FINAL
Secondary Recycling Market Feasibility Study and Preliminary Action Plan

JUNE 2021

Kittitas County Solid Waste Division

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Acronyms and Abbreviations

ASR	alkali-silica reactions
C&D	Construction and Demolition Debris or Material
County	Kittitas County, Washington
CWU	Central Washington University
Cy	Cubic Yard
Ecology	Washington State Department of Ecology
HDPE	High-Density Polyethylene
HDR	HDR, Inc.
HHW	Household Hazardous Waste
HMA	Hot Mix Asphalt
Landfill	Ryegrass Balefill
Lbs	Pounds
MP	Mixed Paper
MRF	Materials Recycling Facility
MRWMD	Monterey Regional Waste Management District, California
MSW	Municipal Solid Waste
PET	Polyethylene Terephthalate
REOI	Request for Expressions of Interest
RFP	Request for Proposals
SCM	supplementary cementitious material
tpd	Tons per Day
tpy	Tons per Year
WGA	Waste Generation Area
WM	Waste Management, Inc.
WSDOT	Washington State Department of Transportation

1 Introduction and Background

1.1 Introduction

Kittitas County (County), in partnership with Central Washington University (CWU), Yakima County, Grant County, and the Ellensburg Business Development Authority (dba CenterFuse), received a grant from the Washington State Department of Ecology (Ecology) Recycling Development Center. The grant supports development of a feasibility study of secondary recycling markets looking towards a regional, comprehensive action plan.

HDR, Inc. (HDR) was retained to document, research and identify innovative and successful recycling management practices or initiatives that may be replicated in Kittitas County, and the region, as they relate to recycling acceptance, handling, marketing and end-use of materials with an emphasis on innovation and sustainable opportunities. This secondary recycling market feasibility study and action plan will provide the County and the region with a foundation for future recycling management options, preliminary action plan and infrastructure necessary for implementation.

1.2 Background

The following provides background information on current recycling management practices in the region.

Kittitas County

In 1980, with the opening of the Ryegrass Balefill (Landfill), the County began baling both municipal solid waste (MSW) and recyclable materials. The County, through their operating contractor for the Landfill and the transfer stations, baled drop-box recyclable materials and collected and marketed those commodities under various contracts. Contracts for recycling of marketed commodities included Elmview, Inc., which managed a recycling sort line and baler operation near the Ellensburg airport.

Elmview, Inc. assists members of the community with developmental disabilities through counseling, work experience, and job placement programs. In 1998, Elmview notified the County that they would no longer have the ability to accept recyclable commodities from the drop-box sites due to declining markets and the labor involved in cleaning and separating the materials from garbage illegally deposited in the drop-boxes. Elmview continued to accept recyclable materials from CWU and source segregated commodities from curbside collection until 2017, when they transitioned away from paper recycling and acceptance of segregated commodities due to declining commodity markets, lack of material, and safety concerns.

One of the County's transfer stations, the Ellensburg Transfer Station, baled and marketed recyclable commodities from 1980 through 1998 that included:

- Cardboard
- Newspaper
- Office paper (high-grade paper)
- Tin
- Aluminum

During this period, glass was segregated by color and taken to Elmview for processing and marketing.

In 1998, the County closed the Landfill under an Agreed Order with Ecology due to a fire that occurred in late 1996. In addition, the Ellensburg Transfer Station collapsed, due to snow load in early 1997. The County decided that a new transfer facility would be constructed to accommodate long-haul of MSW for disposal and that baling of MSW and recyclable materials would no longer be viable.

Upon closure of the Landfill, the County constructed a separate landfill cell to accept construction and demolition debris that is still operational.

In 1998, the County issued the first Request for Proposals (RFP) for transport and recycling of commodities collected in the County recycling drop-boxes, with contract awarded to Michelsen Packaging Company (Central Washington Recycling). Materials were transported to Yakima for processing, with fiber commodities being recycled by Michelsen Packaging into fruit packing materials.

The County awarded contract for operations of the Ellensburg and Cle Elum transfer stations, transport and disposal of MSW, and recycling of commodities accepted in the drop-boxes to Waste Management, Inc. (WM), in 2000. As the sole curbside collection company operating in the County and the operator of the transfer station facilities, WM accepts recyclable commodities and reloads them from their facility located on Third Street in Ellensburg. Commodities are transported to the SMaRT Center single-stream recycling material recycling facility (MRF) in Spokane, where they are processed and marketed. In October 2019, WM announced that glass would no longer be accepted in the Ellensburg curbside recycling program or at the County drop-box sites due to lack of markets and the effects of glass on marketing other recyclable commodities.

Yard waste has been managed by the County since 2009 when they began operations on a 3-acre site located at the Ellensburg Transfer Station to compost yard waste collected through curbside programs and from self-haulers. The facility was funded through a grant from Ecology and is owned and operated by County staff.

Yakima County

Yakima County currently owns and operates two (2) landfills that accept MSW for disposal and three (3) recycling drop-box sites, located at their transfer stations, for collection of recyclable materials that currently accept newspaper, cardboard, pop bottles, milk jugs, and aluminum cans. Materials accepted at the drop-box sites are taken to Michelsen Packaging in Yakima, where the fiber material is re-manufactured into fruit packing material. Due to changing market conditions, Yakima County has recently had to eliminate acceptance of all other plastics and mixed waste paper.

In 2018, due to the Washington State Department of Agriculture Apple Maggot Quarantine, Yakima County was no longer able to transport chipped yard waste material from its yard waste operations to a composting facility near the City of Granger. Yakima County is currently chipping source-separated yard waste and utilizing it as alternate daily cover on their landfills.

Grant County

Grant County owns and operates the Ephrata landfill for acceptance of MSW and two (2) drop-box sites that accept cardboard, aluminum cans and glass. Aluminum cans and glass acceptance were discontinued from

collection at the Ephrata Landfill in 2021. There are also a number of privately owned and operated drop-off sites located in Grant County that accept recyclable materials.

1.3 Recyclable Material Tonnage

Table 1-1 provides 2017 through 2020 regional recyclable materials, in tons, that are segregated and recycled or diverted through various drop-off and collection programs in the three counties.

Table 1-1. Regional Recyclable Materials (in Tons)

Commodity	2017	2018	2019	2020
Kittitas County Transfer Station Recyclables				
Newspaper	124.07	99.50	90.51	49.82
Aluminum	26.97	22.30	23.09	27.47
Magazines	82.33	82.82	81.29	52.10
Tin	23.81	18.87	20.24	17.31
Cardboard	542.00	604.74	618.76	695.93
Pop Bottles	36.30	40.54	36.27	32.46
Milk Jugs	17.47	15.71	15.22	13.50
Glass	291.58	294.22	224.33	0
Yard Waste	2,486.00	2,635.00	2,389.00	2,703.00
Total Kittitas County Recyclables	3,630.53	3,813.70	3,498.71	3,591.59
Kittitas County Curbside Recyclable Commodities				
Curbside Recycling	1,401.55	1,346.47	1,359.11	1,200.25
Curbside Cardboard	73.04	64.85	80.92	644.81
Total Curbside Recyclable Commodities	**1,474.59**	**1,411.32**	**1,440.03**	**1,845.06**
CWU Recyclable Commodities				
Mixed Paper	0	113.60	72.00	36.00
Cardboard	0	20.00	21.40	8.70
Alum/Plastic/Glass	0	4.80	7.20	3.00
Total CWU Recyclable Commodities	**0**	**138.40**	**100.60**	**47.79**
Total Kittitas County Recyclables	**5,105.12**	**5,363.42**	**5,039.34**	**5,484.44**

Table 1-1. Regional Recyclable Materials (in Tons)				
Commodity	**2017**	**2018**	**2019**	**2020**
Yakima County Recyclables				
Newspaper	83.00	89.00	61.00	14.00
Cardboard	106.00	99.00	129.00	205.00
Pop Bottles and Milk Jugs	10.00	12.00	0	0
Aluminum Cans	6.00	7.00	1.00	1.00
Yard Waste	16,527.71	17,100.55	17,809.39	18,434.98
Total Yakima County Recyclables	**16,732.71**	**17,307.55**	**18,000.39**	**18,654.98**
Grant County Recyclables				
Newspaper	189.25	119.23	136.12	154.32
Cardboard	3,888.34	3,593.39	3,544.81	4,901.90
Mixed Waste Paper	14.74	0	6.81	11.24
Aluminum Cans	15.61	20.79	15.55	24.74
Glass	31.39	30.25	32.35	96.68
Comingled Recyclables	1,232.40	1,082.34	1,138.67	1,712.13
Total Grant County Recyclables	**5,371.73**	**4,846.00**	**4,874.31**	**6,901.01**
Total Regional Recyclable Materials	**27,209.56**	**27,516.97**	**27,914.04**	**31,040.43**

In 2015, Ecology conducted a statewide waste characterization study to support the State Solid and Hazardous Waste Plan, "Moving Washington Beyond Waste and Toxics," and performed an in-depth examination of the materials and resources currently being disposed of throughout the state. This study incorporated four additional analysis tasks, specifically:

- A packaging versus product analysis that groups each of the 156 material types into packaging, products, or one of six other material groups.
- Detailed composition results for each of the State's six (6) waste-generation areas (WGAs): Central, East, Northwest, Puget Sound, Southwest, and West.
- A comparison with the 2009 Washington Statewide Waste Characterization Study.
- A supplementary analysis that combines the data collected as part of this study with an additional seven (7) studies completed by other jurisdictions around the state.

Ecology utilizes the data collected in the study to assist municipalities as well as public and private solid waste managers to design targeted material recovery programs. These programs are intended to move

beyond material disposal to managing materials with environmental impacts in mind and ultimately to a healthier Washington State.

Figure 1-1 provides the results from the Central Region waste generation area where waste was characterized in Chelan and Grant counties for the study. The complete study can be found at: https://apps.ecology.wa.gov/publications/documents/1607032.pdf.

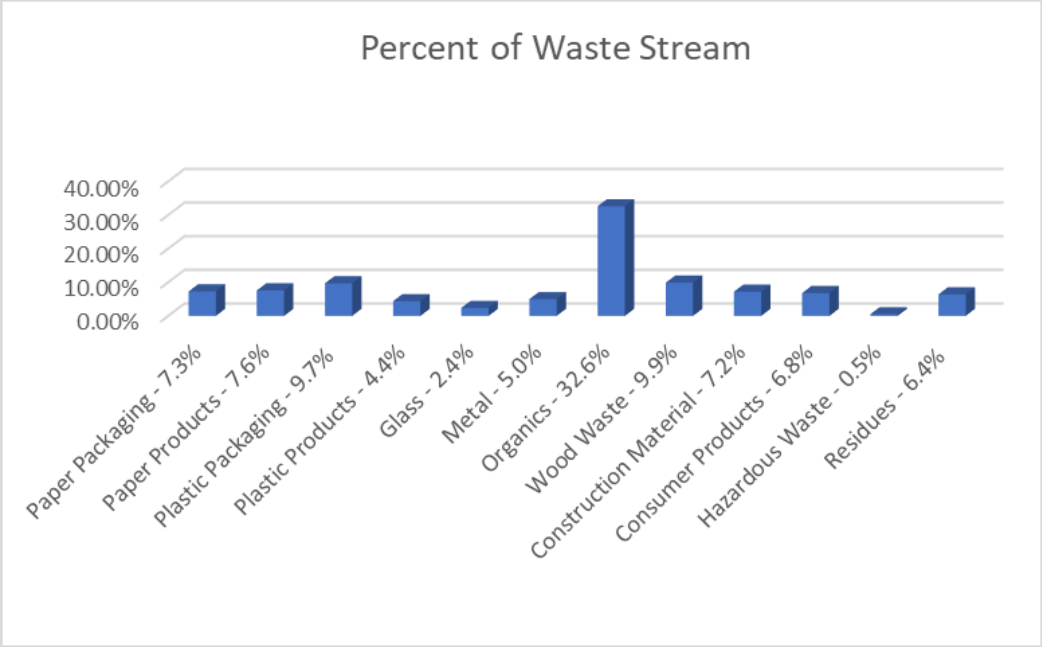

Figure 1-1. Ecology Waste Characterization Study Central WGA (2015-2016)

Of note from Ecology's Waste Characterization Study is that organics, which includes yard and food waste, has the highest percentage of material remaining in the waste stream (by weight) at 32.6 percent, followed by construction and demolition (C&D) materials at 17.1 percent (includes wood waste and construction material from Figure 1-1 above), paper [packaging and products] at 14.9 percent, plastic [packaging and products] at 14.1 percent, and glass at 2.4 percent.

Table 1-2 provides an overview of potential recyclable materials remaining in each counties' waste stream, for 2020, based on Ecology's Waste Characterization Study.

Table 1-2. Waste Characterization Potential Materials Remaining in Waste Stream (in tons)

	Kittitas County	Yakima County	Grant County	Total
MSW Tonnage (2020)	**40,308**	**293,388**	**117,980**	**451,676**
Materials in Waste Stream				
Organics – 32.6%	13,140.41	95,644.49	38,461.48	147,246.38
C&D 17.1%	6,892.67	50,169.35	20,174.58	77,236.60
Paper 14.9%	6,005.89	43,714.81	17,579.02	67,299.72
Plastic - 14.1%	5,683.43	41,367.71	16,635.18	63,686.32
Glass - 2.4%	967.39	7,041.31	2,831.52	10,840.22
Total By County	**32,689.79**	**237,937.67**	**95,681.78**	**366,309.24**

1.4 Recyclable End-Markets and Benchmarking Technical Memorandum

HDR completed a technical memorandum to document research and identify innovative and successful recycling management practices and/or initiatives that could be replicated in the region as they related to recycling acceptance, handling, marketing and end-use of materials with an emphasis on innovation and sustainable opportunities. The technical memorandum was grouped into the following categories and sub-categories for consideration:

Glass Recycling

- Aggregate Material
- Filler
- Sandblasting Media
- Compost
- Fiberglass Manufacturing
- Specialty Glass
- Wine Industry

Commingled Recyclables

- Clean Materials Recycling Facility
- Mixed-Waste Recycling Facility

Construction and Demolition Debris Diversion

- Concrete
- Wood
- Shingles
- Drywall
- Metals
- OCC
- C&D Fines

Recovery Parks

- Resource Recovery Parks

Organics

- Aerobic Composting
- Anaerobic Digestion

2 Stakeholder Engagement and Options for Further Consideration

2.1 Stakeholder Engagement

An initial stakeholder kick-off meeting was facilitated by HDR to provide the project overview and review goals and objectives. Upon completion of the draft Recyclable End-markets and Benchmarking Technical Memorandum, an additional stakeholder engagement was conducted to solicit feedback and recommendation on options for further consideration as potential candidates from the successful recycling management options presented. Stakeholder recommended candidates are further evaluated for economic viability, environmental soundness, social acceptability and achievability in the region for inclusion in the preliminary action plan as part of this document.

Stakeholder groups were represented from Kittitas County, Yakima County, Grant County, CWU and the Ellensburg Business Development Authority. In addition, a separate presentation was made to the Ellensburg Business Development Authority Board of Directors to provide a project overview and solicit input on potential projects in support of progressive economic development.

2.2 Options for Further Consideration

Following stakeholder engagement, the practices and initiatives listed below are to be considered for future recycling management options and infrastructure needs in the region as part of this document. Their purpose is to increase diversion and assist the County and their regional partners with economic development through demonstrated ability to build and sustain effective public/private partnerships. The options for consideration are presented as follows:

Glass Recycling

- Aggregate/Pozzolan in Portland Cement Concrete
- Aggregate/Roadway Bead
- Specialty Glass
- Wine Industry Glass

Commingled Recyclables

- Clean MRF Facility

Construction and Demolition Debris Diversion

- Concrete Diversion
- Wood Diversion
- Drywall Diversion
- Metals Diversion

Recovery Parks

- Resource Recovery Park

Organics

- Aerobic Composting

3 Glass Recycling and Reuse

Beginning in October 2019, the County's waste and recycling contractor WM stopped accepting glass containers as part of its curbside recycling program for the City of Ellensburg. Coincidently, the County also stopped accepting glass as a recyclable item at each of its transfer stations in Cle Elum and Ellensburg. This decision was made due to the myriad of challenges glass recyclers across the United States (U.S.) have consistently faced. The recyclable commodities market for glass is extremely poor due to the abundance and low energy processing rate of its inexpensive raw source (i.e., sand). Glass is also expensive to collect, process, and transport due to its weight and easily breakable nature. When it breaks, glass causes contamination to other recyclable commodities, making them less marketable and of less value. Due to its abrasiveness, glass is damaging to recycling equipment as well.

