Part 1.

Resource Development Challenges in a Growing Urban Centre - Halifax Regional Municipality

A Demographic Profile of Halifax Regional Municipality

Halifax Regional Municipality (HRM) is the largest urban centre in Atlantic Canada. The municipality (Fig. 1) is home to 360 000 people, with more than 300 000 of these residents living in the Halifax-Dartmouth area and surrounding suburbs. In addition to those who reside here, there are approximately 13 000 people who commute daily from outside HRM to jobs in the metropolitan region (Mason, 2004). The area also attracts a significant number from beyond the region for business purposes, shopping and entertainment. Collectively the population makes the municipality a thriving centre of commerce and a fundamental component of Nova Scotia's economy. For a slide show on the demographics and changes in the region over the last 30 years refer to the Halifax Regional Municipality web site http://www.region.halifax.ns.ca/planning/hrmpop.html.

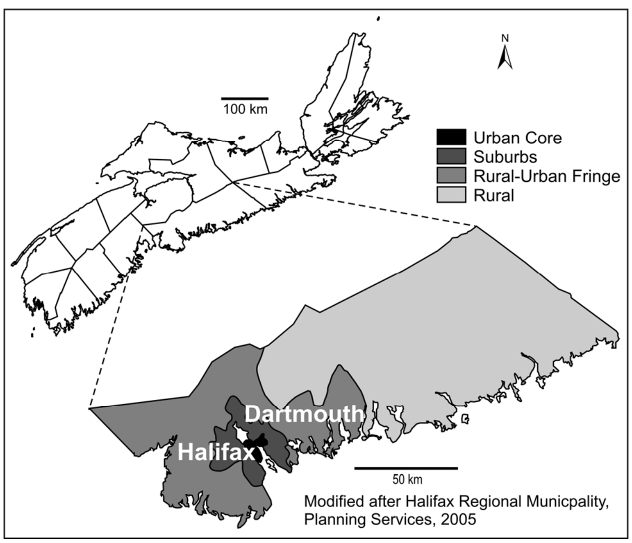

Figure 1. Boundaries of Halifax Regional Municipality (HRM) as well as urban/rural areas within HRM (from HRM website www.halifax.ca/planning/trends/sld008.htm).

HRM is growing at the rate of 1% annually, with a projected population increase to 459 000 by the year 2026 (Halifax Regional Municipality, 2002). Although this growth includes the entire municipality, the vast majority of it will occur in the fringe areas of Metro. In order to accommodate this population increase there is the ongoing need for the physical development of the community, such as new housing (e.g. multiunit residential complexes and subdivisions), improvements in public services (e.g. health centres and schools) and commercial development (e.g. shopping centres and business parks). Connecting it all together is the public infrastructure which permits the community to function safely and efficiently. Roads, bridges, sidewalks and underground services are a few of the services which need constant upgrading and repair. Collectively all aspects of the community interconnect in a way that continues to make the area attractive for people and businesses.

Aggregate Resources in Metro

A critical component of the ongoing development of the community is the construction which takes place in the region. Inextricably connected to this activity is the need for a tremendous amount of building materials. Although not commonly known, the most widely-used construction materials (by weight) today are produced from stone. The Metro area (Fig. 1) consumes more than 3 Mt of crushed stone from local quarries each year (Nova Scotia Department of Natural Resources statistics), making it the largest aggregate market in Nova Scotia. The majority of the rock goes into basic products such as concrete, road base, asphalt and back fill. There are also a broad range of other uses including retaining walls, erosion control, breakwaters and landscaping. A large component of the stone is for the construction and maintenance of public infrastructure such as roads, concrete bridges and underground services. As a result, these materials play a vital role in the continued growth and prosperity of the community.

The overwhelming majority of the stone used in the region is supplied by a series of quarries located in and on the outskirts of the Halifax-Dartmouth area (Fig. 2). These quarries supply the area with the majority of its crushed stone needs. They also sell natural sand products, which are obtained from sources outside the region. These quarries offer two important benefits to the construction industry. First, the bedrock that is processed in the quarries produces the high quality aggregate demanded by modern materials specifications. Today's engineering standards focus on stone performance, requiring the rock to be durable and resistant to agents that can cause premature deterioration of the materials. The life span of the products can have important cost implications if an aggregate based structure (e.g. a highway) has to be repaired or replaced prematurely. Although the vast majority of the rock in the Province will not meet these rigorous standards, the Metro area has been fortunate in this respect. Some of its geology is capable of producing very high quality construction aggregate. Secondly, local sources of stone provide an important cost savings for these heavy, bulk materials. Transportation is the single largest component in the pricing of the delivered stone at the construction site. The farther the materials are transported, the more expensive they are for the buyer (see the section on Distant Truck Hauls). Local sources of stone help minimize these haulage distances and correspondingly the costs of construction and infrastructure. Having a dependable supply of high quality stone in proximity to this large aggregate market has resulted in significant benefits to the community.

