2009 Progress Report on the Annapolis Valley Region Stone Resource Project

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Introduction

The aggregate program continued to research the stone resource in Hants, Kings, Annapolis, Digby and Yarmouth counties (Fig. 1) in 2009. The Annapolis Valley Project was initiated to examine the bedrock and surficial aggregate potential in the region, with the goal of producing resource maps. Sandy tills are being assessed for potential as unconventional sources of sand. Other stone resource occurrences being documented include bedrock suitable for building stone, rock dust for soil amendments, landscape stone potential, bedrock and surficial sources of armourstone, and clay deposits and clay-rich till that can be used to produce engineered soils. Some of the occurrences are being recorded because they are perceived to have economic development potential (e.g. granite deposits for dimension stone), while others could be used in environmental applications (e.g. clay

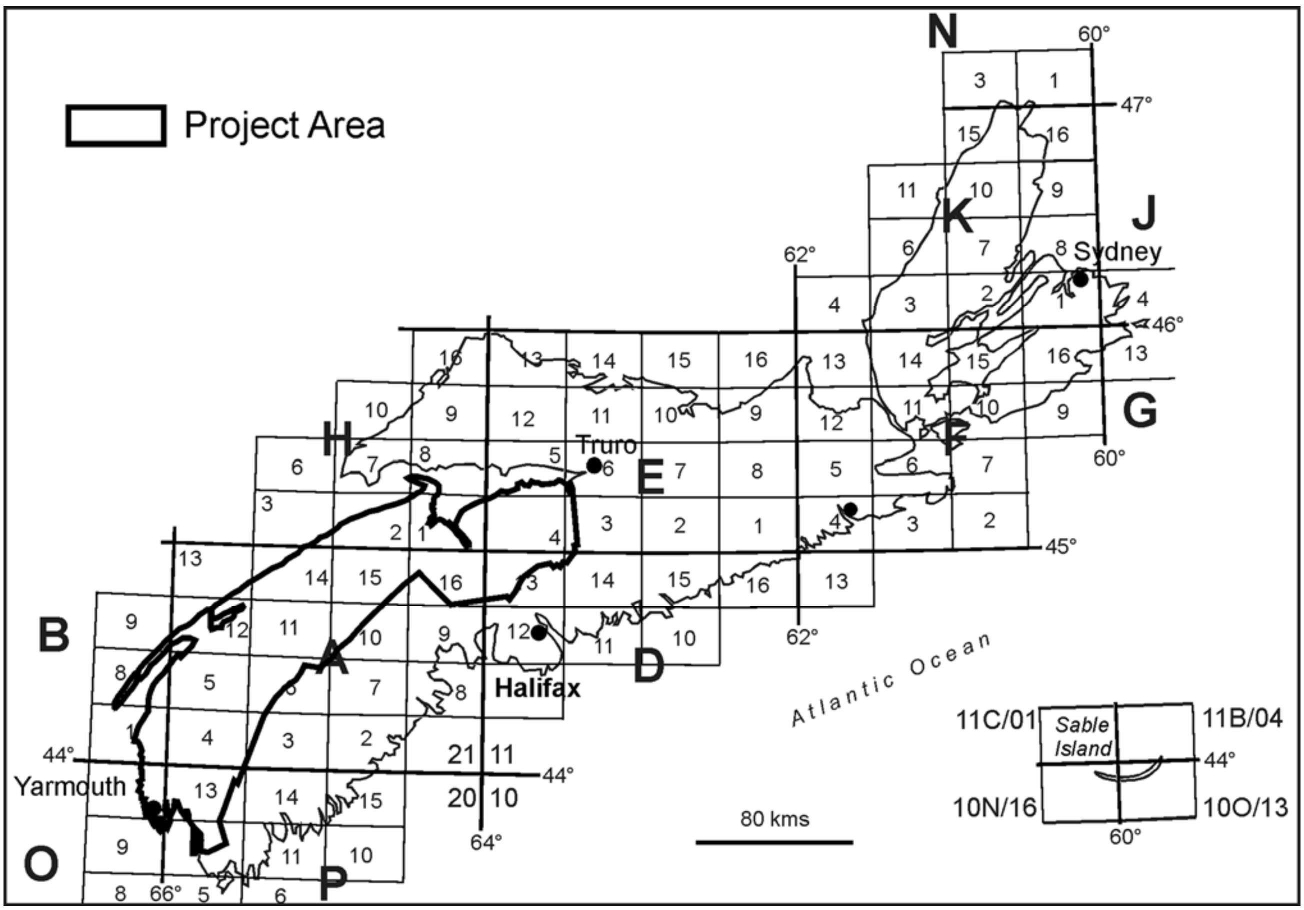

Figure 1. The Annapolis Valley Project is an evaluation of the stone resource potential in Hants, Kings, Annapolis, Digby and Yarmouth counties. An outline of the study area is shown above.

