mixed resin rigid bales nationwide,[9] and all #3-7 plastic containers from King County were exported to China.[3] Regional processors reported in 2015 that markets for durable plastics were limited when the Green Fence was actively enforcing export quality standards in 2013 but had largely recovered. However—though too early to see

significant changes—China's recent National SWORD policy is expected to similarly weaken markets for low-grade materials, including #3-7 plastics, as did the Green Fence.[10]

Both the Association of Plastic Recyclers (APR) and regional processors note the potential for polypropylene (#5 plastic). Companies such as Proctor & Gamble and Unilever have set ambitious goals to increase their use of post-consumer recycled content by 2020 and view polypropylene as a material with high opportunity.[11] In King County, one processor estimated that mixed #3-7 plastic bales typically contains 80 percent polypropylene.[3] Both More Recycling and QRS highlight a need for end market demand for post-consumer recycled content to drive collection and domestic processing of #3-7 plastics. Post-consumer resins can be used to manufacture varied items such as agricultural pipes, septic tanks, and auto parts. QRS noted that local governments have strong purchasing power to require post-consumer recycled content and is looking at producing park benches and curbside recycling collection carts from recycled material.[12] One challenge in producing curbside carts is that blue carts—which King County residents have been trained to identify with recycling—cannot be produced using 100 percent post-consumer recycled plastic; the specific colors of a certain hue (lighter and brighter) require a layer of virgin plastic material that may impact recyclability of the finished product. However, using black garbage collection carts made from recycled #3-7 plastics may be possible.

Barriers to diversion

The largest barrier to diversion of #3-7 rigid plastics is **weak market conditions**—especially domestically—for the material. Market challenges are exacerbated by the projected growth of virgin resin production as a byproduct of fracking; fracking produces ethylene as a byproduct, which is a base polymer for consumer plastics. The U.S. is projected to become the largest producer of virgin resin, exporting 30 billion pounds of polyethylene alone over the next five years.[6] Without consumer demand driving recycled content products, the flake value from processed recycled plastic is too low to compete with virgin material under current market conditions.

One processor noted that markets want clean, clear, and dry plastics—while their MRFs produce wet, mixed, and dirty plastics. One opportunity to address the quality of collected material may be through separate #2 and #5 rigid plastics collection at grocery stores. It is not known to what extent separation and dedicated collection of #2 and #5 rigid plastics at grocery stores is in use in King County. However, the Association of Plastic Recyclers has a toolkit on implementation and operations of such programs at http://www.recyclegroceryplastics.org/.

Additional market development is needed for #3-7 resins in mixed bales. Product manufacturers should work with processors to identify products with potential to use post-consumer content. McConkey (a company based in Sumner, WA), for example, makes plant containers from recycled PET water bottles.[13] They could potentially expand their manufacturing to incorporate recycled plastics into products made from other plastic types.

Key Regional Players

Interviewees

Phone or in-person interviews:

- Nina Butler, More Associates[xii]
- Sego Jackson, Seattle Public Utilities
- Dave Bellon, QRS

Processor surveyed by email:

- Matt Stern, Waste Management
- Todd Burnstein, Recology
- Terry Gillis, Recovery 1

Other potential stakeholders

This section provides an overview of organizations who are currently working to develop markets for #3-7 rigid plastics, or if engaged, could potentially have a large impact on the markets. These organizations represent potential future partners for the LinkUp program.

Value chain position	Player
Collection	Local recycling haulers such as Republic, Waste Management, and Recology
Collection	Grocers, specifically to capture #2 and #5 plastics (see Association of Plastic Recyclers "Recycle Grocery Plastics" program)
Processing	Local MRFs
Processing	The Materials Recovery Facility of the Future project (https://www.materialsrecoveryforthefuture.com/)
Processing	Secondary processors – Titus, QRS
Markets	QRS – (currently) confidential product innovation; developing products using recycled resins.
Markets	Government – enact policies to push requirements for recycled content.

[xii] Formerly Moore Associates. The company changed ownership and branding in 2017 but remains a national plastics recycling expert.

FILM PLASTIC

Film plastic refers to materials such as pallet wrap, agricultural sheeting, produce bags, zip-lock bags, frozen vegetable bags, bread bags, food wrappers such as candy bar wrappers, deli bags, plastic shopping bags (including dry-cleaning bags and newspaper bags intended for one-time use), and all other packaging films. Demand for sub-types of materials (such as chip bags vs. clean produce bags) varies within this broad category; where possible, it has been clarified what specific film subtypes are managed in the discussion of different steps along the value chain.

Material supply

In 2015, residents, businesses, and construction and demolition (C&D)-sector generators in King County and City of Seattle disposed an estimated 85,600 tons of film plastic, which is equivalent to approximately 7.4 million cubic yards of material.

Generation of this material is expected to increase as packaging continues to shift from cardboard to flexible packaging; online retail is one of the drivers of this increase. As reported in a 2016 Washington State Recycling Association's event on shipping packaging, approximately 60 percent of packaging used by Amazon is currently flexible packaging (polybags) and is projected to increase in the future.

Collection

Collection infrastructure for plastic film recycling could use improvement for both residential and commercial generators. Though some commingled recycling programs accept plastic film, film collected from commingled recycling streams has low market value and is challenging to process (see Processing and End Uses section for details). Plastic bag and film take-back programs for residential generators exist at retail locations throughout King County, such as grocery stores; however, there remain opportunities to improve resident knowledge of and participation in these programs. Oregon Department of Environmental Quality's (DEQ) 2014 Plastics Recovery Assessment estimates that the recovery rate of plastic film is 15 percent overall, with commercial film recycling rates lagging behind residential film.[14]

Though some curbside recycling programs in King County accept clean plastic film such as grocery bags, bread bags, and plastic wrap, most do not. King County has encouraged residents to return recyclable film plastic to grocery stores—an existing network of collectors—through the "Bag your Bags, Bring 'em Back" campaign, which is currently not actively promoted other than having a website. The collection network accepts a wide range of plastic film types, including plastic zipper bags (with a rigid plastic closing mechanism), bubble wrap, and dry cleaning bags; however, no recycling collection infrastructure currently exists for other plastic film types such as candy wrappers, frozen food bags, and metallized film (such as chip bags).[15] Residents may also drop off plastic film (as well as Styrofoam) for recycling at King County's Shoreline and Bow Lake Recycling and Transfer Stations.

King County, along with Sego Jackson of Seattle Public Utilities and other participating members of the Northwest Commingled Recycling Workgroup, is discussing bringing the American Chemistry Council's Wrap Recycling Action Program (WRAP) program to the region, which could replace the "Bag your Bags" campaign. Oregon DEQ is also discussing bringing WRAP to Oregon and noted that the department was in part waiting to hire a communications and outreach specialist before doing so to support implementation.[16] Vancouver, Washington piloted a WRAP-based program in 2015 in partnership with Waste Connections, Safeway, and Trex with promising initial results; More Recycling, a research and consulting company that specializes in plastics recycling, reports that Vancouver has since increased retail collection of film by 125 percent and reduced bags going to the material recovery facility (MRF) by 70 percent.[17]

Similarly to residents, businesses that generate small quantities of film can recycle plastic film in select commingled recycling programs; however, most programs do not accept film. Commercial generators may also recycle plastic film by dropping off separated material at transfer stations or other recycling centers. For businesses that produce large volumes of plastic film (such as department stores), businesses may have their own source-separated collection program for plastic film and bale plastic film on-site. Various private companies such as SeaDruNar Recycling and United Recycling provide drop-off locations, pick-up services, or both, typically taking plastic film bales for a fee. For C&D generators of plastic film, clean plastic film can be recycled in mixed C&D bales at King County designated recycling facilities. At Recovery 1, for example, clean plastic film is manually sorted and separated from other materials.

Plastic bags can be directly reused by residential generators, and commercial generators can be encouraged to replace pallet wrap with reusable options; however, the extent to which these activities can be encouraged to reduce disposal of plastic film is unknown.

Processing

Separating plastic film from other commingled recyclable materials remains a challenge to MRFs. Reprocessing of clean plastic film into pellets for remanufacture into new material is adequate, though there remains no large-scale reprocessing option for multi-layer or multi-resin plastic films. Other film processing options include plastic-to-fuel and an emerging mixed plastics-to-crude oil technology. There may be limited implementation of the latter due to low virgin oil prices resulting from fracking.

Recyclable plastic bags and other film collected at participating retail sites—mostly grocery stores—are picked up either directly by recyclers who bale and broker the material to end markets or by retail suppliers who backhaul the bags to recycling facilities. MRFs that receive commingled recyclables from programs that accept plastic bags typically sort and bale them separately from other plastics. However, processors report that loose film poses a challenge to MRF operations. Regional MRFs reported spending $700-$1,000 per ton[18] to remove film from equipment, and that 20-30 percent of recycling center labor is spent addressing operational challenges from

plastic film.[19] Due to the cost of processing film at MRFs and the low market value for MRF film (see section below), King County and members of the Northwest Commingled Recycling Workgroup are pushing for more retail take-back options. Similarly, in part due to challenges that arise when plastic film is placed in curbside recycling bins, Connecticut's Department of Energy and Environmental Protection launched a WRAP-based film recycling campaign statewide in February 2017.[20]

Plastic from clean recyclable plastic bags and other post-commercial films can be reprocessed into pellets for remanufacture into plastic bags and other film packaging. Post-consumer films can also be mixed with wood to make composite lumber products by companies such as Trex.[21] Nationally, 44 percent of reclaimed post-consumer film in the U.S. was processed into lumber, 43 percent into film or sheet, and 13 percent into other products such as agricultural products, buckets, and pallets.[30]

Few processing options exist for multi-layer, multi-resin film packaging. These materials may be blended and molded into durable products, but a report by Resource Recycling Systems (a consulting firm) on flexible packaging recovery notes that no manufacturer today is doing this at a large scale.[22] Terracycle offers a range of recycling programs (residents or businesses ship collected materials to Terracycle) for some of these hard-to-recycle materials, including baby food pouches, drink pouches, and candy and snack wrappers. Some of these collection programs are partially funded by the manufacturer and offered for free, such as recycling through TerraCycle for packaging from ClifBar products.

In 2011, LinkUp identified plastics-to-oil processing through pyrolysis by Agilyx as an emerging processing option. In 2014, Agilyx began shutting down its polystyrene-to-oil operations in Tigard, Oregon due to the low price of oil; the company has instead been developing a process to produce the styrene monomer, a precursor plastics material, from post-consumer polystyrene (commonly used for rigid plastics due to its more brittle nature). The process accepts all forms of polystyrene products (such as cups, plastic plant pots, and polystyrene film packaging), including expanded polystyrene (EPS) and Styrofoam products. The company anticipates production at this new facility beginning in the second quarter of 2017 and will likely increase local markets for polystyrene (#6 plastic) in the future.[23] The company is also working to commercialize a mixed plastics-to-crude oil conversion process that could be a potential option for low-value film, such as MRF films. However, the current status of this technology is not known. Other plastic-to-fuel processing options include refuse-derived fuel. For example, Dow Chemical Co., in partnership with the EnergyBag program in Omaha, has been using non-recyclable films such as chip bags, candy wrappers, and juice pouches as a feedstock to fuel a cement kiln.[17,24]

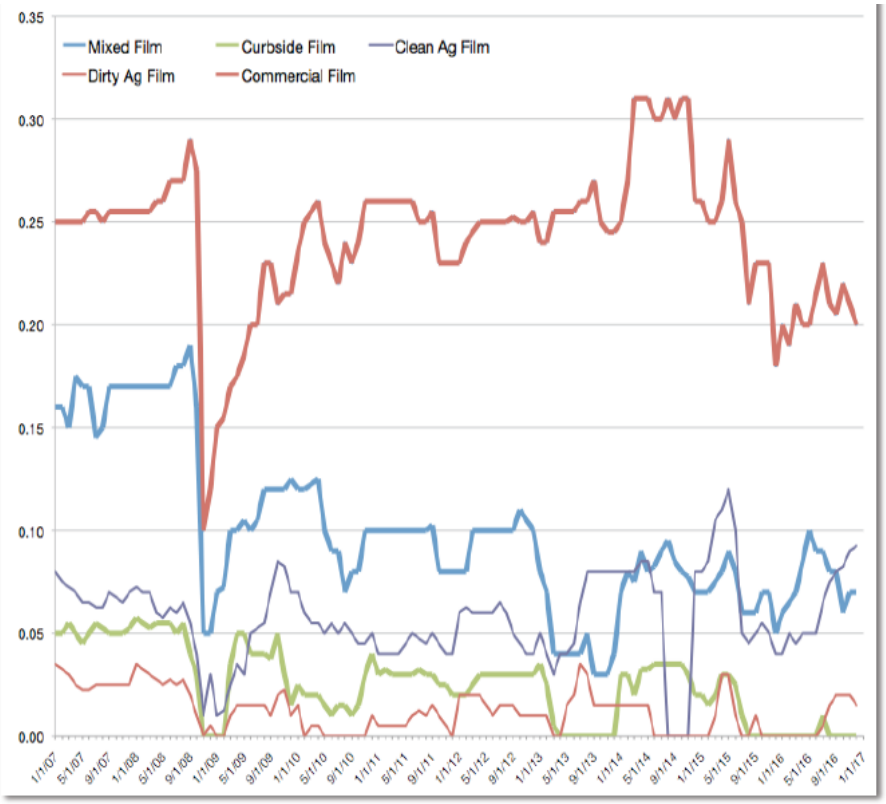
Another emerging processing option for waste plastics, including plastic film, which is being explored in the UK is to incorporate pelletized waste plastics into an asphalt mix used to build roads.[25]

End uses for processed material and existing markets

Markets for film recovered from commingled streams at MRFs are limited primarily to export, though markets for high-quality and clean film remain adequate at the national level. However, regional C&D processors Lautenbach Recycling and Recovery 1 both report currently having to pay to have brokers take their bales of clean and dry plastic film.