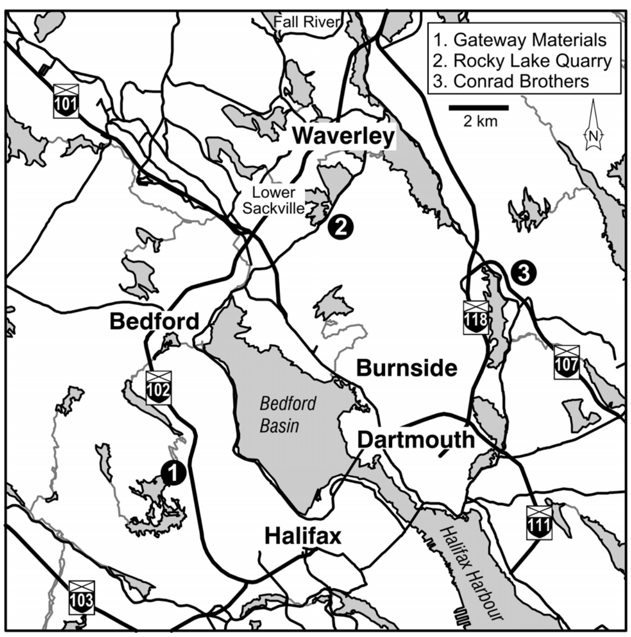

Figure 2. There are three active primary sources of aggregate in the core metropolitan area of the HRM. They are Conrad Brothers, Rocky Lake Quarry and Gateway Materials.

Aggregate Resource Development Issues and Concerns

In spite of the favourable geology and a thriving stone industry, a recent report on the aggregate potential of the Halifax-Dartmouth area concluded that the future of the local resource is being threatened by encroaching development, competing land uses and special issues (Prime, 2001). Concerns largely stem from decades of population growth and urban development which have taken place in Metro's outskirts and rural areas which have been the 'traditional' areas of aggregate resource development potential. For a discussion of these demographics refer to HRM web site http://www.region.halifax.ns.ca/planning/hrmpop.html. As a result, community development is continually encroaching on the resource land and sterilizing the aggregate deposits which lie beneath.

Other constraints on resource development are initiatives aimed at the protection of the natural environment. Issues such as pollution and habitat destruction have lead to the enactment of rigorous legislation to protect air quality, water quality, habitat and species at risk. A description of Provincial regulations can be found at http://www.gov.ns.ca/just/regulations/consregs.htm. Federal legislation is described at http://laws.justice.gc.ca/en/. These regulations, although necessary, are placing significant development constraints on large tracts of resource land. For example, in order to protect water sources, 30 m buffer zones are required between quarries and lakes, streams or other wetlands. Although these separation distances appear to be narrow, each stream sterilizes a 60 m corridor (30 m on both sides) along its course. The abundant streams found in the area cumulatively affect a significant portion of resource potential.

Less obvious, but probably having a greater effect on the aggregate industry, in an urban setting, are regulations and bylaws designed to minimize the socioeconomic impacts on communities. This can include a wide range of issues such as health and safety (e.g. traffic, noise levels, dust), property values (e.g. proximity of heavy industry) and property damage (e.g. blasting). Collectively the regulations and guidelines addressing these concerns have placed severe restrictions on the location and operation of pits and quarries in the region.

Blasting setbacks, for example, can have serious impacts on aggregate resource potential. For reasons of safety and property damage, an 800 m separation distance is required between a quarry and residential dwellings in Nova Scotia. Using 800 m as the radius to determine the area of a circle, a single home can sterilize as much as 2 km^2 of resource land. In densely populated areas this has little effect on the resource because of a host of other factors which would prohibit quarrying (e.g. prohibitively expensive land values, noise and traffic issues). However, in lightly populated, more rural settings this regulation has severely restricted future resource development. Although these areas have the most realistic chance for quarry operations, the scattered houses which occur there can sterilize large blocks of resource land. Any road in the region where new homes can be built is, in effect, a 1.6 km corridor (800 m on each side) where the resource is threatened. New access roads are being built in the region each year.