Prime, G. 2010: *in* Mineral Resources Branch, Report of Activities 2009; Nova Scotia Department of Natural Resources, Report ME 2010-1, p. 99-111.

liners for landfills or armourstone for storm/flood defenses). Over 5000 sites including pits, quarries and other bedrock and surficial exposures have been recorded. Reports containing the findings of this project include stone resource discussions on the Meguma Supergroup rocks (Prime, 2001; Prime and White, 2007), Devonian-Carboniferous granitoid rocks (Prime, 2001; Prime and White, 2004; Prime and Bonner, 2007) and the Jurassic North Mountain Basalt (Prime, 2008).

A critical component of this research is the preparation of a digital database synthesizing data collected by this study as well as a compilation of occurrences from existing surficial and bedrock geological maps. The final product of this project will be released as a digital database including surficial and bedrock resource maps and a report summarizing the findings of the project. The goal is to produce a searchable database consisting of site descriptions, photos, laboratory analyses, land-use information and other geotechnical data. The information should be of interest to a wide variety of users, including the mining industry, government agencies and the general public. It will also provide planners and policy makers with the tools to include this important resource data as part of the planning process.

Digital Database Construction in 2009

The focus of this project in 2009 was the continued acquisition of field data for entry into the Annapolis Valley Project digital database. Entry of field data in the summer of 2009 was carried out by Chelcy Fougere with input from the author as required. For several years Jeff McKinnon has been co-operatively digitizing twenty-six 1:50 000 scale geological maps (13 bedrock and 13 surficial maps) as part of the Annapolis Valley Project. Over the past year, continued quality control of the databases has been undertaken as well as transferring the data from the 1970s vintage 1:50 000 maps.

Field Work in 2009

The field season primarily consisted of field checking discrepancies in the digitized maps and adding new information such as recently opened pits, quarries and road cuts. An important component of the work was the examination of coastal bedrock outcrop and surficial exposures in Yarmouth County. These sites commonly consist of continuous exposure over large areas, which is useful in gaining a better understanding of resource potential. A sampling program was conducted in areas that were previously identified as having stone resource potential. This included the collection of aggregate samples of bedrock to be tested for crushed stone potential, and sampling sandy tills for evaluation of sand content. Several samples of granitic rocks from the South Mountain Batholith were also collected to assess dimension stone potential. The samples will be cut and polished in order to make this determination.

Bedrock Aggregate Potential of the White Rock Formation

Coastal exposures of the Silurian-Devonian White Rock Formation were observed and documented at Cape Forchu and Overton, Yarmouth County, but samples were not collected from these sites in the 2009 field season. Although the development potential of crushed stone quarries in these areas is unlikely (see discussion below), data obtained at the coast can be used to identify the aggregate potential of the unit at other locations.

The White Rock Formation stratigraphy in the Yarmouth area consists predominantly of felsic and mafic metavolcanic rocks deposited as ash falls and flows. There is also a sedimentary component to the strata, however, including tuffaceous metasandstone and conglomerate produced by the erosion and reworking of the volcanic rocks (see White *et al.*, 2001). Collectively the metavolcanic rocks appear to be durable for the production of construction aggregate, but layering in the deposits (Fig. 2), which is similar to thinly bedded sedimentary rocks, may be a drawback, especially if they contain soft alteration minerals or result in a platy clast product. Structural deformation, such as shearing and foliation, would also cause weaknesses (fracturing and soft minerals), which would have a negative impact for aggregate

Figure 2. Outcrop of interlayered metavolcanic and metasedimentary rocks in the White Rock Formation exposed along the shoreline at Overton, Yarmouth County. The colour and texture of the rocks suggests that the stone may be suitable for the production of cut and polished dimension stone products. Locations where the stone has potential for quarrying may be difficult to find, however. Similar geology occurring inland along strike to the northeast may offer the best opportunity for this purpose.

potential. Verifying these concerns will require further investigation, sampling and testing in the future.