Despite its challenges, there are still many beneficial uses for glass if it is collected separately and diverted for recycling and reuse. Some local communities, including Pierce County, Washington, the Oregon-Metro region, and Washington County, Oregon, are collecting glass separately for beneficial reuse markets in lieu of landfilling. Pierce County is collecting container glass at about 30 various drop-off sites, while Oregon-Metro and Washington County are collecting residential glass curbside (typically on the same collection day as other recyclables). In Thurston County, Washington, Concrete Recyclers is accepting the county's used glass bottles, and sometimes old computer screens, and crushing them into a uniform size cullet that contractors can buy and use as a substitute for sand and gravel in backfill and foundation projects. Contractors are able to use glass cullet as a landscape mulch, for drainage media in pervious pavements, as backfill for retaining walls, and as bedding material under sidewalks and small-diameter water and service lines, substituting fine-grained glass cullet for the 2-inch sand cushion layer normally used. Concrete Recyclers is diverting glass from the landfill and have a sustainable business.[1]

In response to the discontinuation of glass recycling in the County, the Ellensburg Glass Recycling Cooperative invested in a small-glass crushing machine called the Expleco GLS2.0 to eventually crush collected residential glass into sand. The cooperative will set up "glass ambassadors" to help decide the best way to collect clean glass and bring it to the crushing center. One of the ways the group wants to use the sand is to fill potholes at the cemetery, and also offer it for free to community residents who want to use it on their properties possibly as landscaping media due to the material's good filtration and drainage or on house facades. The group has also worked in conjunction with CWU to explore the use of sand in concrete mix, which looks promising.[2]

The following sections present the glass recycling and reuse practices and initiatives, for potential management implementation, that were selected for future material management and infrastructure needs in the region, including Kittitas, Yakima and Grant counties.

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[1] Ashenhurst, Natasha. April 2017. Thurston County Chamber. "Concrete Recyclers is Closing the Loop." Concrete Recyclers is Closing the Loop - Thurston County Chamber of Commerce (thurstonchamber.com). (Accessed March 2021).

[2] Holappa, Karl. January 2021. Daily Record News. "Glass Recycling Cooperative takes receipt of glass crusher Monday." Glass Recycling Cooperative takes receipt of glass crusher Monday | Local News | dailyrecordnews.com. (Accessed March 2021).

3.1 Aggregate/Pozzolan in Portland Cement Concrete

It has been scientifically proven that when glass is finely size-reduced into a powder form, it possesses pozzolanic properties. A pozzolan is defined as a class of siliceous and/or aluminous materials that chemically react with calcium hydroxide when finely ground and in the presence of water to form cementitious properties. Due to this phenomenon, there is the potential for glass, or recycled glass cullet, to act as a pozzolanic material and be used as supplementary cementitious material (SCM) to partially replace portland cement in concrete manufacturing. Some studies have shown that glass powder could replace up to 30 percent of cement (by weight) in standard concrete without causing detrimental effects while still achieving the durability and strength requirements.[3] Additionally, they have found that using glass instead of cement reduces global warming and energy demands. Portland cement production is one of the world's main sources of carbon dioxide emissions. In addition to saving landfill space, the energy consumption associated with size-reducing glass to a powder form is offset by the energy saved from needing less fuel combustion in the cement manufacturing kilns.

The challenge of this beneficial use is the intensive process in size reduction of recycled cullet to a proper size and its associated cost. In order to possess pozzolanic properties and not cause alkali-silica reactions (ASR) in concrete, glass needs to be reduced to at least a No. 325 (45-micron) mesh size, with pozzolanic properties increasing as particle fineness increases.[3 & 4] Assuming that glass is collected separately from all other materials and is relatively clean, in order to achieve a powder size, it would likely have to be processed through a horizontal impact crusher and then a ball mill. The local Ellensburg Concrete Plant could be an ideal option as an end market user for glass powder pozzolan sourced from residential collection.

3.1.1 Recommendations

The following actions are recommended related to recovered glass aggregate/pozzolan use in portland cement concrete production in the region:

- Consider forming a regional working group to develop a consistent approach to recovered glass collection, taking into consideration distance and hauling costs.
- Identify potential public/private partnership opportunities available for glass recycling or reuse.
- Conduct feasibility studies to understand the specific processes, requirements and costs for either the development of a new glass processing facility, retrofitting of an existing glass processing facility (e.g., Seattle's Strategic Materials facility), upgrading an existing MRF and reintroduce glass recycling, attracting new businesses, or the investment in multiple mobile crushing machines.

[3] Tucker, et al. 2018. "Economic and life cycle assessment of recycling municipal glass as a pozzolan in portland cement concrete production." Resources, Conservation and Recycling, Volume 129. https://doi.org/10.1016/j.resconrec.2017.10.025. (Accessed March 2021).

[4] Sheeley, April. Fall 2020. "Developing a Collaborative Plan for Recycling Glass in Kittitas County: Results from a Fall 2020 Internship with CWU Sustainability." fall intern.pdf (cwu.edu). (Accessed March 2021).

- Identify procurement model and initiate procurement process for either the development of a new glass processing facility, retrofitting of an existing glass processing facility , upgrading an existing MRF and reintroduce glass recycling, or the investment in multiple mobile crushing machines.
- Conduct a siting study to locate a suitable area for a glass processing recycling facility, if chosen.
- Identify end-markets of pozzolanic glass powder and initiate contracts for sale of materials (e.g., Ellensburg Concrete Plant).

Table 3-1 presents an overview of this option.

Table 3-1. Aggregate/Pozzolan in Portland Cement Concrete Option

Description of Option	• Size-reduce recovered glass into a powder form for use as a pozzolan to partially replace cement (up to 30 percent by weight) in portland cement concrete production.
Actions/Potential Challenges	• Size reduction is an intensive and expensive process as the end product needs to be No. 325 (45-micron) mesh size or less. • Input material would need to be crushed, contaminants removed, and then finely milled. • Would need to purchase at least a horizontal impact crusher and a ball mill. • Need to either identify existing facilities for retrofitting or upgrading or build a new glass processing facility. • The set-up of either independent residential glass drop-off or separate glass collection would need to occur. • Needs sufficient glass quantities to make processing viable.
Rationale for Consideration	• Reduce carbon emissions and energy demands when compared to using cement. • Saves landfill space. • Promotes environmental stewardship. • Creates a marketable and likely revenue-generating end use for glass instead of direct disposal.
Short -term or Long-term Option	• Short-term option would be to identify entities that would utilize glass powder in concrete production. The Ellensburg Concrete Plant appears to be a viable local option. • Long-term option would be to set-up a recovered glass processing system to size reduce material and then use the material in concrete production.
Achievable in the Region	• A total of approximately 11,000 tons of glass is disposed of by Kittitas, Yakima, and Grant counties annually and could instead be diverted. • The Strategic Material's Seattle glass processing facility could be retrofitted to include glass powder size reduction, otherwise a new glass processing facility could be built. Lastly, glass residential curbside collection could be implemented again and the MRF be upgraded to include cleaner glass processing and size reduction. • The local Ellensburg Concrete Plant could be an ideal option as an end market user for glass powder pozzolan sourced from residential collection.

Table 3-1. Aggregate/Pozzolan in Portland Cement Concrete Option	
Potential for Job Loss/Creation	• Creating a glass processing and/or collection system would generate the need for plant/equipment operators and/or collectors.
Potential Effect on Waste Reduction	• This option would give an end use for glass instead of solely landfill disposal.
Potential Cost Implementations	• Refer to Section 3.5 for cost implementations for various applicable glass processing scenarios.
General Implementation Requirements	• Secure an end user (e.g., concrete plant). • County would need to determine which glass processing scenario in this Section 3 is most feasible both logistically and financially. • County would need to determine which collection system would be most ideal, taking into consideration hauling distances and collection points (e.g., curbside, drop-off locations, resident-sourced direct drop off).

3.2 Aggregate/Roadway Bead

Cullet offers a more cost-effective alternative to virgin glass in bead manufacturing. Cullet can be melted into rounded glass pellets, or beads, and then sold, mainly for use in reflective paints used in highway striping, but also potentially for use in peening and cleaning metals.[5] Glass helps make the paint very reflective, which keeps motorists safe while traveling at night.

To be suitable for bead making, cullet needs to be sized to a finely ground range. This size reduction occurs by using crushers and screens. To ensure proper material flow through the screening as well as storage, finely ground material must go through a drying process. Contaminants in the glass stream must also be removed. Differing magnet types are used to remove ferrous and non-ferrous metals, and vacuum systems are used to remove light material (such as paper and organics) from heavier glass fragments.[5]

There are many benefits to using recycled glass cullet instead of virgin materials in bead manufacturing and application. Recycled glass reduces emissions and consumption of raw materials, as it can fully substitute all raw materials, extends the life of plant equipment (e.g., furnaces), and saves energy. Since cullet is free of heavy metals, it typically meets or exceeds regulatory highway bead metal design requirements. Cullet can also reduce energy consumption, as it generally requires 25 to 30 percent less energy to melt cullet than virgin batch materials. A traditional glass-melting furnace is not typically needed when cullet is used in bead manufacturing in lieu of virgin material. This allows for the avoidance of significant air emissions and reduces carbon footprint. Glass cullet use saves on manufacturing costs and potentially on material costs. Environmentally, using recycled cullet helps divert it from landfill disposal and promotes environmental stewardship.[5]

Strategic Materials, Inc.'s, Seattle facility is the only recycled glass processing facility serving the state of Washington. The facility accepts separated glass from commingled collection systems and then uses optical

[5] Strategic Materials. "Bead." Bead | Recycled Glass Leader | Strategic Materials | Glass Recycling. (Accessed March 2021).

sorters and X-ray fluorescence technology to remove contaminants and sort the glass into various colors and sizes. The majority of its processed recycled glass, or cullet, is sent locally to Ardagh Glass, Inc.'s, bottle manufacturing plant, also located in Seattle.[6] Nationally, Strategic Materials supplies a majority of the bead industry's demand for cullet in the form of either unprocessed glass for the grinding process or sized grain for direct placement into the bead furnace.[5]

The feasibility of retrofitting Seattle's existing Strategic Materials plant to manufacture beads and/or increasing capacity to sell more cullet direct to bead manufacturers could be explored.

3.2.1 Recommendations

The following actions are recommended related to recovered glass use in aggregate/roadway bead in the region:

- Consider forming a regional working group to develop a consistent approach to recovered glass collection, taking into consideration distance and hauling costs.
- Identify potential public/private partnership opportunities available for glass recycling or reuse.
- Conduct feasibility studies to understand the specific processes, requirements and costs for either the development of a new glass processing facility, retrofitting of an existing glass processing facility (e.g., Seattle's Strategic Materials facility), upgrading an existing MRF and reintroduce glass recycling, or the investment in multiple mobile crushing machines.
- Identify procurement model and initiate procurement process for either the development of a new glass processing facility, retrofitting of an existing glass processing facility , upgrading an existing MRF and reintroduce glass recycling, attracting new businesses, or the investment in multiple mobile crushing machines.
- Conduct a siting study to locate a suitable area for a glass processing recycling facility, if chosen.
- Identify end-markets of cullet to aggregate/roadway bead and initiate contracts for sale of materials (e.g., Washington State Department of Transportation, or WSDOT).

Table 3-2 presents an overview of this option.

Table 3-2. Aggregate/Roadway Bead Option

Description of Option	• Process and melt recovered cullet into rounded glass pellets, or beads, to be sold and used in reflective paints such as for highway striping.
Actions/Potential Challenges	• Intensive size reduction process to get to appropriate size for use. • Need to either identify existing facilities for retrofitting or upgrading or build a new glass processing facility. • The set-up of either independent residential glass drop-off or serviced separate glass collection would need to occur. • Identify a steady end user (e.g., glass bead manufacturers or WSDOT).

[6] Washington State Department of Commerce. October 2020. "Washington's 'Glass' – Half Full or Half Empty?" Microsoft Word - Recycling Report in Template final edits TV.docx (wa.gov). (Accessed March 2021).

Table 3-2. Aggregate/Roadway Bead Option	
Rationale for Consideration	In comparison to virgin material bead manufacturing: • Reduces emissions and consumption of raw materials (can achieve 100 percent substitution). • Extends plant equipment life (e.g., furnaces). • Saves energy (by 25 to 30 percent). • Saves on manufacturing and material costs. • Cullet meets or exceeds highway bead metal design requirements. • Saves landfill space. • Promotes environmental stewardship. • Creates a marketable and likely revenue-generating end use for glass instead of direct disposal.
Short-term or Long-term Option	• In the short-term, identify potential intermediate and end users. Explore with the WSDOT whether they can directly utilize recovered glass beads in highway paint or specify such use in contracts. • In the long-term, determine if Seattle's Strategic Materials facility could be retrofitted to include equipment for proper size reduction for bead manufacturing. Nationally, Strategic Materials supplies most of the bead industry's demand for cullet in the form of either unprocessed glass for the grinding process or sized grain for direct placement into the bead furnace. Determine if this market option could be expanded to the Seattle facility.
Achievable in the Region	• A total of approximately 11,000 tons of glass is disposed of by Kittitas, Yakima, and Grant Counties annually and could instead be diverted. • The Strategic Material's Seattle glass processing facility could be retrofitted to include glass size reduction, otherwise a new glass processing facility could be built. Lastly, glass residential curbside collection could be implemented again and the MRF be upgraded to include cleaner glass processing and size reduction. • Washington has almost 200 state highways with the majority entirely paved; this likely involves regular maintenance and upkeep, including repainting.
Potential for Job Loss/Creation	• Creating a glass processing and/or collection system would generate the need for plant/equipment operators and/or collectors.
Potential Effect on Waste Reduction	• This option would give an end use for glass instead of solely landfill disposal.
Potential Cost Implementations	• Refer to Section 3.5 for cost implementations for various applicable glass processing scenarios.
General Implementation Requirements	• Secure an end user (e.g., WSDOT). • County would need to determine which glass processing scenario in this Section 3 is most feasible both logistically and financially. • County would need to determine which collection system would be most ideal, taking into consideration hauling distances and collection points (e.g., curbside, drop-off locations, resident-sourced direct drop off).

3.3 Specialty Glass

There are many other uses for glass cullet, including making specialty glass. Specialty glass includes decorative landscaping rocks, terrazzo floor tiles, countertop glass, aquarium chips, fire pit glass, swimming pool accents, and many more.[7]

Glass is a prime decorative material because its colors are vibrant and never fade, as glass is not affected by sunlight's ultraviolet rays. Many local artisan shops or contractors could use recovered glass cullet in their products or designs. For the best quality, recycled glass should be collected as color-separated or processed through an optical sorter and may need to be cleaned for specialty uses.[7]

3.3.1 Recommendations

The following actions are recommended related to recovered glass use as specialty glass in the region:

- Consider forming a regional working group to develop a consistent approach to recovered glass collection, taking into consideration distance and hauling costs.
- Identify potential public/private partnership opportunities available for glass recycling or reuse.
- Conduct feasibility studies to understand the specific processes, requirements and costs for either the development of a new glass processing facility, retrofitting of an existing glass processing facility (e.g., Seattle's Strategic Materials facility), upgrading an existing MRF and reintroduce glass recycling, or the investment in multiple mobile crushing machines. Glass powder processing would likely not be needed for this application. Depending on the use, optical sorting may not be necessary either which would make mobile crushing a potentially ideal processing method.
- Identify procurement model and initiate procurement process for either the development of a new glass processing facility, retrofitting of an existing glass processing facility, upgrading an existing MRF and reintroduce glass recycling, or the investment in multiple mobile crushing machines. The use of a ball mill would likely not be necessary.
- Conduct a siting study to locate a suitable area for a glass processing recycling facility, if chosen.
- Identify end-markets of glass cullet and initiate contracts for sale of materials (e.g., local artisans).

Table 3-3 presents an overview of this option.

Table 3-3. Specialty Glass Option	
Description of Option	• Processing recovered glass to colorful cullet size for use as decorative material such as landscaping rocks, countertop glass, tiles, etc.
Actions/Potential Challenges	• Need to implement a glass processing operation that produces clean and uniformly crushed cullet that would ideally be color-separated from the source or through use of an optical sorter. • Need to either identify existing facilities for retrofitting or upgrading or build a new glass processing facility.

[7] Strategic Materials. "Specialty Glass." Specialty Glass | Recycled Glass Leader | Strategic Materials | Glass Recycling. (Accessed March 2021).