The effect of residential dwellings in the rural areas is being exacerbated by recent life style changes. A growing number of people are, for a variety of reasons, choosing to reside in more tranquil, wilderness settings outside HRM. The appeal of this choice has been enhanced by recent infrastructure improvements in the region which make these remote areas more accessible and the commute to urban jobs, shopping or entertainment safer and less time consuming. New homes and recreational properties are currently being constructed in rural areas throughout the region. This is most evident near the abundant lakes and rivers, which are prime targets for real estate development. The result is sterilization of large blocks of wilderness associated with the blasting set back distance.

A growing concern for the resource is the negative perception that quarrying has generated recently. Several recent attempts to obtain permits for new quarries have received highly vocal opposition from area residents and considerable media attention. The reasons for this are complex, but it generally reflects concerns regarding the impact that quarrying will have on the community. The issues usually brought forward include noise, traffic, dust, water pollution, blasting and property values. Although the regulatory legislation is designed to ensure that these impacts are minimized, many in the public remain distrustful of the industry and cynical that government regulations will protect their interests. The result is that concerned groups have been willing to direct a lot of time and resources toward keeping quarries out of their communities. A proposed quarry may meet all of the requirements of the Pit and Quarry Guidelines under the *Environment Act* (Nova Scotia Department of Environment and Labour, 1999) and still be rejected if public opposition is well organized and vocal. In a rapidly expanding urban area such as Metro, this will continue to have significant consequences for the resource.

Much of the public's skepticism is based on the remnants of an era when producers simply walked away from extraction sites when they were finished, leaving scars on the landscape that were unattractive, unsafe or, commonly, became receptacles for garbage. Land owners of the pits and quarries also contributed to this problem. In many cases the rock was extracted by an aggregate producer or road builder under a lease or royalty arrangement with the property owner. When the operation ceased and the land reverted back to the landowner, there was rarely any incentive for either party to reclaim the site. Many of the pits and quarries were left unprotected from the public, which commonly lead to abuse of the sites. Although industry attitudes toward reclamation are changing and regulatory compliance is improving, the authors acknowledge that community fears and resentments are not without foundation and that public distrust of the aggregate industry will take a long time to mitigate.

A host of other land uses are also affecting aggregate resource potential and development. They include picnic parks, business parks, shopping centres, game sanctuaries, ecologically sensitive areas, hiking trails, golf courses, power transmission corridors, water sheds, highways and natural gas pipelines. Many of these land uses not only sterilize (i.e. permanently remove from resource use) the land they overlie, but affect adjacent areas as well. For example, it is difficult to imagine a quarry being permitted in proximity to the perimeter of a tranquil setting such as a golf course or an ecological preserve. Although there is nothing in legislation directly prohibiting development adjacent to such sites, spirited opposition to the project would be expected.

Many of the alternative land uses also affect the industry and the resource land from an economic perspective. Real estate near an urban centre has become an extremely valuable asset for the land owner. The pace of commercial and residential development in recent years is placing pressure on undeveloped lands in the region. Several residential communities, for example, have recently been constructed in forested areas near the cities. The locations of these high end subdivisions have been selected and promoted for their wilderness appeal. One recent subdivision has incorporated a golf course into the community. These sprawling developments require huge tracts of forest land to be functional and achieve the atmosphere being promoted to the home buyer. Demand for these large blocks of land by developers has dramatically increased the value of property in the region. The producer who finds a site suitable for quarrying may not be able to purchase the land because it may be prohibitively expensive to profitably produce and sell aggregate.

The result is that access to the land for resource development purposes is being severely restricted through the complex interactions of land use issues, regulatory legislation, municipal bylaws and economic factors. This ongoing process is continually and permanently sterilizing more resource land each year. In addition to the shrinking development potential, stone reserves in operating quarries are collectively diminishing at a rate of several million tonnes each year. The problem is compounded by recent economic growth and development which have increased the demand for these materials and accelerated the depletion of the reserves. The irony is that the growth and construction activities which make the aggregate industry thrive are rendering inaccessible the resource which is the foundation of their business activities. This would not be a concern if new operations could replace the depleted deposits with new reserves, but recent attempts to obtain permits for new quarries in the area generally have been unsuccessful. Furthermore, current government planning and zoning policies for the region do not include provisions for the protection of the aggregate resource. In fact recent zoning bylaws in HRM have made stone extraction more difficult than ever before. If aggregate reserves cannot be replenished through the establishment of new operations, enormous pressures will continue to be placed on the resource base over the next few decades. Ultimately the resource land will shrink until there no longer are accessible aggregate deposits in the region.