Dimension Stone Potential in White Rock Formation Metavolcanic Rocks

The White Rock Formation metavolcanic rocks comprise a variety of interesting colours and textures, which may prove appealing as a dimension stone product. Banded layers composed of several shades of grey-green to dark green (Fig. 2) and textures related to ash flows, lava bombs (Figs. 3a, b) and pillow lavas can be observed. There are also conglomerate units that exhibit texturally interesting deformational features associated with shearing (White *et al.*, 2001). Large blocks of the stone observed in the local till are also an indication that local fracturing can produce the large blocks required in the quarrying process. Collectively these characteristics suggest that the rock may have dimension stone potential. It is speculated that blocks of this stone could be quarried and sawn parallel to the layers to produce

Figure 3a, b. (a) An example of the interesting colour and texture in the White Rock Formation metavolcanic rocks at the Cape Forchu lighthouse, Yarmouth County. This site contains a mixture of sedimentary and volcanic rocks associated with ancient volcanic island build up, erosion and sedimentation. (b) This exposure contains a volcanic bomb in the ash layering. The primary purpose of including these shoreline sites in the digital database is to show the characteristics of the stone in the Silurian-Devonian rocks in southwestern Nova Scotia. Resource development potential is not implied, but ecotourism opportunities associated with this classic geology may have considerable value in the future.

cut and polished products of a variety of colours and textures. There may also be the possibility of slicing the blocks at a slight angle to the light and dark layering to produce a widely banded appearance on a polished surface. Extracting large blocks and finishing them to make this resource determination is beyond the scope of the current project.

Non-geological Factors Influencing Stone Resource Potential in the Yarmouth Area

Although the industrial mineral potential of the White Rock Formation in the Yarmouth area appears promising from a geotechnical perspective, this is only one aspect of the resource evaluation process in the Annapolis Valley Project. Where possible, resource assessment also identifies socio-economic factors, environmental concerns and competing interests that may have implications for resource development. This information can be a valuable aid in the early stages of exploration because it can provide a potential developer data that may influence matters such as ‘if’ or ‘how’ a project should proceed. At the very least, the information draws attention to the complexities of development in a given area.

The Yarmouth area is an example of a location where the resource potential is strongly influenced by other issues. One of the most obvious parameters that must be considered when evaluating the rocks in this area is its proximity to the coast. Recent decades have seen an increasing concern regarding development along the coastline of Nova Scotia. The environment, recreation, tourism and the fisheries industry are just a few of the issues that are commonly examined during the environmental review process of a proposed quarry development near the coast. For example, coastal areas may contain sensitive breeding habitat for migratory birds such as ospreys. These areas will be identified after consultation with government biologists and their wildlife databases, and delineated on the resource maps where possible. By identifying biologically sensitive areas, proponents of development projects will be provided with important information that may have a significant impact on the strategy of obtaining permits for a site. Alternatively this information may result in the avoidance of some of these areas or the abandonment of proposed projects because the risks are perceived as too high. A list of groups, agencies and information sources that should be considered when undertaking stone resource evaluation will be included as part of the project database.

Another important factor to consider is the abundance of residential dwellings present along a series of relatively closely spaced secondary roads throughout the area. Regulations associated with the Nova Scotia Pit and Quarry Guidelines (Nova Scotia Department of Environment and Labour, 1999) require an 800 m separation between residential dwellings and aggregate quarries where blasting is part of the operation. This has major implications for resource development because one house can sterilize as much as 2 ha of resource land (Prime and Bonner, 2007). A significant proportion of the high-potential bedrock aggregate resource in the province has been sterilized from future use because of this factor. Note that most dimension stone quarries can operate without the use of explosives so this separation distance is not applicable to those operations. Because of the area’s proximity to Yarmouth, there are also several concentrated residential developments near the town and along the coast which have similar implications for the resource land. The Town of Yarmouth also overlies much of the Silurian geology, a situation that would make quarry development impossible over a large area due to a variety of regulatory, land-use and population issues.

Agriculture is also an important factor in the rural landscape overlying the Silurian-Devonian rocks. An abundance of beef, dairy and horse farms occupy the numerous drumlins (Fig. 4), the surfaces of which have been cultivated for livestock pastures and the production of feed crops. The value of this farmland is related to the general soil fertility of these thick glacial till deposits. The presence of drumlin fields also presents technical challenges for stone resource development because thick till would result in very expensive overburden stripping costs to access the deposit. Collectively,

Figure 4. One of many drumlins that are found in the Yarmouth area. These glacial mounds are the basis of a significant farming economy, a competing land use with implications for future stone resource development in the region. The thickness of these till deposits would also have a negative impact on quarrying because of the stripping costs associated with removal of this overburden to access a bedrock deposit.