Table 3-3. Specialty Glass Option	
	• The set-up of either independent residential glass drop-off or serviced separate glass collection would need to occur. • Identify multiple end users that would likely be relatively small in size (e.g., landscaping company, carpenter, tile/kitchen/bath manufacturers, etc.). • More of a niche market for specialty glass.
Rationale for Consideration	• Glass is not affected by UV rays, so color maintains which is ideal for aesthetic applications. • Creates a diversion method other than landfilling.
Short -term or Long-term Option	• In the short-term, identify potential local companies that could utilize recovered cullet in aesthetic applications. • In the long-term, set-up a recovered glass processing system to reduce contamination, color sort and size reduce material.
Achievable in the Region	• A total of approximately 11,000 tons of glass is disposed of by Kittitas, Yakima and Grant Counties annually and could instead be diverted. • Mobile crushing could be a viable option dependent on cleanliness of the glass input material, the options of end users, and need for color sorting or not. • Local artisan markets or use by residents for home landscaping.
Potential for Job Loss/Creation	• Creating a glass processing and/or collection system would generate the need for plant/equipment operators and/or collectors.
Potential Effect on Waste Reduction	• This option would give an end use for glass instead of solely landfill disposal.
Potential Cost Implementations	• Refer to Section 3.5 for cost implementations for various applicable glass processing scenarios. • Glass powder production using a ball mill would likely be unnecessary.
General Implementation Requirements	• Secure several end users (e.g., local markets). • County would need to determine which glass processing scenario in this Section 3 is most feasible both logistically and financially. • County would need to determine which collection system would be most ideal, taking into consideration hauling distances and collection points (e.g., curbside, drop-off locations, resident-sourced direct drop off).

3.4 Wine Industry Glass

One unique industry to target for glass diversion and reuse is the wine industry. Approximately 300 million cases of wine are sold in the U.S. every year, and the wine bottles from approximately 210 million of those cases end up in landfills. Similarly, the U.S. Environmental Protection Agency estimates that 70 percent of all wine bottles are not recycled.[8]

[8] Green Living Journal. "The RINSE Project Helps Wineries Reuse Wine Bottles." The RINSE Project Helps Wineries Reuse Wine Bottles • Green Living Journal (greenlivingpdx.com). (Accessed March 2021).

It is estimated that 60 percent of a wine's carbon footprint is in the production of its bottle. Reusing wine bottles cuts the carbon footprint of the industry and reduces the amount of glass that ends up in landfills. Similarly, the process of washing a wine bottle for reuse generates less than 5 percent of the carbon emissions created during the virgin production of that same bottle.[8]

Recently, the Cowhorn Winery in Applegate Valley, Oregon, partnered with Wine Bottle Renew to establish a new bioregional program called The RINSE Project. The project cuts per-bottle costs and reduces a winery's carbon footprint by recycling used wine bottles to prepare them for industry reuse. In addition to cleaning, packing, and shipping wine bottles for winery reuse, The RINSE Project culls bottles that have a clouding of the glass, otherwise known as a "bloom," that can cause wine to spoil. The Green Glass Company then upcycles the rejected wine bottles into heirloom glassware.[8]

Locally, after WM phased out curbside glass recycling in Leavenworth due to the unreliable market, a nonprofit association called Waste Loop partnered with local participants in an effort towards diverting glass from the Leavenworth waste stream. As part of this effort, the group acquired a glass crusher, donated by Sleeping Lady Mountain Resort, and started a pilot program with bottlers Eagle Creek Winery and Honey Jun Kombucha, to turn their disused bottles into cullet. The group would like the cullet to be used as fill material and partner with the WSDOT to use it along roadways. The group also collected residential glass through local drop-off events.[9]

The Washington Winegrowers organization could be targeted to implement similar wine-bottle recycling and reuse programs throughout the state. Similarly, Washington State's Vinewise® and Winerywise™ is an online guide to sustainable wine grape growing, winemaking, and business practices. This platform has been developed by a committee of leading Washington State growers and vintners, supported by the work of Washington State University extension staff and researchers, to promote sustainable well-being.[10] The sustainable reuse of wine bottles would fit well within their initiative.

3.4.1 Recommendations

The following actions are recommended related to wine bottle reuse in the region:

- Consider forming a regional working group to develop a consistent approach to recovered glass collection, taking into consideration distance and hauling costs.
- Identify potential public/private partnership opportunities, specifically with wineries, available for glass reuse.
- Conduct feasibility studies to understand the specific processes, regulatory health requirements and costs to sanitize/wash wine bottles for reuse.
- Identify procurement model and initiate procurement process for establishment of wine bottle reuse programs and/or the establishment of grant funding for wineries to be able to participate.
- Conduct a siting study to locate a suitable area for a glass bottle sanitation/washing facility, if not incorporated at the wineries themselves.

[9] Robbins, Jefferson. December 2019. "Closing the 'glass gap' in Leavenworth's recycling options." Closing the 'glass gap' in Leavenworth's recycling options - NCWLIFE. (Accessed March 2021).

[10] Vinewise® and Wineryvise™. "About." About (sustainablewineandgrape.org). (Accessed March 2021).

- Identify end-markets of recovered whole wine bottles and initiate contracts for sale of materials (e.g., wineries).

Table 3-4 presents an overview of this option.

Table 3-4. Wine Industry Glass Option	
Description of Option	• Reuse of empty wine bottles for winery re-distribution.
Actions/Potential Challenges	• Collecting, hauling and handling wine bottles through a bottle sanitation/washing facility without breakage. • Removing adhesives and sanitizing bottles for reuse can be an intensive process. • Cost to reuse wine bottles can be slightly more expensive than buying new bottles. • Need to ensure there are no regulatory health and safety concerns with reusing wine bottles. • Collection of wine bottles without causing breakage. • Would need an increase in storage space at wineries. Wineries may not have space for individual bottle sanitation/washing facility. • Participation rates could be low as it is more of a niche market specific to wine bottles and especially if residents/winery visitors themselves are responsible for direct drop-off of bottles back to the wineries.
Rationale for Consideration	• Cuts the carbon footprint of the wine industry (estimated 60 percent of wine's carbon footprint is from bottle production). • Reduces the amount of glass that is landfilled. • Washing a wine bottle for reuse generates less than 5 percent of the carbon emissions versus production using virgin materials. • Winery business is popular and abundant in Washington (lots of potential end users) but would need to ensure participation in bottle collection for reuse is strong. • Promotes environmental stewardship.
Short-term or Long-term Option	• In the short-term, identify local wineries and begin discussions willingness to participate. One potential entity to contact and partner with is the Washington Winegrowers organization as it already promotes some sustainability initiatives. • In the long-term, set-up either a separate bottle sanitation/washing facility or incorporate these systems at local wineries.
Achievable in the Region	• A total of approximately 11,000 tons of glass is disposed of by Kittitas, Yakima and Grant Counties annually and could instead be diverted. • There are over 1,000 wineries in the state of Washington and about 17.7 million cases of wine are produced annually.[11] This is a widely available end user market.

[11] Washington State Wine. "Stats and Facts." Washington State Wine (washingtonwine.org). (Accessed May 2021).

Table 3-4. Wine Industry Glass Option	
Potential for Job Loss/Creation	• Building an isolated bottle sanitation/washing facility would generate jobs. Incorporating a sanitation/washing station at the winery would also create a need for additional staffing. • Would need to hire people for glass collection system, unless residents or winery visitors themselves are responsible for dropping off their empty bottles directly at the wineries or retail point of sale locations.
Potential Effect on Waste Reduction	• This option would give an end use for glass instead of solely landfill disposal.
Potential Cost Implementations	• Refer to Section 3.5.5 for case study costs associated with existing wine bottle reuse programs and/or standard reuse processes.
General Implementation Requirements	• Secure an end user (e.g., wineries willing to participate). • County would need to determine which collection system would be most ideal, taking into consideration hauling distances and collection points (e.g., curbside, drop-off locations, retail point of sale locations, resident/visitor-sourced drop off directly to wineries). • Ensure no safety hazards and comply with any regulatory standards.

3.5 Probable Capital and Operating Costs

Table 3-5 shows the estimated amount of glass from Kittitas, Yakima, and Grant Counties, which constitutes approximately 2.4 percent of the 2020 waste stream.

Table 3-5. Glass in 2020 MSW Stream	
Area	**Tonnage**
Kittitas[1]	967
Yakima	7,041
Grant	2,832
Total	**10,840**

[1]Kittitas County ceased glass collection in October 2019.

Table 3-6 shows the estimated recovered glass material prices for the Pacific Northwest Region as of March 2021[12] and their potential revenue based on the aforementioned tonnages; however, it was assumed that only 40 percent of the captured glass would be processed well enough to be sellable and generate revenue. While 3-mix is not valuable from a commodities standpoint, as a case study example, Virtuous Products, Inc. (Knoxville, Tennessee) contracts with Cumberland County, Tennessee for its crushed, color-mixed

[12] RecyclingMarkets.net. "Announced Recovered Materials Prices for the Pacific Northwest Region – March 2021." Recycling Markets - Commodity Pricing. (Accessed March 2021).

glass-aggregate (by an Andela Pulverizer system) and pays at a rate of $120 to $150 per ton to eventually make recycled-glass countertops and tables.[13]

Table 3-6. Glass Commodity Prices for Pacific NW and Potential Revenue Based on a 40% Capture Rate[12]

Glass Commodity	Current Average ($)	Kittitas*	Yakima*	Grant*	Total*
Flint ($/ton delivered)	$30	$11,609	$84,495.74	$33,978.24	**$130,082.69**
Amber ($/ton delivered)	$20	$7,739	$56,330.50	$22,652.16	**$86,721.79**
Green ($/ton delivered)	$10	$3,870	$28,165.25	$11,326.08	**$43,360.90**
3-Mix ($/ton delivered as recyclable/disposable – incl. environmental fees/battery surcharge, etc.)	($25)	($9,674)	$(70,413.12)	$(28,315.20)	**$(108,402.24)**

*Note: Estimated that only 40 percent of captured glass is sellable.

Five scenarios were explored for recovered glass processing costs: (1) mobile crushing, (2) build a new glass processing facility, (3) retrofitting an existing glass processing facility (i.e. Seattle's Strategic Materials facility), (4) upgrading an existing MRF to better process and produce cleaner glass, and (5) processing wine bottles for reuse.

3.5.1 Scenario 1 – Mobile Crushing

The use of a mobile crusher could make glass processing an achievable effort at the local level with the ability to produce a 3-mix glass-aggregate at a size of 3/8" minus in a consistency of sand and fine gravel[13] for use as specialty glass or sold for further processing into a pozzolan for portland cement concrete manufacturing or into roadway bead.

The following assumptions were made for this cost analysis:

- To account for a conservative scenario with maximum operating costs, it was assumed all glass tonnage generated in Kittitas, Yakima, and Grant Counties (about 11,000 tons annually) would be processed by 5 total crushers (1 for Kittitas, 3 for Yakima, and 1 for Grant) at a rate of 1 ton per hour; however, the estimated actual glass capture rate would likely be at 40 percent.
- Each mobile crusher would operate at 8 hours per day for 5 days per week for 52 weeks, or 2,080 hours per year.
- It is assumed crushers would be placed in existing structures that have at least a concrete pad and 3-phase electric installation capabilities.[13]
- Glass density is 70 pounds per cubic foot crushed.[14]
- Six 40-cubic yard roll-offs would be needed to store glass and they would be serviced weekly. Each roll-off would cost about $2,500.

[13] Andela Products correspondence May 2021. Contact Us | Andela Products | Richfield Springs, NY.

[14] "User Guidelines for Waste and Byproduct Materials in Pavement Construction – Waste Glass." United States Federal Highway Administration. Waste Glass - User Guidelines - Granular Base - User Guidelines for Waste and Byproduct Materials in Pavement Construction - FHWA-RD-97-148 (dot.gov). (Accessed May 2021).

- Residents drop-off glass themselves to facilities equipped with mobile crushers.
- Pricing does not include process to remove any leftover paper labeling nor color separation.

Table 3-7 identifies the estimated capital costs associated with this scenario.

Table 3-7. Scenario 1: Mobile Crushing Capital Costs

Facility	Description	Glass Total per Week (CY)	Estimated Costs ($)
Glass Storage	Use of six 40-CY roll-offs for all glass storage @ $2,500 each.	220	$14,000
Processing Equipment	**Description**	**Throughput (tph)**	**Estimated Costs ($)**
Crusher	Use of 5 new mobile crushers at a rate of 1 tph to process 11,000 tons of glass material.	1	$26,000
		Subtotal (w/ 5 mobile crushers)	*$144,000*
Other	**Description**	**Percentage (%)**	**Estimated Costs ($)**
Contingency	Equipment contingency	25%	$36,000
Soft Costs	Shipping & Installation	20%	$29,000
		TOTAL	**$207,000**

Table 3-8 identifies the estimated annual operating costs associated with this scenario.

Table 3-8. Scenario 1: Mobile Crushing Annual Operating Costs

Operation	Throughput (tpy)	Cost ($/ton)	Estimated Annual Cost for Total Tonnage ($)
Electrical & Wear Parts	11,000	$6.85	$75,000
Other	**Description**	**Cost ($/hour)**	**Estimated Annual Cost ($)**
Labor	1 laborer per crusher (total 5) for 2,080 hours per year	$20.00*	$208,000
		O&M Costs Subtotal	*$283,000*
		Contingency (10%)	$28,000
		Total	**$311,000**

* Labor rate includes benefits assumed at an additional approximate 35%.

3.5.2 Scenario 2 – Build New Glass Processing Facility

The construction of a new glass processing facility would be beneficial as it could handle glass processing without contamination from other recyclables or non-recyclable materials and could be built to size reduce recovered glass to either aggregate or powder size for purchase. The cost breakdown for this scenario is for three sub-scenarios: (1) a turnkey system equipped with surge hopper, pulverizer, screener, conveyors, service platform, and electrical controls that could remove contaminants and size reduce glass to aggregate size for use as specialty glass[13], (2) a turnkey system also equipped with optical sorters for color separation which would increase revenue based on commodity values, and (3) a turnkey system equipped with optical

sorting as well as a ball mill to size reduce material to glass powder size for use in portland cement concrete production or as roadway bead.

The following assumptions were made for this cost analysis:

- To account for a conservative scenario with maximum operating costs, it was assumed all glass tonnage generated in Kittitas, Yakima, and Grant Counties (about 11,000 tons annually) would be processed; however, the estimated actual glass capture rate would likely be at 40 percent.
- The facility would operate at 8 hours per day for 3 days per week for 52 weeks, or 1,250 hours per year.
- Building cost is estimated $500 per square feet. Building size is estimated at 5,000 square feet (100-ft L:50-ft W). Earthwork and land acquisition costs are not included.
- Glass density is 70 pounds per cubic foot crushed.[14]
- Six 40-cubic yard roll-offs would be needed to store glass and they would be serviced weekly. Each roll-off would cost about $2,500.
- Cost does not include collection and distance hauling to new facility.

Table 3-9 identifies the estimated capital costs associated with this scenario.

Table 3-9. Scenario 2: New GP Facility Capital Costs

Facility	Description	Area (SF)	Estimated Costs ($)
Building	New glass processing facility at 100'x50' @ $500 per SF	5,000	$2.5 million
		Glass Total per Week (CY)	
Glass Storage	Use of six 40-CY roll-offs for all glass storage @ $2,500 each.	220	$14,000
		Facility Subtotal	*$2,514,000*
Processing Equipment	**Description**	**Throughput (tph)**	**Estimated Costs ($)**
(1) Turnkey System (w/ Crusher)	Includes surge hopper, glass pulverizer-screening unit, conveyors, electrical controls and service platform.[13]	10	$302,000
		Subtotal (w/ Facility Subtotal)	*$2.8 million*
Other	**Description**	**Percentage (%)**	**Estimated Costs ($)**
Contingency	Equipment contingency	25%	$704,000
Soft Costs	Shipping & installation	20%	$563,000
		Total (1)	**$4.1 million**
Processing Equipment	**Description**	**Throughput (tph)**	**Estimated Costs ($)**
(2) Turnkey System w/ Optical Sorter	Includes turnkey system w/ pulverizer and optical sorter	10	$840,000
		Subtotal (w/ Facility Subtotal)	*$3.4 million*

Table 3-9. Scenario 2: New GP Facility Capital Costs			
Other	**Description**	**Percentage (%)**	**Estimated Costs ($)**
Contingency	Equipment contingency	25%	$840,000
Soft Costs	Shipping & Installation	20%	$671,000
		Total (2)	**$4.9 million**
Processing Equipment	**Description**	**Throughput (tph)**	**Estimated Costs ($)**
(3) Turnkey System w/ Optical Sorter & Ball Mill	Includes turnkey system w/ pulverizer, optical sorter, and ball mill	10	$2.2 million
		Subtotal (w/ Facility Subtotal)	*$4.7 million*
Other	**Description**	**Percentage (%)**	**Estimated Costs ($)**
Contingency	Equipment contingency	25%	$1.2 million
Soft Costs	Shipping & Installation	20%	$933,000
		Total (3)	**$6.8 million**

Table 3-10 identifies the estimated annual operating costs associated with this scenario.