Almost all bales of plastic packaging film recovered from commingled recycling streams are exported, as there are very limited domestic markets for these materials.[26] In 2015, about half of King County's recovered plastic film went to international markets.[27] This is consistent with broader national trends; 47 percent of postconsumer film was recovered for recycling in the U.S. or Canada, while the remainder was exported.[28]

Markets for high-quality and clean film remain adequate nationally. The figure below shows plastic film scrap prices from 2007 through 2017—prices for commercial film are strongest and mixed film and clean agricultural film prices have remained largely stable, but prices for dirty agricultural film and curbside film (MRF film) are near zero.[29] Figure 1: Plastic film scrap prices from 2007–2017 (Source: More Recycling).



Locally, markets for clean film may remain more challenging. Lautenbach Industries, a processor of C&D recyclables, reported—despite producing clean bales of plastic film recovered from mixed C&D loads—that the company has to pay to recycle plastic film (through a materials broker). Recovery 1 reported that they are currently holding bales of plastic film until there is more demand for the material instead of paying to have a broker accept the material.

Barriers to diversion

Barriers to diversion of film occur at all points of the supply chain, from collection through end markets. These barriers (as well as potential opportunities to address specific barriers) include:

- **Lack of awareness and/or participation in retail film drop-off programs by residential generators of plastic film waste**.[18] Recommendations from both the Northwest Commingled Recycling Workgroup and More Recycling include residential recycling education that prioritizes retail take-back for film over curbside recycling. Education should note that these programs accept other film types in addition to bags.
    - Explore alternatives to retail take-back programs to collect residential film. For example, More Recycling is in conversation with Trex, UPS, and The Gap to assess satellite material take-back programs.[17]
- **Lack of awareness and/or participation in film plastics recycling programs by commercial generators.** Both More Recycling and Oregon DEQ note that commercial generators produce a lot of film that is not being collected—while commercial film also has the highest market price of all film scrap types—representing a significant opportunity for diversion.
    - Smaller businesses may not generate enough plastic film to warrant separate collection services from recyclers. One opportunity may be to develop business networks for collection. For example, in Vancouver, WA, an AmeriCorps intern for the City is working to get small businesses to direct film material to larger anchor stores for recycling.[17]
    - Leverage existing collection networks, such as with businesses that supply paper tissue and towels to large businesses. These suppliers may be able to backhaul the accompanying film wrap for recycling and reuse.[17]
    - At jobsites that generate pallet wrap, one barrier to recycling is a lack of knowledge and/or interest in collecting pallet wrap in a way that keeps it sufficiently clean for processing facilities to recycle.
- **Recruiting retailers to participate in take-back programs can be a challenge** due to real or perceived barriers such as space constraints, inconvenience to the retailer, and public dumping or collection of low-quality material.
    - When engaging retailers, promote the opportunities for value generation: the collected material has market value and can be sold in bales, and being a retail take-back site can bring customers in the door.

- **Plastic film is still challenging for MRFs to process** when collected in commingled MSW streams, particularly to sort and separate. Jurisdictions can work to promote source-separated collection of film (such as through retail take-back) over curbside single-stream collection.
    - Loose plastic film gets stuck in MRF sorting equipment, causing MRF slowdowns and adding costs to the entire commingled recycling system.[19]
    - The Ellen McArthur Foundation's New Plastics Economy initiative identifies innovative sorting mechanisms for post-consumer film as a priority action to improve plastic recycling economics and quality.[30]
    - Nationally, though MRFs have capability to sort, bale, and transport film, some have reported challenges finding buyers for curbside-collected film due to cost of processing and market conditions.[180]
- There are currently **limited to no processing options for multi-resin and/or multi-material films** such as chip bags, except as feedstock for refuse-derived fuel in some markets.[22]
    - The New Plastics Economy report estimates that 13 percent of the global plastic packaging market is multi-material film by weight; the report also notes that innovation in reprocessing technology for this material is needed.
- The existing processing capacity is primarily for clean LDPE or HDPE film; very few processors have capacity to wash film since it is a costly process. [18]

Key Players

Interviewees

Phone or in-person interviews:

- Nina Butler, More Associates
- Sego Jackson, Seattle Public Utilities
- Troy Lautenbach, Lautenbach Industries
- Terry Gillis, Recovery 1
- David Allaway, Oregon DEQ

Processor survey by email:

- Matt Stern, Waste Management
- Todd Burnstein, Recology
- Terry Gillis, Recovery 1

Other potential stakeholders

This section provides an overview of organizations who are currently working to develop markets for plastic film, or if engaged, could potentially have a large impact on the markets. These organizations represent potential future partners for the LinkUp program.

Value chain Position	Player
Collection	Current and/or potential future take-back sites, such as large grocery chains (Safeway, QFC, PCC, Fred Meyer, Whole Foods)
Collection	WRAP and More Recycling
Collection	• Vancouver, WA • Seattle Public Utilities • Northwest Commingled Recycling Workgroup • Other jurisdictions considering WRAP programs
Collection	Amazon—not currently engaged, but could potentially have large impact if they partnered in collection, particularly alternatives to retail take-back.
Collection	Department of Ecology—expressed interest in leading WRAP or other film program.
Processing	MRFs—Recology, Republic Services, Waste Management
Processing	Agilyx in Oregon—mixed plastics-to-crude oil conversion
Markets	Trex—partnering with City of Vancouver, WA. Use recycled film product to produce composite lumber.
Markets	Regional brokers of material, such as Skagit Steel
Multiple	• National resources – www.plasticfilmrecycling.org • More Recycling's Value-chain Case Studies (in-progress) • Connecticut Department of Environmental Protection (launched a statewide WRAP campaign in February, 2017) • Oregon DEQ – previously completed assessment of plastics markets and processing options (published January 2015) and considering implementing statewide WRAP program)

FOOD AND FOOD-SOILED PAPER

Material supply

In 2015, residents, businesses, and construction and demolition (C&D)-sector generators in King County and Seattle disposed an estimated 300,900 tons of food and compostable food-soiled paper, or approximately 21 percent of the overall waste stream by weight.

Food scraps and compostable paper diversion continues to be a strong area of interest both in the region and nationwide; capture of food scraps is seen as critical to meet ambitious waste diversion targets both in the Northwest and beyond. In the City of Seattle, landfill disposal of food scraps and compostable paper by residential, commercial, and self-haul generators has been prohibited since January 1, 2015.

A portion of food scraps is still edible food. A recent study of service management businesses and restaurants in King County, completed by Cascadia, estimated that approximately three-quarters of food waste generated was edible food.[31] There remain significant opportunities in food scraps reduction and prevention; however, upstream waste management of food waste is beyond the scope of the LinkUp program, which focuses on reuse and recycling.

Collection

Commercial haulers operating in King County and Seattle offer organics collection to both residential and commercial customers. Nearly all single-family households (99 percent) in King County have access to curbside organics collection that includes food scraps.[32] Unpackaged food scraps and approved compostable paper products can be collected along with yard waste in the same containers. Challenges to food scraps collection are both customer access (such as at multi-family units where organics collection is not required or offered by property management) and participation in diversion programs.

In 2012, approximately 13 percent of residential food scraps were captured in composting programs despite near countywide availability of curbside collection service among single-family residents.[33] Participation rates appear to be increasing, though there remains room for improvement: in the 2017 King County food diversion cart tag study, baseline food scrap capture rates averaged 45 percent overall.[34] Seattle's capture rates are estimated at 57 percent for food scraps and 40 percent for compostable paper.[35]

Both King County, the City of Seattle, and many area cities have implemented public education and outreach campaigns to promote and increase participation in food scrap diversion through curbside organics collection. The City of Seattle also offers education and technical assistance to businesses to help them set up composting service and comply with the food scrap disposal ban.

Some homeowners choose to compost vegetative food scraps and compostable paper onsite in backyard compost or worm bins. Other homeowners may choose to dispose of food scraps through in-sink garbage disposal. Similarly, businesses may collect and dispose of food scraps using on-site processing options (discussed in the Processing section).

Processing

Composting is the primary processing option for food scraps and compostable paper in the region; composting capacity appears adequate for the quantity of food scraps currently collected from King County. However, more processing capacity is likely needed if food scraps and food-soiled paper diversion significantly increases in King County and surrounding regions. Commercial composters who process material generated in King County include:[xiii]

- Cedar Grove Composting (two facilities: Maple Valley, WA and Everett, WA)
- Lenz Enterprises (Stanwood, WA)

These composting facilities can together process approximately 500,000 tons of organic material per year.[xiv] They are currently operating near capacity, reportedly processing approximately 444,000 tons of material from both King and Snohomish counties in 2016.[36] Representatives from the local health jurisdictions—Public Health – Seattle & King County and Snohomish Health District—did not report any planned changes to processing capacity and noted that both Cedar Grove in Maple Valley (King County) and Lenz Enterprises in Stanwood (Snohomish County) are operating near their permitted capacities.[37] The Snohomish Health District representative overall saw potential for additional processing in Snohomish County:[37]

- In 2016, Cedar Grove in Everett had approximately 80,000-90,000 tons of remaining permitted capacity. However, this available capacity will be diminished once Seattle starts sending its curbside collected yard and food waste to the facility in the fall of 2017 (which had formerly gone to the Maple Valley facility).
- Lenz in Stanwood is permitted for 75,000 tons, but the facility as-built can process up to 125,000 tons.[37] In order to take additional material Lenz would need to increase its

[xiii] PacifiClean in Quincy, WA is not currently taking organic material from the City of Seattle due its location in the apple maggot pest-free area of eastern Washington. As of mid-2016, they reported that they were evaluating the economic feasibility of incorporating a heat treatment to kill all apple maggots into their operations (http://www.goodfruit.com/assessment-analyzes-risk-for-spread-of-apple-maggot/) in order to accept organics from the quarantine areas of the state.

[xiv] Cascadia reported in the 2015 King County Recycling Market Assessment that the permitted capacity for organics was approximately 850,000 tons per year. The updated figure in this document (500,000 tons) does not include processing capacity at PacifiClean, which is not currently accepting material from quarantined areas in Western Washington.

permitted throughput through the Puget Sound Clean Air Agency (PSCAA) and the local health jurisdiction.

Processors interviewed similarly noted a distinction between permitted capacity (throughput and storage thresholds allowed by the local health jurisdictions and PSCAA) and operating capacity (what could be processed with the available facilities and equipment). Cedar Grove did not report the potential maximum operating capacity of their facilities today but indicated that it would be adequate to handle food from new diversion programs. They also noted that they could process more organics, including food, under their current permit if the set of materials covered under the local health jurisdiction permit were interpreted differently.[38] In general, industry representatives noted that permitting can take up to months or even years. Though there appears to be potential to expand permitted capacity at existing facilities, representatives from Public Health – Seattle & King County and Snohomish Health District reported that no processor has approached them about siting new or increasing existing capacity at this time.[37]

The Public Health – Seattle & King County representative reported limited potential for new or expanded processing capacity in Western Washington, citing limited physical space, high cost of land, and resident concerns about odors as barriers.[37] She noted that capacity to process additional organics with increased food and food-soiled paper diversion is likely adequate, however, if the material could be processed at facilities in Eastern Washington. However, transporters and composters would need to obtain a special permit from the Department of Agriculture to transport, receive, and compost organic materials from apple maggot quarantine areas (all of Western Washington) in the pest-free areas of Eastern Washington. Transporters and processors are exploring heat and grinding pre-processing technologies for organic feedstocks from the quarantined areas that would enable them to be transported to facilities in Eastern Washington, but they have not yet identified suitable or cost-effective options that meet the requirements set by Department of Agriculture.[37] She also noted a need for stronger end markets for composted material to support expansion of processing capacity.

