

# Potential Recycled Glass Products for Manufacturing in Anchorage, Alaska



Prepared for  
The Municipality of Anchorage  
Solid Waste Services

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## **EXECUTIVE SUMMARY**

Glass recycling in Anchorage ceased when the sole operator of a glass processing facility discontinued operations and collection of glass was suspended in January 2009. However, Anchorage residents continue to request glass recycling services as part of their overall recycling and solid waste services. The Municipality of Anchorage (MOA) Solid Waste Services (SWS) seeks to improve recycling services for residents and businesses by exploring private-sector solutions for local glass recycling.

SWS contracted with the Alaska Manufacturing Extension Partnership, Inc. (AMEP) to research and identify the potential markets for glass cullet (waste glass collected for recycling) in Anchorage. The review identified a variety of potential local markets for recycled glass processed in Anchorage. These markets can be categorized into several segments: aggregates, abrasives, traction, filtration, and other niche markets.

The glass recycling program in Anchorage yielded 1,500 tons per year of recyclable glass. Estimates based on U.S. EPA's national data indicate that Anchorage could yield up to 15,000 tons per year with a more aggressive recycling program. There are a variety of crushed glass cullet processing systems available on the market. It appears that a two-ton-per-day sized processing system may be the minimum threshold quantity required to financially break even. The processing equipment must be matched to produce material that meets the product specifications of the target markets.

Even in a good market, recycled glass processing has marginal economics because glass cullet typically competes with sand, an abundant and inexpensive material. There are niche markets in abrasives, traction, and specialty uses that may command higher prices that justify processing costs. Glass also can be processed along with construction and demolition concrete recycling processing streams to "use up" significant quantities of glass cullet at low cost for aggregate uses.

The easiest market to develop may be aggregates, such as those used in the base or leveling courses for the construction of roads and parking lots. The American Association of State Highway and Transportation Officials (AASHTO), Federal Highway Administration (FHWA), and other technical and regulatory bodies have conducted extensive testing, including frost and cold weather testing. Based on the results, these agencies developed standards for the use of crushed glass in aggregates.

The potential to mix crushed glass cullet into aggregates exists for many applications including roadway and parking lot base or leveling courses, glassphalt, pipe bedding, drainage material, fill and concrete. Industry needs to lead the way by identifying a few key markets that require amended technical specifications. Then the MOA needs to support industry by amending those specifications to facilitate the creation of those few key markets.

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Another ready market is abrasives. Glass cullet is a well accepted material for sandblasting and was the primary product manufactured by the former Anchorage glass plant. Glass competes with garnet, iron slag, nickel fleck, ultra high pressure water and other blasting media, so it may be difficult to capture a high percentage of the market. Users of abrasive blasting media include ship repair facilities, metal fabricators, bridge repair and maintenance companies, and others from Seward to Fairbanks.

Alaskans also use sand in a variety of traction products. Glass may be substituted for sand in many of these applications. The Alaska Railroad, a significant consumer of traction sand, experimented with the use of crushed glass as a traction product, and although initial tests proved positive, it ultimately did not meet the railroad's specific requirements. Glass has been used on occasion locally for traction on private parking lots, and has potential for other traction products.

Filtration products, such as swimming pool filtration, septic treatment sand filters, water well packing sand and subdrains and French drains offer an opportunity to replace or supplement sand products with local recycled glass.

Numerous other niche markets exist for processed glass cullet. These include landscaping pavers and blocks, topsoil production, countertops, tumbled glass applications, and a variety of craft products. These all represent a very small end market and some entail intense processing of the glass product but may offer a very high end-market value.

At least four or five local established industry participants are interested in exploring the feasibility of processing glass. Sand and aggregate processors are equipped to process recycled glass for construction customers, once technical specifications for crushed glass aggregate are defined and put in place.