Table 3-10. Scenario 2: New GP Facility Annual Operating Costs				
Scenario	**Operation**	**Throughput (tph)**	**Cost ($/ton)**	**Estimated Annual Cost for Total Tonnage ($)**
(1) Turnkey System	Electrical & Wear Parts	10	$4.08	$45,000
	Other	**Description**	**Cost ($/hour)**	**Estimated Annual Cost ($)**
	Labor	2 laborers for 1,250 hours per year	$20.00*	$50,000
			O&M Costs Subtotal	*$95,000*
			Contingency (10%)	$9,500
			Total (1)	**$105,000**
Scenario	**Operation**	**Throughput (tph)**	**Cost ($/ton)**	**Estimated Annual Cost for Total Tonnage ($)**
(2) Turnkey System w/ Optical Sorter	Electrical & Wear Parts	10	$9.04	$98,000
	Other	**Description**	**Cost ($/hour)**	**Estimated Annual Cost ($)**
	Labor	3 laborers for 1,250 hours per year	$20.00*	$75,000
			O&M Costs Subtotal	*$173,000*
			Contingency (10%)	$17,000
			Total (2)	**$190,000**

Table 3-10. Scenario 2: New GP Facility Annual Operating Costs

Scenario	Operation	Throughput (tph)	Cost ($/ton)	Estimated Annual Cost for Total Tonnage ($)
(3) Turnkey System w/ Optical Sorter & Ball Mill	Electrical & Wear Parts	10	$21.11	$230,000
	Other	**Description**	**Cost ($/hour)**	**Estimated Annual Cost ($)**
	Labor	4 laborers for 1,250 hours per year	$20.00*	$100,000
			O&M Costs Subtotal	*$330,000*
			Contingency (10%)	$33,000
			Total (3)	**$363,000**

* Labor rate includes benefits assumed at an additional approximate 35%.

3.5.3 Scenario 3 – Existing Glass Processing Facility Retrofit

The retrofitting of an existing glass processing facility to be able to produce glass powder in addition to crushed aggregate would be beneficial as the building structure and main required pieces of equipment are already present. The major piece of equipment that would likely need to be added is a ball mill to further size reduce the aggregate to a powder size for pozzolanic use.

The following assumptions were made for this cost analysis:

- To account for a conservative scenario with maximum operating costs, it was assumed all glass tonnage generated in Kittitas, Yakima, and Grant Counties (about 11,000 tons annually) would be processed; however, the estimated actual glass capture rate would likely be at 40 percent.
- The facility would operate at 8 hours per day for 3 days per week for 52 weeks, or 1,250 hours per year.
- Assumes retrofitting the Seattle Strategic Materials glass processing facility which already includes optical sorters and XRF technology.[6] The main addition would be a ball mill to generate glass powder for pozzolanic use.
- Glass density is 70 pounds per cubic foot crushed.[14]
- Six 40-cubic yard roll-offs would be needed to store glass and they would be serviced weekly. Each roll-off would cost about $2,500.
- Cost does not include collection and distance hauling to Seattle's Strategic Materials facility, which is located at least 100 miles from the aforementioned counties.

Table 3-11 identifies the estimated capital costs associated with this scenario.

Table 3-11. Scenario 3: Retrofit Existing GP Facility Capital Costs			
Facility	**Description**	**Glass Total per Week (CY)**	**Estimated Costs ($)**
Glass Storage	Use of six 40-CY roll-offs for all glass storage @ $2,500 each.	220	$14,000
Processing Equipment	**Description**	**Throughput (tph)**	**Estimated Costs ($)**
Ball Mill	Addition of ball mill to existing Strategic Materials glass processing facility.	18	$1.3 million
		Subtotal (w/ Facility costs)	*$1,314,000*
Other	**Description**	**Percentage (%)**	**Estimated Costs ($)**
Contingency	Equipment contingency	25%	$331,000
Soft Costs	Shipping & Installation	20%	$265,000
		TOTAL	**$1.9 million**

Table 3-12 identifies the estimated annual operating costs associated with this scenario.

Table 3-12. Scenario 3: Retrofit Existing GP Facility Annual Operating Costs			
Operation	**Throughput (tph)**	**Cost ($/ton)**	**Estimated Annual Cost for Total Tonnage ($)**
Electrical & Wear Parts	18	$12.08	$131,000
Other	**Description**	**Cost ($/hour)**	**Estimated Annual Cost ($)**
Labor	1 laborer at 1,250 hours per year	$20.00*	$25,000
		O&M Costs Subtotal	*$156,000*
		Contingency (10%)	$16,000
		Total	**$172,000**

* Labor rate includes benefits assumed at an additional approximate 35%.

3.5.4 Scenario 4 – MRF Upgrade

The retrofitting of an existing MRF with glass recovery would be beneficial as it could clean-up glass processing to make the output product cleaner. The cost breakdown for this scenario is provided on four sub-scenarios: (1) adding a clean-up system that better removes non-glass content contaminants, (2) adding a clean-up system also equipped with optical sorters for color separation to increase revenue based on commodity values, (3) adding a clean-up system equipped with optical sorting as well as a crusher to size reduce material to glass-aggregate size, and (4) adding a clean-up system equipped with optical sorting, a crusher and a ball mill to size reduce material to a glass powder size for pozzolanic properties.

The following assumptions were made for this cost analysis:

- To account for a conservative scenario with maximum operating costs, it was assumed all glass tonnage generated in Kittitas, Yakima, and Grant Counties (about 11,000 tons annually) would be processed; however, the estimated actual glass capture rate would likely be at 40 percent.
- Each clean-up system would operate at 8 hours per day for 3 days per week for 52 weeks, or 1,250 hours per year.

- Assumes upgrading an existing MRF to process and output cleaner glass.
- Glass density is 70 pounds per cubic foot.[14]
- Six 40-cubic yard roll-offs would be needed to store glass and they would be serviced weekly. Each roll-off would cost about $2,500.
- Cost does not include collection and distance hauling to existing MRF.
- Operating costs do not include MRF operating costs for other present materials (e.g., metal, paper, and plastic separation).

Table 3-13 identifies the estimated capital costs associated with this scenario.

Table 3-13. Scenario 4: MRF Upgrade Capital Costs

Facility	Description	Glass Total per Week (CY)	Estimated Costs ($)
Glass Storage	Use of six 40-CY roll-offs for all glass storage @ $2,500 each.	220	$14,000
		Facility Subtotal	*$14,000*
Processing Equipment	**Description**	**Throughput (tph)**	**Estimated Costs ($)**
(1) Clean-up System	Based on a single-stream system that includes adjustable sizing screens, closed air separation with the glass removed at presort, protected storage bunkers, and non-glass content reintroduced to the main line.[15]	10	$736,000
		Subtotal (w/ Facility costs)	*$750,000*
Other	**Description**	**Percentage (%)**	**Estimated Costs ($)**
Contingency	Equipment contingency	25%	$187,000
Soft Costs	Shipping & Installation	20%	$150,000
		Total (1)	**$1.1 million**
Processing Equipment	**Description**	**Throughput (tph)**	**Estimated Costs ($)**
(2) Clean-up System w/ Optical Sorter	Includes clean-up system w/ optical sorter	10	$1.3 million
		Subtotal (w/ Facility costs)	*$1,314,000*
Other	**Description**	**Percentage (%)**	**Estimated Costs ($)**
Contingency	Equipment contingency	25%	$322,000
Soft Costs	Shipping & Installation	20%	$257,000
		Total (2)	**$1.9 million**

[15] "Glass Clean-up Systems in MRF." April 2017. Closed Loop Foundation. PowerPoint Presentation (closedlooppartners.com). (Accessed May 2021).

Table 3-13. Scenario 4: MRF Upgrade Capital Costs			
Processing Equipment	**Description**	**Throughput (tph)**	**Estimated Costs ($)**
(3) Clean-up System w/ Optical Sorter & Crusher	Includes clean-up system w/ optical sorter and crusher	10	$1.4 million
		Subtotal (w/ Facility costs)	*$1,414,000 million*
Other	**Description**	**Percentage (%)**	**Estimated Costs ($)**
Contingency	Equipment contingency	25%	$357,000
Soft Costs	Shipping & Installation	20%	$285,000
		Total (3)	**$2.1 million**
Processing Equipment	**Description**	**Throughput (tph)**	**Estimated Costs ($)**
(4) Clean-up System w/ Optical Sorter, Crusher & Ball Mill	Includes clean-up system w/ optical sorter, crusher and ball mill	10	$2.7 million
		Subtotal (w/ Facility costs)	*$2,714,000 million*
Other	**Description**	**Percentage (%)**	**Estimated Costs ($)**
Contingency	Equipment contingency	25%	$684,000
Soft Costs	Shipping & Installation	20%	$547,000
		Total (4)	**$4.0 million**

Table 3-14 identifies the estimated annual operating costs associated with this scenario.

Table 3-14. Scenario 4: MRF Upgrade Annual Operating Costs				
Scenario	**Operation**	**Throughput (tph)**	**Cost ($/ton)**	**Estimated Annual Cost for Total Tonnage ($)**
(1) Clean-up System	Electrical & Wear Parts	10	$6.79	$74,000
	Other	**Description**	**Cost ($/hour)**	**Estimated Annual Cost ($)**
	Labor	2 laborers for 1,250 hours per year	$20.00*	$50,000
			O&M Costs Subtotal	*$124,000*
			Contingency (10%)	$12,000
			Total (1)	**$136,000**
Scenario	**Operation**	**Throughput (tph)**	**Cost ($/ton)**	**Estimated Annual Cost for Total Tonnage ($)**
(2) Clean-up System w/ Optical Sorter	Electrical & Wear Parts	10	$11.75	$127,000
	Other	**Description**	**Cost ($/hour)**	**Estimated Annual Cost ($)**
	Labor	3 laborers for 1,250 hours per year	$20.00*	$75,000

Table 3-14. Scenario 4: MRF Upgrade Annual Operating Costs				
			O&M Costs Subtotal	*$202,000*
			Contingency (10%)	$20,000
			Total (2)	**$222,000**
Scenario	**Operation**	**Throughput (tph)**	**Cost ($/ton)**	**Estimated Annual Cost for Total Tonnage ($)**
(3) Clean-up System w/ Optical Sorter & Crusher	Electrical & Wear Parts	10	$13.03	$142,000
	Other	**Description**	**Cost ($/hour)**	**Estimated Annual Cost ($)**
	Labor	4 laborers for 1,250 hours per year	$20.00*	$100,000
			O&M Costs Subtotal	*$242,000*
			Contingency (10%)	$24,000
			Total (3)	**$266,000**
Scenario	**Operation**	**Throughput (tph)**	**Cost ($/ton)**	**Estimated Annual Cost for Total Tonnage ($)**
(4) Clean-up System w/ Optical Sorter, Crusher & Ball Mill	Electrical & Wear Parts	10	$25.10	$272,000
	Other	**Description**	**Cost ($/hour)**	**Estimated Annual Cost ($)**
	Labor	4 laborers for 1,250 hours per year	$20.00*	$100,000
			O&M Costs Subtotal	*$372,000*
			Contingency (10%)	$37,000
			Total (4)	**$409,000**

* Labor rate includes benefits assumed at an additional approximate 35%.

3.5.5 Scenario 5 – Wine Bottle Reuse

In order to reuse wine bottles, residents would have to drop-off their empty bottles either to separate washing facility or to wineries and the wineries would have to be equipped with machinery that could thoroughly clean and sanitize the bottles while also properly removing old labeling.

The following are case study examples of wine bottle reuse programs and associated costs:

- Bunker Hill Vineyard and Winery in Parrish, Florida uses 100 percent recycled wine bottles. The winery owners either pay for the shipping for customers to send back their empty wine bottles or visitors bring their empty bottles to the winery. While sanitizing the bottles for reuse is not as cost-efficient as buying new bottles the owners feel reusing bottles is the environmentally responsible

thing to do.[16] As of 2015, the winery had repurposed about 54,000 bottles since its opening in 2010 and have reduced their carbon footprint by 60 percent.[17]

- Of the approximately 147,000 tons of wine bottles in Catalonia, about 43 percent of the bottles are not reused.[18] The reWine project established for southern Europe has a main objective to demonstrate the viability of a sustainable system for the collection, cleaning, and reuse of glass bottles in the Catalan wine industry. As part of the project, consumers, producers, bars, restaurants, wholesalers and shops were involved in a pilot study focusing on the reuse of wine bottles, from washing, labelling, bottling and distribution on the market and until their collection.

This sanitation process involved the following steps (as shown in Figure 3-1):

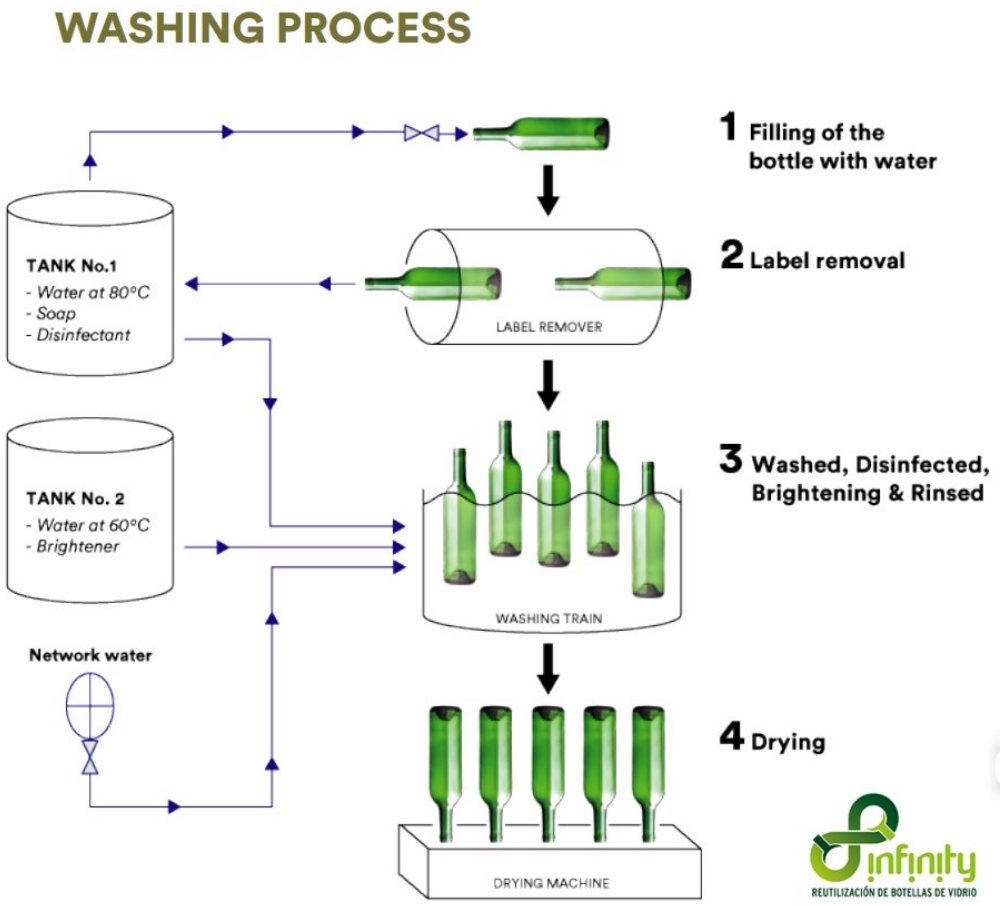

Figure 3-1. Wine bottle sanitation process for reuse. [18]

[16] Button, K. October 2015. "Meet the Winery That's Never Purchased a Wine Bottle." Earth911. Meet the Winery That's Never Purchased a Wine Bottle | Earth911. (Accessed May 2021).

[17] "Recycling." Bunker Hill Vineyard & Winery. Bunker Hill Vineyard (Accessed May 2021).

[18] "Environmental Feasibility of Wine Glass Packaging Reuse Scenarios in Catalonia." reWine. PosterReWine_RGB. (Accessed May 2021).