Maintaining the quality of finished product is critical to compost markets,[45] and processing challenges noted by composters include:

- Contamination of composting feedstocks, particularly from glass and plastic film.
- Composting feedstocks are in transition. Regional commercial facilities were originally designed primarily for yard waste and not for the mix of food, yard, and compostable packaging that is collected and processed today. Processors have expressed a need for upgraded technology to manage the new material mix, such as upfront contaminant removal processes and backend screening systems for film plastic in particular.[32]
- Processors have expressed a desire to better anticipate the future feedstock mix, noting a need for better information on volumes and incoming materials to inform investments in capacity, equipment, and labor.[32]

- Financing for technology upgrades at existing facilities is potentially a challenge.

Though not widely used to process organic feedstocks in the Northwest, anaerobic digestion is another option for processing food scraps. Anaerobic digestion is a process through which bacteria convert organic material into a renewable fuel source (biogas). In general, anaerobic digestion has more stringent specifications on incoming feedstock materials that can and cannot be processed. Byproducts of the process can be used as a soil amendment (often marketed as liquid fertilizer), or as composting feedstocks. Solid digestate, should it result from processing, may also be used as animal bedding on farms. Emerging but not yet proven potential markets for solid digestate include replacing peat moss in horticulture, use in the manufacture of particleboard or wood-plastic composites, molding it into biodegradable plant pots, or using it as a fuel feedstock.[39]

In the region, small-scale, on-site digesters by companies such as Impact Bioenergy are an emerging processing option. Impact BioEnergy has pilot projects for its HORSE system—which advertises a processing capacity of 135-960 pounds per day for food, paper, grass, and liquids—at Fremont Brewing in Seattle (with grant funding from Seattle Public Utilities) and at sites in Auburn and Vashon Island.[40] Impact BioEnergy has also received grant funding from King County to test how liquid digestate from its process performs as a soil amendment at Seattle Tilth's Green River Farm, and to study the feasibility of a community-scale digester on Vashon Island.[41] Small-scale processing systems such as Impact Bioenergy's HORSE typically require more manual operation, and may require more user time and labor for activities such as contaminant removal if handling less clean or compositionally consistent streams of organic material.

WisERG is also commercializing an on-site solution for food scrap management. The WisERG Harvester receives and pre-processes food scraps into a semi-liquid mixture (a slurry) at the point of generation. The slurry is pumped out and transported to a secondary facility in Redmond, WA for final processing into a liquid fertilizer for land application. The WisERG Harvester can process up to 4,000 pounds of food scraps per day, and the food scraps are used to produce a liquid fertilizer.[42] WisERG Harvesters are currently in use at several grocery stores in King County and Seattle. The Harvester is not an anaerobic digester; it does not produce bioenergy for use where it is deployed. It also does not accept food-soiled paper or other compostable non-food products for processing. However, the Harvester has been designed with a data tracking and reporting component that may help grocery stores and other large generators of food manage and reduce their food scrap disposal over time.

Another company emerging in the Northwest is Divert, Inc. Like WisERG, Divert offers services to help retailers monitor and measure waste to identify opportunities for waste reduction. Unlike WisERG, Divert collects unsold food in its original packaging; Divert analyzes the accompanying data such as food quality, packaging integrity, expiration dates, and price markdowns to provide participating stores with actionable recommendations to adjust in-store food management

procedures. After completing data collection and analysis, Divert uses a network of processors (depackagers, digesters, and composters) to divert unsold food products. In Washington, the company currently takes material from major food retailers and processes it at a facility in Oregon.

High-volume commercial generators such as food processors may send food byproducts to be used as animal feed or to other manufacturers. Some wholesalers, grocers, restaurants, and other food service establishments also donate surplus food that is suitable for consumption to meal programs and food banks. Other processing options for high-volume generators include grinding wet food waste into a slurry (similarly to in-sink garbage disposals) and shipping the slurry to a wastewater treatment plant or other anaerobic digestion facility.[43] This mechanism is used by Waste Management for a residential route in Cambridge, Massachusetts; it is also used in Tacoma at the University of Puget Sound and in Marin County, California.

HDR recently completed a feasibility study of anaerobic digestion (AD) systems for King County, to examine AD opportunities that could help the County achieve its recycling, zero waste of resources and landfill life extension goals. The study identified opportunities and analyzed potential partnerships under a variety of strategies, and conducted economic and GHG analyses of three scenarios: small distributed AD systems, AD at the South Waste Water Treatment Plant, and dedicated AD at County transfer stations. Study results showed that "AD is expensive and complex, relative to landfilling or composting." It's especially challenging to extract organics from the municipal solid waste stream, and source-separated organics (SSO) are already being collected and processed by the private sector.

The Division could continue to explore opportunities for AD in the region, and small-scale AD at one of its facilities or in partnership with a private sector processor. These may hold promise in the short-medium terms. Source-separated organics streams are likely to be less costly to process than mixed waste. To identify source-separated organics streams for diversion, the Division should work with partner cities, generators, or collectors to identify sources of large quantities of otherwise disposed organics.

End uses for processed material and existing markets

Composters report that market prices and sales for compost products have been stable. Maintaining the quality of finished product is key to maintaining adequate market demand for compost; processors must balance the costs of adding processing steps (such as for additional contaminant removal) with maintaining competitive market prices for finished product.[45]

In 2015, composters reported selling most of their finished product to government agencies and landscapers; the percentage of product sold to agricultural applications ranged from less than 5–10 percent depending on the facility. However, as composting feedstock supply (and

corresponding production) increases, Washington State organics composting stakeholders view agricultural applications as the primary market that can take up the increased finish material.[44]

Challenges to getting compost into agricultural markets include the following:

- Compost is more expensive to purchase and apply compared to other soil amendments such as manure. There are also additional costs associated with transportation and delivery of compost product to Central and Eastern Washington markets.
- The specifications for finished compost are more stringent for agricultural uses than those for landscaping and gardening, requiring improved contamination management.[44] Keeping finished compost clean is critical to ensuring adequacy of end markets.[45]
- For composters looking to sell finished products to certified organic agricultural producers, accepting food-soiled compostable packaging can affect the compliance of the compost product by the National Organic Program (NOP).[46] Under today's NOP guidelines, compost made from recyclable papers (such as waxed cardboard and colored paper) and compostable plastics are not eligible for organic certification; producers of certified-organic compost have to manage packaging-containing organics streams separately.

In 2013, King County provided a grant to Washington State University for demonstrations of compost on King County farms. This grant was an adjunct to a study on compost use on farms in Snohomish County that included both research trials and demonstrations of compost use in collaboration with local compost producers, county offices, and local Conservation Districts. The research trials found that farmers participating in on-farm demonstrations in 2015 reported improved crop production in 68 percent of the trials and 55 percent of the farmers reported increased soil water retention.[47] Washington State University also published a study on a compost use decision-making process that demonstrates how to conduct a break-even analysis given compost price, estimated product yield, and application rate; how to estimate what compost application rate would maximize profit; and how to identify what combination of compost and inorganic fertilizer minimizes costs.[48] Additional work is required before this decision-making process can be made into a tool that farmers can readily use.

Interviews with regional composters in 2015 indicated a need to diversify their customer base; some processors reported heavy reliance on single buyers.[32] Other potential markets for finished compost include municipal and construction projects.

Barriers to diversion

Barriers to diversion of food scraps and potential actions to overcome the barriers include:

- **Low participation in collection programs (particularly among commercial generators)** - Organics diversion challenges that businesses have reported include time and cost associated with programs, contamination by consumers (for businesses that

generate post-consumer food waste), and a lack of data about their waste streams.[49] The Massachusetts Department of Environmental Protection (DEP) is implementing technical assistance, grant, and loan programs to build collection and on-site organics management systems for commercial generators, especially among those who generate less food scraps. The largest generators in Massachusetts are generally already participating in organics diversion; Massachusetts DEP sees future diversion opportunities among smaller businesses and institutional generators of food waste.[50]

  - Consider providing assistance with waste audits in technical assistance programs. Businesses interviewed in the Seattle *Food Waste Prevention Report* said that it could be motivating to divert organic material if they knew what was in their waste.
  - The County may consider mandatory methods such as a food scraps disposal ban to increase participation in diversion programs. The City of Seattle banned disposal of food and food-soiled paper by residential and commercial generators in 2015. Before implementing the residential food waste disposal ban, Seattle provided all single-family residents the opportunity to request a countertop organics container free-of-charge, and required all residents to subscribe to organics collection service.
  - Remove regulatory barriers for smaller, on-site processing facilities. For example, in Massachusetts, compost and anaerobic digestion facilities that handle 105 tons per week or less of material are exempt from most solid waste regulations.[43]

- **Contamination of organics streams** - Contamination makes it more difficult or costly to produce clean compost or other processed organics products for which there is market demand. Contributors to contamination include customer confusion that arises from lookalike products and variance in what materials are accepted across jurisdictional boundaries.
  - In general, managing contamination through education and outreach is more cost-effective than handling contamination in processing.[44]
- **Price sensitivity of potential customers for compost products** - Bark, biosolids, or other soil amendments are, in general, less expensive than recycled compost products. In addition to concerns about price, farmers have also noted lack of information, plastic contamination, and equipment and time associated with spreading compost as barriers to using compost.[47]
  - Continue to demonstrate added value for use of compost versus lower-cost products. Examples include the compost marketing toolkit produced by the Northeast Recycling Council, which includes a model marketing plan, a resource list, and on-farm compost case studies. Local compost demonstration projects include Seattle Tilth's Community Learning Gardens and King County's reclaimed water and biosolids demonstration garden at the South Treatment plant in Renton.
  - A 2012 recycling market report from Vancouver, B.C. noted that farmers were interested in side-by-side demonstration trials for compost vs. "normal" farm practices by known and trusted farms.[51] Agriculture tours for farms using municipal

compost have taken place in Ontario's Peel Region; consider implementing similar tours in King County. WSU grants have previously been used to fund on-farm compost trials in both King and Snohomish counties (described in more detail in the previous "End uses" section).
  - With tools such as the WSU Compost Use Decision-Making Tool, help farmers evaluate the costs and potential benefits of using compost at their sites.
- **Potentially limited processing capacity for future organics diversion** - Though organics processing capacity today is adequate for the material collected today, several regional processors are operating near or at their maximum permitted capacities. Food scraps and other compostable materials, however, remain a large portion of the disposed waste stream. Existing processors report that they have operating capacity beyond what is currently permitted, but it is not known if this additional capacity will be sufficient to accommodate more composting of urban organic feedstocks.
- **Expand and/or diversity markets** - Though end markets are not yet a barrier to food scraps diversion, the organics processing industry has identified a need for larger and diverse markets for finished compost and byproducts of anaerobic digestion. Market expansion activities could potentially include:
  - Requiring local, recycled compost product for municipal use, such as in highway construction. For example, Seattle has mandatory specifications for compost and bioretention soil (which includes compost in its mix) for all City-funded projects that require use of compost from permitted facilities that compost material generated and collected within the City of Seattle.[52] Seattle's Stormwater Code, which requires implementation of stormwater management best practices to the extent possible, also promotes the use of compost and bioretention soils in development projects. Ensure that King County's clearing and grading code requirements are being enforced. They require use of compost (if soil is not retained) on development sites where soils have been disturbed.
  - Collaborating with trade associations (e.g., nursery landscape associations, landscape professionals, and compost producers) to identify market strategies.
  - Continuing to work with organics processors and industry groups (e.g., Washington Organics Recycling Council, Compost Manufacturing Alliance (CMA), U.S. Composting Council (USCC)) when setting materials acceptance criteria for food scraps diversion programs, addressing compost quality issues, and implementing compost end market development.
  - Convening public and private players to collaboratively work through key issues, such as compost contamination (e.g., continued participation in the Organics Contamination Reduction Workgroup).
  - Improving upstream customer education to reduce compost contamination, which helps to improve finished product quality (which has access to better markets) and can reduce required processing labor and cost.

  - Continuing to explore opportunities for anaerobic digestion in the region, potentially with source-separated organics streams. Work with partner cities, generators, and organics collectors to identify potential feedstocks for small-scale AD at a County facility or in partnership with a private-sector processor.
- **Regulatory barriers** - While Cascadia did not identify existing studies of specific regulatory barriers to organics diversion in Washington (both California and Massachusetts have completed more state-specific evaluations), over half of survey respondents to a 2016 Department of Ecology-funded survey on organics management reported that Washington is "very far" or "far" from having economic and regulatory incentives aligned to support full organics recovery and beneficial use.[53] Some regulatory challenges highlighted in open-ended comments include the following:
  - Multiple survey respondents commented on a lack of coordination and consistency between different governmental agencies as a regulatory challenge. One survey respondent reported it is difficult to manage competing priorities of different agencies, citing a biosolids operation plan that was approved by the Department of Ecology but not by the clean air regulator.
  - Agencies that regulate air quality do not distinguish small-to-medium facilities from larger ones—the air permit requirement is the same regardless of size. A survey respondent noted the cost of compliance with air quality regulations as a barrier for smaller agricultural on-farm composting operations. Similarly, it has been reported to King County that air permitting has been a barrier to small, distributed processing facilities such as Impact BioEnergy's HORSE digester. The small, moveable digester requires the same permit as a large-scale facility, and the $5,000 permit cost is significant relative to the price and size of the digester itself, putting the digester in a classification that may mean it is over-regulated.[40]
  - Survey respondents noted the time and cost of compliance with existing regulations, which can increase operating costs for processing facilities. Though not explicitly noted as a barrier, one processor interviewed for this assessment noted anticipating that the permitting process for expanding composting capacity would take several years.