Figure 5a, b. The Davis Lake leucomonzogranite in East Kemptville may have building stone potential because of its blue-grey colour and a location that commonly underlies remote forest land. The permitting process for a new quarry development is often less complicated in areas where resource-based industries are a major component of the local economy. (a) Outcrop of this granitic rock is rare in the area. This site is most likely outcrop, but the possibility that it may be a very large glacial boulder cannot be ruled out. (b) This photo of a freshly broken glacial boulder shows the unusual colouring of this rock.

these geotechnical, land-use and environmental issues severely limit the resource potential in the Yarmouth area. Continuing along its geological trend to the northeast of Route 101 in South Ohio and Brazil Lake, the stone resource potential in the volcanic rocks is faced with similar land-use and regulatory obstacles. Residential dwellings are common and new developments of lakeside homes and recreational properties continue to expand in the area. As a result, the entire area will be included in the stone resource database but flagged for potential conflicts related to resource development.

Dimension Stone Potential of Devono-Carboniferous Granites

East Kemptville

Several samples of granitic rocks from East Kemptville, Yarmouth County, were collected to evaluate dimension stone potential. Leucomonzogranite of the Davis Lake Pluton is a grey, medium- to coarse-grained megacrystic rock (Figs. 5a, b) which should produce cut and polished products similar to those used in the dimension stone market today. The combination of texture and attractive grey colour (described variously as blue-grey to smoky grey) may have appeal for applications such as wall cladding, kitchen counter tops and floor tiling. An important consideration in the evaluation of the leucomonzogranite for dimension stone purposes is its location in the interior of Yarmouth County. Although there are small communities in the area, there are also relatively remote locations where land-use pressures are comparatively low. In geotechnical terms, evaluating this granitoid rock for dimension stone potential is hampered by the general absence of outcrop, but from a resource evaluation perspective this is offset by the presence of an abundance of large glacial boulders. The size of the boulders is indicative of wide joint spacing in at least some of the underlying bedrock, suggesting that large quarry blocks are possible. The lack of outcrop prohibited a more focused identification of a specific exploration target. The occurrence is restricted to a general site description, photo documentation and the collection of samples from boulders for cutting and polishing.

Castle Frederick

Samples of granitic rock were collected from a Crown land site at Castle Frederick, Hants County, to examine the rock's dimension stone potential. The exposure at this site is excellent because of recent blasting associated with road construction (Figs. 6a, b). This medium- to dark-grey and pinkish-grey mafic porphyry consists of fine- to coarse-grained rock with varying amounts of megacrysts. There is a large variability in joint spacing, but much of the bedrock is capable of producing large blocks associated with widely spaced joints. The rock is mineralized, including pyrite and galena as veins along some of the joint and fault fractures and an abundance of limonite along most fracture faces (Smith *et al*., 2006). The internal appearance of the large blocks of rock (between the fractures) is generally fresh and unaltered with a variety of colours and textures. The presence of lead and pyrite may hamper quarrying at this site. Iron staining along the road indicates that acid drainage is occurring in the northerly, downslope direction of the road. It may be possible to quarry the large blocks while remediating the site to prevent future drainage problems. It is also possible that exploration adjacent to this road cut may reveal similar stone without the mineralized zones.

Figure 6a, b. The blasting that created this road cut (Fig. 6a) at Castle Frederick has exposed a mafic porphyry which may have potential for building stone applications. This site is complicated by the presence of sulphides and lead along some of the fracture planes. Note the uncommonly abundant limonite along the joint fractures. Otherwise, the rock is generally fresh in appearance (Fig. 6b). Samples have been taken for cutting and polishing.

Dimension Stone Potential of the Goldenville Group

The Goldenville Group contains rock that has been used extensively for building stone purposes. The term 'building stone' in this discussion, however, should not be confused with the factory manufactured, sawn and polished stone used in products such as memorial stone, wall cladding or counter tops. The rock for these highly finished applications is selected on the basis of numerous parameters such as colour, patterns in the stone, ability to 'take a polish', impermeability and architectural appeal. Due to the rather ordinary colouring and textures of the Goldenville Group rocks, they are unlikely to be suited to factory finished applications. Rather, the building stone potential here refers to rock that breaks naturally into shapes that can be used for less formal applications such as walls and patios. These lower end dimension stone applications typically have textured surfaces and less precise interlocking of the pieces. Although these materials require less precise fitting than mechanically dressed stone products, the structures they create are equally appealing. A well constructed stone wall is an architectural creation that attests to the high level of skill required to do this work. Production of these materials typically requires very little processing at the quarry, where the rock may simply require fragmentation by blasting charges or ripping using heavy equipment. Stone masons select stone from piles created by heavy equipment or shot-rock piles (i.e. the unprocessed blast rock) and take it to the construction site where it is trimmed by hand for final fit in the structure. Alternatively, some stone producers and brokers will provide the stone mason with hand selected, hydraulically split materials on pallets which are delivered to the construction site.