Future Aggregate Supply Options for Metro

If the local, traditional sources of stone disappear in the Metro area, what choices will the aggregate producers have for obtaining these important materials in the future? Based on the experience of other, larger urban centres around the world which have faced similar experiences, the options for Metro would include the following: (1) 'importing' stone from distant quarries by truck, (2) 'importing' stone using bulk transport by train, barge or ship, (3) dredging offshore marine gravels on the Scotian Shelf, or (4) underground mining in proximity to Metro. Each of these options is briefly examined below.

Distant Truck Hauls

Based on conventional sources of aggregate, the simplest choice for Metro would be long hauls from distant sources by truck. The benefit of this method (from the perspective of Metro residents) is its perceived low level social and environmental impact due to the absence of quarries in or near the community. Direct-hauling the materials to market, as needed, involves trucking-related issues. Since trucking is a necessary component in any method of delivering aggregate to the market, this option would ostensibly minimize disruption to the community. It could also be phased in over time as local deposits become exhausted. In terms of physical impacts, it is unlikely that area residents would observe any changes to their surroundings during or following the conversion to these sources of stone.

One major disadvantage is the high price of the landed stone. Transportation is the largest component in the cost of delivered aggregate and trucking is the most expensive method of delivering the stone (Table 1). In order to understand the economics of long hauls by trucks, the potential sources of high quality stone outside Metro which may be accessible for quarrying in the future must be considered. Based on factors such as geology, highway systems, land use issues and economic considerations, the most likely source areas would be the Cobequid Highlands, the South Mountain and the North Mountain. Sourcing stone from these areas could mean transportation distances of 100-150 km to the Metro aggregate market. These distances are completely arbitrary and will vary depending on land use changes, land access issues and highway systems.

What are the implications of truck haulage distances of this magnitude? In order to answer this question it is necessary to determine the transportation costs per unit of distance. It has been estimated that truck haulage costs in the United States vary from 10-25 cents US per ton per mile (Barker and Harben, 2002). When converted into Canadian currency (based on $1 US = $1.20 Canadian at present) and metric measurements, this cost is 8-19 cents Canadian per tonne per kilometre. These numbers will fluctuate because of variables such as fuel costs and currency exchange rates.

A more direct measure for haulage, applicable to the local market, is the rate that Nova Scotia Department of Transportation and Public Works (2004) pays independent trucking companies to deliver stone for their construction projects (Table 2). If one allows an average delivery distance for aggregate in the Metro area of 30 km (average haulage distance for aggregate in urban centres of the United States based on Banino (1994) estimates) the transportation cost is $3.80/t.

Table 1. Comparison of haulage methods for aggregate. Note that all numbers are based on imperial measure and the United States dollar (after Barker and Harben, 2002).

Factor	Truck	Train	Barge	Ship
US cents/Ton-mile[1]	10-25 (High)	2-4 (Moderate)	0.75-1 (Low)	0.1 (Very Low)
Rates and regulation[2]	Negotiated (→ Regulated)	Negotiated (→ Regulated)	Negotiated (↓Regulated)	Negotiated Free Market
Flexibility	Very high	Moderate	Low	Very low
Capacity US (Typical) Europe	25 ton	100 ton	1200 ton (15-40) 1500 (4-6)	60 00 dwt[4] 150 000 dwt[5]
Subsidy type	Roadway	Track[3]	Locks	Ports
Containers	Yes	Yes	Yes	Yes
Negotiations (Mostly confidential)	Easy; often via regional dispatcher	Hard; RR often not very responsive	Easy with broker, harder without	Easy with broker, very hard without

[1]These are typical values which vary greatly based on volume and location. Does not include loading and unloading costs.
[2]All types are usually regulated for safety and environmental compliance
[3]Federal land (USA) ceded for laying track in 1800s; railroad maintains own track now
[4]Maximum size that can transit the Panama Canal and on Great Lakes
[5]Maximum size that can transit the Suez Canal

Table 2. Standard rates for truck haulage of aggregate in Nova Scotia (after Nova Scotia Department of Transportation and Public Works, 2004).

