

# **CITY OF TORONTO GLASS MARKET DEVELOPMENT STUDY**

**(WDO OPT-R2-10)**

*Prepared for*  
**The City of Toronto**

*in Partnership with*



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## Table of Contents

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	<u>Page</u>
Summary	1
1.0 Introduction	4
2.0 Approach	4
3.0 Abrasive Blasting	5
4.0 Manufacture of Fibreglass Insulation	10
5.0 Water Filtration - Drinking Water Companies	11
6.0 Water Filtration - Rapid Flow Water Filters	12
7.0 Water Filtration - Municipal Wastewater Treatment	13
8.0 Water Filtration - Industrial Water Filtration	17
9.0 Golf Course Bunker Sand	18
10.0 Reflective Road Paint	22
11.0 Art Glass	23
12.0 Asphalt Roofing Shingles	23
13.0 Special Coatings	26
14.0 Winter Sand	27
15.0 Material Crushers	28
Appendix A	30
Appendix B	31
Appendix C	32

## **Executive Summary**

This study investigated 13 different sectors in the Greater Toronto Area (GTA) in order to find potential markets for the 13,000 tonnes/year of mixed broken glass generated in the City of Toronto's blue box program. In part, the study found that there is a limited amount of market development currently underway in the private sector. Owens Corning staff, for instance, indicated that the company has a plan to re-examine production problems caused by contamination in mixed broken glass in the manufacture of fibreglass insulation. Feedstock at the company's Toronto fibreglass insulation plant currently includes post-industrial glass only. If these technical problems can be resolved, Owens Corning staff suggested that the demand for post-consumer glass could be between 20 and 25 tonnes/day.

Minpro International Ltd. is apparently active in the development of processed crushed glass products for several applications, including the production of a golf course bunker sand substitute. Information collected to date suggests that processed crushed glass produced with Minpro equipment meets US Golf Association (USGA) suggested guidelines for bunker sand, though improvements to the product's colour are required. Minpro staff indicated that colour adjustments are a relatively minor task. There are no data available which estimate the potential size of the bunker sand market. Preliminary figures developed for this report - based on a wide range of planning assumptions - estimate potential utilization of processed crushed glass could be between 1,800 and 9,000 tonnes/year.

Three sectors were identified as promising applications that warrant research and consideration through pilot projects. Pilot projects are required in order to answer questions concerning technical efficacy and to develop firmer production estimates. These sectors are abrasive blasting, a substitute for winter sand and a powdery material for the asphalt shingles industry.

Preliminary estimates suggest that Toronto's mixed broken glass could be used to produce approximately 4,000 tonnes/year of blasting media with a retail value of \$75-\$100/tonne. There are no data that can be used to assess the overall size of the blasting media market or to indicate how much glass is presently used in blasting

applications, though preliminary information suggests niche markets could utilize processed crushed glass as a blasting media. Pilot projects are recommended to test the feasibility and effectiveness of processed glass including its capacity to clean the surface of concrete swimming pools.

Processed crushed glass that does not meet blasting product specifications could potentially be used as a substitute for winter sand. Data concerning annual utilization of winter sand were not available from the City of Toronto purchasing department. However, planning estimates based on anecdotal information suggest annual usage of winter sand is between 8,000 and 12,000 tonnes/year. The current price paid by the City of Toronto for winter sand is between \$9 and \$13/tonnes delivered. A pilot project is recommended to examine a number of technical issues including safety, effectiveness at providing traction on streets and sidewalks, cost of production and capacity to distribute this material with the existing truck fleet.

A third potential application is the production of a powder used in the asphalt shingles industry. Currently, a finely ground product made from dolomite is used as a filler material in asphalt shingles and as a dust to prevent bundles of shingles from sticking together. Additional research and a pilot project are recommended in order to determine if a glass-based product can be produced, the cost of production and its competitive advantage compared with products made from dolomite.

In order to implement a pilot project, it is necessary to secure the services of a crusher. Fourteen aggregate crushing contractors were contacted in order to determine crushing capacity and to assess their general level of interest. Three firms expressed interest in working on a pilot project: one each in Toronto, Brampton and Huntsville. Staff from all three firms indicated a willingness to discuss a pilot project in more detail in order to work out logistics and costs. Although Huntsville is a two-hour drive from Toronto, this crushing firm also retails a range of aggregates including golf course bunker sand and blasting media. As such, they may be interested in working with the city to both produce and market processed crushed glass products.

The Toronto firm expressed an interest in exploring the possibility of crushing glass to produce a blending material that could be added to granular aggregate. Staff from this

firm indicated the most probably short-term market for this product would be capital projects undertaken by the City of Toronto and Toronto Transit Commission (TTC). In order to develop this market, it would be necessary to obtain approval from City and TTC engineers to use a blended aggregate in their respective capital works projects. Potential utilization of crushed glass by this Toronto crusher is estimated to be between 5,000 and 10,000 tonnes per year.

In early March 2001, Consumers Glass announced that changing market conditions - primarily the closure of the Molson's Breweries plant in Barrie, Ontario and the concomitant loss of a major cullet customer - necessitated a significant reduction in amount of coloured glass it would purchase. Consumers Glass indicated that it would now purchase up to 700 tonnes per month of coloured glass, for an annual upset demand of 8,400 tonnes. Work is on-going to help support alternative market economic evaluations for priority communities in light of Consumers' recent announcement.

## **1.0 Introduction**

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According to 1999 data, the City of Toronto recycling program processes approximately 23,000 tonnes/year of residential container glass. Approximately 55% or 13,000 tonnes/year consists of mixed coloured broken glass. Currently, this material is used by the City as an aggregate substitute in various applications at the Keele Valley landfill (e.g. roadbed construction, backfill around methane gas collection pipes, etc.). When the landfill closes (estimated to be the fall of 2002), municipal uses for this material will be reduced significantly.

WDO funding provided the City of Toronto with a grant to research new market opportunities for the mixed broken glass that comes from the City's municipal blue box program. Enviro RIS was contracted to undertake this work on behalf of the City. The scope of work proposed for this project was as follows:

- Task 1 - Research potential applications.
- Task 2 - Conduct interviews with personnel in the industry in order to quantify market need, substitution prices and technical barriers.
- Task 3 - Identify opportunities for pilot projects that could reduce barriers to mixed broken glass utilization.