Key Players

Interviewees

- Susan Thoman, Compost Manufacturing Alliance
- John Fischer, Massachusetts Department of Environmental Protection
- Cassie Bartholomew, StopWaste (Alameda County, CA)
  Note: the interview with Cassie Bartholomew at StopWaste primarily centered on upstream food waste reduction activities such as the Smart Kitchen Initiative, the Northern California Recycling

Association's "State of Food Waste in Alameda County" report, and activities in schools in partnership with local health departments. Food waste reduction activities are outside the scope of the LinkUp program and not described in this mini-market assessment.

- Yolanda Pon, King County Health District
- Anna Alfred, Snohomish Health District
- Jason Lenz, Lenz Enterprises
- Stephan Banchero, Cedar Grove
- Ryan Begin, Divert Inc.

Other potential stakeholders

Value chain Position	Player
Upstream	LeanPath (software), Washington Organics Contamination Reduction Workgroup, and organizations working on food recovery.
Upstream	StopWaste (Alameda County, CA)
Collection	Haulers (Recology, Republic Services, Waste Management)
Collection	Large food waste generators, such as restaurants and food manufacturers.
Processing	Composters WA Organics Recycling Council Emerging on-site technologies: Impact BioEnergy, WisERG. Elsewhere: grind-to-energy, Zero Waste Energy and Hitachi (anaerobic digestion), dehydrators and pulpers.
Markets	Washington State University (research on use of compost or digester byproducts), local agricultural users such as farms, nursery landscape associations, landscape professionals and associations.

CLEAN WOOD

Clean wood refers to recyclable wood material that is free from coatings (e.g., paint and treatments) such as creosote or chromated copper arsenate (CCA) and is not mixed with other materials in such a way that it cannot be separated. Clean wood includes items such as dimensional lumber, wooden pallets, wooden crates, and engineered wood products, including particleboard and plywood.

Material supply

In 2015, residents, businesses, and construction and demolition (C&D)-sector generators in King County and Seattle disposed of an estimated 124,900 tons of clean wood, or approximately nine percent of the overall waste stream—both municipal solid waste (MSW) and C&D by weight. Of material generated by the C&D sector only, clean wood is approximately 25 percent of the waste stream.[xv] Of this material, nearly 80,000 tons (63 percent) was disposed by generators in King County. In King County and Seattle, disposal of clean wood from C&D projects is banned.

Collection

Overall, collection infrastructure for clean wood is adequate, especially for C&D generators of wood waste. Residential and commercial generators can take clean wood to King County transfer stations, and C&D generators can drop-off clean wood at designated/certified C&D processing sites or contract for pick-up.

There are three King County solid waste transfer stations that accept separated loads of C&D generated clean wood. Limited amounts of clean wood mixed with C&D waste are brought to the County-owned transfer stations in hand-unloaded vehicles (C&D in tip-bed vehicles or tip-bed trailers is not allowed). Several commercial recycling companies, such as United Recycling, Drywall Recovery Services, Rainier Wood Recyclers, and Recovery 1, and commercial junk removal companies also offer pick-up and/or drop-off locations for clean wood. Fees vary by location and volume of material.

Recovery 1 has reported seeing an increase in loads containing contaminated wood (e.g., treated wood or asbestos), but they did not know if this increase was due to increased contamination or a result of seeing more material overall. Facilities like Recovery 1 make use of lead and asbestos screening devices (handheld analyzers) and ask drivers about the origins of their loads to ensure materials are clean before accepting loads for drop-off.[54] Lautenbach

[xv] These figures are for clean wood disposed of as garbage. Much of the clean wood generated in King County and Seattle is currently used as hog fuel. While energy recovery from hog fuel is considered a form of diversion, future assessments of the clean wood market may want to consider the tonnage of wood waste used for hog fuel instead of other recycling or reuse end markets as part of the available supply.

Recycling also noted that they use contracts with customers that clearly describe what materials can and can't go in drop-boxes as another strategy for ensuring collection of material free of contaminants.[55]

Materials such as clean wood pallets and crates can be directly reused. Retail stores selling reclaimed building materials such as Second Use in Seattle and Tacoma offer opportunities to reuse clean wood. Several online exchange tools such as King County's Industrial Materials Exchange (IMEX) and the Materials Innovation Exchange can also help facilitate the exchange and reuse of commercial products, including building and wood waste—however, these exchanges are not widely used.

Processing

Processing capacity and infrastructure for clean wood is adequate in King County. In 2015, processors reported that they have excess capacity or room to expand C&D processing,[56] and no processor interviewed for this assessment reported receiving more clean wood than their facilities could manage. King County-designated C&D recycling facilities, which have agreements with the County to properly manage C&D materials, include:[56]

- DRS (formerly CDL Recycle) (Renton and Woodinville)
- United Recycling (Snohomish and Seattle)
- Maltby Recycling (Snohomish)
- Recovery 1, Inc. (Tacoma)
- Republic Services' Black River Transfer and Processing Facility (Renton)
- DTG Enterprises (Woodinville)

Reportedly, recyclable wood makes up approximately 50-60 percent of incoming feedstock to regional processing facilities. This portion changes in other regions; for example, it may be as low as 40 percent in other parts of the West Coast such as California, where wood is a less common building material.[55]

Almost all collected wood waste in the region is used for hog fuel, a mix of wood chips, fiber, and bark that can be burned for fuel. A 2013 research paper from Washington State University found that over 70 percent of diverted wood waste in the state of Washington was used for energy recovery.[57] For the two processors interviewed, all clean wood is currently processed through a grinder and sold to paper mills as hog fuel.[54,55]

A small quantity is going to compost or chipped for mulch.[58] Clean wood collected at King County transfer stations, such as untreated dimensional lumber, goes to Cedar Grove for composting. Several years ago, Recovery 1 was selling designer mulch made from dyed, recovered clean wood; however, the company stopped producing designer mulch two-three years ago. The company reported that, though the product was high-quality and had a favorable

response from customers, they stopped pursuing this line of business primarily due to operational challenges associated with getting dye (which is non-toxic, but has high turbidity) out of their stormwater treatment systems, believing the cost of addressing operational challenges outweighed benefits from selling designer mulch product.[54]

Pallets can be refurbished and resold (if not in a condition for direct re-use), and woodchips can be used to manufacture particle board.

End uses for processed material and existing markets

Market demand for wood in King County is stable but weak and highly dependent on hog fuel. Prices are low because supply is exceeding demand.

Paper mills have traditionally been the primary market for hog fuel. However, the market has shrunk due to mill closures across the region.[56] In 2015, one processor reported prices of approximately $25 per bone-dry ton of wood for hog fuel, and other processors reported that they had to pay to remove their wood supply.[56] Market conditions today remain competitive. For example, Recovery 1 reported seeing increased competition in hog fuel markets following the temporary closure of a paper mill in Port Angeles due to the need for suppliers to find alternatives.[54] City of Seattle staff have also reported news that clean wood in the region is being landfilled in the Bellingham area due to a lack of end markets.[59] Current wood market challenges are not limited to Northwest Washington—Vancouver, B.C. has also reported challenges,[59] and wood beetle disease has flooded clean wood markets in California, resulting in further oversupply.[55] The processors interviewed for this assessment noted that maintaining quality of clean wood for hog fuel has been critical to maintaining access to buyers—there is little to no tolerance for contaminants in their piles.[54,55]

Though clean wood can be used to produce mulch, processors noted a limited market size for the material and competition with bark, which is cheap and readily available in the Northwest.[54,55] Recovery 1 noted that though their designer mulch product was positively received by its users, the company did not continue to pursue the market due to associated operational challenges on the processing side.

In King County, some clean wood goes to compost markets instead of hog fuel, where composters can use wood chips as a bulking agent in their process.

King County is exploring market opportunities for reprocessing or expanding markets for salvaged lumber, a subset of clean wood. As part of this effort, King County is working with Ocino, Inc. to develop a salvaged lumber warehouse to consolidate, process, and market salvaged wood and other valuable C&D materials.[56] Ocino, Inc. specializes in remanufacturing salvaged wood into new building products such as molding, siding, flooring, ceiling tile, and furniture. Portland, Oregon markets for reclaimed wood are stronger, with higher demand for

non-structural, decorative accent pieces. New apartment construction, for example, are using salvaged wood for floors or ceiling accents.[60]

Other potential end uses for clean wood include as a feedstock in the manufacture of particleboard and other engineered wood products, or as animal bedding, though local or regional at-scale examples were not identified. No processors interviewed for this assessment reported currently pursuing alternative end uses for clean wood. Recovery 1 previously produced an experimental prototype of a mixed wood-plastic panel made from recycled clean wood and plastic film that could potentially replace oriented strand board—however, the company is not currently pursuing development of this product due to time, labor, and overall required investment.[54]

Another emerging opportunity for processing of clean wood waste could be remanufacture into cross-laminated timber, an engineered building material—though cited as a possibility, no company appears to be yet incorporating wood waste into its process.[61,62]

Barriers to diversion

The primary barrier to diversion of clean wood is the **limited market**—the generation of clean wood outpaces the market demand for end uses such as hog fuel and as a composting bulking agent, driving prices for clean wood down. Low wood prices make the economics of C&D recycling more challenging since wood is one of the most prevalent materials processors receive and recover at 55-60 percent of the incoming stream (not counting rejected loads that may contain lead or asbestos contamination).[54,55]

A processor in the 2015 King County *Market Assessment for Recyclable Materials* stated that, "everything hinges on wood markets and prices; a stable, long term home for wood is critical to our success." [56] Strategies processors noted to ensure access to challenging hog fuel markets were primarily to leverage long-standing relationships with the mills (note: well-established processors in the region were interviewed) and to maintain high quality of the recovered material with little to no contaminants.[54,55] Processors recognized the potential risk in dependence on a single market, but did not describe any plans to diversify at this time.

In discussing clean wood disposal bans, one processor discussed a need for mandates at both ends of the supply chain. Front-end requirements such as disposal bans impact end markets, and market requirement mandates (such as implementing recycled content requirements in purchasing) may be needed to balance competing economic impacts.[55]

Key Players

Interviewees

Phone or in-person interviews:

- Shawn Wood, City of Portland
- Troy Lautenbach, Lautenbach Industries
- Terry Gillis, Recovery 1

Processor survey by email:

- Matt Stern, Waste Management
- Terry Gillis, Recovery 1

Other potential stakeholders

This section provides an overview of organizations who are currently working to develop markets for clean wood, or if engaged, could potentially have a large impact on the markets. These organizations represent potential future partners for the LinkUp program.

Value chain Position	Player
Collection	Haulers of commercial and C&D material
Processing	Commercial and C&D recyclers
Processing/Markets	Composters (Cedar Grove, Lenz, PacifiClean)
Markets	Salvage warehouse and reclaim – Ocino, Inc.
Markets	Paper mills – such as WestRock (formerly Simpson Tacoma Kraft) (Tacoma), Port Townsend Paper Corporation
Markets	Engineered wood product manufacturers – such as Globe Machine Manufacturing (Tacoma), APA – The Engineered Wood Association (Tacoma) Cross-laminated timber manufacturing – D.R. Johnson Lumber Co. in Southern Oregon; Forterra has a current initiative to bring cross-laminated timer manufacturing to the area (http://forterra.org/subpage/clt)
Multiple	Construction and Demolition Recycling Association (CDRA)
Multiple	Other jurisdictions with similar market challenges: • City of Portland (OR) • Oregon Metro • Vancouver, B.C

GYPSUM

Gypsum products include gypsum wallboard (sometimes also referred to as sheetrock, drywall, or plasterboard) or other interior wall coverings made of a gypsum sheet sandwiched between paper layers. This material may be unpainted ("clean") or painted (typically from demolition projects). Gypsum wallboard was a LinkUp focus material in 2007. Both Seattle and King County ban the landfill disposal of new construction drywall scrap.

Material supply

In 2015, an estimated 14,200 tons of clean gypsum and 40,300 tons of painted gypsum generated in King County and Seattle were disposed. Together, these materials are nearly four percent by weight of all disposed waste—both municipal solid waste (MSW) and construction and demolition (C&D). In Seattle and King County, clean/new gypsum from C&D projects is banned from disposal.

Collection

Limited amounts of gypsum, mixed with C&D waste, are brought to the County owned transfer stations in hand-unloaded vehicles (C&D in tip-bed vehicles or tip-bed trailers is not allowed).