Goldenville Group rock types that are capable of making these products are metasandstone (also commonly called quartzite or metagreywacke) and the finer grained equivalent rock known as metasiltstone. The value of this stone is (1) the natural shapes produced when the rock is broken in the quarry and (2) the weather-resistant durability that these rocks possess due to metamorphism. The natural shapes of the rock fragments typically consist of blocks with at least two parallel opposing faces and flat slabs with parallel faces (flagstone). In some of the rock the fractures result in orthogonally shaped blocks similar to bricks because the joint sets are perpendicular to each other. These shapes are also affected by fractures along bedding plane weaknesses and cleavage (deformation-related) fractures. The rock was previously described in this report as having a very ordinary colour unsuited to polished products, but this pale grey to grey-green rock is visually appealing in fence and wall applications (Fig. 7). Metamorphism associated with the Goldenville Group rocks has also made the metasandstone extremely hard, water resistant, weather resistant and durable from a structural perspective. Finally, this rock is ubiquitous to the western half of

Figure 7. This dam at Gardners Mills, Yarmouth County, is constructed of Goldenville Group metasandstone, which was most likely obtained from fieldstone (glacial till boulders). It is an excellent example of the skill that goes into the construction of these structures.

mainland Nova Scotia and the most common source of quarried aggregate in the region. The Halifax-Dartmouth area has numerous examples of dry stone fences, retaining walls and masonry stone buildings constructed from metasandstone that has been hand selected from local bedrock aggregate quarries. Thus, the stone has a long history of use and proven record of durability spanning at least a century.

During the course of this field work, sites in the Goldenville Group having the geological conditions that could be exploited solely for the production of orthogonal- and slab-shaped pieces of stone for building stone applications were recorded. As a result, two geological features were identified that are amenable to the quarrying of this type of stone.

One of the geological features that can produce these pieces of stone is structural in origin. Joints, which can be defined as repeating fractures in bedrock where there has been no observable movement, are common to all of the Goldenville Group rocks. They typically occur as joint sets, each of which are oriented in a different direction. In metasandstone the primary joint set typically contains fractures that are spaced >0.5 m apart. Although there is generally considerable variability in this spacing (even within the confines of a quarry or road cut), closely spaced jointing (<0.5 m) appears to be relatively rare. Metasandstone with fractures, which are typically 8-30 cm apart, appears to be highly suited to making dimension stone for applications such as walls. This is because many of the stones created as a result of these fractures have parallel opposing faces in at least one plane, with many blocks having orthogonally oriented sides or a rectangular shape. The blocks are also of a manageable size for manual lifting by stone masons and have dimensions that will fit the typical width of applications such as stone walls. An example of the product in Figure 8 illustrates the appeal of this stone and the craftsmanship required to make these structures. The thin, flat pieces can also be used for flagstone in the construction of patios and walkways. It should be noted that joint planes are not always perfectly parallel, but within the dimensions of small blocks, the opposing faces will more or less result in product with an even thickness. An example of an occurrence in the East Uniacke area is shown in Figure 9. The joint spacing in this metasandstone outcrop ranges from 5 cm to 40 cm over a distance of more than 20 m (perpendicular to the strike of the fractures) along a woods road cut. The occurrence description is based on outcrop observations, but it also contains the speculation that the deposit probably extends along strike and perpendicular to the strike of the joints beyond the margins of the outcrop. The East

Figure 8. This stone wall and steps were constructed from joint-fractured metasandstone and are another example of the quality of work done by stone masons. Selecting pieces from the pile that will fit the wall with minimal trimming requires an experienced eye for stone.

Figure 9. This metasandstone outcrop in the East Uniacke area of Hants County has closely spaced vertical jointing, and may have potential as a building stone deposit. Such sites probably have little value in the short term but they need to be identified and flagged for their potential use in the future. Resource potential, like any other land use, needs to be included in the land-use planning process so that deposits such as this are protected from sterilization.

Uniacke occurrence is in an isolated area which was recently clearcut and could be easily accessed for development.