## **2.0 Approach**

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Given the project budget and schedule limitations, the project team decided to focus resources on markets that appeared to offer the greatest potential for mixed broken glass utilization. Based primarily on research previously undertaken by the Clean Washington Center and its former director David Dougherty (a member of this study team) the project team focused on three general areas: 1) abrasive blasting, 2) fibreglass manufacturing and 3) water filtration. Within the field of water filtration, four different subsets were targeted: drinking water companies; rapid flow water filters; municipal wastewater treatment and; industrial water filtration.

Several niche markets were also investigated as potential opportunities for mixed broken glass. They are art glass, golf course bunker sand substitutes, reflective road paint, asphalt roofing shingles, industrial paint and a substitute material for winter sand.

Research results for each sector investigated are presented in the following sections.

### 3.0 Abrasive Blasting

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#### 3.1 Background: Types of blasting media <sup>1</sup>

Blasting is a process used to clean metal, plastic and cement surfaces. Blasting is also used to prepare a surface to a desired profile in preparation for coating. Shot peening is used to increase the fatigue life of structural metal in automotive and aerospace applications (e.g. transmission gears, turbine blades and vanes, landing gear, connecting rods in high performance engines, airframe components, powertrain components). There are many different types of materials used in blasting, as described below. Where available, price estimates are based on a medium grade quality from GTA retailers delivered to downtown Toronto and will vary according to the amount purchased.

- **Flint silica sand:** A common silica sand for cabinet blasting operations. \$100/tonne.
- **White Lightning:** This is a silica-free blasting material. \$110/tonne.
- **Walnut shells:** Used to remove paint, lacquer, rust, scale, carbon and chemical deposits, and to deflash molded plastic parts. Also used to clean various types of engines (e.g. gasoline, diesel and aircraft engines) and steam turbines as well as general cleaning in restoration of buildings, bridges

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<sup>1</sup> <http://www.perstrip.com/otherblast.htm>. Viewed December 12, 2000.

and outdoor statuary. Walnut Shells measure between 3 and 4 on the MOHS scale.<sup>2</sup>

- **Corn cob grit:** A soft, low-dust abrasive used for finishing, polishing, deburring and deflashing. It is used to blast wood, aluminum, fiberglass, buildings and boats. Corn cob granules are biodegradable, non-toxic and non-sparking and measure 4.5 on the MOHS scale.
- **Aluminum Oxide:** Aggressive surface for cleaning hard surfaces. This material measures 9 on the MOHS scale and lasts longer than slag and sand.
- **Silicon Carbide:** One the hardest abrasives; works well cutting hard materials (e.g. ceramics, silicon, and quartz). Unlike aluminum oxide, silicon carbide will produce new cutting edges as the media breaks down. This material registers 9.5 on the MOHS scale.
- **Steel Shot and Grit:** Aggressive surface cleaning and conditioning. Available in the form of shot (round homogenous balls) or grit (crushed steel shot) and different levels of hardness. Steel shot is commonly used in "shot peening" which improves the fatigue properties of metal products. Steel media is long lasting and can be used on a wide range of high production applications.
- **Stainless Steel and Zinc Cut Wire:** Aggressive surface cleaning and conditioning.
- **Rice Hulls:** Used for carbon removal and blast cleaning.
- **Garnet:** Used for blast cleaning and water jet cutting.
- **Glass Beads:** Used for a variety of surface treatments, including cleaning, honing, polishing, peening, and finishing. Beads do not remove bare metal,

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<sup>2</sup> See Appendix B for a description of the MOHS mineral hardness scale. Data from <http://www.baaqmd.gov/permit/handbook/s11c01pd.htm>. Viewed December 12, 2000.

nor do they leave an embedment. Manufactured from a high-grade, lead-free, soda lime type glass and contains no free silica. Glass beads measure 4.5 to 6.5 on the MOHS scale.

- **Ground Cullet.** Used for many applications including cleaning, deposit removal, surface preparation, and finishing. Cullet contains no free silica, and comes in a variety of sizes. Ground cullet measures 5.5 to 6.5 on the MOHS scale. Approximate cost is \$75 to \$100/tonne.

### 3.2 Results

Blastek is reported to be one of the largest surface preparation companies in North America. According to company staff, processed crushed glass has limited applications as a blasting media because of its technical properties and relative financial implications. Crushed glass is, in some applications, suitable as a blasting agent on stainless steel. Although processed crushed glass can clean a surface, its technical weakness is that it does not create a good 'profile.' After blasting with crushed glass, the flat, dull surface is not readily suited for many types of specialized coatings. Many coatings require a particular surface texture in order to bond well with the surface. This technical limitation was confirmed by the Ontario Chair of Society for Special Coatings (SSPC), an association of abrasive blasting and coatings companies.

In addition to technical considerations, Blastek staff indicated that the financial aspects of blasting with glass limit the range of its applicability. For instance, although steel grit costs about \$700/tonne, it can be collected for reuse 30-40 times. Based on these rough estimates, the net purchase cost is about of \$20/tonne. After its final use, the remaining dust can be taken to a steel recycler where the cost of disposal is far less than that for landfilling. The problem with glass is that it shatters into un reusable pieces after one application and needs to be disposed immediately, at about \$75-100/tonne.

A technical consultant contacted for this report indicated that the market potential for processed crushed glass would likely be restricted to niche markets where surface

profiling is not a primary concern.<sup>3</sup> These potential markets include cleaning parts, stainless steel or cement surfaces. He indicated that processed crushed glass could compete against glass beads, garnet or slag used by small air blast operations if the correct technical specifications could be manufactured and if processed crushed glass were proven to be an effective cleaner. A typical small air blast operation purchases approximately 450 kilograms of glass beads/week, or 22 tonnes/year.

A Toronto area sand blasting company expressed interest in conducting a pilot project in order to determine if processed crushed glass could effectively clean the surface of concrete swimming pools. The owner of this company indicated that he does not have any storage capacity as he operates a mobile business. As a result, he would require a bagged glass product (50 or 100 lb bags) loaded on skids (one skid holds 30 100-lb bags). He said a typical job requires about 3 skids (approximately 1.4 tonnes per skid). Currently, he pays \$7 per 100-lb bag of silica sand, which is approximately \$154/tonne. The glass specification for this application would be between 12 and 30 mesh.