Drop-off locations operated by companies such as New West Gypsum (Kent), DRS (in Renton and Woodinville), Construction Waste Management (Mukilteo), and Resource Recovery Services, Inc. (in Woodinville) are available throughout the County. A range of other companies offer pick-up service (typically through temporary roll-off container services, collecting mixed C&D materials), such as K.T. Recycling and Hungry Buzzard for most of King County. Both the drop-off and pick-up services typically handle mixed C&D. Fees vary by location and volume of material.

Processing

Drywall is accepted for processing by the King County designated and Seattle-certified mixed C&D recyclers such as DRS, United Recycling, and Recovery 1. Processing capacity for clean gypsum in King County appears to be adequate; processors such as New West Gypsum report that they can process more material than they are currently receiving. The recycling process for gypsum varies by facility but always entails separating the gypsum from the paper, each having separate end markets. There are fewer processors in King County who process demolition gypsum.

New West Gypsum in Kent does not accept painted/demolition gypsum for processing due to concerns expressed by buyers of processed material about potential for contamination by paint, wallpaper, and potentially asbestos.[63] New West's facility in Vancouver, B.C. does accept demolition waste for processing because there is a disposal ban in place on all gypsum (clean or

painted). However, the facility in Kent currently has capacity to process more material than it is currently receiving, and New West Gypsum has told King County LinkUp that it wants to bring in more post-consumer material because its clients want material to be locally sourced.[64] In 2015, New West Gypsum's facility in King County was operating at 25 percent of its capacity,[65] and in 2017, reported that the facility overall can still process more material than it is receiving. New West Gypsum reported that it is not currently considering accepting demolition material.[63]

Processing of painted gypsum requires additional steps to confirm—either through random testing of loads or by requiring that those delivering loads provide adequate accompanying documentation—that it does not contain lead-based paint or other contaminants. Asbestos from building materials, such as joint compound, textures and paint, is also a concern in painted gypsum recycling. At New West's Vancouver facility, there are additional protocols in place to screen processed material. All pre-1990 material is screened and tested, and all job sites in Vancouver are supposed to be remediated if there is advanced knowledge of asbestos on site.[63]

The processors interviewed for this assessment—Recovery 1 and New West Gypsum—do not accept painted/demolition gypsum wallboard. Drywall Recycling Services (DRS/CDL Recycle) does accept that material for recovery and stated that was in part due to their position as one of the largest privately owned gypsum processors in Washington.[66]

End uses for processed material and existing markets

The gypsum recovered from gypsum wallboard can be used in a variety of applications: as an ingredient in cement production, mixed with cement clinker to regulate setting of cement, for soil remediation, and for agricultural purposes. For New West Gypsum, gypsum wallboard manufacturing is still a major user of recycled gypsum.[67] Drywall Recycling Services reported that their markets for processed gypsum are primarily agricultural markets in Eastern Washington and, in contrast to reports from New West Gypsum, said there are currently few local markets for remanufacture of recovered gypsum.[66]

The 2012-2013 mini market assessment noted that gypsum wallboard manufacturing was a high-demand but lower-value end market for recovered gypsum and reported that gypsum wallboard manufacturers, such as Certainteed in Seattle and Georgia Pacific in Tacoma are using recovered gypsum as part of their feedstock. Representatives from their respective product sales departments were not able to provide more detail about the sources of recovered gypsum used for manufacturing. Product sheets from Certainteed show that it incorporates recycled gypsum into its product lines—the Easi-Lite and Type X drywall products contain 34-38 percent recycled content. Recycled content is about half waste material diverted from Certainteed's manufacturing process, while the other half is post-consumer material from construction projects. Reject drywall from manufacturing in Seattle is sent to New West Gypsum for recycling.[68]

Demand for recovered gypsum product remains strong. In the 2015 Recyclable Materials Market Assessment, several regional processors reported that their markets "can't get enough [gypsum]" and that they can "move every ton [they] get [their] hands on." New West Gypsum noted that this assessment of market demand remains true in 2017.[63]

Barriers to diversion

In general, barriers to diversion of gypsum appear to be primarily related to **collection**. Processing capacity and capability exists for this material and markets are generally strong, especially for clean gypsum; no processors interviewed reported weak end markets or inadequately diversified markets as a barrier to diversion. Barriers to diversion include:

- Collection for mixed C&D material is widely available, but processors would still like to capture more material. The **weight and bulk of gypsum material** can make hauling costly and sorting the material challenging.
    - In the 2012-2013 mini-market assessment, New West Gypsum reported that generators and haulers are unwilling to drive to a recycling facility rather than a transfer station.
    - Drywall generators and haulers may not want to invest the time required to make sure their loads meet the requirements of recycling facilities: highly recoverable mixed loads or only drywall.
- **More limited processing capacity and end markets for painted/demolition gypsum**. Some processors reported accepting only clean gypsum for processing. New West Gypsum noted both that buyers of processed gypsum material are "leery" of demolition gypsum due to potential contaminants and that additional investment in testing equipment and on-site procedures would be needed to do so.[63]
    - The estimated quantity of painted/demolition gypsum disposed to landfill in 2015 from King County and Seattle was nearly three times that of clean gypsum. There remains opportunity for diversion of this material by identifying end markets willing to tolerate recovered painted gypsum or working with processors to increase regional capacity to accept and process this material.

Key Players

Interviewees

Phone or in-person interviews:

- John Pahulje, New West Gypsum Recycling, Inc.
- Terry Gillis, Recovery 1
- Troy Lautenbach, Lautenbach Industries
- Shawnda Anderson, Drywall Recycling Services (DRS/CDL Recycle) (phone query only, not a formal interview)

** Note: Troy Lautenbach was interviewed about gypsum markets, but all of his product is sent to New West Gypsum for processing, so his comments were not incorporated into this assessment.*

Other potential stakeholders

This section provides an overview of organizations who are currently working to develop markets for gypsum wallboard, or if engaged, could potentially have a large impact on the markets. These organizations represent potential future partners for the LinkUp program.

Value chain Position	Player
Collection	Companies offering C&D roll-off container pick-up services
Collection	Companies offering C&D roll-off container pick-up services
Processing	Processors: New West Gypsum, Recovery 1, DRS/CDL Recycle, Resource Recovery Services
Markets	Mushroom farms
Markets	Potential buyers for soil amendment (Eastern WA agriculture)
Markets	Manufacturers of wallboard – CertainTeed (Seattle), Georgia Pacific (Tacoma), United States Gypsum (Oregon)

ELECTRONICS

Material supply

In 2015, residents, businesses, and construction and demolition (C&D)-sector generators in King County and Seattle disposed an estimated 7,500 tons of electronics, or approximately five-tenths of one percent of the overall waste stream by weight. While a relatively small portion of the waste stream today, a study by the U.S. Environmental Protection Agency in 2013 found that electronics are the fastest growing waste stream in the country,[69] and electronics (excluding home appliances) are banned from the landfill in King County and Seattle. Cell phones, computers, computer monitors, and televisions have been banned from garbage and at solid waste disposal facilities in King County since 2005.

Collection

Residents and businesses in King County have access to electronics recycling, primarily through drop-off programs. Both collectors and processors reported they have capacity to and would like to collect more material overall.[70,71] Reported challenges to collection include convenient access to recycling and the perception that recycling should be free (materials not covered by the product stewardship program typically are recycled for a fee). While E-Cycle Washington publishes annual reports on the amount of covered electronics it collects by type and county, the project team did not find data on public awareness of electronics recycling programs or recycling rates for non-covered products.

Computers, laptops, monitors, tablets, televisions, portable DVD players, and e-readers are covered under a statewide product stewardship program, E-Cycle Washington. This program requires that manufacturers and retailers take responsibility for collection, recycling, and public education on recycling opportunities for covered products. This program established free drop-off locations for covered electronics throughout Washington for residents and small businesses (under 50 employees). Materials covered by the E-Cycle program represent approximately 10 percent of disposed electronics in King County and Seattle. Other disposed electronics in the waste stream include cell phones, printers, computer peripherals (e.g., keyboards and mice), audio/visual equipment, and corded small appliances. Many E-Cycle recycling drop-off locations also accept other electronics not covered by the product stewardship program, though potentially for a fee.

The table below provides examples of specific materials that are covered and not covered by the E-Cycle program (bolded items are also banned from disposal in King County).

Covered	Not covered
• **Televisions** • **Computers** • **Computer monitors** • Laptops • Tablets • E-readers • Portable DVD players	• **Cell phones** • Peripherals (e.g., keyboards, mice) • Fax and copy machines • DVD players • Gaming devices • Printers

Residential curbside collection of electronics for recycling is available in a few jurisdictions if scheduled in advance, typically for an additional fee. For example, this service is available in the cities of Seattle, Bothell, Issaquah, Kirkland, and Redmond. There may be restrictions on the size or number of items accepted for collection. Service availability and fee structures vary by jurisdiction; the project team did not identify a summary of residential curbside electronics recycling opportunities for King County cities, however this would be useful for analysis and planning purposes.

Commercial generators with 50 employees or more are not eligible for free drop-off of electronic waste through E-Cycle. Commercial generators must pay a fee to recycle their electronics. Some, but not all, registered E-Cycle collectors will accept commercial material.

Electronics that are still functional have high potential for reuse, most commonly through resale at thrift stores, such as Goodwill and Salvation Army, electronics retailers, or online. Goodwill donation centers accept items from both residential and commercial generators.

Aaron Blum from ERI noted the primary barriers to collection are the price of collection and convenience to customers. He noted that "real recycling costs money, but the battle is always having people understand they have to pay for it."[72] Access to and knowledge about collection options was also a challenge noted by a survey respondent in E-Cycle's 2016 Local Government and Community Satisfaction Report Summary. This respondent noted that, "…we are all coming to understand that there are accessibility issues, race, and social justice issues that are unlikely to be adequately addressed through legislated collection convenience standards… it is now better understood that other approaches and locations may be needed to provide opportunities to properly recycle electronics to all citizens and small businesses."[73] Friendly Earth reported that the company could overall accept and collect more material but did not identify any particular barriers to collection. Friendly Earth also noted growing awareness by customers about e-

Stewards and other third-party certifications for recyclers and felt that being an e-Steward certified recycler helps drive material to the company over its competitors.[71]

Processing

In general, processing capacity for electronics appears to be adequate; processors report that they can process more material than they are currently receiving. While consumer product trends have affected the types of items recyclers are receiving and processing, recyclers have been able to accommodate the changes.

As of April 2017, there are seven registered e-waste processors under the E-Cycle Washington program: Ace Metal Company, ECS Refining, Electronic Recyclers International (ERI), E-Waste LLC, EWC Group, Simon Metals, and Total Reclaim.

Processing of electronics for recycling begins with disassembly into component parts (e.g., circuit boards, batteries, and casing and core materials (e.g., plastic, metals, glass). Disassembled items that cannot be directly reused or recycled are shredded and then further separated into their core materials. Electronics processors reported selling commodity materials to both domestic and international end markets. Some processing facilities may also repair devices for resale (where feasible) or recover functional component parts to put into other devices or sell separately.

ERI, an electronics recycler with seven locations nationwide, reported that their facilities are operating at 40-50 percent of capacity and could all accept and process more material. ERI estimated that its location in Sumner, WA is at 55 percent capacity.[72] Friendly Earth, a collector and processor in Seattle, also reported interest in receiving more computers and IT assets (e.g., data center material). Friendly Earth expanded its warehouse approximately four years ago, and has additional capacity to accept and collect more material.[71]

End uses for processed material and existing markets

Overall, the processors interviewed for this assessment—ERI and Friendly Earth—indicated that end markets for processed material are adequate.[xvi] End markets for metals and mercury are primarily domestic, while end markets for commodities such as circuit boards and plastics are primarily overseas. There is a significant lack of domestic markets for plastics recovered from electronics. Markets for cathode ray tube (CRT) glass and mercury-containing devices remain

[xvi] There are many electronics recyclers in King County; the two interviewed processors represent only a subset of electronics recycling activity in the region. Their responses may not represent the views of the local electronics recycling industry as a whole.

challenging, but the cost of processing and marketing this material is covered by the value gained from other commodities in electronic products.[72]

Resale and reuse remains a large market for computers and peripherals—in 2014, approximately 29 percent of recycled computers were refurbished or directly resold in Washington.[74] ERI reports that refurbishing and reselling is their priority, where it is possible, for materials that arrive at their facility.[72]

Markets for commodities from processed electronics, as reported by the processors interviewed for this assessment and as documented in the 2016 E-Cycle Washington Standard Plan Annual Report for other regional processors,[xvii] are as follows:

- There is a strong domestic market for battery recycling, and ERI reported that approximately 99 percent of batteries from electronics are recycled domestically.[72]
- Plastics are primarily sold overseas; ERI estimated that 95 percent of plastics are sold to Southeast Asia.[72] Other reported end markets for plastics in the 2016 E-Cycle Washington Standard Plan Annual Report include domestic plastics brokers, China, and in one case, Canada.[75]
- Steel, copper, and other metals are consolidated at local scrapyards.
- Circuit boards are sold to refineries that can extract the metals (gold, silver, palladium) present. Circuit boards are split into two grades (low and high), based on the quantity of metal present. A CRT television is an example of a product with a low-grade board; a server or some desktop computers would have high-grade boards.
    - There are no U.S. refineries that can accept low-grade circuit boards. Low-grade boards are sent to facilities in South Korea and Belgium. Other reported end markets for circuit boards are smelters in Canada and Japan.[75]