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Table 1 - Summary of Potential Markets in Anchorage for Recycled Glass

<u>Market Segment</u>	<u>Product Uses</u>	<u>Market Characteristics</u>
Construction Aggregates	Base course, leveling course, glasphalt, pipe bedding, filter material, fill and concrete. Substitute for gravel, sand. May be processed with construction and demolition concrete to reduce handling and processing costs.	Ready market for high-volume, low-value, uncleaned glass, widely used. Anchorage buyers and processors exist but lack of technical specifications is a barrier. LEED certification is partially driving demand. Price of \$10 - \$30 per ton.
Abrasives	Ship building and repair, metal fabrication, bridge painting, water jet cutting.	Superior to silica as no concerns with silicosis and less dust. Widely used. More cleanup than ultra high pressure (UHP) water. Previous Anchorage processor relied on this market. Price \$30-\$150 or higher per ton.
Traction	Various industrial and consumer applications. Sold in bulk for industrial uses or bagged for consumer and light industry.	Replaces sand for winter and safety traction. May be mixed with paint, asphalt, tile or other media depending on the use. Sand can cost from \$18-\$500 per ton.
Filtration	Municipal water treatment, septic filtration, swimming pool filtration, water well packing.	Good filtration medium. May require cleaned glass. Could be an important element of the product mix. \$30-\$130 per ton.
Other Niche Markets	Crushed glass countertops, tiles, decorative pavers and blocks, topsoil additive. Glass tile, aquarium sand, blown glass, jewelry and art, tumbled glass, hydroponic medium.	Glass offers a bright-colored flair to non-structural countertops and blocks. Offers superior drainage and structure to soil. Very small and irregular niche markets for high-value, sorted, cleaned glass.

## **PURPOSE**

Glass recycling in Anchorage ceased when the sole operator of a glass processing facility discontinued operations and collection of glass was suspended in January 2009. However, Anchorage residents continue to request glass recycling services as part of their overall recycling and solid waste services. The Municipality of Anchorage (MOA) Solid Waste Services (SWS) seeks to improve recycling services for residents and businesses by exploring private-sector solutions for local glass recycling. SWS is facilitating private investment by providing this research that identifies market and product options.

SWS contracted with the Alaska Manufacturing Extension Partnership, Inc. (AMEP) to research and identify the potential markets for glass cullet (waste glass collected for recycling) in Anchorage. AMEP is an affiliate of the USDC National Institute of Standards and Technology, Manufacturing Extension Partnership (MEP). MEP affiliates in field offices across the U.S. work with processing companies and local governments to conduct research and improve the competitiveness of recycled materials processing facilities.

The goal of this review is to provide tangible information that may accelerate the path to private-sector investment in glass processing by lowering the information-gathering costs and business risks. AMEP reviewed published materials and internet postings, and conducted selected interviews with industry participants. Specifically, this review identified:

1. Engineering test results, regulations, articles and personal contacts that would support amendments to technical specifications to include cullet as an aggregate in road base applications. The review also identified other organizations and state and local governments that may lend their expertise. Road-base applications are a high-volume, low-margin market that could potentially use the majority of Anchorage's recycled glass.
2. Value-added cullet niche markets may generate higher margins that could contribute to a profitable mix of crushed glass products.

Additional product specific research and analysis is necessary to quantify market potential in the region, and was not part of the scope for this project.

A significant body of research and business development activity has been conducted to support glass recycling across the United States, much of it during the 1990's. The MEP Environmental Program conducted a series of research projects with the Clean Washington Center (CWC) that provided detailed descriptions and specifications for a number of markets, from aggregates to septic filtration to roofing materials. This review leans heavily on this body of work to describe niche markets. Please see the bibliography for a list of publications. A set of .pdf files, printed reports and bound conference proceedings were submitted with this report for further in-depth analysis. Some references are proprietary and contact information for acquiring them is provided. Additionally a copy is available for reference at the Solid Waste Services recycling coordinator's office.