The average cost to wash a bottle was found to be about 0,15 Euros ($0.18 US) per bottle.[19] Based on the size of the winery and other listed logistical factors, the average costs of a reused bottle (in Euro per bottle; 1 Euro equates to $1.20 US) versus a new bottle were reported as follows with reused bottles generally costing slightly more:

		Cost of a reused bottle			Cost of a new bottle
		Average cost (€/bottle)	Min. cost (€/bottle)	Max. cost (€/bottle)	€/bottle
A. HORECA	A1. MEDIUM SIZE WINERY	1,23	1,17	1,31	1,17
	A2. LARGE WINERY	0,33	0,26	0,41	0,29
B. LARGE RETAIL+ logistics	B1. MEDIUM SIZE WINERY AND RETAIL	4,89	0,36	7,21	0,35
	B2. SMAILL SIZE WINERY AND RETAIL	0,7	0,65	0,8	0,65
C. Small retail + wine tasting	C1. SMALL WINERY AND TASTE	0,73	0,67	0,84	0,67
	C2. SMALL WINERY AND LOCAL STORES	0,75	0,67	0,85	0,67
D. Integrated washing	D1. SMALL WINERY AND INTEGRATED WASHING	0,6	0,6	0	0,61
E. Retail+ waste collection point	E1. MEDIUM SIZE WINERY+RETAIL	1,23	1,17	1,33	1,17
	E2. LARGE WINERY+RETAIL	0,34	0,26	0,44	0,26

Figure 3-2. reWine bottle cost assessment for wine bottle reuse versus single-use.[19]

Some of these costs, however, could be offset through reducing distance to a standalone washing facility and/or by having an on-site integrated washing system (cost would be around 0,13 Euro, or $0.16 US, instead of 0,15 Euro, or $0.18 US).

Approximately 17.7 million cases of wine are produced at Washington wineries annually.[11] Assuming there are 12 bottles to a case, that equates to about 212 million bottles. If, for example, the cost of wine bottle reuse for a medium-sized winery from the reWine study (1,23 Euros or $1.48 US per bottle) was taken and applied to just 1 percent of the State's wine bottle production number, the cost to sanitize and reuse wine bottles would be approximately $3.1 million. In comparison, using the cost of a new bottle for a medium-sized winery based on the reWine study (1,17 Euro or $1.40 US) and applying it to only 1 percent of the total number of Washington winery bottles annually produced, the cost would be approximately $3.0 million, or just $100,000 less. In the same sentiment, wine bottle washing costs for the same 1 percent scenario for a medium-sized winery at $0.18 per bottle would be approximately $382,000.

- One suggested piece of equipment needed for bottle labeling removal is a fluid bed dryer to burn away paper and contaminants. This piece of equipment, based on a 20 ton per hour system, can cost an average of approximately $800,000.[20] The annual operating cost would be approximately $80,000 assuming the annual operating cost is about 10 percent of the capital cost.
- An alternative equipment piece to the fluid bed dryer is a water bubble tank which can retail, based on a 20 ton per hour system, for about $190,000.[20] While more inexpensive, it is not as efficient at removing contaminants.

[19] "Project Feasibility Report." November 2020. reWine. PROJECT FEASIBILITY REPORT (rewine.cat). (Accessed May 2021).

[20] "System and Process for Producing Clean Glass Aggregate from Recycled Glass." 2005. US20060243301A1 - System and process for producing clean glass aggregate from recycled glass - Google Patents. (Accessed May 2021).

3.5.6 Summary of Scenarios

A summary of the aforementioned five recovered glass processing scenarios, including capital and operating costs, is in Table 3-15 below.

Table 3-15. Summary of Scenario Capital and Operating Costs

Scenario	Total Capital Costs ($)	Total Operating Costs ($)
1. Mobile Crushing	$207,000	$311,000
2. New GP Facility		
(1) Turnkey System (w/ Crusher)	$4.1 million	$105,000
(2) Turnkey System w/ Optical Sorter	$4.9 million	$190,000
(3) Turnkey System w/ Optical Sorter & Ball Mill	$6.8 million	$363,000
3. Retrofit Existing GP Facility	$1.9 million	$172,000
4. MRF Upgrade		
(1) Clean-up System	$1.1 million	$136,000
(2) Clean-up System w/ Optical Sorter	$1.9 million	$222,000
(3) Clean-up System w/ Optical Sorter & Crusher	$2.1 million	$266,000
(4) Clean-up System w/ Optical Sorter, Crusher & Ball Mill	$4.0 million	$409,000
5. Wine Bottle Reuse (see case studies in Section 3.5.5)	$800,000+ (for fluid bed dryer)	$0.40-$1.50 per bottle to reuse

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4 Commingled Recyclables

The following section presents the commingled recyclables practices and initiatives, for potential implementation, that were selected for future management and infrastructure needs in the region.

4.1 Overview

A Clean Material Recovery Facility (MRF) processes source-separated, commingled recyclables so they no longer are disposed of in area landfills and are shipped to other facilities as commodities. For planning purposes, this section includes information on a Single-Stream MRF-type facility similar to the existing MRF owned by Larimer County, Colorado and currently operated by Waste Management of Colorado and a smaller version of a MRF operated by Douglas County in Washington. Single-stream sourced materials are assumed to be "clean" by virtue of segregation from MSW. This allows Single-Stream/Clean MRFs to have relatively high recovery rates and low residue/contamination rates. Typically, materials managed at a MRF include various types and grades of containers and paper products (fiber), the most common of which include:

- Aluminum (used beverage cans)
- Steel cans (tin cans typically used for canned foods)
- Scrap metal (mixed types of non-container metal)
- Plastic containers
- Glass containers
- Newspaper or old newspaper (ONP)
- Cardboard or old corrugated cardboard (OCC)
- Mixed paper (MP)

There are several types of Clean MRFs, the most common of which include dual-stream and single-stream MRFs. A dual-stream MRF receives the containers separately from the paper or fiber materials because the collection system uses two bins for recyclables and thus sorts the containers and fiber materials on two separate processing lines. Single-stream recycling collects all the recyclable materials in a single bin or container, and the MRF equipment must separate the containers from the fiber materials and then into the designated commodities. For this discussion, a single-stream MRF, the most common type of MRF, is assumed. It should be noted that the principles, costs, and impacts are similar for a dual-stream MRF, with a few exceptions.

MRF technology is constantly changing with new approaches that better separate and process the mixed stream into commodities. MRFs have moved away from a simple conveyor with sorters on both sides to screening devices that separate materials by their varying properties. Optical sorters in use today, when properly arranged, are much more efficient than manual sorters, but still require quality control measures. Robotic sorting is beginning to be applied and, while faster than manual sorting at identifying target materials, still needs some development before it will be common on process lines. At the same time, the material mix and characteristics of the various fiber and container materials are constantly changing as well. These factors, plus changes in markets and local needs, all add up to a facility that will need steady

updating on a periodic basis. Few MRFs operate for more than about 5 to 10 years without major changes and equipment updates.

In 2020, 2,780 tons of recyclable were collected in Kittitas County, 220 tons in Yakima County and 6,900 tons in Grant County for a total of 9,900 tons. Yakima County tonnage does not include recyclable materials collected curbside as those commodities are collected and recycled separately.

In addition, based on Ecology's Waste Characterization Study, paper packaging and products account for 14.9 percent and plastic packaging and products account for 14.1 percent of materials remaining in the waste stream. Based on Table 1-2. Waste Characterization Potential Materials Remaining in Waste Stream, utilizing a conservative estimate of a 20 percent capture rate for diversion from the disposed paper and plastic fraction of 131,000 tons, the region has the potential to recycle an additional 26,200 tons of commingled recyclables through a regional facility for a total of 36,100 tons.

4.2 Clean Materials Recycling Facility

A Clean MRF can be sized to meet the needs of the County and their regional partners. As an example, Douglas County, Washington, has an established rural drop-off recycling program utilizing collection trailers. These sites are serviced by the Solid Waste Programs Office, and collected recyclables are processed at the Douglas County Processing and Recycling Center. Collected recyclables are sorted, processed, and stored until a sufficient quantity is available for transportation to market. The designated recyclables collected at the drop-off sites are determined by their current market value. Douglas County accepts the following commodities for processing and marketing:

Figure 4-1. Douglas County Baler

- Source-separated newspaper
- Phonebooks
- Magazines/Catalogs
- Corrugated cardboard
- Mixed residential paper
- Steel/Tin cans
- Aluminum cans
- Polyethylene terephthalate (PET) #1 – Soft drink bottles, sport drinks –clear plastic beverage containers
- High-density polyethylene (HDPE) #2 – Milk jugs, juice jugs –clear or opaque plastic beverage containers

As a regional approach, the County could consider siting a larger Clean MRF to process recyclable commodities, including Yakima and Grant County's materials. Larimer County, Colorado, currently owns and contract operates a recycling center for all recyclables collected in the County. Larimer County currently accepts the following recyclable commodities:

- Office paper
- Newspaper
- Corrugated cardboard
- Paperboard and low-grade paper
- Glass bottles and jars
- Aluminum
- Tin

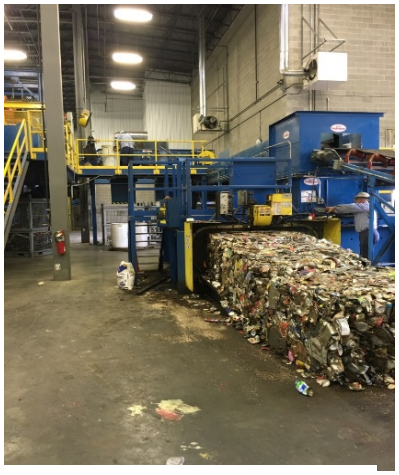

Figure 4-2. Larimer County MRF

Larimer County processes approximately 40,000 tons of materials per year through their MRF and provides pricing for recyclable commodities that is updated monthly, which can be found on their website at: https://www.larimer.org/solidwaste/prices.

4.3 Review of Markets

There are existing markets for source-separated recyclable materials, many of which fluctuate depending on the season, overseas markets, shipping container availability, and economic conditions. Marketing commingled recyclable materials is much more challenging with limited market availability. The following provides a brief overview of some markets for source-separated recyclable materials.

Paper/Fiber

Currently, cardboard and paper collected in Kittitas and Yakima counties is taken to Michelsen Packaging in Yakima for processing into fruit-packing materials. Cardboard and paper collected in Grant County is taken to various processors in the state. With a local option for fiber, the market is stable in Central Washington for these types of materials. In 2019, NORPAC, which is located in Longview, Washington, pledged to bring in an additional 400,000 tons per year of recycled paper as it shifts one-third of its production capacity into packaging production. This expansion, when completed, is predicted to have the ability to consume all available mixed paper grades in Washington, Oregon, and Idaho.

PET (#1) and HDPE (#2) Plastics

Markets for mixed plastics are currently weak to non-existent due to the restrictions on contamination standards by China. To have a marketable material, PET and HDPE would need to be sorted carefully and markets would need to be established.

Aluminum and Tin

Aluminum prices were weak in 2020 but are expected to see some stabilization in 2021 with tin and steel prices fluctuating heavily. There are local markets for these materials in the Portland and Seattle areas such as Schnitzer Steel.

Glass

Information on glass markets and options is included in Section 3– Glass Recycling.

4.4 Recommendations for Commingled Recycling

The following actions are recommended related to potential development of capacity for commingled recycling in the region:

- Consider forming a regional working group to develop a consistent approach to commingled recyclables management.
- Identify potential public/private partnership opportunities available for recycling of commingled recyclables.
- Solicit community input relating to commingled recyclables and potential disposal bans to be considered.
- Develop a business case to support commingled recyclables management which would include: current and future state waste characterization information, tonnage projections, impacts of state legislation, project options (technology, ownership, procurement approaches).
- Conduct a siting study to locate a suitable area for a commingled recycling facility.
- Identify procurement model and initiate procurement process for development of a commingled recycling facility if option is determined to be viable.
- Identify end-markets of recyclable materials and initiate contracts for sale of materials if viable.

Table 4-1 presents an overview of commingled recycling.

Table 4-1. Commingled Recycling Option – Clean MRF

Description of Option	• Development of a regional clean MRF.
Actions/Potential Challenges	• County can facilitate interlocal cooperation in the region for recycling of commingled and/or further source separated materials. • Region can promote recycling of materials cooperatively. • Regional partnerships would need to be developed and maintained to support a clean MRF. • Placing materials bans from disposal may be necessary to achieve tonnage needed to effectively operate a facility. • Recyclable materials may not be readily available in the region and would require partnerships with other municipalities or the establishment of public/private partnerships. • Current contractual relationships with private industry may need to be modified to allow for implementation of a clean MRF in the region.
Rationale for Consideration	• This option has the potential to divert recyclable materials from disposal. • This option has the potential to bring jobs into the community.
Short -term or Long-term Option	• Implement in the medium term, sustain over the long term if viable.

Table 4-1. Commingled Recycling Option – Clean MRF	
Achievable in the Region	• Potential to achieve in the region.
Potential for Job Loss/Creation	• High potential for job creation through development of a regional facility.
Potential Effect on Waste Reduction	• Assuming a capture rate of 20% there is the potential for waste reduction with diversion of 36,100 tons of recyclables annually from the regional waste stream.
Potential Cost Implementations	• Refer to Section 4.5 for probable capital and annual operating costs. • Significant costs for sorting equipment and labor to meet the strict material cleanliness requirements. • Recycling markets and revenues can vary greatly as shown over past five years.
General Implementation Requirements	• A full scale program may require mandatory curbside collection of recyclable materials and potentially drop-off sites as well. • County could implement a mandatory recycling ordinance for the commercial sector, followed by one for the residential sector as processing capacity becomes available. • For optimal results, the program should be implemented regionally with additional partner participation. • Commingled recycling collection could be added to existing collection services or through separate collection routes. • County would need to secure or develop processing capacity. • County would need to determine if in-County facility might be co-located with other facilities (i.e. part of Resource Recovery Park or new Ellensburg Transfer Station complex). • County would need to identify a business model (e.g. DBO-Design-Build-Operate) and procurement process (e.g. REOI, RFQ, or RFP).

4.5 Probable Construction and Operating Costs

A clean MRF sized for annual throughput of 36,100 tons commingled recyclables is estimated to require an approximate 43,000 square-foot building for material receipt, sorting and processing, baling, bale storage and loose material storage. Existing recyclables and new diversion would need to be directed to this regional facility. Table 4-2 provides a summary of the annual recyclables tonnage potentially diverted for the region.

Table 4-2. Commingled Recyclables Diversion			
Materials	**Captured Recyclables (Tons)**	**Existing Recyclables (Tons)**	**Total**
Papers/Fibers	13,460	9,636	23,096
Plastics #1 and #2	12,737	70	12,807
Aluminum	-	76	76
Tin	-	25	25
Glass	-	97	97

The following assumptions were made for this cost analysis:

- Site topography is relatively flat with stable soils.

- Construction and operating costs assume new site and building.
- MRF operations assume one-shift 8 hours per day, 5 days per week for 52 weeks.
- MRF processing equipment includes feeder, conveyors, sorting stations, bunkers, screens, separators, optical sorter, magnets, eddy-current separator and 2 balers.
- Land purchase price not included in costs.
- Costs do not include collection, remote drop-off sites or hauling to the MRF.
- Trailers for haul of recovered materials not included.

Table 4-3 identifies the estimated capital costs associated with this scenario.

Table 4-3. Clean MRF Capital Costs

Facility	Description	Area (SF)	Estimated Costs ($)
Site Work	Earthwork, roadways, stormwater management, utilities, fencing, landscaping	5.5 acres	$1.07 million
MRF Building	Pre-engineered building with electrical, mechanical, fire protection, loading docks, concrete & foundations	43,000	$6.50 million
Elevated Gallery	Office, conference room, education center, locker rooms	2,500 (within MRF Building footprint)	$310,000
Scale House & Scale	Scale house, truck scale and software system	300	$230,000
		Facility Subtotal	*$8.1 million*
Other	**Description**	**Percentage (%)**	**Estimated Costs ($)**
General Contractor Fees	General contractor markup	10%	$810,000
Contingency	Construction & equipment contingency	25%	$2.03 million
Soft Costs	Design, construction management, soils investigations, permitting	20%	$1.62 million
		Total Facility	**$12.9 million**
Processing Equipment	**Description**	**Throughput (tph)**	**Estimated Costs ($)**
Recycling Process Equipment	Infeed, conveyors, sorting stations, bunkers, screens, separators, optical sorters, magnets, eddy-current separator, balers with installation & startup	15-20	$8.40 million
Mobile Equipment	Front-end loader, skid loader, forklift, 3 roll-off containers, roll-off truck	NA	$624,000
		Subtotal Equipment	*$9.0 million*
Other	**Description**	**Percentage (%)**	**Estimated Costs ($)**
Contingency	Equipment	10%	$900,000
		Total Processing Equipment	**$9.9 million**

Table 4-4 identifies the estimated annual operating costs associated with recycling approximately 36,100 tons per year of commingled recyclables.