It is improbable that all 13,000 tonnes of mixed broken glass generated in the Toronto each year could be utilized as a blasting abrasive. A preliminary estimate by one company suggests that 30% of all glass that passes through a crusher and 12 to 30-mesh screen would meet product specification requirements. Based on this figure, annual production of processed crushed glass as a blasting media is estimated to be approximately 4,000 tonnes/year. The potential retail value of this product is between \$75 and \$100/tonne.

Based on these results, the use of processed mixed broken glass as a blasting media in niche markets appears promising. There are, however, several technical questions that need to be resolved, as noted below.

- Evaluate capacity to produce a final product that meets product specifications (e.g. minus 12 or 30 mesh that is uniform in size). Without size uniformity, crushed glass would not be a marketable product. A small number of private firms have indicated a willingness to discuss the possibility of participating in a

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<sup>3</sup> Personal communication with Hugh Roper, a consultant in the field of abrasive blasting.

pilot project to test their capacity to produce a crushed glass product to specification.

- Confirm that pulverized glass is silica-free. Although technical consultants confirm that crushed glass is silica-free, the use of this material as a blasting media may require certification from a provincial or federal authority.
- Determine if crushed glass leaves a deposit on concrete. If it does, glass may not be an effective blasting media for cleaning concrete swimming pools because the deposit could interfere with the coating that is applied after the concrete surface has been cleaned. A closer examination of this question does not appear feasible within the scope of this research project, as swimming pool work could start no earlier than late spring.

### **3.3 Summary**

Preliminary data indicate that processed crushed glass may be suitable for use in niche markets that involve surface cleaning of parts, stainless steel and concrete surfaces. In some applications, crushed glass could be used as a substitute material for walnut shells or glass beads. Opportunities for crushed glass as blasting media substitute in a wide range of application are limited because the surface profile it creates is unsuitable for specialty coatings.

Opportunities for pilot projects appear promising. There are a number of questions that need to be answered before Toronto's mixed broken glass could be processed and marketed as a blasting media. All of these questions could be answered in relatively small-scale projects. In addition, three crushing firms contacted for this report indicated a willingness to discuss participation in a pilot project.

## **4.0 Manufacture of Fibreglass Insulation**

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### **4.1 Results**

According to Owens Corning staff, the company displays an Eco Logo on their fibreglass insulation packaging to signify that the product contains 35% recycled content (by net weight). The company currently uses post-industrial material such as plate and windshield glass. In the past, Owens Corning included post-consumer glass in the production process. Usage of this material was stopped because metal and ceramic contamination in the glass caused problems in the furnace and on the production line (e.g. the contamination blocked small shoots used to produce strings of fibreglass).

Owens Corning staff indicated they have the necessary in-house technical expertise in the US to resolve production problems related to post-consumer glass contamination. The company also indicated they have a tentative plan for the first quarter of 2001 to reintroduce post consumer material into production through an agreement with Nexcycle. This will be possible when and if the company is able to transfer their in-house technical expertise from the US to Toronto to resolve production barriers.

Assuming contamination problems can be resolved, Owens Corning staff estimated that consumption of post-consumer material could be 20-25 tonnes/day, representing 50% of the daily raw material feedstock requirement. The basic specification for processed crushed glass in this production process is 12 mesh with very low contamination and organic count (e.g. 1% or less).

No pilot projects are recommended for this sector because post-consumer glass has been used in the past to manufacture fibreglass insulation. Moreover, one private company possesses in-house technical expertise to examine the production problems.

### **4.2 Summary**

The potential Toronto-area market for post-consumer crushed glass in the manufacture of fiberglass insulation is estimated to be between 20-25 tonnes/day, or approximately 5,000 tonnes/year. To achieve this level of consumption, technical barriers related to the

way in which manufacturing processes handle contamination in post-consumer material need to be resolved. One company in the Toronto area has the in-house technical capacity to examine these barriers. Staff at a second manufacturing firm in the GTA indicated that the company does not use recycled content in their production process.

## **5.0 Water Filtration - Drinking Water Companies**

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### **5.1 Results**

Echo Springs is one of the largest bottled water companies in Ontario, with sales in 1998 totaling \$15 million. Its products are sold in major department stores and offices. Staff at Echo Springs indicated that silica is not used as a filtering media in the water bottling process. When water is filtered, a 0.45-micron membrane filter (e.g. possibly made from polypropylene) is used to screen out microbiological particles.

Information provided by staff at the Canadian Bottled Water Association confirmed that this is the standard filtering practice in Ontario. Therefore, there are no known opportunities to use processed crushed glass as a filtering media in this sector.

### **5.2 Summary**

There are no known opportunities for the use of processed crushed glass as a substitution material for silica or other filtering media in this sector.

## 6.0 Water Filtration - Rapid Flow Water Filters

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### 6.1 Results

Staff at Jacuzzi Canada indicated they were familiar with the idea of using processed crushed glass as a substitute for silica in water filters. However, they suggested that glass would not work well in this application because crushed glass is not porous enough to create strong adhesion properties. Therefore, particulate in the water would not be filtered to a satisfactory degree.

Webster and Sons is one of the largest wholesalers of swimming pool supplies in the Toronto area. Staff at this firm indicated they sell about 22 tonnes/month of silica sand to various pool installers during peak season – April to October (estimated to be approximately 200-300 tonnes/year). The two of its largest wholesale customers are Capital Pool Industries and Around About Pools. Webster and Sons sells silica to retailers for about \$2.90 per 50-pound bag (approximately \$125/tonne). Staff at this company indicated they have never considered the use of processed crushed glass as a substitute for silica.

Capitol Pool Industries staff indicated that a typical pool installation requires about 300 pounds of sand. This sand retails to the pool customer for \$5 for a 50-pound bag, which is approximately \$220/tonne. At this rate, the cost of sand for a typical filter is approximately \$30 per installation. Staff at this company have never examined the possibility of using processed crushed glass, primarily because silica has a long track record of effective utilization.

Assuming that a typical swimming pool filter requires 300 pounds of sand and that sales of pool filter sand are at least 200-300 tonnes/year (figures based on sales from one Toronto area supplier), new pool installations in the Greater Toronto Area are estimated to be at least 1,400 to 2,200/year.

There may be opportunities for pilot projects in this sector. However, the timing of this research project does not permit the implementation of a pilot that would, by necessity, begin in the late spring or summer seasons. In addition, the preliminary data obtained

for this report suggests that pool filters may not utilize large quantities of glass. For these reasons, no action in this sector is recommended.