A second feature that can be exploited to produce dimension stone has a sedimentary origin, although to a lesser extent there is also a deformational component to this potential. Thinly bedded and interbedded metasandstone and metasiltstone occur in very specific locations in the Goldenville Group stratigraphy. The Goldenville Group has been interpreted as consisting of thick sequences of turbidite deposits originating in a deep ocean setting. Most of the stratigraphy consists of thick (>1 m) metasandstone beds separated by lesser amounts of metasiltstone and slate. In the more distal areas of this depositional environment there are fine-grained sedimentary rocks, some of which are transitional with the slate-dominated Halifax Group. The thin interbeds of metasiltstone and metasandstone (Fig. 10a) are typically separated by thin layers of muscovite and chlorite. The micaceous layer creates a plane of weakness between the individual beds which permits them to be separated by ripping with heavy equipment, hydraulic splitting or possibly blasting with the aid of light explosive charges. The result is that this rock tends to break into natural pieces along the bedding plane weaknesses to produce rectangular and tabular shapes that can be quarried to produce blocks and flagstone. Bedding layer breaks or fractures typically produce stone that is approximately 8-30 cm in thickness. Because there is often foliation in fine-grained metasandstone and metasiltstone (a product of alteration and deformation), the best locations to obtain parallel-faced shapes in the stone would be locations on the limbs of folds where foliation is parallel to bedding, which produces a flat, even surface during splitting. The plane of weakness associated with the foliated fine-grained metasandstone and metasiltstone may also allow some of these deformed rocks to be split to almost any thickness (Fig. 10b). One question that remains at this time is whether or not the planes of weakness associated with bedding and foliation are constant with depth. In other words, can the rock deeper in the deposit be split with similar forces and methods or does the rock become more competent and cohesive below the near-surface zone? The upper 1-2 m of bedrock have obviously been influenced by a number of factors, such as past glacial activity, permafrost pressures and weathering processes.

Sandy Tills as Sources of Sand

The high demand for sand in products such as concrete, traction sand and masonry sand has resulted in the depletion of glaciofluvial sand deposits throughout the province. The continued (and most likely accelerating) need for these important materials in the future necessitates an evaluation of the feasibility of using sandy tills for producing sand. The focus of the work was the thick granite tills that appear as large mounds along the Atlantic Uplands (Stea *et al.*, 1992) in the study area. It remains to be determined whether or not the tills can be processed economically with an acceptable yield of high quality product. Deposits with a high proportion of unusable fines (silt and clay) would require costly wash processes and produce significant volumes of waste materials. Large amounts of oversize stone (clasts larger than sand size, including boulders), which are common in the granitic tills, would also have to be treated as waste rock. Deposits containing large proportions of waste would also require extensive equipment and operator time as well as the problem of large storage areas on the site. Due to haulage costs, distance to markets also plays a major role in the

Figure 10a, b. These coastal exposures in the Goldenville Group at Black Point, Digby County, consist of (a) thinly interbedded metasandstone and metasiltstone (photo by C. E. White), and (b) continuous metasiltstone, respectively. These rocks can be split along bedding plane weakness to produce blocks and slabs suitable for dimension stone. The success of quarrying these sedimentary rocks for this purpose is complicated by a cleavage plane resulting from structural deformation. For splitting purposes the location of the deposit should be on the limb of a fold where cleavage is parallel to bedding. These coastal sites are not suitable for building stone extraction, but there is a strong possibility of tracing the strike of this rock inland where there is similar stone in locations more amenable to quarrying. The primary concern in the inland locations would be land-use issues and thick till cover.

determination of the potential of a deposit. Distant sources would undoubtedly be a deterrent to future development possibilities.

Several areas were sampled in the study area from exposures such as road cuts and borrow pits used for woods road construction (Fig. 11). No attempt was made to channel sample the sediments because of the paucity of exposures. These glacial sediments are often complicated due to their depositional history. The deposits are typically variable in composition, consisting of a complex mixture of predominantly massive, poorly sorted sediments and minor amounts of well-sorted, water laid materials. As a result, samples taken from very localized areas in the deposits can best be described as grab samples that appeared to be typical of the exposure. The materials are being tested for grain size distribution and the Sand Equivalent Test.

Evaluating a deposit by taking grab samples near the surface of the deposits and conducting grain size distribution tests should only be seen as a preliminary step in assessing the sand potential of these deposits. Establishing the proportion of oversize materials such as boulders in a deposit, for example, is a more costly operation. If the laboratory results prove promising, they will simply highlight the need for more investigation in the future. Determining the true potential of these nontraditional sand sources in southwestern Nova Scotia will require the interest and significant financial investment by industry. This will only occur when current sources of sand in glacial meltwater deposits are no longer available and alternative sources become a realistic possibility.