Table 4-4. Clean MRF Annual Operating Costs

Operations	Description	Estimated Annual Cost ($)
Labor	21 to 22 FTE including shift foreman, 15 sorters/laborers, 2 heavy equipment operators, 1 baler operator, 2 mechanics, fraction of manager and marketer	$1.12 million
Facility Maintenance & Coverage	Insurance estimated at 1% of buildings & equipment costs; site maintenance at 2% site work; and building repair/depreciation at 3% of building	$359,000
Equipment O&M	Maintenance and fuel costs on estimated hours of operation for each equipment	$340,000
Utilities	Electricity, heating, water, sanitary sewer and communications	$357,000
Residuals Haul & Disposal	Assumes 15% contamination on top of the commingled recyclables (equals 5400 tpy)	$682,000
	O&M Costs Subtotal	*$2.80 million*
	Contingency (10%)	$280,000
	Total Annual O&M Cost	**$3.1 million**
	O&M Cost per Ton	**$85/ton**

Revenue from the sale of recyclables will help off-set some of the operating costs. Assuming current average market rates for various recovered materials and estimated $30 per ton cost for trailer haul to markets, potential revenue could be between $5.0 to $5.2 million annually.

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5 Construction and Demolition Debris Diversion

The following section presents the C&D debris diversion practices and initiatives, for potential management implementation, that were selected for future material management and infrastructure needs in the region.

5.1 Overview

Processing of C&D materials is a process that can vary according to the types of materials available and the demand (markets) for the materials that can be developed from the process. C&D processing facilities are common in regions where there are high disposal fees or high landfill diversion requirements. Some C&D processing facilities tend to focus on specific materials such as lumber/woody wastes as opposed to concrete and asphalt. For the purposes of this study, we focus on construction materials (e.g., wood, drywall, asphalt shingles, concrete, metals).

The C&D process begins with construction materials receipt onto a tipping floor (or outdoor pad in some cases). Materials are first viewed visually, and mobile equipment is used to remove large or bulky items or high-value materials. Typically, a loader or a grapple is used to lift and place materials onto a conveyor or surge hopper to convey the material to the sort lines and mechanical equipment for separation. In most cases, a combination of mechanical equipment and manual labor is used to separate the material into various commodities. The types of processing that can be used include:

- Air separators: To separate small pieces of paper
- Magnets: To recover ferrous metal
- Optical-sorting: To separate wood and aluminum
- Vacuum system: To separate film plastics
- Vibratory screen (small stones/rocks): To separate small stones/rocks, which will be reused for construction and will avoid use as alternative daily cover
- Vibratory screen (wood): To separate wood

These types of facilities usually recover between 70 and 80 percent of the material they process. The optimal capacity is in the range of 300 tons per day per infeed line. The C&D processing equipment can have a useful operating life of approximately 7 to 10 years, as these facilities operate under difficult conditions. Many C&D facilities are retrofitted throughout their life with new processing equipment as needed.

Kittitas, Yakima and Grant counties are currently landfilling C&D received through their operations. The County operates a separate limited purpose landfill which accepts approximately 9,000 tons per year of mixed C&D materials and is currently segregating concrete and asphalt for reuse.

Based on Ecology's Waste Characterization Study and Table 1.2 – Waste Characterization Potential Materials Remaining in Waste Stream, utilizing a conservative estimate of 20 percent capture rate for diversion from the disposed C&D material fraction of 77,236 tons, the region has the potential to recycle an additional 15,500 tons of material through a regional facility.

5.2 Examples of Facilities Handling C&D

The following provides an overview of two approaches to handling of C&D materials. The Waste Management (WM) facility processes loads of mixed C&D waste, whereas the Factoria Transfer Station in King County, Washington requires that the parties delivering loads physically separate the C&D materials, which are sent elsewhere for processing.

Waste Management

WM's bulk waste facility, located in Davis, Florida, is located on 15 acres of land and brings in 22,425 cubic yards of C&D, yard waste, and bulk waste per day. The facility is reported to divert 75 percent of C&D materials for recycling or reuse. The facility sorts concrete, wood, and metal using a conveyor line that processes 750 cubic yards per hour. The concrete, wood, and metal are separated using both positive and negative sorting. The recovered concrete is crushed and used as a road base, the clean wood is ground and used as mulch, and the metals are collected and sold into the market. A layout of the facility can be seen in Figure 5-1.[21]

Figure 5-1. Layout of Waste Management C&D Facility

King County, Washington

King County, Washington recently completed construction of a new transfer station at a cost of $92.8 million (the Factoria Recycling and Transfer Station). The 80,000-square-foot facility handles 225,000 tons annually, including clean wood, scrap metal, green waste, hazardous waste, asphalt, and trash. This gold LEED and SWANA gold excellence winner was designed to be flexible and to allow materials to be more easily recovered for recycling. The facility began operation in October 2017 and was anticipated to recover approximately 5,000 tons of wood, metal, yard waste, and other recyclables in its first year of operation.

[21] Bloch, Emily, South Florida Sun Sentinel. "Waste Management premiers new recycling facility in Davie." http://www.sun-sentinel.com/community/the-trailblazer/fl-dcg-waste-management-facility-20180510-story.html. (Accessed December 2018).

There are dedicated areas for appliances, carpet, tires, shingles, and mattresses and other indoor areas for collecting and sorting clean wood, scrap metal, and other materials.[22]

5.3 Potential Recovered Materials

C&D debris is generated when new and existing buildings are renovated or demolished and when highway and street projects occur. Commonly recovered C&D materials include concrete, wood, bricks, shingles, drywall, metals, rigid plastics, OCC, and fines. Below are some common C&D materials that can be recovered:

Concrete

A significant volume of concrete is generated during the early phases of construction projects. Recycling concrete is beneficial because it is diverted from disposal and used to replace virgin materials such as gravel. Concrete is crushed to reduce the particle size and then screened to remove oversized pieces. This material is mixed with clean concrete to create a valuable product.

Wood

Wood products are extensively used for building construction and outdoor structural applications (fences, decks, utility poles) in the U.S.. Wood products enter the C&D stream as scrap both from new construction and from the demolition of in-service wood structures. Depending on the application, some wood products may be treated with chemicals to delay biological decay. Wood in the C&D stream is generally commingled with other building components and needs to be separated using manual and mechanical techniques. Source-segregated wood from construction projects or wood product manufacturing plants may be processed at facilities that solely process wood. The wood is typically ground for most of its current common end uses. The ground material then may be passed through a screen to remove wood fines. The remains from the screen are conveyed under a magnet to extract any ferrous materials such as screws, hinges, and nails. Larger wood chips can be used as boiler fuel, and the clean lumber is often used to produce mulch. Contamination from pressure-treated wood, painted wood, and particle board and plywood (glue) are a concern.

Shingles

Asphalt shingles consist of an asphalt-impregnated mat, the bottom of which is coated with a fine mineral surface and the top of which is coated with a colored coarser mineral fraction. Re-roofing projects produce a relatively large amount of uniform material over a short time. Asphalt shingles constitute a large fraction of the roofing loads. Re-roofing projects are associated with wastes that are considered contamination to the asphalt shingles, which reduces the quality and market for these materials. On-site separation for re-roofing projects is preferred to promote recycling. During shingle recycling, shingles are sorted, cleaned, and then processed into dry granular asphalt pieces that can then be used to make hot mix asphalt (HMA).

[22] King County Solid Waste Division. "Factoria Recycling and Transfer Station." https://swana.org/Portals/0/Awards/2018/Winners/Excellence2018-CT-TS-gold.pdf. (Accessed January 2019).

Drywall

Gypsum drywall (also referred to as wallboard or plaster board) is a major interior wall material in residential and commercial buildings in the U.S. Drywall consists of a gypsum core, which constitutes 90 percent of the weight of the drywall product, covered on each side with a paper backing. A relatively large percentage is wasted during construction compared to other materials, as drywall must be cut to meet the interior wall dimensions and openings of the building. It should be noted that it is easier to find markets to recycle clean drywall scraps (i.e., generated during construction) into new drywall, but that there are fewer facilities that will accept drywall recovered through building demolition.

Metals

To recover metals, magnets can be placed at different parts of a processing system, a metal grappler can be employed or materials can be hand separated. For a mixed C&D system, a magnet is used to remove any ferrous materials. During the screening process of concrete, a magnet can be used as the primary operation to remove all the bulky metals, and hand picking can come secondarily to remove the smaller pieces that would otherwise be missed. Ferrous materials can then be sold directly into the market. Other large ferrous and non-ferrous materials can be removed in standard picking operations. Typical examples include metal framing joists, wiring, conduit, and various hardware.

Old Corrugated Cardboard (OCC)

OCC is another material that can come from many construction projects. This material can be separated using processing equipment at a MRF, or it can be separated by hand, baled, and sold into the market to be made into new cardboard products, compost, or roofing felt.

C&D Fines

With C&D debris processing systems, a fines component can be one of the largest fractions recovered. While the composition will vary based on the source material and the equipment design, this material can be anywhere from 2 inches to ¾ inch minus gradation. Depending on regulations, this material is typically used as an alternative daily cover at MSW and C&D landfills. In some cases, this material is used as non-structural fill for developments or grading at golf courses, where the material is ultimately covered by other materials, and when certain criteria are met regarding the material leaching potential for certain groundwater analytes. The composition of C&D fines may include sand, grit, organics, small paper, crushed block/brick, and drywall. The majority of facilities that recover concrete fines use it as landfill alternative daily cover.

5.4 Review of Markets

There are a few existing markets for C&D materials, many of which fluctuate depending on the season and economic conditions. The following provides a brief overview of some markets for C&D materials.

Concrete/ Asphalt Recycling

Washington State has developed strategies for reuse and recycling of construction aggregate and recycled concrete materials as required by Revised Code of Washington 70A.205.700. The County should consider the amount of recycled materials that can be used in the bidding process for stakeholder construction

projects. Recycled concrete, when crushed, can be used as a substitute for limestone aggregate; as a foundation for roadway pavement, soil stabilization, and pipe bedding; and as landscape material.

Clean Wood

Fuel and color mulch production are the largest markets for recovered C&D wood. The County should consider collaborating with existing C&D facilities to explore opportunities to enhance wood recovery and recycling. The County could include specs for mulch made from recycled material as part of their operations. Unless there is a market for clean wood in the area, it may not be feasible to separate this material.

Shingles

The production of HMA is one of the major uses of the recovered shingles. The County should consider engaging roofers, the Central Washington Home Builders Association and HMA plant operators within the County and region for exploring the technical feasibility of this end use. Alternate uses for recycled shingles include dust control on rural roads, cold patch, and temporary roads or driveways.

Drywall

The County could work with C&D recyclers and the agricultural industry in the County to explore opportunities to recover and recycle drywall. Gypsum can be used as a soil amendment and can improve soil drainage and plant growth.

Metals

Ferrous materials can be sold directly into the market when separated.

5.5 Recommendations for C&D Diversion

The following are recommendations intended to increase diversion of C&D materials in the short term:

- Consider forming a regional working group to develop a consistent approach to C&D materials management.
- Explore opportunities to develop markets for recycled C&D materials, which could include requirements for certain recycled content of materials used by County departments/divisions.
- Investigate ways to increase procurement opportunities to include items with recycled content or derived from diverted materials, including recycled C&D materials for projects such as paving, etc.
- Continue to work cooperatively to develop potential C&D diversion ordinances to ensure construction waste is being diverted properly.
- Continue to segregate potential reusable C&D materials at the landfill, such as asphalt and concrete, and develop markets for other segregated materials such as metals and drywall.
- Consider C&D recycling opportunities that can be accomplished at a resource recovery park (as discussed in Section 6).

In the mid to long term, the following recommendations are presented:

- Conduct a business case for development of a C&D recycling facility to understand the return on investment for a new facility. The County could undertake a business plan for the development of

a C&D recycling facility, evaluate existing and future markets for recovered materials, and partnership opportunities with private industry.

Table 5-1. C&D Diversion Option	
Description of Option	• Encourage C&D diversion through additional regional programs and ordinances. • Construct a C&D materials recycling facility.
Actions/Potential Challenges	• Recycled C&D waste can also be used for new construction projects preserving virgin materials. • Markets for some materials are developing. As markets develop this will make recycling more financially viable. • Current volumes of C&D are limited due to small volumes and privately operated limited purpose landfills in the region. • It will be challenging for a County-owned facility to compete with the private sector. • Habitat for Humanity is a well-established business model that should be included in future opportunities for greater C&D diversion.
Rationale for Consideration	• Recovering C&D diverts materials from landfill disposal. • Other jurisdictions in Washington State have enacted ordinances requiring diversion of C&D materials. • The County is expected to see increased growth and construction over the foreseeable future.
Short -term or Long-term Option	• Implement in the short to mid-term, sustain over the long-term.
Achievable in the Region	• Potential to achieve in the region.
Potential for Job Loss/Creation	• Potential for job creation through the procurement of environmentally preferred products in increase demand for recycling materials and drive market development. • High potential for job creation through the construction and operation of a C&D materials recycling facility.
Potential Effect on Waste Reduction	• Potential to increase waste reduction.
Potential Cost Implementations	• C&D processing facility capital cost ranges from $10 million to $20 million. Facility design throughput 100,000 tpy. • Open air processing equipment and sort lines approximately $2 million to $5 million depending upon equipment. • Costs to develop C&D processing would depend on the type of facilities co-located and facility development. • Capital costs associated with land acquisition not included. • Develop options for C&D diversion in tandem with the Resource Recovery Park Option.
General Implementation Requirements	• Review marketplace for viable outlets for diversion of C&D debris. • Discuss options and receive input from waste haulers, businesses and other processing facilities to determine limitations in the market. • Meet with Habitat for Humanity and the Central Washington Homebuilders Association for support. • Determine whether an active (C&D processing facility) or passive (Ordinance) role in the market is required. • Consider implementation plan to opportunities that can be accomplished with a resource recovery park. • Build business case for preferred option.

6 Recovery Park

The following section presents an overview of the concepts for recovery park practices and initiatives, for potential management implementation, that were selected for future material management and infrastructure needs in the region.

6.1 Overview

Resource Recovery Parks, also known as Eco Parks, involve the co-location of reuse, recycling, compost processing, manufacturing, and retail businesses in a central facility and/or campus. These parks allow integration between producers and consumers by supporting some infrastructure demands (e.g., energy demands) and material supply for both groups. Introducing reuse and drop-off centers, MRFs, C&D recycling facilities, and energy recovery facilities to the same location brings more efficient and effective opportunities for materials and energy exchange. Communities have also integrated large recycling facilities that include drop-off centers for reusable materials, a center to purchase used items, and a center for items to be repaired all under one roof. Several communities across the U.S. have developed resource recovery parks such as Berkeley and Monterey, California, and Kent County, Michigan. These examples are further described below.