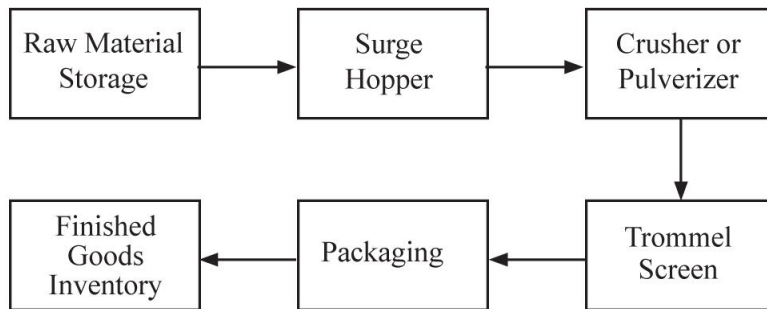
## PROCESSING RECYCLED GLASS INTO PRODUCTS

Processing recycled glass into various marketable products is accomplished by variations on a few basic manufacturing processes: storing, crushing, sorting, cleaning, and packaging. The general process starts with collected glass, which has been stored in piles. A loader scoops the glass into a surge hopper that feeds a prescribed amount of glass at a steady rate into a crusher or pulverizer. The pulverizer breaks up the glass into small pieces with no sharp edges, and removes most of the paper and other debris.

The glass cullet may then move into a trommel screen or vibratory screen, where debris is removed, possibly with the aid of a fan and/or magnet. The trommel screen can also sort according to size for different product uses. At this point, the cullet may be bagged and palletized or stored in bulk. Conveyors move the cullet from hopper to pulverizer to trommel screen to bagger. Finally, the finished goods inventory is stored and sent to market.

Additional steps of color sorting and cleaning may be added, though the processing and handling costs are not likely to be absorbed by markets. Modifications to this basic process will produce a range of products from low value, mixed-grade material to high-value, cleaned and graded material.

**Figure 1 - Cullet Processing Flow Diagram**



Many processes create a finished product of glass sand that is 3/8" or smaller in diameter with rounded edges. The crushed glass can be sorted to various screen sizes depending on the desired product specification. The glass edges are rounded and safe for handling. Debris from labels, caps and other foreign matter is typically less than 5% by weight, particularly when a fan is installed with the trommel screen to remove paper. The cullet is mixed color, which is acceptable for aggregate, abrasive, traction, filtration, and some landscape markets.

Glass processing is an economic challenge, as evidenced by the loss of the local glass processor in Anchorage and the suspension of glass-recycling operations in several major cities in the U.S. There are many elements that add incremental costs to a processing operation,

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including feedstock collection, raw materials handling, wear parts in processing equipment, and the addition of processing steps. At one Anchorage aggregate processor, for example, each pass through the crusher adds about \$10/ton to the finished costs. Each individual product and market must be carefully evaluated to determine whether those particular product specifications can earn prices that offset incremental costs.

In the short term, the most promising product may be a high-volume/low-value aggregate made using existing processing equipment. Ultimately, the local recycled glass industry would likely need to satisfy a product mix that included both high-volume/low-value markets and smaller, high value markets. To succeed, a processor would need to maintain a dominant market share in the few local value-added niche markets, such as blast abrasives, water jet, and traction. A successful industry also would need to include a processor and market for an aggregate product, such as those used in construction (roadways, pipe laying, earth work).

Economies of scale are also an important consideration. The example below from a CWC study shows that a one-ton-per-hour system did not meet its break-even point, while a two-ton-per-hour processing system was economically viable. This study is based on sales to abrasives and fused glass markets, with an average product price of \$125 per ton.

**Table 2 - Economics of Small-Scale Cullet Processing Systems (Example)**

Operating Capacity (tons per year)	1,300 tons	2,800 tons
Price per ton	\$125	\$125
Revenue (sales per year)	\$131,625	\$283,500
Variable Costs (annual costs incl. mgr. labor)	\$125,104	\$191,608
Fixed Costs (only property, plant, equipment)	\$18,870	\$46,315
Total Cost (variable + fixed costs)	\$143,974	\$237,923
Net Margin (revenue - total cost)	(\$12,349)	\$45,577

Source: “*Small-Scale Recycled Glass-to-Fines Processing System.*” CWC. (41)

Glass recycling in Anchorage yielded approximately 1,100 to 1,500 tons per year, 91% of which was delivered by consumers and businesses to public drop-off sites with the remaining 9% from a commercial glass collection route. An estimate based on U.S. EPA national glass generation and disposal data indicates that potentially 10,000 to 12,500 tons per year of post-consumer glass is recoverable from Anchorage’s waste stream with an aggressive recycling program.