km	$/t	km	$/t	km	$/t	km	$/t
1	1.40	51	5.69	101	10.61	151	16.20
2	1.54	52	5.78	102	10.72	152	16.31
3	1.68	53	5.88	103	10.83	153	16.43
4	1.79	54	5.97	104	10.93	154	16.56
5	1.90	55	6.06	105	11.03	155	16.67
6	2.01	56	6.16	106	11.14	156	16.79
7	2.11	57	6.26	107	11.25	157	16.92
8	2.19	58	6.35	108	11.35	158	17.04
9	2.27	59	6.44	109	11.46	159	17.15
10	2.36	60	6.53	110	11.57	160	17.28
11	2.43	61	6.63	111	11.67	161	17.40
12	2.50	62	6.73	112	11.78	162	17.52
13	2.56	63	6.82	113	11.88	163	17.65
14	2.62	64	6.91	114	12.00	164	17.77
15	2.68	65	7.01	115	12.10	165	17.89
16	2.74	66	7.11	116	12.21	166	18.02
17	2.79	67	7.20	117	12.32	167	18.14
18	2.84	68	7.30	118	12.43	168	18.26
19	2.88	69	7.40	119	12.54	169	18.39
20	2.92	70	7.49	120	12.65	170	18.51
21	3.01	71	7.59	121	12.76	171	18.65
22	3.10	72	7.69	122	12.87	172	18.77
23	3.19	73	7.79	123	12.98	173	18.89
24	3.27	74	7.88	124	13.09	174	19.02
25	3.35	75	7.99	125	13.20	175	19.15
26	3.45	76	8.08	126	13.32	176	19.27
27	3.53	77	8.18	127	13.43	177	19.41
28	3.62	78	8.27	128	13.54	178	19.53
29	3.70	79	8.38	129	13.64	179	19.66
30	3.80	80	8.48	130	13.76	180	19.79
31	3.89	81	8.57	131	13.87	181	19.92
32	3.97	82	8.67	132	13.98	182	20.04
33	4.06	83	8.78	133	14.10	183	20.18
34	4.15	84	8.87	134	14.21	184	20.30
35	4.24	85	8.97	135	14.32	185	20.44
36	4.33	86	9.08	136	14.45	186	20.57
37	4.41	87	9.18	137	14.56	187	20.70
38	4.51	88	9.27	138	14.67	188	20.83
39	4.60	89	9.37	139	14.79	189	20.96
40	4.69	90	9.48	140	14.90	190	21.09
41	4.77	91	9.58	141	15.02	191	21.23
42	4.87	92	9.68	142	15.14	192	21.36
43	4.96	93	9.79	143	15.25	193	21.50
44	5.05	94	9.89	144	15.37	194	21.63
45	5.15	95	9.99	145	15.49	195	21.76
46	5.24	96	10.09	146	15.60	196	21.90
47	5.33	97	10.20	147	15.72	197	22.03
48	5.41	98	10.30	148	15.84	198	22.16
49	5.51	99	10.40	149	15.96	199	22.31
50	5.60	100	10.51	150	16.07	200	22.44

The rate more than triples to \$12.65/t at a distance of 120 km from the market centre. Using 120 km for a hypothetical source of stone for Metro in the future (this is not an unreasonable number given that Metro's sand supplies come from similar and greater distances today), at today's haulage rates, the 3 Mt of aggregate used each year in the Metro area would cost an additional \$26.5 million (\$12.65 - \$3.80 = \$ 8.85 x 3 000 000 t = \$26 550 000) in **transportation charges alone**. Note that these costs are in addition to the price of the stone paid to the producer at the quarry gate. Even using an average distance of 60 km adds more than \$8 million in trucking charges to the delivered price of the stone.

This has significant socioeconomic implications, given that the vast majority of this stone goes into the construction and maintenance of infrastructure. One kilometre of new, paved, two-lane highway, which can use as much as 27 000 t of aggregate for road base and asphalt (Paul Reynolds, Nova Scotia Department of Transportation and Public Works (NSTPW), personal communication, 2005), could cost a further \$238 950 (\$8.85 x 27 000 t) if the materials have to be hauled an additional 90 km from a source 120 km away. Any significant increase in materials costs would negatively impact on public works budgets, requiring more funds to maintain the same level of construction or, if spending did not increase, a significant reduction in service to the community. As another example, the average newly constructed house in Canada uses between 300 t and 400 t of aggregate for products such as concrete, asphalt and backfill. Using NSTPW's current trucking rates (Table 2) and the minimum figure of 300 t of stone, the additional cost to build the home using the distant quarry described above would be \$2655. This is more than 1% of the cost of a typical new home in the Metro area.