An electronics collector also noted the most challenging materials for the company are CDs, DVDs, and VHS tapes (items related to but not categorized as electronic waste). The collector has not been able to find recycling options for these materials.[71] Flat panel display (FPD) televisions reportedly are also very difficult to recycle. The component parts have limited to no value and fluorescent tubes in liquid crystal display (LCD) panels, which must be treated as hazardous waste, are labor-intensive to remove and handle.[76]

[xvii] As part of the annual reporting requirements for registered processors in E-Cycle Washington, processors report the weight of all covered products processed and a description of the processes and methods used to recycle covered products, including the facility location. Electronics recycling processes are reported by material of concern, process (e.g., dismantling, shredding, magnetic separation), "fate of recycling process," and end-of-life processing destination. The 2016 report can be found here: http://www.ecy.wa.gov/programs/swfa/eproductrecycle/docs/2016WMMFAAnnualReport.pdf

Barriers to diversion

Barriers to electronics diversion include:

- **Processors interviewed for this assessment reported low participation in electronics recycling programs** for products that generators must pay a fee to recycle (products not covered by E-Cycle Washington). Processors report additional capacity to process electronics—one reported a desire to collect more computers and other IT assets in particular. Potential barriers to consumer participation in electronics recycling include cost avoidance (for example, some consumers do not want to pay to recycle select goods, believing recycling should be free) and limited awareness of or access to drop-off sites.
    - Outreach strategies and the extent to which there is outreach about electronics recycling programs varies from jurisdiction to jurisdiction.[73]
    - In Seattle, a survey respondent in E-Cycle's *2016 Local Government and Community Satisfaction Report* noted potential accessibility issues regarding education about E-Cycle collection.[73]
    - Opportunities to address participation challenges may include:
        - Conducting consumer research on awareness of electronics recycling programs by residents and businesses in King County for items that are collected for a fee. The project team did not identify examples of existing research.
        - Working to expand E-Cycle to cover additional product types; this would help overcome the resistance of residents and businesses to paying for recycling items that are not covered. Programs in Oregon and British Columbia accept a wider range of products for recycling than E-Cycle Washington.[xviii] Continue monitoring these programs for potential successes and lessons learned for hard-to-recycle materials and alternative fee structures.[77]
- **Producer trends that impact processing** including light-weighting of material and reduced product sizes. Recyclers note fewer old and heavy TVs and computers, collecting instead flat-screens, laptops, and tablets. As products get smaller, processors have to disassemble more material to get the equivalent quantities of separated component parts for recycling. In addition, new product development may be ahead of available

[xviii] Oregon E-Cycles accepts printers and peripherals, unlike E-Cycle Washington. British Columbia's electronics recycling program, administered by the Electronics Products Recycling Association, includes free recycling for commercial generators. British Columbia's program also accepts free-of-charge several electronics products not currently covered by E-Cycle Washington or Oregon E-Cycles, such as gaming devices, cell phones, and medical monitoring devices (e.g., electronic blood pressure devices and microscopes).

processing infrastructure; new product development such as internet-enabled devices, drones, and gaming equipment may pose challenges to existing recyclers.

- Shrinking product sizes also increases the complexity in recovering precious metals and rare earth materials that are used in computer chips and other electronic circuitry, driving up processing costs.
- ERI reports that new devices such as iPads and tablets often require manual disassembly because these products contain lithium batteries, increasing labor costs associated with processing these materials. Lithium battery products cannot be shredded due to risk of explosions and fire. However, these products often have higher quantities of commodity material in them and may have higher potential for refurbish and resale, which have helped balance out added processing costs.[72]
- **Rapidly changing commodity markets and reliance on overseas market for some commodities (such as plastics)** - The market for components such as CRT glass can be unstable; in 2011, the Oregon Department of Environmental Quality (DEQ) recommended that regional staff monitor available electronics recycling markets and adjust policies as needed.[78] The DEQ report recommended considering the ability to separate shredded plastics by type and grade and to handle plastics coated with brominated flame retardants to enhance and improve recyclability of plastics from electronics.
- ERI noted that the CRT glass market is dwindling today, but they anticipate continuing to see CRTs in the recycling stream for at least another 10 years. The company expressed concern about hazardous waste landfill disposal becoming the last remaining option for this material;[72] disposal of CRT glass is on the rise in California.[79]

- **Consumer trends that drive replacement of electronics before end-of-product life** - This increases overall generation of material for disposal or recycling; consumers may not know where to bring items for recycling or be aware of their resale options.
  - ERI reported that the average life of a cell phone today is nine months. For ERI, the shortened product cycle has opened more opportunities for refurbishment and resale of collected material;[72] however, there appears to be opportunity for broader waste prevention and reuse education for electronic products.

Other considerations

There are also concerns about product tracing and accountability of recycling of electronics. e-Stewards and R2 are two independent, third-party electronics recycling certifying bodies that ensure that certified recyclers comply with health and safety regulations, hazardous waste disposal requirements, and record-keeping requirements for electronics. King County government requires its electronics to be recycled by e-Steward certified recyclers. In 2016, Basal Action Networks' e-Trash Transparency Project revealed that several electronics recyclers—including Total Reclaim, who at the time was e-Steward certified—were exporting flat-screen televisions and monitors to undocumented recycling facilities in Hong Kong. Total Reclaim received a $440,000 fine by the Department of Ecology for the alleged mishandling of material; the company has appealed the penalty, but the hearing has been postponed with no future date set as of September 2017.

Key Players

Interviewees

Phone or in-person interviews:

- Aaron Blum, ERI
- Brian Marchlewicz, Friendly Earth
- Sego Jackson, Seattle Public Utilities

** The project team also attempted to reach Walter Alcorn of the Consumer Technology Association, Mark Dabek at REPC, and Ace Metals, but was not able to successfully connect.*

Other potential stakeholders

This section provides an overview of organizations who are currently working to develop markets for electronics, or if engaged, could potentially have a large impact on the markets. These organizations represent potential future partners for the LinkUp program.

Value chain Position	Player
Collection	ERI, Total Reclaim, Friendly Earth, and other registered collectors/processors.
Collection	Goodwill, Salvation Army, and other resale shops that receive electronics.
Collection	Electronics retailers (who often operate take-back programs for both E-Cycle Washington covered and non-covered electronics).
Processing	ERI, Total Reclaim, Ace Metals, and other registered and/or certified collectors/processors.
Markets	Secondary plastics processors (e.g., Titus, QRS); if expanding plastics processing capacity in the Northwest, ensure there is consideration of plastics from electronics as well.
Markets	Electronics refurbishers/resellers
Multiple	E-Cycle Other electronics product stewardship programs (such as those in California, Oregon, and British Columbia)
Multiple	Connect with large product manufacturers (e.g., Apple, Amazon) to discuss design for recyclability concerns.
Multiple	Basal Action Network – accountability and tracing of electronics recycling e-Stewards – third-party certification

Appendix A: Definitions of Key Terms

- **Recycling**: describes the re-processing of material into a useful new material, such as the conversion of recovered paper and board to new paper. Composting is considered a form of recycling as well. Energy recovery from burning materials is not considered recycling in this assessment.
- **Recovery**: describes the collection of material for recycling, such as through single-stream curbside collection programs. However, not all recovered material is recycled.
- **Diversion:** describes prevention of material from being disposed of to landfill. Recycling and composting are forms of diversion. Diversion also includes energy recovery end uses, such as burning wood waste as hog fuel.
- **Capture rate**: how much of a material is recycled or composted out of the total generation of the material, typically expressed as a percentage. For example, to calculate the capture rate of food scraps, we would calculate it as follows: (tons composted / (tons composted + tons recycled + tons disposed). In this example, food scraps in the recycling bin do not count towards the capture rate because food scraps are a contaminant to the commingled recycling stream and would be disposed.
- **Municipal solid waste (MSW)**: refers to everyday materials generated and disposed of by residents and businesses.
- **Construction and demolition (C&D)**: refers to materials generated by construction, renovation, and demolition projects.
- **Commercially collected material**: material collected through a contracted hauling service such as Waste Management, Republic Services, or Recology.
- **Self-hauled material**: material that is taken directly to a transfer station or disposal facility by resident or business that generated the material, or by businesses that specialize in junk removal from residential properties.

Appendix B: Supplementary Data

HISTORICAL WASTE DISPOSAL TRENDS

The table below shows the split of waste between the MSW and C&D streams for past materials previously targeted by the LinkUp program. In general, the MSW stream (residential, commercial, and self-haul) is the larger contributor to the overall disposal of these materials.

Table 2: Disposal trends of past LinkUp focus materials, split by MSW and C&D streams

	2007		2015	
Material Type	MSW	C&D	MSW	C&D
Asphalt Shingles	4,250	3,918	6,268	4,951
Carpet	32,507	2,442	14,911	1,458
Dimensional Lumber	54,469	11,221	48,210	9,516
Expanded Polystyrene Products	8,749	785	475	327
Furniture/Mattresses	27,622	654	18,690	769
Gypsum Wallboard	5,594	19,397	15,957	6,623
Textiles	29,887	589	24,940	491

KING COUNTY LINKUP MARKET ASSESSMENTS

In 2012, Cascadia conducted "mini" market assessments for the following seven materials:

- Disposable diapers
- Food waste and compostable paper
- Furniture
- Gypsum
- Polycoated paper containers and packaging
- Plastic Film
- Textiles

These materials were chosen for evaluation primarily because they were moderate to large components of the MSW stream. Other factors considered in selection of these materials was the availability of local collection infrastructure and processing and/or end markets. Cascadia also completed a more comprehensive recycling market assessment in 2015, which included chapters on the following broader material categories: commingled curbside recyclables, organics, and C&D materials.

The table below summarizes findings from both market assessments, including end uses for the material, and barriers to diverting materials from disposal. Related questions are noted in the far right column, noting information gaps and recommended follow-up items for 2016.

Table 3: Summary of 2012 mini-market assessments

Material	Annual Disposed Tons (2011)[xix]	Key Findings	End Uses	Barriers to diversion	Potential 2016 follow-up items
Food waste and compostable paper	178,113 tons	▪ 2011 food waste capture rate (excluding compostable paper) approximately 13%. ▪ Both the 2012 and 2015 assessment deem composting capacity adequate for regional demand. ▪ Anaerobic digestion is an emerging processing option, but barriers such as limited ability to accommodate paper and packaging and higher per-ton processing costs remain. ▪ Feedstock supply expected to increase with 2015 food waste/compostable paper disposal ban in Seattle. Contaminants are also expected to increase with the introduction of more food scraps. ▪ Regional processors will need to invest heavily in equipment and systems to effectively manage	▪ Compost and soil amendments	▪ Meeting emerging compost quality standards ▪ Contamination, particularly due to bioplastics. ▪ Odor complaints may make permitting new or expanded processing challenging.	▪ What is the status of technology for reliable sorting and separation of bioplastics in the recycling stream? ▪ What is the status of AD projects in the region? Have the barriers been lessened since 2012? ▪ Is local/regional processing infrastructure for compostable plastics adequate considering the anticipated increase in its use? ▪ What are primary contamination sources and rates, and how can they be mitigated for processors? ▪ Is regional market demand for soil amendment/compost products adequate for the increasing feedstock supply?

[xix] Material tonnages shown are for the MSW stream in King County only unless otherwise noted.

		changing feedstocks; some report that market prices and sales of compost are not sufficient to cover increased processing costs.			
Polycoated paper and containers	41,972 tons	▪ Mill that purchase polycoated/aspetic material want it separated from other papers, but the MRFs that serve King County do not have the ability to separate it out. ▪ In King County, polycoated material is included in mixed waste paper bales; it is possible that polycoated materials are discarded/disposed from these bales on processing, and they may even be rejected. ▪ The Carton Council, which includes the four largest carton manufacturers, are working to advance carton recycling in North America. — Cite increased need for stakeholder coordination and engagement	▪ Fiber is used to produce tissue and toweling ▪ Whole cartons can be used to make wallboard, sheathing, ceiling tiles, and roofing sheet.	▪ Local MRFs lack the ability to sort and separate polycoated cartons. ▪ Existing polycoated carton specification from mills that purchase this material does not address other polycoated materials, such as drink cups. ▪ No regional end-market user	▪ Has sorting/separation technology improved? ▪ Has the polycoated carbon specification been expanded to address other materials? ▪ Are there new or emerging regional end-markets? ▪ The Carton Council has published its outthrow study. Are there other key findings/new research to note?
Gypsum	32,904 tons in MSW and C&D stream	▪ Accepted by private recyclers at five locations in King County, four of which also process the material. ▪ Locally recovered gypsum typically used as part of feedstock by local gypsum wallboard manufacturers.	▪ Recycled into the same product, gypsum wallboard ▪ Soil additives ▪ Paper from gypsum wallboard is recyclable	▪ Generators and haulers unwilling to drive to recycling facility instead of a transfer station or ensure that loads would meet the requirements of a recycling facility.	▪ Has the demand for gypsum changed since 2012? ▪ What have been the outcomes of past Linkup projects on gypsum recycling?