Many companies sell new and used individual pieces of processing equipment and complete turnkey glass cullet processing systems. Company representatives provide a wealth of information to prospective customers. Without recommendation, the following equipment manufacturers are listed as resources to allow individuals wanting to research their own specific business prospects.

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Andela Products, [www.AndelaProducts.com](http://www.AndelaProducts.com)

Glass Aggregate Systems [www.GlassAgg.com](http://www.GlassAgg.com)

C.S. Bell Co., [www.csBellCo.com](http://www.csBellCo.com)

A lower risk and low-commitment processing option may be to mix glass with existing aggregate or construction and demolition concrete crushing operations. No additional investment in equipment is required, as the glass would be folded into existing processes. This is perhaps the easiest and least expensive way to recycle all glass generated in Anchorage.

The ongoing maintenance costs of replacing worn parts is a significant component of operating costs. The type of equipment used, and the cost of those wear parts, will have a significant impact on overall profitability. The hardness of glass creates higher wear on abrasion-style systems, which fractures the glass into sharp shards. The hardness of glass does not have a greater wear effect on impactors, hammermills, pulverizers, semiautogenous grinding, and similar types of crushers. These types of crushers produce the desired round-edged particles that are not sharp to the touch.

Minimizing raw material costs is also important. Many cullet processors charge glass suppliers a fee to accept glass. The glass acceptance fees are typically lower than solid waste disposal tipping fees. The marginal economics on the processing and market side require careful monitoring of specific costs before assuming that cullet processing could generate revenues for upstream recycling collection and transfer activities. Additionally, the previous collection model in Anchorage was largely supplied (91%) by public drop-off sites where a fee was not collected. This report does not include a review of upstream supply activities. Additional information on upstream supply is available from Alaskans for Litter Prevention and Recycling (ALPAR), a local non-profit that coordinated most of the collections.

In interviews for this review, several local companies expressed an interest in exploring entry into the glass processing industry. These potential processors were interested in satisfying a variety of markets, including construction aggregates, traction, and abrasives. Any investment into glass-processing equipment should be analyzed with project-specific details regarding supply, demand, product mix and specifications, local technical specifications for glass, and overall processing volumes.

## **AGGREGATES**

The market with the most initial potential and long-term stability is aggregates. Glass has many similar properties to naturally occurring aggregates and is a suitable direct substitute in many applications. The historical Anchorage supply of 1,100 to 1,500 tons per year, and even a potential 10,000 tons per year of glass represents only a fraction of the local aggregate market. The glass feedstock could be absorbed by the industries using aggregates as long as technical specifications allow for its use, and the glass is processed to meet those specifications at an economic rate.

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Using crushed glass in aggregate is a benefit to projects seeking to use more environmentally sustainable products, including those seeking Leadership in Energy and Environmental Design (LEED) or National Green Building Standard (NGBS) certification. The Anchorage Assembly on August 12, 2008, approved an ordinance (AO No. 2008-93) to require that all new (or renovations larger than 5,000 square feet) public facilities and buildings using municipal funds be LEED certified. The ordinance also included a fee-reduction incentive for private construction that achieves LEED or NGBS certification. The use of recycled products, including glass and construction and demolition materials, is one minor element of certification.

The Municipality of Anchorage (MOA) facilitated the creation of markets in Anchorage for recycled asphalt pavement (RAP) and recycled concrete aggregate (RCA) by amending technical specifications to allow for the use of these products. Initial allowance on selected projects led to inclusion of RAP in the Municipality of Anchorage Standard Specifications (M.A.S.S.) and currently RCA is allowed on a case by case basis. A similar opportunity exists to amend technical specifications for both the MOA and State of Alaska to allow for the use of recycled glass in aggregates such as base course, leveling course, asphalt, pipe bedding, filter material, fill, concrete, and drainage uses.