There would also be additional environmental costs associated with long truck hauls for a given amount of stone. Increasing the distance from 30 km to 120 km would approximately quadruple (a 300% increase) the amount of fuel consumed, the volume of air emissions released, the rate of truck related deterioration of highways along the haulage corridors and the wear on haulage equipment **per tonne of stone delivered to the construction site**.

Finally, there would be other socioeconomic impacts over time associated with road safety issues. Each additional kilometre that the stone is hauled increases the risk of traffic accidents.

As a responsible society, we should make every effort possible to keep these costs to a minimum. However, the authors acknowledge that the long truck haul is an option used elsewhere. Stone products from one southern Ontario aggregate quarry are being trucked almost 400 km in the Niagara Region (Bateman, 2003).

Bulk Transport from Distant Sources

Alternatively, shipping large quantities of aggregate long distances by rail, barge and bulk carrier can be very cost effective methods of delivering stone (Table 1). Many urban centres on the Eastern United States seaboard obtain their stone in this manner. Although each of these modes of transportation has its advantage, they all involve trans-shipping. This means that the stone must be offloaded and stockpiled at a central storage location for future use. The materials are then reloaded and delivered by truck to their final destination as needed. All of this handling and storage can reduce or eliminate any cost advantage to these methods. It is the opinion of the authors that finding the strategically located block of land in or near Metro, where large volumes of stone could be unloaded, stockpiled and redistributed, would be a difficult and costly task, with no guarantee of success.

Marine Sand and Gravel Sources

Research indicates the presence of large deposits of marine sand and gravel on the Scotian Shelf (Miller and Fowler, 1987). Offshore mining of these materials could supply the Metro market at some point in the future. However, there would probably be major environmental hurdles to overcome and there is no guarantee that the stone would pass materials standards in the Province. Natural gravels are rarely used today for high quality aggregate applications in Nova Scotia. Furthermore the probable source rocks for much of these glacially-derived sediments are Meguma Zone lithologies which may contain considerable amounts of deleterious materials such as slate, friable granites or acid producing sulphides. Similar to the bulk transportation options discussed above, this method would require a central storage and distribution terminal and the costs associated with reloading for truck delivery. This is an unlikely option in the foreseeable future.

Underground Mining

Underground mining has been successfully used in urban centres elsewhere in North America. Eighty-two underground quarries operated in the United States in 2003 (United States Geological Survey, 2004). This method eliminates much of the above ground activities which are a concern in urban areas. The room and pillar caverns which are produced using this extraction technique can also make excellent storage facilities following the closure of the operation. However, it is a well known mineral industry axiom that subsurface mining for any mineral commodity, whether it is copper, gold or construction stone, is more expensive than open-pit operations. For underground mining of large volume, bulk commodities such as aggregate, which generally are the lowest price per unit of all mined commodities, to be profitable would require special circumstances. The small number of underground aggregate mines among the 3223 quarries in the United States in 2003 (United States Geological Survey, 2004) is evidence of this conclusion. In addition to the economic costs, this method of mining still requires above ground activity and trucking at the mine site. Thus, although social effects on the community are reduced, they are still present. There is also the potential of environmental impacts on the water table and any private water supplies associated with mine dewatering activities. The conclusion drawn by the authors is that underground aggregate mining is a highly unlikely option for the area in the near future.

Other Sources

Mineral aggregate will probably continue to be the primary source of aggregate in the foreseeable future, but there are a variety of other materials which are being used today. They include recyclables (e.g. Portland cement concrete and asphalt) and byproducts from other industries (e.g. slag). Although it is very unlikely that these stone substitutes will become the primary source of materials in the future, they have the potential to provide part of Metro’s aggregate needs. Issues of quality and sources will prevent them from playing a major role in such a large market, but advances in technology could quickly change the significance of unconventional aggregate sources.

Although all of the above options are potential sources of stone, it is impossible to anticipate which could be used in the Metro area in the future. They all have detractions and they all can be very expensive choices for the consumer. Furthermore, it is impossible to predict changes to regulatory legislation, materials standards, zoning or bylaws which might favour or exclude one of these sources. Technological advances may also offer other solutions in the future. Ultimately, the well being of the community and the environment should be the key priorities in the decision-making process.