## 6.2 Summary

The focus of research in this sector was the pool filter industry. These filters include plastic cartridges as well as larger frame filters. Preliminary data suggest there are limited opportunities to use processed crushed glass as a substitute material in this sector.

## 7.0 Water Filtration - Municipal Wastewater Treatment

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### 7.1 Background data: Toronto Water Filtration System

Four water filtration plants supply drinking water to the City of Toronto and a portion of York Region (York Region accounts for approximately 15% of Toronto's production). An overview of each filtration plant is provided in Table 7-1 below.

**Table 7-1  
Toronto Water Filtration Plants**

Plant	Location	Total Filtrated Water Produced in 1999 (m/l)	% of total	1999 Days of Operation
Harris	West Scarborough	251,900	45%	365
Horgan	East Scarborough	154,400	27%	365
Clark	Etobicoke	142,900	25%	358
Island	Toronto Island	14,400	3%	91
<b>Total</b>		<b>563,500</b>	<b>100%</b>	

Note: m/l equals millions of litres.

Source: Toronto Works and Emergency Services, Water and Wastewater Services Division, 1999/2000 Annual Report.

- Harris Plant:** Settled water passes through 40 dual media filters. Filter media consist of 0.5 metres (m) of graded gravel with the largest particle size on the bottom, covered by 0.3 m of sand and a 0.3 m top layer of anthracite.

- **Horgan Plant:** Water passes through 8 dual media filters. Filter media consist of 0.305 m of graded gravel covered by 0.35 m of sand and 0.460 m of anthracite.
- **Clark Plant:** Settled water passes through 18 dual media filters. Filter media consist of 0.457 m of graded gravel covered by 0.3 m of sand and 0.45 m of anthracite.
- **Island Plant:** Water passes through 6 dual media filters. Each filter consists of 0.56 m of anthracite and 0.2 m of sand, resting on a bed of graded gravel. The Island plant is used primarily during the summer to meet peak demand and to supply water when other plants are closed for maintenance.

### Typical Filter Specifications

Each filter typically consists of one rectangle that holds six cylinders. Each cylinder is 17 metres in diameter. The typical depth of each cylinder is approximately 1.2 metres. Therefore, the volume of each typical cylinder is approximately 286 cubic metres. A description of the filter media used in a typical cylinder along with the estimated volume and respective material size is listed in Table 7-2.

**Table 7-2**  
**Description of Filter Media in a Typical Cylinder**

Material	Depth (mm)	Effective Material Size (mm)	Volume (cubic metres)
Anthracite	460 mm	1.05 - 1.15 mm	104.4
Silica sand	300 mm	0.45 - 0.5 mm	68.1
Gravel top layer	51 mm	1.2 - 2.39 mm	11.6
Gravel layer	76 mm	2.39 - 4.75 mm	17.3
Gravel layer	76 mm	4.75 - 12.75 mm	17.3
Gravel layer	76 mm	12.75 - 25.4 mm	17.3
Bottom gravel layer	178 mm	25.4 - 50.8 mm	40.4
<b>Total</b>	<b>1.217 m</b>	<b>n/a</b>	<b>286</b>

Table 7-2 shows that a typical cylinder contains 300 mm of sand that ranges between 0.45 and 0.5 mm in size. The volume of sand in a typical cylinder, assuming 17-foot diameter, is approximately 68 cubic metres. Assuming that the density of sand is 1.5 tonnes/cubic metre, each cylinder uses about 100 tonnes of sand.

The potential utilization of processed glass as a substitute for sand in water filtration systems - under ideal conditions - is shown in Table 7-3. The table shows estimates for the total amount of silica sand used in Toronto's water filtration system. Estimates were calculated by multiplying the number of filters by six in order to estimate the total number of filtering cylinders (each filter has six cylinders). Because the depth of sand in each cylinder (shown for each filtration plant in the table) and the diameter of each cylinder - 17 metres - are known, it was possible to calculate the approximate volume of sand in each cylinder. When these figures were multiplied by the total number of cylinders, it was possible to estimate the total volume of sand used in each filtration plant and for the city's filtration system as a whole. Assuming that sand has a density of 1.5 tonnes/cubic metre, the mass of sand in each filtration plant could be estimated.

As shown in Table 7-3, the city's water filtration system is estimated to have approximately 45,000 tonnes of sand. The table also shows that the proposed filtration system expansion in Scarborough is expected to consist of six filters utilizing an estimated total of 3,700 tonnes of silica sand.

**Table 7-3  
Estimated Volume and Mass of Sand in Toronto's Water Filtration System**

Filtration Plant	# of filters	# of cylinders	Depth of sand (metres)	Volume of sand (cubic metres)	Weight of sand (tonnes)
Harris	40	240	0.30	16,300	24,500
Horgan	8	48	0.35	3,800	5,700
Clark	18	48	0.30	7,300	11,000
Island	8	48	0.20	2,200	3,300
<b>Total</b>	<b>74</b>	<b>261</b>		<b>29,700</b>	<b>45,000</b>
Proposed Plant	6	24	0.30	2,500	3,700

Note: Figures may not sum due to rounding.

## 7.2 Results

City of Toronto staff indicated that a filter consists of gravel, silica sand and a top layer of anthracite (see above for details). Anthracite requires periodic replenishment, estimated to be two to three inches every 2 to 3 years. Sand and gravel do not usually require regular replenishment, but are typically replaced once every 10 to 20 years.

The cost of anthracite is approximately \$300-\$400/tonne delivered. The cost of silica sand depends on the required specification (i.e. effective size and uniformity coefficient) but could cost between \$125 to \$175/tonne delivered. This material is often shipped in bags in order to minimize the potential for contamination and for ease of handling at the job site.

The City of Toronto is currently in the early planning stages of constructing six new filters at the Horgan plant in Scarborough. Much of this planned capacity would be used to service new growth in York Region. The cost of each filtration system (filters plus related infrastructure) is estimated to be in the range of \$10-\$15 million. Therefore, the entire project is expected to cost between \$60 and \$90 million. There are no plans to use processed crushed glass in these new filtration systems.