Figure 11. Several sandy tills were sampled and sieved to determine the percentage of sand present in the matrix of the deposits. In order to have potential as a sand source, the ratio of sand to waste (clay, silt and stone) should be relatively high. This is only the first step in the evaluation process. The more difficult problem will be the determination of how much stone (i.e. > sand size) is present in these deposits. This measurement will not be attempted in this study.

Sand and Gravel in Coastal Exposures

An evaluation of the aggregate potential of sand and gravel deposits can often be advanced by examining shoreline exposures. Surficial maps typically indicate where the glacial meltwater and glaciomarine deposits (i.e. sand and gravel) are located, but there is little information about the nature of the resource. A very thick sand and gravel deposit on a surficial map (e.g. Stea *et al*., 1992) cannot be distinguished from areas on the map where these meltwater deposits exist as a veneer and are of no value to the extractive industry. A large component of the fieldwork in this study has focused on distinguishing the resource development potential from deposits that have minimal extractive value. A regional study of this nature must typically rely on the limited information that can be documented in pits, ditch cuts, road cuts and stream exposures. Unless these sites are new or have recently been exposed (e.g. new workings in a pre-existing pit), however, the face is commonly a vegetated slope of loose debris or talus that covers the original sediments. Exposing these deposits using hand tools is limited to very small faces, which probably are not representative of the deposits. Many coastal locations, on the other hand, are repeatedly battered by storms each year, continually yielding fresh exposures. Examining these extensive, continuous exposures commonly provides a new perspective on a deposit. Glaciomarine deposits on the surficial maps, for example, can commonly be thin (e.g. Fig. 12), indicating that many of them can be dismissed as potential sources of aggregate. Sites where they are located in environmentally sensitive areas and near residential and recreational properties would also be rejected because their thickness would require the disruption of a very

Figure 12 This gravel veneer (top metre of exposure) overlying till at Church Point, Digby County, is an example of glacial sand and gravel deposits delineated on the surficial geology maps that would not be suitable for aggregate extraction. In addition to the problems of location, the deposits do not have a thickness that would warrant extraction.

Figure 13. A small boulder deposit near Gilbert Cove, Digby County. These unusual deposits have been identified in several locations in the study area. The precise depositional origin of the boulders is unknown, but they appear to have a glacial or early post-glacial origin. The concentrations of boulders may have use as sources of rip rap and armourstone.

large area of land to extract a relatively minor amount of material. The result is that fieldwork along the coast is a very valuable method of distinguishing resource potential.

Glacial Boulder Deposits

During the course of this study a number of glacial boulder deposits were identified (Fig. 13). These unusual deposits are typically less than 0.5 ha in area, commonly occupy former swales in flat topography and have a slightly elongated shape. They are composed entirely of boulders ranging in size from 0.5-1.5 m in diameter with a speculated deposit thickness probably being less than 2 m. The boulders vary from subrounded to angular and the surface of the deposit is approximately flat topped and horizontal. There is at least one example in the study area where the deposit is on a slight incline. From a distance the deposits look like an ephemeral stream bed, but water has never been observed among the boulders, even during periods of high precipitation. A final interesting aspect of the deposits is that trees are rarely observed among the boulders and when present, only in a stunted form.

The origin of these deposits is not known. There has been the suggestion that post-glacial freeze-thaw cycles and soil creep (solifluction) over hundreds of years have caused the boulders to slowly move and cluster on low ground. If this is the case, the boulders have moved in areas where there is very little slope. Alternatively, there may be a late-stage glacial meltwater origin or component to the deposits. The complete absence of fines in the deposits suggests that substantial water flow associated with ice-contact meltwater may have been at least partially responsible for these deposits. Evidence for the origin of the deposits remains elusive, however.

From a stone resource perspective these small boulder deposits were documented as occurrences because of their possible value as sources of rip rap and armourstone. They are commonly located on flat-lying terrain and easily accessible by woods roads. Much of the time glacial boulders used for coastal protection require substantial equipment and operator time to separate the rock from the till matrix or fines. These deposits consist exclusively of boulders within a very narrow range of dimensions. They could be extracted and placed on trucks with very little effort. Furthermore, because the deposits don’t appear to contain water, there should not be any environmental concerns regarding their removal. The small size of the deposits, however, limits their value as a stone resource.

Documenting Abandoned Pits

During the course of the Annapolis Valley Project hundreds of abandoned pits have been examined and documented. If the pit occurs in sand and gravel this information can be used to identify the continuation of sand and gravel deposits on adjacent land or, conversely, as an indicator that the deposits are exhausted, which also has value in a resource study. If the pits occur in other types of surficial deposits, the information can be used to identify the type of materials and possible uses, such as clay-rich tills that may have potential for making engineered soils. Documentation of the pits also may have value in the future for a subsequent land use, such as an aquaculture site if there is ponded water, or for the placement of bee hives. Collectively, the locating and documentation of the sites has many resource and land-use values.