Given this wide range of potential products, it does not make sense to preemptively amend technical specifications for all possible uses of crushed glass. Glass cullet processors must identify their desired products so specific technical specifications can be written. Cooperation between industry and regulatory bodies is required to create aggregate markets for crushed glass cullet. An analysis of the most cost effective aggregates is beyond the scope of this document.

**Table 3 - Uses and Recommended Maximum Cullet Levels in Construction Aggregate**

	Maximum cullet content (%)	Maximum debris level (%)	Minimum compaction level (%)
<i>Structural Applications</i>			
Roadway base course	15	5	95
Roadway subbase	30	5	95
Embankments	30	5	95
Static structural loads	30	5	95
Fluctuating load	15	5	95
Nonstructural fill	100	10	85
Utility bedding backfill	100	5	90
<i>Drainage</i>			
Retaining wall	100	5	95
Foundation drainage	100	5	95

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Drainage blanket	100	5	90
French drain	100	5	90

Source: “*Cullet What You Will: In the Aggregate, It’s Fine.*” Kirby. (8)

### ***Road construction***

The use of glass in road construction applications as an aggregate blend is common in the Lower 48, including northern tier states with freeze-thaw cycles. A group of 15 state transportation departments cooperated with the Recycled Materials Research Center (RMRC), Federal Highway Administration, and the American Association of State Highway and Transportation Officials (AASHTO) to conduct a series of studies on crushed glass cullet. The studies set out testing standards, physical properties and ultimately standard specifications for the use of cullet as an aggregate in road base applications.

This body of research became the foundation for AASHTO M 318-01 “*Standard Specification for Glass Cullet Use for Soil-Aggregate Base Course,*” AASHTO. (15) which government agencies may refer to when adopting their own specifications. “The specification makes it easier for states. Without a specification, it is particularly hard for county or municipal engineers to try something new. Having an AASHTO specification makes it easier for the states to give the stamp of approval,” said Frank Palise of the New Jersey Department of Transportation.

These AASHTO specifications also include the use of other recyclable materials, including asphalt shingles, asphalt pavement, recycled concrete pavement in granular base, and recycled concrete pavement in Portland cement. AASHTO and RMRC representatives said they would provide support and assistance to any effort undertaken in Alaska. A profile and contact information for AASHTO and RMRC are provided below.

- American Association of State Highway and Transportation Officials (AASHTO)

Mission excerpt: “The American Association of State Highway and Transportation Officials advocates transportation-related policies and provides technical services to support states in their efforts to efficiently and safely move people and goods.”

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- Recycled Materials Resource Center

Mission excerpt: “To work cooperatively with Federal and State officials to reduce the institutional barriers that limit widespread use recycled materials and to ensure that such increased use is consistent with the sustained environmental and physical integrity... To make information available to State transportation departments, the Federal Highway Administration, the construction industry, and other interested parties”

Note: Wisconsin has model highway and building codes that RMRC has helped adapt to other states.

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### ***Crushed glass aggregate in frozen ground***

Several northern tier states expressed concerns about the behavior of crushed glass cullet in aggregates when exposed to freeze-thaw cycles. The New Hampshire Department of Transportation funded a study titled “*Frost Susceptibility of Crushed Glass Used As Construction Aggregate*” that was published in the Journal of Cold Regions Engineering (7). The study found that, at 100% cullet and 30% cullet-aggregate mix, the cullet had negligible to very low frost susceptibility. The abstract is presented here:

Abstract: The frost susceptibility for 100% glass cullet and 30% by weight glass cullet-aggregate specimens was determined using ASTM D 5918. The cullet has negligible to very low frost susceptibility, and it did not increase the frost susceptibility of the aggregate. Based on a comparison of grain size distribution of the cullet and aggregate with the work of others, we conclude that the material tested represents typical cullet for which other engineering properties have been determined; therefore, this information can be added to the current body of knowledge about the engineering properties of glass cullet.

## **ABRASIVES**

The former Anchorage-based recycled glass processor (EK Industries) relied almost exclusively on the abrasives market for revenues. This approach has some merit due to the presence of existing customers who are willing to pay higher prices for recycled-glass abrasive material. EK Industries’ abrasive product was high quality, clean, graded and blended to specifications. Several of the abrasives customers apparently were pleased with the product quality, and the pricing was competitive with alternatives. In these applications, glass has superior properties in many cases to alternative products.