6.2 Examples of Recovery Parks

Urban Ore Eco Park, Berkeley, California

The Urban Ore Eco Park is located on 3 acres of land and acts as a mall for the resale and repair of used items. This facility is split into two departments: the General Store and a Building Materials Exchange. The General Store includes cabinets, hardware, lighting, furniture, art and media collections, books, clothes, household goods, and more. The Building Materials Exchange includes doors, windows, tiles and stone, lumber, bathtubs, sinks, and more. All the materials at the Urban Ore Eco Park are reused and have been dropped off by people or salvaged. Most of the materials brought to the Eco Park are salvaged at the Berkeley Transfer Station through a reuse partnership with the City of Berkeley that gives workers of the Eco Park complete salvage rights from the tipping floor. Before 2012, the City of Berkeley paid Urban Ore $40 per ton for the material salvaged, which was significantly lower than the $126 per ton the City would pay if it went to a landfill. The revenue payment was eventually removed; however, Urban Ore still salvages materials and makes revenue from the sale of the materials in the store.[23]

People may drop off materials for store credit or cash or may purchase materials. Some items that may require substantial skilled labor to repair may be dropped off for a small fee. It is preferred that items dropped off at the Urban Ore Eco Park for reuse require little to no work before being resold. The drop-off

[23] EPA. "Zero WASTE Case Study: Berkeley." https://www.epa.gov/transforming-waste-tool/zero-waste-case-study-berkeley. (Accessed January 2019).

area manages a wide range of materials for diversion as listed above for the General Store and Building Materials Exchange. Figure 6-1 shows the layout of the Urban Ore Eco Park.[24]

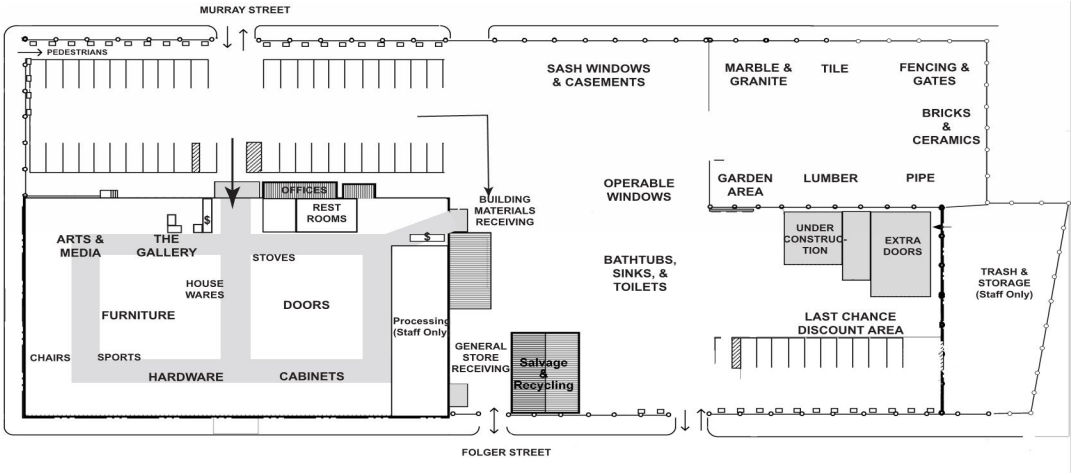

Figure 6-1. Urban Ore Eco Park Layout

Monterey, California

Monterey Regional Waste Management District (MRWMD) operates a landfill, a MRF, a Household Hazardous Waste (HHW) Collection Center, a Landfill Gas to Energy Facility, an Organics to Energy Facility, a Buy Back Center, a Community Franchise Collection Facility, and a Resale Store. This resource recovery park also contains an educational center and a location to meet the MRWMD staff. These facilities are all located in the same area and integrated to recover energy and materials. In total, the land area for this resource recovery park is approximately 610 acres.[25] The full site plan can be seen in Figure 6-2.

Figure 6-2. Site Plan for Monterey Regional Resource Recovery Park

[24] Urban Ore. "About Us." http://urbanore.com/about-us/. (Accessed January 2019).

[25] Monterey Regional Waste Management District Website. http://www.mrwmd.org/facilites/. (Accessed December 2018).

The Monterey Peninsula Landfill spans 461 acres and accepts about 200,000 tons per year. Gas is collected at the landfill and sent to the Landfill Gas to Energy Facility using a series of pipes. The Landfill Gas to Energy Facility uses four engine generators to burn the gas as fuel to create 5 megawatts of renewable electricity and the methane removed from the landfill is approximately 9,000 tons per year. Excess gas goes to a landfill gas flare that burns the gas to remove methane.

The MRF is owned by MRWMD and processes residential and commercial recyclables, C&D debris, and commercial mixed waste. The floor plan of the public drop-off area for the MRF can be seen below in Figure 6-3. The public drop-off area allows for the separation of mattresses and C&D materials.

The Last Chance Mercantile is a reuse store that diverts at least 700 tons of materials from being disposed of annually. This store receives donated items such as clothes, furniture, books, scrap metal, household paint and products, and electronic waste drop-off. The store also reclaims items directly off the tipping floor. The reuse store generates more than $800,000 per year in revenue by selling refurbished or used items. This location is not a nonprofit; therefore, residents do not get a tax donation receipt. Residents may also drop materials off at the HHW Collection Facility. Sixty percent of the HHW (e.g., paint) is sent to the Last Chance Mercantile and the rest is sent to the recycling facility for processing. The Monterey Resource Recovery Park also includes a buy-back center for bottles and cans. Residents pay a 5- to 10-cent deposit when purchasing cans or bottles and may redeem their deposit when returning the cans and bottles to redemption/buy-back centers.

MRWMD also owns an Anaerobic Digestion System through a public-private partnership with Zero Waste Energy. The system consists of four steel digester tanks that accept a blend of 70 percent food scraps and 30 percent yard trim. Annually, the digesters process 5,500 tons of materials. In a 21-day period, organisms in the digesters break down the biodegradable materials, creating methane gas and small amount of carbon dioxide that is cleaned and used to fuel a heat and power engine to produce electricity. The electricity is used for the Monterey Regional Water Pollution Control Agency, which neighbors this site.

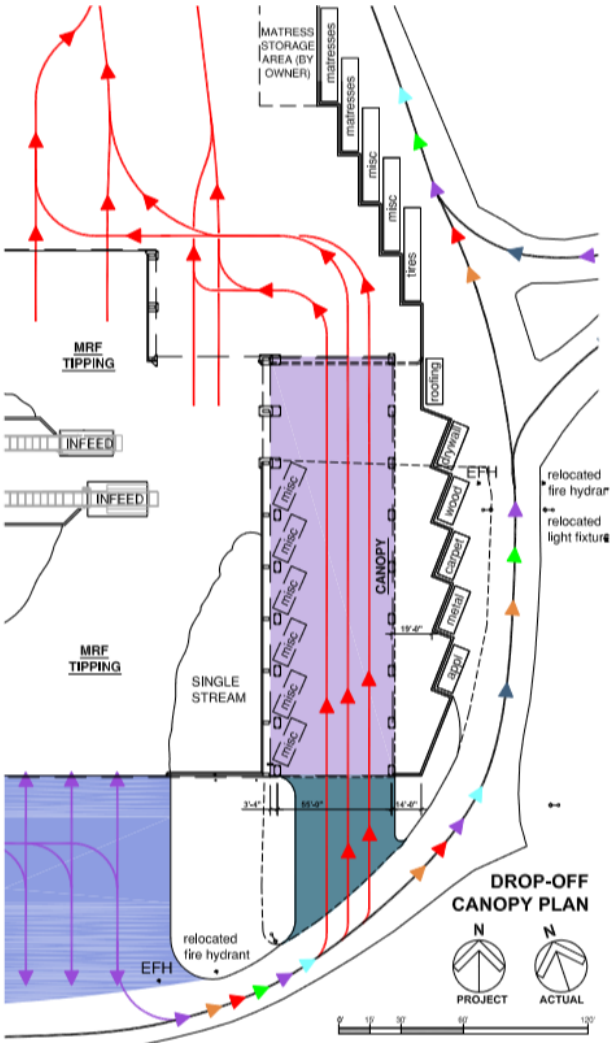

Figure 6-3. Floor Plan for MRWMD MRF External Material Drop-Off Area

Kent County, Michigan

Kent County, Michigan, completed a Sustainable Business Park Master Plan in 2018 to create a plan to attract sustainable businesses to a County-owned property near their existing landfill. The County issued a Request for Proposals in September 2020 and received nine responses for an anchor tenant facility at the site. The County is currently reviewing proposals received. Additional information can be found on the Kent County website: Sustainable Business Park | ReimagineTrash.

6.3 Recommendations for Development of a Resource Recovery Park

The following are recommendations related to potential development of a resource recovery park in the County:

- Undertake a review of available space and future role of County-owned and other sites that could support development of a resource recovery park.

- Develop a "Facilities Plan" that summarizes the waste management infrastructure that is required in the long-term, and that identifies the approach(es) preferred to secure this infrastructure. The elements that could be included in a resource recovery park could vary based on the County's decision on what infrastructure it chooses to own, and what infrastructure the private sector may be encouraged to develop.
- Undertake a business case for the development of a resource recovery park, focusing on the ability to integrate waste management infrastructure in the longer term. As noted in the preceding sections, glass and C&D materials recycling could be integrated into a resource recovery park, along with organics composting described in the following section.
- Identify potential public/private partnership opportunities available for resource recovery park development.

Table 6-1 presents an overview of resource recovery parks.

Table 6-1. Resource Recovery Park Option

Description of Option	• Develop a Resource Recovery Park in Kittitas County.
Actions/Potential Challenges	• Resource recovery parks that focus on reuse and recycling can give residents more convenient opportunities to recycle. • The County would need to identify a suitable location for the resource recovery park and siting facilities. • Development of a resource recovery park at an alternative location could alleviate strain and congestion at the current Ellensburg Transfer Station location and result in more efficient operations. • Location of a resource recovery park could be considered as part of the siting process for the potential new Ellensburg transfer station facility.
Rationale for Consideration	• This option has the potential to divert unwanted and difficult to recycle material from disposal. • This option has the potential for co-location at the potential new Ellensburg transfer station site. • Resource recovery parks
Short-term or Long-term Option	• Implement in the short to mid-term, sustain over the long-term.
Achievable in the Region	• Potential to achieve in each participating County.
Potential for Job Loss/Creation	• Creation of jobs dependent on type of facilities located at the park.
Potential Effect on Waste Reduction	• Levels of waste reduction and diversion would vary according to type of facilities located within the resource recovery park and their function.
Potential Cost Implementations	• Costs to develop a resource recovery park would depend on the type of facilities co-located. • Capital costs associated with land acquisition and facility development. • Capital and operating costs will vary according to facilities developed and range of services provided. It may be possible to reduce some capital costs for facility development depending on the extent of shared infrastructure at the potential new Ellensburg transfer station site.

Table 6-1. Resource Recovery Park Option	
	• A resource recovery park could be developed as a public-private-partnership limiting public capital development costs. • Additional costs would include staffing and promotion and educational materials. • Promotional methods may also be necessary to attract customers to donate and buy from a reuse store. • Potential for decrease in diversion processing costs and/or disposal fees by reducing the quantity of materials requiring management. • Potential for some change in operating costs related to collection, disposal and processing. Reductions in some areas may be offset by increases in other areas. • Costs associated with developing a business plan and facilities plan in the order of $40,000.
General Implementation Requirements	• County would need to undertake business case for facility development with potential partnering options considered. • County would need to identify a potential site as well as potential facilities that could be co-located. • Site and facilities would need to be permitted. • REOI's or RFP's would need to be developed, issues and awarded. • Public-private partnerships could be utilized in the development of sites and facilities. • Facilities would need to be constructed.

Individual facility costs for organics management, glass recycling, MRF and C&D diversion are included in those sections separately. Implementation, development and construction costs of an initial resource recovery park building and infrastructure to recover and market C&D and glass and other commodities can range from $1 million to $5 million depending on the potential availability to co-locate at the new Ellensburg Transfer Station site or to utilize the current Ellensburg Transfer Station site for a focused resource recovery park.

7 Organics

The following section presents the organics practices and initiatives that were selected for future material management and infrastructure needs in the region.

7.1 Overview

Effective January 1, 2017, the Washington State Department of Agriculture amended Washington Administrative Code 16-470 by adding MSW, yard debris, organic feedstocks, organic materials, and agricultural waste to the list of commodities regulated under the Apple Maggot Quarantine. Based on this rule change, portions of Kittitas and Yakima counties fell into quarantine areas that require special permits for transportation and disposition of yard debris and organics. Grant County is a non-quarantine county and therefore special permits are not required for disposition of yard and food waste.

Curbside collection of yard waste has been available in Kittitas and Yakima counties for several years. Kittitas County currently owns and operates a yard waste compost facility and markets finished materials. Yakima County is currently segregating yard waste, chipping it for volume reduction and utilizing the material as an alternate daily cover at their landfills.

In 2020, Kittitas County segregated and composted approximately 2,700 tons of yard waste and Yakima County segregated approximately 18,400 tons for use as an alternate daily cover material on their landfills. These organic materials account for 21,100 tons that is segregated and compostable.

Furthermore, based on Ecology's Waste Characterization Study, organics has the highest percentage of materials (yard and food waste) remaining in the waste stream. As shown in Table 1-2. Waste Characterization Potential Materials Remaining in Waste Stream, and utilizing a conservative estimate of a 20 percent capture rate for diversion from the disposed organics fraction of 147,246 tons, the region has the potential to compost an additional 29,400 tons of organics through a regional facility for a total of 50,500 tons.

In April 2019, the Washington State Legislature passed the Food Waste Reduction Act which requires Ecology to author a food waste prevention plan and annually measure progress towards food waste reduction goals. The region will need to consider productive uses of inedible food materials and if composting will meet the goals and objectives that are outlined in Ecology's final plan.

The Washington State Legislature considered several legislative actions during the 2021 regular session that could directly affect how organics are handled in the state in the future. SB 5286 was specifically directed toward increasing management of organics and composting. While that bill ultimately failed it is expected to be revised and reconsidered for future legislative action.

7.2 Aerobic Composting

Aerobic composting has been successfully employed on source-separated organics and yard/agricultural wastes and wastewater biosolids. Aerobic composting can include several different processes; however, the

two most common are aerobic windrow composting and forced aerated static pile (ASP) composting. Windrow-style composting is usually conducted outdoors, while ASP composting is usually employed indoors. However, some ASP composting is conducted outdoors in areas that are isolated from odor receptors. Other outdoor operations have used an aerated bag system to contain the materials.

In windrow composting, the materials (generally green material with limited percentage of food wastes) are placed in elongated piles called windrows that are aerated naturally through a "chimney effect" or by mechanically turning the piles with a machine or piped forced aeration to improve porosity. Frequent turning of the pile introduces oxygen, accelerates physical degradation of feedstocks, and provides an opportunity to adjust the moisture content to the optimum level. This technology can be particularly odorous when food waste is included in the feedstock at quantities greater than 15-20 percent, and/or the windrows are not frequently turned to maintain an aerobic condition. The average time required for active composting through windrows is 8 to 12 weeks.

The aerated composting process refers to any number of systems used to biodegrade organic material without physical manipulation during primary composting. It may be in windrows, open or covered, or in closed containers (in-vessel). In ASP composting technology, fresh air is forced into (and pulled out of) the pile to speed up the process and to try to ensure that the system remains aerobic. This method is suited to managing greater percentage of food wastes in the feedstock and producing large volumes of compost in relatively small areas. The blended feedstock mixture is usually placed on perforated piping or trenches, providing air circulation for controlled aeration. This technology can be particularly odorous if the composting pile is mis-managed creating pockets of anaerobic activity.

In most facilities using the forced aeration compost process, a series of perforated pipes or trenches draw air down through the windrows to an air collection manifold that runs under the windrows or piles. The compost-air can be drawn through the compost using a blower system, which then pushes the air through a biofilter that acts as an emission and odor control system. Alternatively, air can be injected into the windrows or piles; however, this can result in dispersing the potentially odorous air and therefore not recommended as the sole procedure. Some systems can switch the airflow between vacuum and injection providing greater control to optimize the aerobic composting while controlling odors.

In-vessel food waste aerobic composting can also take place in highly controlled, automated equipment using a combination of agitation and temperature/moisture control to convert food scraps into compost in just a few days. Current models on the market have modest capacity, with larger units being able to process up to 1.5 tons per day. This technology is most efficient for use with small food waste generators such as schools, hotels/conference centers, malls/food courts, cruise ships, hospitals, amusement parks, and sports stadiums. As such, the in-vessel technology is not recommended for a regional facility.

Figure 7-1. Kittitas County Windrow Composting Operation

Kittitas County currently operates a yard waste composting facility at the existing Ellensburg Transfer Station and has established markets for composted material. Local markets could be established with suppliers in the region, including Morton and Sons in Yakima, Natural Selection Farms in Granger, the WSDOT and other nurseries and agricultural operations. Markets may be limited due to the regulations under the Apple Maggot Quarantine.

7.3 Recommendations for Aerobic Composting

The following actions are recommended related to potential development of capacity for recycling organics in the region:

- Develop a business case to support organics management including: current and future state waste characterization information, tonnage projections, impact of state legislation and Apple Maggot Quarantine, and project options (technology, ownership, procurement approaches).
- Negotiate interlocal agreements with regional participants if the County decides to pursue a County-owned facility.
- Investigate feasibility of processing food waste in current windrow composting operations with a pilot program established in the County.
- Conduct a siting study to locate a suitable area for potential development of a regional composting facility or determine if the new Ellensburg Transfer Station site has available space.
- Identify procurement model and initiate procurement process for development of organics processing facility.
- Identify end-markets for compost and initiate contracts for sale of materials.
- Commence construction of regional organics processing facility for operation.

Table 7-1 presents an overview of aerobic composting.