Email queries concerning the use of processed glass as a sand substitute in filtration systems were circulated through the Ontario Water Works Association (OWWA) and American Water Works Association (AWWA) websites. The emails generated a number of responses, all of which indicated no knowledge of an existing water filtration system that uses processed glass as a filter media in municipal applications. In addition, a number of questions and concerns were raised regarding the viability of glass as a filter media. These comments centred on the following issues:

- the consumer's perception about the use of glass in municipal filtration systems;
- the long-term durability of glass to act as an effective filter media;
- the ability of glass particles to absorb matter;
- the density of glass;
- health concerns about the possibility of glass fines in drinking water;
- the cost of existing materials (e.g. silica sand) is relatively low when balanced against perceived risk of using an untested material.

### **7.3 Summary**

Toronto's municipal water filters contain a number of materials including silica sand, which could potentially be replaced with processed glass. Typically, filter sand is replaced once every 10 to 20 years. As such there is a low opportunity to utilize processed crushed glass in this application. The City of Toronto is currently in the early planning stages of a new series of filters in Scarborough. Estimates suggest that the total demand for sand in these filters is approximately 3,700 tonnes. Notwithstanding engineering and technical issues, there may be an opportunity for a limited test pilot in one of these new filters.

Based on comments made by water works engineers across the continent and by City of Toronto staff, there appears to be little enthusiasm concerning the potential use of processed crushed glass as a filter media. Long-term effectiveness, public perceptions and a balance between cost and perceived risk are all issues that need to be addressed before processed crushed glass is likely to be viewed as a viable filter media in municipal water treatment facilities.

## **8.0 Water Filtration - Industrial Water Filtration**

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### **8.1 Results**

CANCO Filter Inc. is a Toronto-area company that designs and manufactures industrial filtration systems. The president of the company indicated he has never heard of anyone using processed crushed glass as a filter media. He also indicated that there are several potential problems or questions concerning the use of crushed glass in industrial applications. First, crushed glass could escape from the filter frame during backwashing thereby contaminating the filtered liquid or other filters. The president of CANCO indicated that he observed this problem in a study conducted several years ago. Second, processed crushed glass is an inappropriate filtering media for incoming water treatment, if for no other reason than the optics of using glass to clean drinking water.

A third potential area of concern is the uncertainty of how glass would react with different types of contaminants and operating conditions. One of the advantages of using sand is that its reaction to varying temperatures and different end-uses is predictable. A final concern is the uncertainty of backwashing crushed glass and how much energy would be required to clean the glass, especially if it were tightly packed together.

A number of private companies were contacted for this project in order to obtain information concerning the design and operation of their industrial filtration systems. None of these firms expressed an interest in discussing their system or the possibility of attending a workshop to discuss potential applications for glass. Given the lack of information and apparent interest, no pilot projects concerning the use of glass in this sector are recommended.

## **8.2 Summary**

A typical industrial waste filter uses between 200 and 10,000 pounds of sand depending on the application. There are a number of technical issues that need to be resolved before crushed glass could be promoted as a substitute for sand in industrial filters. These issues would need to be explored in depth using pilot projects, all of which requires far more work than is permitted within the scope of this project.

## **9.0 Golf Course Bunker Sand**

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### **9.1 Background**

There are approximately 620 golf courses in Ontario.<sup>4</sup> Approximately 40% of this total, or 230 courses, are located in and around the GTA. The City of Toronto itself owns five public courses.

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<sup>4</sup> Number of Ontario courses listed on the website: <http://www.golf-ontario.com/>. Visited January 25, 2001.

There are eight factors that should be considered when selecting golf course bunker sand.<sup>5</sup> They include:

- particle size
- particle shape (low sphericity means a rectangular shape while high sphericity means almost round)
- penetrometer value (this measures the sand's resistance to compression)
- crusting potential
- chemical reaction (pH) and hardness
- infiltration rate
- color
- overall playing quality

Particle size is often selected on the basis of how the golf course superintendent wants the bunker to play and local weather conditions.<sup>6</sup> Bunker sand that contains a relatively large percentage of coarse particles will result in a tendency for the golf ball to lie on top of the sand, thereby providing golfers with a relatively easy shot out of the trap. A higher percentage of fine particles will create a more difficult shot, or hazard, because the ball will have a tendency to sink into the sand. Silica sand is a preferred bunker material because its angular shape (i.e. many well-defined sharp edges) and hardness resist change caused by exposure to the outdoor environment and raking. The US Golf Association suggests the following bunker sand particle size distribution, as shown in Table 9-1.<sup>7</sup>

**Table 9-1  
USGA Suggested Bunker Sand Particle Size Distribution**

US Sieve	Diameter (mm)	USGA Recommended % in Sieve
10	2.0	3% or less
18	1.0	7-10%
35	0.50	60-75% falling between 35 to 60 mesh sizes
60	0.25	
100	0.15	Maximum 20%
270	0.05	Maximum 5%
Pan	Pan	Maximum 5%

<sup>5</sup> "Bunker Sand Selection," Jim Moore. Website <http://www.sandfinder.com/bunker%20sand%20selection.htm>. Visited February 27, 2001.

<sup>6</sup> Personal communication with Jim Moore, Director of Construction Education Programs of the USGA Green Section.

<sup>7</sup> <http://www.palmercc.com/golfcoursesand.htm>

## 9.2 Results

According to a golf course architect contacted for this project, a typical new golf course requires approximately 1,500 to 2,000 tonnes of bunker sand, although some courses could use as much as 7,000 tonnes.<sup>8</sup> This architect also indicated that golf courses designed to a high standard prefer Ohio 535 sand, regarded by some as one of the best bunker sands available. The cost of this sand delivered to the Toronto area is approximately \$60-80/tonne (Canadian dollars). Depending on a number of factors (e.g. weather, usage, etc.) bunker sand is replenished once every 5-10 years.

Golf courses that require less expensive bunker sand typically use a product from a broker called Hutcheson Sand and Mixes in Huntsville. Staff at this company indicated that their bunker sand retails for approximately \$25-\$35 per tonne delivered to the Toronto area.

The golf course superintendent at Cranberry Resort indicated that he has been in discussions with Minpro International regarding the possible piloting of processed crushed glass as a bunker sand substitute.<sup>9</sup> He indicated that the physical specifications of the processed crushed glass provided by Minpro were comparable with Ohio 535 sand. However, the colour of the crushed glass sample was clear and therefore not satisfactory. Apparently, Minpro is working to improve the color. Minpro staff indicated that this was a fairly simple matter to correct. To date, crushed glass has not been used in any Ontario golf course bunkers. Similarly, the Director of Construction Education Programs of the USGA Green Section indicated that processed crushed glass has not yet been used as a bunker sand substitute in the US.<sup>10</sup>

Assuming that the technical requirements can be resolved, the potential market for processed crushed glass as a substitute for bunker sand looks promising. Table 9-2 shows estimates for crushed glass utilization for three scenarios. These estimates were calculated by using the planning following assumptions:

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<sup>8</sup> Personal communication with golf course architectural staff at Thomas McBroom and Associates, Toronto.