However, EK Industries’ business model was ultimately not successful. Because the company was using equipment with high operation and maintenance costs, it did not achieve profitability. Also, developed market size was smaller than the quantity of Anchorage’s collected glass.

### ***Sand blasting abrasive***

A well-established, medium-value market for cullet exists as a blast abrasive medium in sand blasting applications such as ship repair and building facilities, metal fabricators, bridge maintenance applications, and other sand blasting uses. Although sand is an abundant and inexpensive material, it is no longer a preferred blasting medium due to health, safety and environment issues related to silicosis and sand dust. Glass competes as a replacement with many other blasting media such as copper slag, nickel fleck, ultra high pressure water, olivine, garnet, and others. Crushed glass also compares favorably with alternatives, and can

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be an important part of the product mix of a recycled glass processor. Glass is up to 30% to 50% lighter and is harder than some alternatives, which reduces purchasing and disposal costs significantly. Many federal contracts specify recycled-glass media.

TriVistro, ([www.TriVistro.com](http://www.TriVistro.com)) a Seattle-based recycled glass processor, sells a significant volume of glass blasting media at various grades depending on the specific end use of the abrasive.

### ***Water jet cutting***

Water jet cutting offers another niche market. Water jet cutters use ultra high pressure water jets to cut metal and other materials that require a fine cutting path. There are two water jet cutters in Southcentral Alaska. Both of these companies use highly processed garnet as cutting medium, which is mixed into the water as a slurry. These water jet cutters may purchase up to \$1,000 to \$3,000 of garnet per month.

## **TRACTION**

Traction sand is a ready market with a variety of existing segments in both consumer and industrial markets. Glass is a proven acceptable substitute for sand in traction uses when the glass is cleaned and sorted down to about 30 mesh and smaller. Depending on the market, the glass sand is either sold in bulk, in forkliftable bags, or in hand-carry consumer size bags. Consumer traction sand for home and office is sold in many retail outlets. These products come in a variety of mesh sizes and bag weights, and may contain ice melting chemicals and other product modifications.

Industrial traction sand is sold in quantities ranging from one-yard forkliftable bags to railcar loads. Industrial product specifications are often much tighter than consumer specifications, because the sand is applied with a wide variety of equipment and the sand must perform a very specific function that varies from user to user. Glass must be rigorously tested to define its characteristics when applied to a given industrial use. From this testing, a set of specifications may be developed and processing steps may be designed to meet those specifications.

## **FILTRATION**

Recycled glass that has been crushed and screened to the same specifications as sand can be used as a filtration medium.

### ***Swimming pool filtration***

Crushed glass could be used to replace imported sand and filter media for swimming pools. This market, like many other niche markets, is too small to justify the investment in a processing facility but may contribute to overall profit margins.

### ***Septic treatment sand filters***

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Some properties have site limitations which preclude the installation of conventional septic systems and therefore require advanced treatment of wastewater prior to soil infiltration. In Anchorage, an Intermittent Dosing Glass Filter was installed in 1997 off the Old Seward Highway near Potter Marsh. The system is composed of a lift station (primarily settling and pumping), an intermittent dosing glass filter (50% the size of a sand filter) and separate drain field. This system was inspected in 2008 and was in excellent working condition with no developed biomat in the drain field. The popularity of this type of treatment system has declined in the past decade in favor of other specialized treatment media and not currently likely to command a significant quantity of product.

Sand is mostly used in septic system construction as a filter at the bottom of the drainfield between the drain rock and accepting soil. This application would most likely require a direct inch-per-inch substitution and not have a quantity reduction applied as in the treatment system above. The municipal on-site regulations would also need to be changed to specifically include glass as an acceptable filtration media, or engineers can request substitution on a case-by-case basis. The State of Washington Department of Public Health accepts properly processed glass as a sand filter medium.