		▪ Local markets are generally strong; material has high demand despite a lower-value end market. ▪ The 2015 assessment noted that New West Gypsum relocated a facility from Pierce to King County; it is operating at 25% capacity. ▪ Markets remain strong, and prices are stable.	▪ New potential markets include mushroom substrate and cement.	▪ For development of new or expanded infrastructure, challenges include operational considerations and space requirements, as material cannot get wet and dust control is required.	
Diapers	28,200 tons	▪ Rapidly growing portion of disposed waste; quantities have grown tenfold in the last 40 years. ▪ Limited recyclability – players include Knowaste (UK) and TerraCycle (New Jersey). — Terracycle has successfully tested diaper recycling, but has not launched a program due to lack of collection infrastructure and sponsors. ▪ Composting of diapers has limited viability due to challenges in separating plastic films and concerns about pathogens. ▪ Toronto and other parts of Ontario compost diapers. Toronto also accepts diapers for anaerobic digestion.	▪ Fibers can be recycled into cardboard products, animal bedding, compost additives ▪ The fibers can also be composted (see Ontario as an example), but the plastics are discarded after the process. ▪ Plastics can be recycled into containers, fiber sheets, construction materials, etc.	▪ No regional processing capacity ▪ No facility in the U.S. ▪ Both start-up costs and O&M costs are high; feasibility studies for other West Coast cities show it to be economically infeasible.	▪ Has the status of Terracycle's program implementation since changed? ▪ Are the estimated costs of start-up and O&M still the same as 2012, or has technology improved or costs gone down? ▪ Do Toronto and other parts of Ontario still accept diapers in composting programs? If so, how have they overcome known challenges? If not, why did they stop accepting the material?

Textiles	26,702 tons	▪ Mostly clothing, rags, curtains, and other fabrics. ▪ King County has an extensive collection network. ▪ Bellevue and Issaquah have contracted for textile collection in curbside programs. ▪ Prices are strong - $0.18-$0.19 per pound[xx] ▪ Exports to Canada, Africa, India, South America, and Pakistan are strong. ▪ Existing stakeholder groups are the Council for Textile Recycling and the Secondary Materials and Recycled Textiles (SMART) A follow-up research effort was conducted in September 2016. Some key findings include: [xxi] ▪ Since the 2012 assessment was completed, the number of countries with bans or increased regulations around textile imports have increased.	▪ Resale/reuse ▪ Processing into wiping rags ▪ Into fiber for denim insulation, recycled content clothing, carpet padding, mattresses, and soundproofing material.	▪ Consumers may not know what is appropriate for donation; misconception is likely that clothing that cannot be worn should be disposed. ▪ Not in the interest of collectors to advertise that they take clothing that is not reusable, which are lower-quality and can contaminate other loads.	▪ Any reported outcomes from Threadcycle/other local efforts to promote donation of clothes not only for reuse, but also recycling? ▪ Have any policies/incentives been implemented to encourage collectors to take clothing that is not reusable? ▪ What is the status of new/emerging textile recycling processes, such as that developed by local company Evrnu? ▪ Have any major market players (e.g. processors, end markets) in the PNW entered/exited the market in the past few years? What effect, if any has this had on local market conditions? ▪ Is the incoming volume of used clothing into the PNW thrift store market too much to handle? Is the quality of material visibly falling as low

[xx] Cascadia completed a memo summarizing research on the global textiles market in September of 2016. This memo reported 2014 clothing prices between $0.15 and $0.18 per pound. The memo also cited July 2016 data from the International Trade Administration's Office of Textiles and Apparel that suggested varying textile prices by export region of $0.13 to $0.49 per pound.

[xxi] These findings are from a September 2016 research memo for the LinkUp program on global textiles markets.

		▪ Use of polyester material is on the rise; however, polyester textiles are typically low in value and do not have viable closed loop recycling options at this time. ▪ There is little-to-no reliable domestic or Pacific Northwest-specific data about how textiles collected flow to end markets, which limits our understanding of market conditions and barriers to diversion.			quality "fast fashion" pieces become more and more prevalent and overwhelm the used clothing stream?
Plastic Film[xxii]	25,563 tons	▪ In general, there are no recycling options for non-industrial plastic film. Disposed plastic film in King County is mostly non-industrial plastic. For plastic film that is recyclable:	▪ Re-manufacture into plastic bags and other film ▪ Mixed with wood for composite products (e.g., Trex decking).	▪ No market or end use for non-industrial plastic packaging. ▪ For recyclable material, barriers are related to collection and processing, not end	▪ Any reported outcomes from the King County take-back campaign? ▪ Are there any emerging markets/end-uses for non-industrial plastic packaging?

[xxii] The King County waste characterization studies in 2011 and 2015 divide plastic film into five material types, defined below. Of these, only recyclable plastic bags and industrial packaging film plastic are considered recoverable or potentially recoverable in King County.

- *Recyclable plastic bags*—plastic shopping bags. Examples include dry cleaning bags and newspaper bags. Does not include produce bags.
- *Industrial packaging film plastic*—film plastic used for large-scale packaging or transport packaging, such as shrink-wrap, mattress bags, furniture wrap, and film bubble wrap.
- *Non-industrial packaging film plastic*— all film used as food packaging or in another non-industrial capacity, such as produce bags, zip-lock bags, frozen vegetable bags, bread bags, and candy bar wrappers.
- *Plastic garbage bags*—plastic bags sold for use as trash bags, for both residential and commercial use. This type includes garbage, kitchen, compactor, can-liner, yard, lawn, leaf, and recycling bags. This type does not include other plastic bags, like shopping bags, that might have been used to contain trash.
- *Plastic film products*—Items made of film plastic not intended for a single use, such as shower curtains, kid's pools, and utility tarps.

		▪ Most curbside programs do not accept plastic shopping bags, but some do. ▪ "Bag your bags, bring 'em back" campaign in King County promotes take-back at stores. ▪ Limited domestic markets, almost all bales are exported. ▪ About half of recycled film is sold to international markets. The overseas market was impacted by Operation Green Fence but was reported as recovering in 2015.	▪ Pyrolysis is an emerging option for plastics-to-oil (Agilyx is one company working on commercializing this). ▪ There is an emerging market in the southeast U.S.; one company is recycling plastic film into car parts.	markets. Loose plastic film is problematic for MRF equipment	▪ Have the markets for plastic film changed since 2012? ▪ What is the status of the pyrolysis/plastics-to-oil technology noted in 2012? ▪ What is the status of the plastic film-to-car parts process noted in the 2015 market assessment? ▪ Plastics Recovery Facilities (PRFs) have grown in popularity since the assessment was completed. To what extent can PRFs handle plastic film?
Furniture	9,709 tons	▪ Many existing outlets for furniture reuse, mostly resale. ▪ Recycling of unsold items mostly depending on ability of collectors to dismantle furniture to component parts. — Ease of dismantling can depend on construction of furniture and mix of materials used. ▪ The local reuse market is stronger than recycling for furniture.	Varies, but: ▪ Padding/textiles used for carpet and automotive industries ▪ Untreated wood – wood chips and mulch	▪ Damaged goods have limited to no consumer appeal. ▪ Consumers may not know about reuse options. ▪ Use of cheap materials and poor production contributes to high turnover of furniture. ▪ Recycling is not an option for most furniture wood as it is treated.	▪ What regional/national design-for-recyclability groups are working on furniture and other similar goods?

Washington Commingled Recycling Workgroup Report (2016)

Challenges identified by materials processors included the following:

- Entanglement of **plastic bags and film** in sorting equipment. Processors recommended excluding them from commingled curbside bins and promoting take-back to participating retailers instead.
  - The report notes that regional MRFs spend $700-$1,000 per ton to remove film and that 20-30 percent of recycling center labor is spent addressing operational challenges from plastic film.
- Difficulty distinguishing **compostable and degradable plastics** from recyclable types of plastics, resulting in potentially contaminated bales.
- Contamination of other commingled materials, particularly paper products, and potential damage to MRF equipment from **broken glass**.
- Ongoing presence of **food-contaminated paper** in commingled recycling.
- Processing challenges associated with **polycoated paper**, which is difficult to sort and cannot be processed by all paper mills.

Opportunities identified included:

- **Reducing public confusion** about what can be recycled due to variances in programs across the region. Actions include developing coordinated education programs and standard RFP language.
- **Promoting design of packaging and products with recyclability in mind.** Actions include cross-stakeholder group dialogue, participation in national packaging design efforts, and exploration of funding opportunities for alternative recycling systems for materials that are not compatible with existing MRFs.
- **Promoting standardization of packaging labels and messaging.**
- **Exploring the potential for a Regional Plastics Recycling Facility (PRF)** in the Northwest to address the increasingly complex mix of plastic resins and containers in the stream.

Other relevant findings from the report include: upstream energy savings from recycling instead of manufacturing new material (Table 4), and data on MRF revenue and incoming tons by material type (Table 5).

Table 4: Energy savings of recycling over manufacturing with virgin material, by material type

Material	Energy savings per recycled ton (million BTUs/ton)	Energy savings relative to total manufacturing from virgin material
Cardboard	15.1	55%
Glass	2.1	28%
Aluminum	153	76%
Steel	20	55%
Mixed Metals	66.6	75%
Mixed Paper	21	62%
Newspaper	16	41%
PET plastic	32.1	62%
HDPE	50.4	75%

Table 5: MRF incoming material composition and revenue, by material type

Material	Incoming tons (%)[xxiii]	MRF revenue (%)
Cardboard	29%	28%
Glass	16%	Negative (-2.5%)
Aluminum	1%	12%
Steel	2%	2%
Mixed Paper	20%	20%
Newspaper	22%	25%
Plastic	5%	14%

KING COUNTY GREENHOUSE GAS EMISSIONS INVENTORY

In keeping with upstream and lifecycle considerations of materials as a possible future materials selection criteria, we reviewed the 2012 King County Greenhouse Gas Emissions Inventory. The consumption-based methodology incorporates the emissions associated with *production* of a material ("embodied" emissions). We can look at what goods and services require more emissions to produce in order to make purchasing decisions (including decisions around waste reduction and reuse) that will have the greatest lifecycle benefit.

[xxiii] Does not sum to 100%; balance of materials is garbage (residuals) to the MRF.

The table below shows emissions factors for a subset of materials based on the 2008 consumption-based inventory. Embodied emissions presented in this report are normalized to dollars spent; additional work may be required to align baseline units for ease of comparison to other LinkUp evaluation criteria (e.g., to per ton metrics).

Table 6: Select consumption-based emissions intensity factors for materials in King County

Material	Embodied Emissions Intensity (kgCO2e/$)
Home Energy and Appliances	
Heating and cooling appliances	0.59
Lighting	0.73
Food-related appliances	0.69
Food	
Red meat	2.25
Dairy	1.71
Beverages	0.63
Grains, baked goods	0.79
Fruit and vegetables	0.98
Poultry and eggs	1.42
Frozen food	1.02
Other Goods	
Furnishings and supplies	0.18
Computers	0.25
Other Electronics	0.64
Clothing	1.07

Appendix C: Materials Evaluation Matrix

Evaluation Metrics

We discussed potential material evaluation metrics with King County and City of Seattle stakeholders during the initial engagement process. We assigned points to each metric based on the relative rank of the material, where a low score is indicates more potential for priority (e.g., more tons, higher ability to influence), and a high score suggests less priority. The metrics and their potential score and relative weighting are shown in the table below.

Weight	Potential Score	Evaluation Metric	Unit of Measure	Data sources
24%	1-14[xxiv,xxv]	Disposed tons (C&D and MSW)	Tons per year	Local waste characterization studies from 2012-2015
		Disposed volume	Cubic yards per year	Various published sources (U.S. EPA, CalRecycle, Tellus) and in-house field data from Cascadia
24%	1-14	GHG emissions avoided if not landfilled and if recycled[xxvi]	Metric tons of CO_2e per ton of material	U.S. EPA WARM v.14; mattress data from CalRecycle
24%	2, 8, or 14	Ability to influence	Qualitative rank: low, medium, high	Local market studies, web-based research, stakeholder input
24%	2, 8, or 14	Market strength	Qualitative rank: low, medium, high	Local market studies, web-based research, stakeholder input
4%	0 or 2.5	Priority in the County Comprehensive Plan	Yes or no	2013 King County Comprehensive Plan
	6-59	**Total possible score**		

[xxiv] For scoring purposes, we combined disposed tons and volumes into a single scoring category. The disposed volumes are heavily influenced by disposed tons, and we wanted to reduce the influence of disposed tons alone on decision-making.