Table 7-1. Aerobic Composting Option	
Description of Option	• The region develops an organics processing facility or procures capacity at another facility.
Actions/Potential Challenges	• The region would need to secure/source private sector processing capacity or develop their own processing/composting facility. • Regional participants would need to establish interlocal agreements to develop a county-owned/operated composting facility. • Development of end-markets for composted materials.
Rationale for Consideration	• Organics, including yard waste, continue to make up large percentage (32.6%) of the waste stream disposed in the region. • The region needs processing capacity and operations to comply with the WSDA Apple Maggot Quarantine regulations. • The region needs processing capacity prior to implementing a food waste collection program. • Diverting organics from disposal reduces GHG emissions and can result in beneficial by-products such as compost.
Short -term or Long-term Option	• Short-term option to establish interlocal agreements with potential regional participants. • Short-mid-term option to procure adequate processing capacity. • Short-mid-term option to develop a processing facility which would be maintained over the long term.
Achievable in the Region	• Potential to achieve in the region or in each participating County.
Potential for Job Loss/Creation	• High potential for job creation through development of a regional facility. • Limited potential for job creation associated with hauling material if processing located outside the region.
Potential Effect on Waste Reduction	• Estimated to divert approximately 50,000 tons of organics from disposal in the region. • Provides regional option for implementation of food waste diversion, along with more yard waste diversion, which accounts for a conservative estimate of an additional 29,000 tons of organic material.
Potential Cost Implementations	• Refer to Section 7.4 for opinion of probable construction and annual operating costs. • If turned windrow operations cannot adequately manage odors, significantly greater construction costs needed for ASP technology. • Initial regional organics compost facility requires approximately 8 acres land with potential for expansion.
General Implementation Requirements	• Region would need to secure or develop processing capacity. • Regional partners would need to establish interlocal agreements. • County would need to decide if in-County facility might be co-located with other facilities (i.e. Resource Recovery Park, new Ellensburg Transfer Station facility). • The County would need to identify a business model (e.g. DBO-Design, Build, Operate) and procurement process (e.g. REOI, RFQ, RFP). • Plan flexibility into the facility to be able to convert from windrow composting to forced aeration, if or when needed.

7.4 Probable Construction and Operating Costs

A regional organics composting facility sized for windrow composting of approximately 50,000 tons organic material annually will need at least 8 to 10 acres for receiving area, mixing, compost pad, curing pad, finished compost screening and storage area, run-off retention pond, and operational traffic lanes. Initial windrow operations will need to maintain the feedstock mix to maximum 20% food waste with the remaining as yard waste. Increasing food waste diversion will require either more yard waste and wood waste for windrow composting or the County would then need to convert the facility to forced aeration technology such as ASP. Compost operations should focus on maintaining parameters within the ranges provided in Table 7-2.

Table 7-2. Composting Operating Parameters

Parameter	Best Management Practices (BMPs)
C:N Ratio	30 to 45
Moisture Content	40% to 60%
Net Bulk Density	850 lbs/cy, Target Maximum
Oxygen	>10%
Temperature	130 – 140 degrees Fahrenheit

The following assumptions were made for this cost analysis:

- Site topography is relatively flat with stable soils.
- Construction and operating costs assume windrow composting with a compost turner. No forced aeration technology.
- Windrows assumed to be 8 feet high by 16 feet wide and 100 feet long.
- Pads are sized for 12 weeks total of active composting and curing.
- Finished compost storage area provided for up to 60 days' worth of compost.
- Compost facility operations assume 8 hours per day, 5 days per week for 52 weeks.
- Some mobile equipment such as water truck may be shared with other facilities if co-located on the same site.
- Land purchase price not included in costs.
- Costs do not include buildings such as maintenance shop, offices, etc.
- Costs do not include collection, remote drop-off sites or hauling.

Table 7-3 identifies the estimated capital costs associated with this scenario.

Table 7-3. Regional Organics Compost Facility

Facility	Description	Area (Acres)	Estimated Costs ($)
Pads	Impervious receiving area, mixing, compost pad, curing pad, screening and storage	8-10	$1.94 million
Stormwater Management	Drainage system and retention pond	Included in Acres Above	$570,000
		Facility Subtotal	*$2.51 million*

Table 7-3. Regional Organics Compost Facility			
Processing Equipment	**Description**	**Organics (tpd)**	**Estimated Costs ($)**
Mobile Equipment	Includes front-end loader, compost turner, water truck and screening machine	200	$1.45 million
		Subtotal (w/ Facility Subtotal)	*$3.96 million*
Other	**Description**	**Percentage (%)**	**Estimated Costs ($)**
Contingency	Construction & equipment contingency	25%	$990,000
Soft Costs	Design, construction management, permitting	15%	$594,000
		Total	**$5.54 million**

Implementation of forced aeration technology, construction and equipment could range from $10 million to $20 million depending upon several factors including site, availability of utilities, outdoors or enclosed, etc.

Table 7-4 identifies the estimated annual operating costs associated with composting approximately 50,000 tons per year of organic materials through mechanically turned windrows.

Table 7-4. Regional Organics Compost Facility Annual Operating Costs		
Operations	**Description**	**Estimated Annual Cost ($)**
Labor	4 FTE including 2 heavy equipment operators, 1 laborer and fraction of mechanic and manager	$222,000
Equipment O&M	Maintenance and fuel costs on estimated hours of operation for each equipment	$120,000
Utilities & Water	Water usage assumed at 130 gallons/ton plus water added into initial feedstock mix, and miscellaneous utilities at 15% of Labor and Equipment O&M	$122,000
Administration & Overhead	10% of Labor and Equipment O&M	$34,000
	O&M Costs Subtotal	*$498,000*
	Contingency (10%)	$50,000
	Total Annual O&M Cost	**$548,000**
	O&M Cost per Ton	**$11/ton**

Revenue from the sale of compost can help off-set some of the operating costs. Compost sales can range from $20 to $60 per ton (or cubic yard) depending upon quality and location. Based on facility throughput of 50,000 tons, approximately 28,000 tons per year of finished compost is calculated to be produced. Kittitas County is currently selling compost, depending on load size, for $30 to $60 per ton. At an average sale price of $40 per ton, approximately $1,120,000 in revenue could be generated per year.

8 Preliminary Action Plan

A preliminary action plan matrix is presented in Table 8.1 to assist the County, and regional partners, consider potential recommended actions, responsibilities, costs and schedule as they move forward with implementation of practices and technologies that meet the goals and objectives of economic viability, environmental soundness, socially acceptable and achievable in the region. The preliminary action plan matrix presents each option as separate recommendations for the County and regional partners to consider.

The most viable options recommended for consideration in the short to mid-term are:

- Glass Recycling and Reuse for aggregate/pozzolan to be developed through public/private partnership opportunities in the region with local concrete companies or other glass recycling and reuse facilities in the state with consideration given to climate change and sustainability.
- Establishment of a Resource Recovery Park developed in tandem with C&D Diversion and Glass Recycling and Reuse. This would allow for potential recyclable materials to establish markets and diversion methods through a resource recovery park model and business plan.
- Regional Organics Processing Facility to be developed with regional partners, in a regional location, to manage organics through a composting facility with resale of finished compost.

Table 8-1. Preliminary Action Plan

Recommendation	Implementation Responsibility	Implementation Cost	Implementation Schedule[1]
Glass Recycling and Reuse			
A. Aggregate/Pozzolan in Portland Cement Concrete			
Consider forming a regional working group to develop a consistent approach to recovered glass collection, taking into consideration distances and hauling costs.	County/CWU/Regional Partners/CenterFuse/Waste Haulers	Staff Time	Short-Term
Identify potential public/private partnership opportunities available for glass recycling and reuse.	County/CWU/Regional Partners/CenterFuse/Waste Haulers	Staff Time	Short-Term
Conduct feasibility studies to understand specific processes, requirement, and costs for either the development of a new glass processing facility, retrofitting an existing glass processing facility, upgrading an existing MRF and reintroduce glass recycling, attract new businesses or the investment in multiple mobile crushing machines.	County/Regional Partners/CenterFuse	$35,000	Mid-Term
Identify procurement model and initiate procurement for either the development of a new glass processing facility, retrofitting an existing glass processing facility, upgrading an existing MRF and reintroduce glass	County/Regional Partners/CenterFuse	Staff Time	Long-Term

Table 8-1. Preliminary Action Plan			
Recommendation	**Implementation Responsibility**	**Implementation Cost**	**Implementation Schedule[1]**
recycling, or the investment in multiple mobile crushing machines.			
Conduct a siting study to locate a suitable area for glass processing recycling facility.	County/Regional Partners/CenterFuse	$35,000	Long-Term
Identify end-markets of pozzolanic glass powder and initiate contracts for sale of materials (e.g. Ellensburg Cement Plant).	County/Regional Partners/CWU/CenterFuse	Staff Time	Long-Term
B. Aggregate/Roadway Bead			
Consider forming a regional working group to develop a consistent approach to recovered glass collection, taking into consideration distance and hauling costs.	County/CWU/Regional Partners/CenterFuse/Waste Haulers	Staff Time	Short-Term
Identify potential public/private partnership opportunities available for glass recycling and reuse.	County/CWU/Regional Partners/CenterFuse/Waste Haulers	Staff Time	Short-Term
Conduct feasibility studies to understand specific processes, requirement and costs for either the development of a new glass processing facility, retrofitting an existing glass processing facility (i.e. Seattle's Strategic Materials Facility), upgrading an existing MRF and reintroduce glass recycling, attract new businesses, or the investment in multiple mobile crushing machines.	County/Regional Partners/CenterFuse	$35,000	Mid-Term
Identify procurement model and initiate procurement for either the development of a new glass processing facility, retrofitting an existing glass processing facility, upgrading an existing MRF and reintroduce glass recycling, or the investment in multiple mobile crushing machines.	County/Regional Partners/CenterFuse	Staff Time	Long-Term
Conduct a siting study to locate a suitable area for glass processing recycling facility.	County/Regional Partners/CenterFuse	$35,000	Long-Term
Identify end-markets of aggregate/roadway bead and initiate contracts for sale of materials (e.g. WSDOT).	County/Regional Partners/ CWU/CenterFuse	Staff Time	Long-Term
C. Specialty Glass			
Consider forming a regional working group to develop a consistent approach to recovered glass collection, taking into consideration distance and hauling costs.	County/CWU/Regional Partners/CenterFuse/Waste Haulers	Staff Time	Short-Term
Identify potential public/private partnership opportunities available for glass recycling and reuse.	County/CWU/Regional Partners/CenterFuse/Waste Haulers	Staff Time	Short-Term

Table 8-1. Preliminary Action Plan			
Recommendation	**Implementation Responsibility**	**Implementation Cost**	**Implementation Schedule[1]**
Conduct feasibility studies to understand specific processes, requirement and costs for either the development of a new glass processing facility, retrofitting an existing glass processing facility, upgrading an existing MRF and reintroduce glass recycling, or the investment in multiple mobile crushing machines. Potential optical sorting may not be necessary which would make mobile crushing a potentially ideal method.	County/Regional Partners/CenterFuse	$35,000	Mid-Term
Identify procurement model and initiate procurement for either the development of a new glass processing facility, retrofitting an existing glass processing facility, upgrading an existing MRF and reintroduce glass recycling, or the investment in multiple mobile crushing machines. The use of a ball mill would likely not be necessary.	County/Regional Partners/CenterFuse	Staff Time	Long-Term
Conduct a siting study to locate a suitable area for glass processing recycling facility.	County/Regional Partners/CenterFuse	$35,000	Long-Term
Identify end-markets of glass cullet and initiate contracts for sale of materials (e.g. local artisans).	County/Regional Partners/CenterFuse	Staff Time	Long-Term
D. Wine Industry Glass			
Consider forming a regional working group to develop a consistent approach to recovered glass collection, taking into consideration distance and hauling costs.	County/CWU/Regional Partners/CenterFuse/Waste Haulers/Wineries	Staff Time	Short-Term
Identify potential public/private partnership opportunities, specifically with wineries, available for glass recycling and reuse.	County/CWU/Regional Partners/CenterFuse/Waste Haulers/Wineries	Staff Time	Short-Term
Conduct feasibility studies to understand specific processes, regulatory health requirements and costs to sanitize/wash wine bottles for reuse.	County/Regional Partners/CenterFuse/Wineries	$35,000	Mid-Term
Identify procurement model and initiate procurement process for establishment of wine bottle reuse programs and/or establishment of grant funding for wineries to be able to participate.	County/Regional Partners/CenterFuse	Staff Time	Long-Term
Conduct a siting study to locate a suitable area for glass bottle sanitation/washing facility, if not incorporated at the wineries themselves.	County/Regional Partners/ CWU/CenterFuse	$35,000	Long-Term
Identify end-markets of recovered whole wine bottles and initiate contracts for sale of materials (e.g. wineries).	County/Regional Partners/ CWU/CenterFuse	Staff Time	Long-Term

Table 8-1. Preliminary Action Plan			
Recommendation	**Implementation Responsibility**	**Implementation Cost**	**Implementation Schedule[1]**
Commingled Recyclables			
Consider forming a regional working group to develop consistent approach to commingled recyclables management.	County/CWU/Regional Partners/CenterFuse/Waste Haulers	Staff Time	Short-Term
Identify potential public/private partnership opportunities available for recycling of commingled recyclables.	County/CWU/Regional Partners/CenterFuse/Waste Haulers	Staff Time	Short-Term
Solicit community input relating to commingled recyclables and potential disposal bans.	County/ CWU/Regional Partners	Staff Time	Short-Term
Develop a business case to support commingled recyclables management.	County/CWU/Regional Partners/CenterFuse/Waste Haulers	$35,000	Mid-Term
Conduct a siting study to locate a suitable area for a regional clean MRF.	County/Regional Partners/CenterFuse	$35,000	Mid-Term
Identify procurement model and initiate procurement process for facility development.	County/Regional Partners/CenterFuse	Staff Time	Long-Term
Identify end-markets for recyclable materials and initiate contracts for sale of materials.	County/Regional Partners/CenterFuse	Staff Time	Long-Term
C&D Diversion			
Consider forming a regional working group to develop consistent approach to C&D diversion.	County/CWU/Regional Partners/CenterFuse	Staff Time	Short Term
Explore opportunities to develop markets, which could include requirements for certain recycled content materials use by County departments/divisions.	County/CWU/Regional Partners/CenterFuse	Staff Time	Short-Term
Investigate ways to increase procurement opportunities to include items with recycled content or derived from diverted materials, including recycled C&D materials for projects such as paving, etc.	County/CWU/Regional Partners/CenterFuse	Staff Time	Short-Term
Continue to work cooperatively to develop potential C&D diversion ordinances to ensure construction waste is being diverted properly.	County/Regional Partners	Staff Time	Mid-Term
Continue to segregate potential reusable C&D materials at the landfills and develop markets.	County/Regional Partners	Staff Time	Mid-Term
Consider C&D recycling opportunities that can be accomplished at a resource recovery park.	County/CWU/Regional Partners/CenterFuse	Staff Time	Short-Term

Table 8-1. Preliminary Action Plan			
Recommendation	**Implementation Responsibility**	**Implementation Cost**	**Implementation Schedule[1]**
Resource Recovery Park			
Review available space and future role of County-owned or other sites that could support development of a resource recovery park.	County/CenterFuse/Other	Staff Time	Short-Term
Develop a "Facilities Plan" that identifies approach to secure infrastructure.	County/CenterFuse/Other	$5,000	Short-Term
Undertake a business case for development of a resource recovery park.	County/CenterFuse/Other	$35,000	Short-Term
Identify potential public/private partnership opportunities available for resource recovery park development.	County/CenterFuse/Other	Staff Time	Short-Term
Organics			
Develop a business case to support regional organics management including: current and future state waste characterization information, tonnage projections, impact of state legislation and Apple Maggot Quarantine, project options (technology, ownership, procurement approaches).	County/Regional Partners/CWU/CenterFuse/Cities	$35,000	Short-Term
Negotiate interlocal agreements with regional participants if the County decides to pursue a County-owned facility.	County/Regional Partners	Staff Time	Short/Mid-Term
Investigate feasibility of processing food waste from a pilot program established within the County.	County/Waste Management/CWU/Cities	$50,000	Short/Mid-Term
Conduct a siting study to locate a suitable area for potential development of a regional composting facility or determine if the new Ellensburg Transfer Station site has available space.	County/Regional Partners/ CenterFuse/CWU/Cities	Staff Time	Short/Mid-Term
Identify procurement model and initiate procurement process for development of organics processing facility.	County/Regional Partners/CenterFuse/CWU/Cities	Staff Time	Short/Mid-Term
Identify end-markets for compost and initiate contracts for sale of materials.	County/Regional Partners/CenterFuse/CWU/Cities	Staff Time	Short/Mid-Term
Commence permitting, design and construction of a regional organics processing facility for operation.	County/Regional Partners/CenterFuse/CWU/Cities	$5,540,000	Mid-Term

[1] Short-term 12 to 18 months, Mid-term 18 to 36 months, Long-term more than 3 years.