<sup>9</sup> Personal communication with Rick Buttonham.

<sup>10</sup> Personal communication with Jim Moore.

**Table 9-2**  
**Estimated Potential Utilization of Crushed Glass as a Bunker Sand Substitute**

Item	Scenario 1	Scenario 2	Scenario 3
GTA Courses	240	240	240
Tonnes/course of bunker sand	1,500	1,500	1,500
All tonnes bunker sand	360,000	360,000	360,000
Replenishment cycle	10 years	10 years	10 years
Glass Market Share	5%	10%	25%
<b>Potential Glass Usage (tonnes/year)</b>	<b>1,800</b>	<b>3,600</b>	<b>9,000</b>

- Courses in the GTA would be the medium term target market. A wider area of the province was not selected for these estimates in order to develop conservative figures and to reflect the fact that aggressive marketing of a bunker product would likely require a narrow geographic area over the short to mid-term.
- Each existing golf course was assumed to have 1,500 tonnes of bunker sand (the lowest figure reported in the text above).
- Bunker sand is replenished once every ten years (a conservative estimate from figures described above).
- Three market share scenarios were developed. The first scenario assumes that 5% of all bunker sand on GTA courses that would normally be replenished on an annual basis is instead replaced with processed crushed glass. In Table 9-2, this is called a 5% market share. The second and third scenarios assume market shares of 10% and 25%, respectively.

Based on these assumptions and calculations, potential utilization of processed crushed glass is estimated to be approximately 1,800 to 9,000 tonnes/year. The degree to which these figures can be achieved depends on the development of an effective and price-competitive product and implementation of an aggressive marketing program.

### **9.3 Summary**

The technical features of processed crushed glass need to be verified with Minpro. Research is also required to determine if crushed glass can be applied on top of an existing bed of sand or if the bunker has to be emptied first before processed crushed glass can be applied. Assuming that these issues can be resolved and that a competitively priced product can be produced, the potential market is significant and warrants further investigation.

## **10.0 Reflective Road Paint**

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### **10.1 Results**

Flexolite Ltd. manufactures glass beads used in the production of reflective road paint for Ontario and other provinces. The president of the company indicated that post-consumer glass could be used to make the glass beads but the material would have to be clear cullet only; mixed broken glass does not meet the technical requirements of reflective road paint. Currently, the Flexolite feedstock consists of cuttings from windshield manufacturers. The long-term availability of this post-industrial feedstock could become a problem as there is a trend toward darker tints in windshield glass. If this trend continues, new sources of clear glass would be required.

Because the City of Toronto cannot currently colour separate mixed broken glass, there is not opportunity for crushed glass utilization in this sector.

### **10.2 Summary**

There is no known market opportunity for mixed broken glass in this sector because the glass beads used in reflective road paint need to be clear.

## 11.0 Art Glass

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### 11.1 Results

The owner of Kaleido Glass Limited indicated that the plate glass used for stained glass projects in the Toronto area comes from the US. There are no manufacturers of this type of glass in Ontario. Staff at the Craft Studio located in York Quay Centre indicated that glass artists use a product called “soda glass,” which is essentially sand with soda added. Artists do not use tempered glass, which is used to manufacture consumer packaging. Harbourfront artists and Sheridan College glass art students import soda glass from a US manufacture that sells off-spec products for artwork. Thus, there are no opportunities to utilize processed mixed broken glass in this sector.

### 11.2 Summary

There are no known opportunities for processed post-consumer crushed glass in this sector.

## 12.0 Asphalt Roofing Shingles

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### 12.1 Background

Asphalt roofing shingles generally consist of a mat (made from either felt or fibreglass) covered with asphalt and rock granules, with the following construction specifications:<sup>11</sup>

- Asphalt cement: 19 to 36 % by weight. Organic shingles contain 30-36% asphalt. Fiberglass shingles contain 19-22% asphalt.
- Mineral filler/stabilizer (e.g. limestone, silica, dolomite, etc.): 8-40% (90% of the granules are smaller than 0.15 mm, 70% are smaller than 0.08 mm.)
- Mineral granules (ceramic-coated natural rock, sand-sized): 20-38%.

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<sup>11</sup> California Integrated Waste Management Board web site:  
<http://www.ciwmb.ca.gov/ConDemo/factsheets/ShinglIn.htm>. Viewed December 12, 2000.

- Felt backing (mat): 2-15%. There are two types of mats: organic felt, made with paper and fiberglass.

## 12.2 Results

Asphalt roofing shingles are covered with granules made from specific grades of crushed stone. The purpose of this granule is three-fold. First, it blocks UV radiation from coming in contact with the asphalt. According to roofing research, asphalt will degrade to point of failure after one year if not protected from UV radiation, thereby resulting in an ineffective roofing system. The second purpose is aesthetic. The granules used on the shingles can be coloured to meet market preferences. In many cases, a ceramic glaze is applied to the granules to achieve color changes. Third, the granule provides the shingle with a shield against the weather. Because shingles are marketed as a product that can last up to 20 years, the granule must embed firmly in the asphalt to resist extreme forms of weather.

In order to meet these product requirements, a specific type of granule is required. It must have a fine grain, be uniform in size and be free of pyrites or calcite. It must crush into cubical shapes, be opaque and dense enough to block UV radiation and accept pigment. A quarry near Madoc, Ontario supplies IKO plants in Ontario and several US plants with a gray andesite stone. A 3M mine in Havelock, Ontario supplies many different asphalt shingle manufactures across the continent with a green andesite stone.<sup>12</sup> 3M is reported to be the single largest supplier of asphalt shingle granule on the continent, which sells for approximately CDN \$100/imperial ton (depending on quantity, freight charges and colour). The general size specification for shingle granule is mesh 11. A range of screen sizes - from 10 to 35 mesh - ensures that the entire surface of the shingle is covered with large and small granules.