### ***Water well packing sand***

Closely graded sand is often used around water well inlets to provide adequate flow while keeping out native soils. Properly graded crushed glass was found to be a viable substitute for silica sand. In Anchorage, wells must be at least 40 feet deep, which generally requires drilling and eliminates the ability to use packing sand or cullet. Limited markets outside of Anchorage may be identified and developed.

### ***Subdrains and French drains***

Glass can be directly substituted or blended with sand or gravel to produce material for below grade water drainage. Applications include groundwater diversion and storm water management.

## **NICHE MARKETS**

Niche markets are those in which very specialized raw materials, sometimes requiring additional processing, are sold to a very small market segment, often for a high price. Generally speaking, the tighter the specifications, the higher the price of the glass or sand material. Three costly specifications for recycled glass are color separation, grain size, and cleanliness or lack of debris. Additional processing steps are required to meet these specifications, which can drive up the cost significantly and reduce the markets that are best suited for the product. Below is a general listing of some uses where crushed glass cullet has been determined to be an acceptable input. This listing does not speak to the economic viability of the market, or even whether these markets exist in Southcentral Alaska.

### ***Landscaping pavers and blocks***

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Cullet can be added to a standard cement mix to make non-structural bricks, blocks and pavers. However, cullet has properties that cause an alkali-silica chemical reaction that weakens cement and concrete over time. For this reason, the use of cullet should be limited to non-structural blocks.

### ***Topsoil production***

Crushed glass is an inert, silica-based aggregate, similar to sand. It has been used favorably as an input in topsoil to promote drainage and provide structure. The rounded edges of crushed glass (when processed with an impactor type crusher) are safe to handle in potting soil and topsoil without risk of being cut by shards.

### ***Plaster, countertops, terrazzo tiles***

Glass cullet use is acceptable in plaster, countertops, and other non-structural uses where the aesthetic appeal of glass is desired. Sunlight or bright lighting on the crushed glass particles adds a new dimension of sparkle and color to any medium where it is applied. Recycled glass chunks give any masonry product an interesting pattern, a bright hue, and a light-catching accent when used as a surface material. Recycled glass countertops and terrazzo tiles are particularly popular products that have achieved wide market acceptance. Glass is just one of many different styles and only commands a small share of the specialty countertop market. Formica, granite, wood, stone and concrete are all competitive products. For this use, the glass must be tumbled to remove the sharp edges, and often it is given a weathered texture.

### ***Glass clay body flux***

Very fine glass dust is a waste material generated by several industries. Glass fines may be combined with clay mixtures to reduce firing temperatures of ceramic bodies. A lower firing temperature shortens kiln time, reduces kiln temperature and saves energy.

### ***Glass fusing kits for craftspeople***

Recycled, color-sorted, cleaned glass is often used to make tile. One value-added product is pre-assembled kits that include washed recycled glass and all of the materials for craftspeople to make glass tile.

### ***Ceramics raw material***

Recycled glass, when cleaned and color separated, may be used as inputs for craftspeople or commercial ceramic operations. Sandhill Industries, formerly located in Fairbanks, AK, used Alaska Science and Technology Foundation support to develop a method of using post-industrial recycled glass to make decorative outdoor glass tiles. The Sandhill method used 750 BTU's to make a pound of tiles, compared with 1,800 BTU's for traditional ceramic tiles. The company developed a successful niche and moved to Boise, Idaho, to take advantage of markets, supply and other economic factors.

### ***Hydroponic rooting medium***

Hydroponic, or "soil-less," plant growth requires an inert medium to hold the plant roots and facilitate the flow of plant food to the roots. Processed glass was found to be an acceptable base for growing basil plants in a hydroponic growing system.

### ***Glass blowing and glass casting***

Post-consumer recycled glass is not a good medium for glass blowing or glass casting without performing batch modifications. Care should be taken when advocating recycled crushed glass for glass blowing applications.

### ***Tumbled glass***

Tumbled glass is also used in ponds, aquariums, fireplace beds, and rock gardens. Tumbled glass customers require color sorting and color mixing of cleaned glass with no debris.

## BIBLIOGRAPHY

A digital .pdf copy of these articles, or ordering information for proprietary articles, is available by request from Anchorage Solid Waste Services.

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