[xxv] We applied the most recent available waste characterization studies—King County's 2015 Waste Characterization Report; King County's 2007-2008 Construction and Demolition Waste Characterization Study; City of Seattle's 2012 Construction, Demolition, and Land Clearing Waste Composition Study; City of Seattle's 2012 Commercial and Self-Haul Waste Streams Composition Study; and City of Seattle's 2014 Residential Waste Composition Study—to the reported disposed tons in 2015. Volumes were calculated from these tonnages using published density factors.

[xxvi] Emissions factors are taken from the per ton estimates of GHG emissions per ton of material recycled and per ton of material landfilled as published in Version 14 of EPA's WARM Tool for all materials except for mattresses, which are not built into the tool. The emissions factor for mattresses is derived from Table 6 of CalRecycle's 2012 report, *Mattress and Box Spring Case Study* and assumes that recycling diverts 85% of the mattress and box spring mass from landfill.

In addition, the matrix also includes data from web-based research and stakeholder input on existing or emerging processing options and social responsibility considerations. These criteria do not impact scoring of materials since there was not enough data for all materials to develop a qualitative assessment; however, the data is provided for additional context.

Ranking Materials

We used the combined score of the evaluation metrics described above to determine a priority ranking of low, medium, or high priority for each of the materials. Materials with a combined score of 6–23 were considered high priority, materials with a combined score of 24–41 were considered medium priority, and materials that scores 42 or higher were considered low priority in this assessment.

Several materials (indicated with an asterisk in the table) were considered as part of a market assessment process in 2012. A "mini market assessment," a brief 2-3 page report summarizing the quantities that could potentially be diverted, current recyclability of the material, end uses for recovered material, and barriers to diversion, was produced for each of these materials in 2012.

	EVALUATION METRICS								SCORING								
Potential Focus Material (* indicates material was included in 2012 mini assessments)	**Estimated tons and % of waste disposed (MSW & C&D), 2015 Seattle and King County**	**Volume in disposed waste stream (2015)** (cubic yards)	**Avoided emissions per ton from recycling and preventing landfill** (mtCO2e/ton of material)	**Ability to Influence** (low/med/ high)	**Market Strength** (low/med/ high)	**Ability to Influence (justification)** (notes about partnerships, infrastructure, momentum, and local markets that exist)	**Existing or emerging processing options**	**Is this a priority material in the King County comp. plan (2013)?**	**RANK - Tons & Volume (1 = fewest tons/volume; 14 = most tons/volume)**	**RANK - Per Ton Potential Emissions Reduction (1 = least potential, 14 = most emissions reduction)**	**RANK - 2013 KC Comp Plan Priority (2.5 = in comp plan, 0 = not in comp plan)**	**RANK - Ability to Influence (14 = high, 8 = med, 2 = low)**	**RANK - Market Strength (14 = high, 8 = med, 2 = low)**	**OVERALL SCORE high score = higher priority**	**Overall ranking** (6-23 = high priority, 24-41 = medium, 42-59 = low)	**Social responsibility considerations**	**Other notes.** (other factors such as market growth of materials)
***Food and compostable/ food-soiled paper**	300,900 (21.4%)	1,900,300	0.7	High	High	Lots of momentum today; many interested parties in King County and Seattle; processing capacity (compost) sufficient; alternatives growing. Contamination challenges exist but feasible to address.	Composting, anaerobic digestion. Emerging: On-site, small-scale AD	Y	14	7	2.5	14	14	52	**High**	Large portion of domestic food waste is still edible food.	
Clean wood	124,000 (8.8%)	1,384,300	1.5	Medium	High	Existing disposal ban on clean wood in Seattle; King County's disposal ban on clean wood will apply to C&D transfer stations in 2018.	Hog fuel; deconstruction and salvaged lumber; mulch from clean wood; wood/plastic material composites.	Y	12	12	2.5	8	14	49	**High**		In 2012-2013 period, Cascadia recommended not studying dimensional lumber due to previous LinkUp investment in market development efforts with limited success; noted no substantial changes to market dynamics since.
***Textiles**	35,600 (2.5%)	305,600	N/A	High	High	Existing partnership between City of Seattle and King County; robust collection networks. However, overseas demand is falling, as have prices.	Reuse/resale markets; cut down and used as rags; reprocessed into insulation and carpet padding.		10	7	0	14	14	45	**High**	Volumes of secondhand clothing have impacted developing markets; there is a trend of increasing regulations and/or bans overseas on imported textiles.	Recyclers report a trend of declining quality of collected material (new material blends, impact of fast fashion)

	EVALUATION METRICS								SCORING								
Potential Focus Material (* indicates material was included in 2012 mini assessments)	**Estimated tons and % of waste disposed (MSW & C&D), 2015 Seattle and King County**	**Volume in disposed waste stream (2015)** (cubic yards)	**Avoided emissions per ton from recycling and preventing landfill** (mtCO2e/ton of material)	**Ability to Influence** (low/med/ high)	**Market Strength** (low/med/ high)	**Ability to Influence (justification)** (notes about partnerships, infrastructure, momentum, and local markets that exist)	**Existing or emerging processing options**	**Is this a priority material in the King County comp. plan (2013)?**	**RANK - Tons & Volume (1 = fewest tons/volume; 14 = most tons/volume)**	**RANK - Per Ton Potential Emissions Reduction (1 = least potential, 14 = most emissions reduction)**	**RANK - 2013 KC Comp Plan Priority (2.5 = in comp plan, 0 = not in comp plan)**	**RANK - Ability to Influence (14 = high, 8 = med, 2 = low)**	**RANK - Market Strength (14 = high, 8 = med, 2 = low)**	**OVERALL SCORE high score = higher priority**	**Overall ranking** (6-23 = high priority, 24-41 = medium, 42-59 = low)	**Social responsibility considerations**	**Other notes. (**other factors such as market growth of materials)
***Film plastic**	85,600 (6.1%)	7,341,300	1.0	High	Medium	Lots of momentum today; many interested parties and organization (locally and nationally); limited recycling infrastructure and processing options, however. Problematic for MRFs, so high impact if addressed. Expected to grow in use.	Plastics recovery facilities to improve collection/sorting; reprocessing for pellets or resin; composite lumber; potentially pyrolysis and other emerging plastics-to-oil technology	Y	12	8	2.5	14	8	45	**High**	Windblown litter	
Electronics (covered by E-Cycle)	700 (0.1%)	3,500	2.5	Medium	Medium	Infrastructure in place for recycling collection (E-Cycle). Potential opportunities for monitoring/oversight ensuring electronics are actually recycled.	Shredded and sorted into plastic, metal, and computer chips; sold separately on markets	Y	1	14	2.5	8	8	34	**Medium**	Many have toxic components; concerns about "recycling" that gets shipped overseas and dumped.	Quantities of this material expected to grow.
#3-7 plastics	3,300 (0.2%)	252,900	1.0	Medium	Medium	Limited domestic markets for this material, particularly while oil prices are low. New PRFs coming online (e.g., QRS Baltimore facility). Growing NW interest in siting PRF locally.	Plastics recovery facilities to improve collection/sorting; reprocessing; pyrolysis and other emerging plastics-to-oil technology	Y	5	8	2.5	8	8	32	**Medium**	Most #3-7 bales get sent overseas (whether recycled or used for waste to energy harder to track); domestic recycling opportunities more limited.	

	EVALUATION METRICS								SCORING								
Potential Focus Material (* indicates material was included in 2012 mini assessments)	**Estimated tons and % of waste disposed (MSW & C&D), 2015 Seattle and King County**	**Volume in disposed waste stream (2015)** (cubic yards)	**Avoided emissions per ton from recycling and preventing landfill** (mtCO2e/ton of material)	**Ability to Influence** (low/med/ high)	**Market Strength** (low/med/ high)	**Ability to Influence (justification)** (notes about partnerships, infrastructure, momentum, and local markets that exist)	**Existing or emerging processing options**	**Is this a priority material in the King County comp. plan (2013)?**	**RANK - Tons & Volume (1 = fewest tons/volume; 14 = most tons/volume)**	**RANK - Per Ton Potential Emissions Reduction (1 = least potential, 14 = most emissions reduction)**	**RANK - 2013 KC Comp Plan Priority (2.5 = in comp plan, 0 = not in comp plan)**	**RANK - Ability to Influence (14 = high, 8 = med, 2 = low)**	**RANK - Market Strength (14 = high, 8 = med, 2 = low)**	**OVERALL SCORE high score = higher priority**	**Overall ranking** (6-23 = high priority, 24-41 = medium, 42-59 = low)	**Social responsibility considerations**	**Other notes. (**other factors such as market growth of materials)
Mattresses	8,800 (0.6%)	197,700	1.05	Medium	Medium	New collection pilot in King County transfer station; new EPR legislation in CA. Markets are generally stable, but industry experts note that large quantities are needed to attract processors and make recycling financially viable.	Broken down into component parts, foam primarily recycled into carpet padding	Y	6	7	2.5	8	8	32	**Medium**	Often found among illegal dump sites; mattress collection, transportation and recycling creates entry level manual labor jobs (CalRecycle and PSI reports have estimates)	Approximately 270,000 mattresses are discarded annually in King County.[xxvii]
***Gypsum (clean, new)**	14,200 (1.0%)	59,300	(0.1)	Medium	High	Existing landfill ban on new gypsum scrap in Seattle; sufficient capacity in the region to process; LinkUp program has previously invested in gypsum recycling efforts.	Remanufacture into new drywall; used in cement production		6	1	0	8	14	29	**Medium**		
Electronics (not covered by E-Cycle)	6,800 (0.5%)	32,300	2.5	Medium	Low	Limited infrastructure for recycling collection electronics not covered by E-Cycle. Some materials may be diverted to reuse/resale stores.	Shredded and sorted into plastic, metal, and computer chips; sold separately on markets		3	14	0	8	2	27	**Medium**		
Asphalt shingles	11,200 (0.8%)	29,600	0.1	Medium	Medium	Existing market development efforts have been successful in incorporating provisions for use of recycled asphalt in WSDOT specifications; growth of recycled	Recycled into hot mix asphalt pavement and cold patch.	Y	4	4	2.5	8	8	27	**Medium**		

[xxvii] http://your.kingcounty.gov/extranet/dnrp/swd/MSWMAC_%26_SWAC/2016-MSWMAC-6-10-16-Agenda-7-Link-Up.pdf

	EVALUATION METRICS								SCORING								
Potential Focus Material (* indicates material was included in 2012 mini assessments)	**Estimated tons and % of waste disposed (MSW & C&D), 2015 Seattle and King County**	**Volume in disposed waste stream (2015)** (cubic yards)	**Avoided emissions per ton from recycling and preventing landfill** (mtCO2e/ton of material)	**Ability to Influence** (low/med/ high)	**Market Strength** (low/med/ high)	**Ability to Influence (justification)** (notes about partnerships, infrastructure, momentum, and local markets that exist)	**Existing or emerging processing options**	**Is this a priority material in the King County comp. plan (2013)?**	**RANK - Tons & Volume (1 = fewest tons/volume; 14 = most tons/volume)**	**RANK - Per Ton Potential Emissions Reduction (1 = least potential, 14 = most emissions reduction)**	**RANK - 2013 KC Comp Plan Priority (2.5 = in comp plan, 0 = not in comp plan)**	**RANK - Ability to Influence (14 = high, 8 = med, 2 = low)**	**RANK - Market Strength (14 = high, 8 = med, 2 = low)**	**OVERALL SCORE high score = higher priority**	**Overall ranking** (6-23 = high priority, 24-41 = medium, 42-59 = low)	**Social responsibility considerations**	**Other notes. (**other factors such as market growth of materials)
						hot mix asphalt use is slow but anticipated to continue.											
Carpet	20,800 (1.5%)	43,900	2.4	Low	Low	Limited processing capacity in the region, coupled with weak demand for post-consumer material.	Recycled into engineered fibers, new carpet (and padding)	Y	6	13	2.5	2	2	26	**Medium**		
Treated wood	115,700 (8.2%)	1,268,900	N/A	Low	Low	Processing and separation of treated wood is still challenging.	Limited options for treated wood		11	7	0	2	2	22	**Low**		
***Gypsum (painted, used)**	40,300 (2.9%)	158,200	(0.1)	Low	Medium	Local processors can also handle demolition and painted gypsum. However, some recyclers are reluctant to accept post-construction drywall waste due to concerns over lead and asbestos contamination.	Most recycled drywall production uses clean/pre-consumer drywall; other recycled drywall is used for agricultural purposes such as a soil conditioner.		9	1	0	2	8	20	**Low**		
Tires	800 (0.1%)	6,200	0.4	Medium	Low	Growing push to collect in Seattle and nearby (Tacoma); local interest in options beyond RDF.	refuse-derived fuel; shredded as a fill material; hot melt asphalt (crumb rubber modifier)		1	5	0	8	2	16	**Low**	Improper disposal; toxics; stockpiles are a health and safety risk.	

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