All personnel contacted for this report indicated that the main reason crushed glass could not be used as a substitute for granular andesite is the inability to block UV radiation. 3M staff indicated that it might be possible to treat crushed glass with an UV inhibitor though the process would likely be cost prohibitive. Moreover, even if

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<sup>12</sup> Andesite is a dark, fine-grained volcanic rock. It occurs as lava flows and dikes in regions where the plates of the earth's crust collide with one another.

processed crushed glass were treated with inhibitors, the long term stability and effectiveness of the product is uncertain, a key concern for shingle manufacturers where products are expected to last 15 to 20 years in all types of weather. In addition, there are other uncertainties with respect to how well the glass would embed into the asphalt and the effectiveness of pigment changes.

A second potential application for processed crushed glass is a substitute for dolomite. Dolomite (calcium magnesium carbonate) is a hard mineral (3.5-4 on the MOHS scale) often pinkish in colour though it can also be white and gray. It is similar to limestone except that dolomite is heavier and harder. Dolomite is used largely as a building stone for the manufacture of refractory furnace linings and as magnesium carbonate for pipe coverings.

In the manufacture of shingles, dolomite can be used as a dusting material between sheets in a bundle (about minus 50 mesh) or as a filler stabilizer in the asphalt (minus 100 mesh). Depending on quantity and location, the cost of dolomite ranges between \$6 and \$60/tonne. Aggregate grades cost about \$6/tonne while fillers are approximately \$12/tonne. No cost estimates were available for the dusting material.

No quantities of usage in the shingles market were available for dolomite in either dusting or filler applications. Dusting and filler applications represent potentially promising markets if processed crushed glass can be shown to be an effective and cost competitive substitute for dolomite.

### **12.3 Summary**

There is no known market opportunity for mixed broken glass in the production of asphalt roofing shingles because of the technical limitations of glass to block UV radiation, the uncertainty regarding how well glass could become embedded in the asphalt and its reaction to coloration processes. Glass crushed to a powder consistency could potentially be used as a substitute for dolomite as a filler or dusting material used to prevent shingles from sticking together when packed in bundles. The capacity to produce a glass-based product that meets market specifications cost-effectively would need to be tested in a pilot project.

## **13.0 Special Coatings**

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### **13.1 Results**

The Ontario chair of the Society for Protective Coatings (SSPC) indicated that fillers are rarely added to bulk up paint. He did say that fibreglass is added to some paints designed to provide structural reinforcement and resistance properties in tank applications (e.g. oil tanks and water tanks in filtration plants). Sherman Williams manufactures this type of paint in Cleveland, for instance.

PPG Paints in Mississauga manufactures auto paint. PPG staff indicated that mixed colored glass is never used as a source of filler material because the feedstock needs a consistent ratio of colours in order to produce a consist color of paint. PPG makes other specialty paints in the US, which is where the company's research and development facilities are located.

Sico Paints manufactures several types of industrial paints in Montreal. In the Toronto area, Sico produces residential paint for which there is no potential application for processed crushed glass.

Given that the potential markets are located outside the GTA area, no pilots for this application are recommended.

### **13.2 Summary**

Research undertaken by the Clean Washington Centre suggests that crushed glass could be used as mineral filler in some types of paint. Information collected or this report suggests there are no opportunities in the Toronto area to use processed crushed glass as an additive in special coatings as these types of paint are manufactured outside the GTA.

## 14.0 Winter Sand

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### 14.1 Background

Winter sand is a low-grade aggregate spread on roads and sidewalks primarily to improve traction for vehicular and pedestrian traffic. One supplier contacted for this report suggested the following specification for winter sand.

**Table 14-1  
Suggested Effective Material Size for Winter Sand**

Percent of Material	Material Size (millimeters)
90-100%	minus 4.75 mm
50-95%	minus 2.36 mm
29-90%	minus 1.18 mm
0-70%	minus 0.60 mm
0-35%	minus 0.30 mm
0-15%	minus 0.15 mm

### 14.2 Results

No reliable data are currently available regarding the purchase of winter sand by the City of Toronto. Staff from the City's department of supplies and purchasing indicated that current records show an annual purchase of 400 tonnes/year. Staff also indicated that these figures are incorrect and significantly understate actual usage.

Anecdotal information suggests that at one time Scarborough purchased 400 tonnes/month of winter sand. Assuming that Scarborough (population 521,000) represents one fifth of Toronto's population, pro-rated annual consumption of winter sand in the city as a whole is estimated to be approximately 10,000 tonnes/year. Assuming that winter sand usage varies with weather conditions, a range of 8,000 to 12,000 tonnes/year has been assumed for the purposes of developing a planning estimate.

For comparison purposes, the Town of Huntsville (population 18,000) uses approximately 18,000 tonnes/year in an area that experiences more severe winter road

conditions. Staff from York Region indicated that annual purchases for use by the Regional government are approximately 3,000 tonnes/year at an approximate cost of \$10/tonne delivered (this quantity excludes purchases by lower tier municipalities).

Assuming that the 8,000 to 12,000 tonne/year estimate is within a reasonable order of magnitude, the city could utilize a potentially large portion of its processed crushed glass in this application. Although this application is not expected to generate any significant revenue for the city, it could result in modest financial savings by reducing the purchase of winter sand and avoiding the cost of landfilling mixed broken glass.

Additional research and a pilot project are recommended in order to answer a number of technical questions. These include:

- degree of safety on public streets and sidewalks
- cost of crushing glass to the necessary effective size
- capacity to distribute this material with existing truck fleet
- capacity to minimize loss of traction on streets and sidewalks
- cost comparison with winter sand.

### **14.3 Summary**

Winter sand represents a potential low-grade, high volume application for processed crushed glass during the winter season. Winter sand is generally used on cold winter days to improve traction on the streets and sidewalks. Further study is recommended to determine if processed crushed glass can be used in an effective and safe manner.

### **15.0 Material Crushers**

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In order to design and implement a pilot project, it may be necessary to secure the services of a material crusher. To this end, fourteen crushers in and around the GTA were contacted in order to determine technical capacity and assess preliminary interest in possible participation in a pilot project.

Three firms expressed some level of interest in participating in a pilot project. One each in downtown Toronto (Strada-Harbour Aggregates, 416-543-1750), Brampton (Classifier Milling Systems, 905-451-3387) and Huntsville (Hutcheson Sand and Gravel, 1-800-461-5521).