One important but commonly unrecognized reason for visiting the sites is identifying unused materials left behind after the extractive operation has ceased. At dozens of sites this can include piles of crushed and screened product, top soil and oversize materials. All of these materials may have value in the future but they are commonly forgotten by the pit owner at the time the materials were extracted or, in the case of a new land owner, there may be a lack of awareness that these materials exist. The primary interest in these sites is the oversize materials, which are separated by large screens (called grizzly screens) and piled to the side of the operation. In the study area there are several sites where large piles of this rock have remained after the pits were abandoned and now are concealed by vegetation (Fig. 14). The boulders are typically larger than 30-50 cm in diameter and may be as much as 1 m across. Because these deposits usually result from the action of glacial meltwater, the boulders are commonly rounded. Unlike the weathered glacial boulders found at the surface and subjected to millennia of freeze-thaw cycles, these boulders are generally smooth because they were buried and protected from surface weathering. The result is that this type of stone is extensively used by the landscape industry to make retaining walls

Figure 14. A large pile of boulders in an abandoned pit near Milford, Annapolis County. Many abandoned, overgrown sand and gravel pits in the study area contain large ‘waste’ piles of oversize rock that was removed prior to the crushing and screening process. An inventory of these privately owned and Crown sites is important because these materials can be used in the future for a variety of purposes.

or as decorative stone in gardening. The demand for this stone in some areas can also be a challenge for the landscape and excavating companies to meet. Documentation of these occurrences is seen as an important aspect of the Annapolis Valley Project, particularly from the viewpoint that it is an easily accessible commodity that maximizes the use of existing extraction sites while reducing the need to open new sites.

Future Project Activities

Work will continue to make final preparations to the digital data base and to check the remaining discrepancies in the digitized data in the field. Geoscience Information Services staff will play a critical role in the preparation of the resource maps and database. Air photo interpretation will be required to delineate recently discovered sand and gravel deposits, which will then be transferred to the digital database. It is anticipated that a preliminary version of the database will be completed by the end of 2010. Queries regarding the stone resource potential in the Annapolis Valley region or other locations in the province can be directed to Garth Prime by phone (902-424-8146) or email (primega@gov.ns.ca).

References

Nova Scotia Department of Environment and Labour 1999: Pit and Quarry Guidelines; guidelines under the Environment Act; Nova Scotia Department of Environment and Labour, 8 p.

Prime, G. 2001: Overview of bedrock aggregate potential in the Halifax-Dartmouth metropolitan area, Nova Scotia; Nova Scotia Department of Natural Resources, Economic Geology Series ME 2001-1, 74 p.

Prime, G. 2008: An overview of the industrial mineral potential of the North Mountain Basalt; *in* Mineral Resources Branch, Report of Activities 2007; Nova Scotia Department of Natural Resources, Report ME 2008-1, p. 93-99.

Prime, G. and Bonner, F. 2007: Bedrock aggregate development potential in western Halifax Regional Municipality; Nova Scotia Department of Natural Resources, Economic Geology Series ME 2007-1, 51 p.

Prime, G. and White, C. E. 2004: Potential granitic aggregate sources in the Halifax Regional Municipality area; Nova Scotia Department of Natural Resources, Open File Illustration ME 2004-1.

Prime, G. and White, C. E. 2007: Bedrock aggregate potential of the Meguma Group; *in* Mineral Resources Branch, Report of Activities 2006; Nova Scotia Department of Natural Resources, Report ME 2007-1, p. 123-136.

Stea, R. R., Conley, H. and Brown, Y. 1992: Surficial geology of the province of Nova Scotia; Nova Scotia Department of Natural Resources, Map ME 1992-3; Scale 1:500 000.

Smith, P. K., Prime G. and Weir, D. 2006: Castle Frederick (NTS 21/A16): A new Pb-Zn (-?Ag) mineral occurrence; *in* Mineral Resources Branch, Report of Activities 2005; Nova Scotia Department of Natural Resources, Report ME 2006-1, p. 143-147.

White, C. E., Horne, R. J., Teniere, J. P., Jodrey, M. J. and King, M. S. 2001: Geology of the Meteghan River-Yarmouth area: a progress report on the southwest Nova Scotia mapping project; *in* Mineral Resources Branch, Report of Activities 2000; Nova Scotia Department of Natural Resources, Report ME 2000-1, p. 95-111.