The Toronto firm's main line of business is crushing recycled concrete to produce granular aggregate. The owner of the company indicated that he is interested in discussing the details of a pilot project in which crushed glass would be blended into a granular aggregate. He suggested that private contractors might not - in the short-term - be interested in purchasing this type of product because of a conservative preference for known commodities. However, City of Toronto and TTC capital projects represent two potential short-term market opportunities. Combined sales of granular aggregate by this company to the City and TTC are approximately 50,000 to 100,000 tonnes per year, depending on the nature and scale of capital projects.

The utilization of crushed glass in this market application is significant. Preliminary figures suggest that up to 10% of the aggregate weight could consist of crushed glass.<sup>13</sup> Assuming annual aggregate sales of 50,000 to 100,000 tonnes, the potential market for glass is 5,000 to 10,000 tonnes per year. The market might be larger if private contractors could be shown that a blended aggregate product is technically sound and cost-effective.

The main market barrier is approval from City and TTC engineers to use a blended granular. Preliminary conversations with engineers at both the City and TTC indicate that an application would need to be submitted that includes lab analyses of the blended product along with documented technical research.

Although a two-hour drive from Toronto, the firm in Huntsville not only crushes various types of aggregate but also retails a range of related products including bunker sand, winter sand and blasting abrasives. The firm in Brampton primarily sells crushing equipment but is interested in discussing opportunities.

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<sup>13</sup> Brad Harper from Miller Paving indicated that Miller typically includes 10% glass in its granular B mix for asphalt work. This percentage is based on their own lab analysis.

**APPENDIX A**  
**FIRMS AND AGENCIES CONTACTED FOR THIS REPORT**

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3M Havelock, ON  
3M St. Paul MN  
American Water Works Association (AWWA)  
Aqua Blast  
Blastek  
Hunt industrial Minerals Inc.  
Canadian Bottled Water Association  
Canadian Roofing Contractor's Ass.  
Canadian Water and Wastewater Association (CWWA)  
Canadian Water and Wastewater Association  
CANCO  
Capitol Pool Industries  
City of Toronto  
Clay and Glass Association  
Craft Studio - York Quay Centre  
Classifier Milling Systems  
Cranberry Resort  
Echo Springs  
Environment Canada  
Flexolite Ltd.  
Golf Superintendents Association of Ontario  
Hutcheson Sand and Gravel  
IKO Shingles  
Jacuzzi Canada  
Kaleido Glass Limited  
MTO  
National Roofing Contractor's Ass.  
Ontario Crafts Council  
Ontario MOE  
Ontario Water Works Association  
Owens Corning  
Pan Abrasives  
PPG  
PPG Paints in Mississauga  
Sico Paints in Mississauga  
Society for Special Coatings (SSPC)  
Star Sandblasting  
Strada-Harbour Aggregates  
Thomas McBroom and Associates  
Visual Arts Ontario  
Webster and Sons  
Region of York Department of Supplies and Purchases

## APPENDIX B

### MINERAL HARDNESS SCALE <sup>14</sup>

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The hardness of a mineral is a measure of its resistance to abrasion and atomic structure. Mineral hardness is measured on the Mohs Scale. It is a relative scale with rankings from 1 (softest) to 10 (hardest), as shown below with examples of everyday items.<sup>15</sup>

1. Talc (e.g. pencil lead = 1-2)
2. Gypsum (e.g. fingernail = 2.5)
3. Calcite (e.g. old copper penny, brass = 3.5)
4. Fluorite (e.g. iron)
5. Apatite and Anthracite<sup>16</sup> (e.g. tooth enamel, knife blade, glass = 5.5-6.0)
6. Orthoclase and Andesite<sup>17</sup> (e.g. steel file = 6.5)
7. Quartz
8. Topaz
9. Corundum (e.g. sapphire, ruby)
10. Diamond

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<sup>14</sup> <http://www.mcli.dist.maricopa.edu/aaim/linear/L0.html>. Viewed December 12, 2000.

<sup>15</sup> <http://www.galleries.com/minerals/hardness.htm>. Viewed December 12, 2000 and <http://duke.usask.ca/~reeves/prog/geoe118/geoe118.mohs.html>

<sup>16</sup> <http://anthracite-filter-media.com/lakecite.htm>

<sup>17</sup> <http://www.pacinter.net/users/osiris/baquito/baquito.htm>. Viewed December 12, 2000.

**APPENDIX C**  
**MESH SIZES AND SAMPLE APPLICATIONS**

Table C-1 lists a variety of potential applications where processed glass could potentially be used as a substitute material along with respective markets and suggested mesh sizes.

**Table C-1**  
**Potential Glass Applications and Suggested Mesh Sizes**

<b>Mesh Size</b>	<b>Screen Opening (mm)<sup>18</sup></b>	<b>Market</b>	<b>Application</b>
8 - 16	1.18 - 2.36	Winter sand	29-95% of sand in this size range
10 - 35	1.35 - 0.45	Asphalt roofing shingles	Rock granules
12	1.21 - 1.65	Blasting	Prepare steel to white metal surface
12	1.21 - 1.65	Fibreglass insulation manufacturing	Glass feedstock
12 - 30	1.21 - 0.68	Abrasive blasting	Wheat starch and walnut shells <sup>19</sup>
20 - 80 +	0.91 - 0.22	Abrasive blasting	Corn cob grit
30	0.68 - 0.52	Abrasive blasting	Fine silica
35 - 60	0.25 - 0.5	Golf course bunker sand	6-75% of particles within this range
38	0.45 - 0.5	Water filters	Silica sand
50	0.40 - 0.37	Asphalt roofing shingles	Dusting material between sheets
60 - 325 +	0.32 - 0.04	Abrasive blasting	walnut shells
100	0.19 - 0.14	Asphalt roofing shingles	filler/stabilizer
150 - 200	0.10	Coatings	Elastomeric Roof Coating
200	0.08	Gravel dust	Spread minerals on lawn
200	0.08	Slow water filter	Municipal water filtration
325	0.04	Coatings	Flat latex paint

Notes: One micron equals 0.001 mm.

<sup>18</sup> <http://www.wovenwire.com/reference/mesh-locator.htm>. Viewed December 12, 2000.

<sup>19</sup> [http://www.epa.gov/ttn/uatw/paintst/ps\\_pmact.html](http://www.epa.gov/ttn/uatw/paintst/ps_pmact.html). Viewed December 12, 2000.