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SURFICIAL AGGREGATE-RESOURCE MAPPING IN NTS MAP AREAS 1M/1, 1N/12 AND 1N/13

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ABSTRACT

Surficial aggregate mapping on the Avalon Peninsula and nearby areas is part of a continuing regional survey to locate aggregate deposits to alleviate construction problems resulting from aggregate shortages and poor-quality aggregate. In 2009, mapping was completed along the western part of the Avalon Peninsula in NTS map area 1M/1, and on the Isthmus of the Avalon in NTS map areas 1N/12 and 13. Sand and gravel deposits were identified at many locations throughout the map area. Although most are small, there are several large deposits that can support a multi-year quarry operation. Deposits sampled vary from fine sands and silt, to sandy gravel, gravel, and boulder gravel, and range in quantity from 3000 m^3 to 2 000 000 m^3. Most deposits are located near shorelines and contain small quantities of material; these deposits are unsuitable for quarry locations. Some of the larger deposits are located 1–3 km inland and will require road construction to access them.

INTRODUCTION

Definition of aggregate depends on the producer, location and use of the material (Smith and Collis, 1993). Aggregate, as used in the context of this report, is defined as any hard, inert material such as gravel, sand, crushed stone or other mineral material used in the construction industry (Rutka, 1976; Carter, 1981). The demand for aggregate is closely associated with construction activity, and road construction and maintenance is by far the most important use of mineral aggregates. Water and sewer systems, driveways, building foundations, backfill and landscaping, all require aggregate. Aggregates are characterized by their high bulk and low unit value, so that the economic value of a deposit is a function of its proximity to a market area, as well as its quality and size (Vanderveer, 1982). Comprehensive planning and resource-management strategies are required to make the best use of available resources, especially in areas experiencing rapid development. Such strategies must be based on a sound knowledge of the total mineral aggregate-resource base at both local and regional levels.

Aggregate materials can be, i) processed and used as Class A gravel (aggregate with a diameter of less than 19 mm having a specified proportion of finer grain sizes and 3 to 6 percent silt–clay; Department of Transportation, 1999), or Class B gravel (aggregate with a diameter less than 102 mm, having a specified proportion of finer grain sizes and 3 to 6 percent silt–clay; Department of Transportation, 1999), ii) processed to mix with a cementing agent to form concrete, asphalt and mortar, or iii) used as unprocessed, out-of-pit material. The suitability of quarry materials for aggregate use depends on their composition. The silt–clay quantity is important. High silt–clay volumes can cause instability, such as flowage. Too much silt–clay in concrete (>2 percent) can interfere with the bonding process between the aggregate and the cementing agent. High silt–clay aggregate (greater than 15 percent) can be used for earth filled dams, fill and sub-grade road material. Low silt–clay volumes can result in loss of compaction. The presence of deleterious substances (such as silt–clay coatings or iron oxide staining on the surface of the aggregate), or of blade shaped fragments, can cause bonding problems with the cementing agent, or the breakdown of aggregate with time.

Knowledge of the nature and distribution of the surficial aggregate deposits (sand, gravel and low silt–clay materials) can assist in estimating the construction cost of projects requiring aggregate. When it is necessary to identify new aggregate sources for production of large quantities of construction materials, the surficial geology of the area and the bedrock geology are important considerations. In a large-scale operation, it may be more economical to truck granular products longer distances rather than use inferior material close at hand; processing cost could be lower and the quality of the product higher, therefore, offsetting the high cost of transportation.

The suitability of aggregate depends on physical properties and the capability of the rock to withstand stresses placed upon it when used as a construction material. The lithology of the pebble fraction (16 to 32 mm) defines the petrographic characteristics (Canadian Standards Association, 1973; Ontario Ministry of Transportation, 1994; Bragg, 1995). The petrographic number can range from 100 to 1000, and is derived by taking the sum of the percentage of each rock type present in the pebble fraction (in a sample of approximately 100 pebbles) multiplied by a petrographic factor (based on soundness and durability) assigned to that rock type (Ricketts and Vatcher, 1996). The petrographic factor is determined mostly by type and grain size of the rock in a given sample, and by weathering (fresh, slightly, moderately, highly, or intensely weathered) and fracturing. The lower the petrographic number, the better the quality of aggregate material. For example, clean, hard, fresh granite would normally have a petrographic number of 100, whereas soft, friable shale would have a petrographic number of 1000. Most deposits contain a combination of different rock types having different petrographic factors. The proportion of each of these components determines the petrographic number. For most purposes, aggregate material used in concrete requires a petrographic number of 135 or less, whereas in road asphalt and Class A and B gravels, a petrographic number up to 150 is acceptable (Department of Transportation, 1999). The presence of silt–clay coatings (clean, thin, medium, thick), staining, rounding of pebbles, and the number of fracture faces and their sphericity are important considerations in using an aggregate for concrete. These factors affect the bonding capabilities of concrete, and the amount of water necessary to make a concrete, both of which have a direct relation on the strength of a concrete.

LOCATION AND PHYSIOGRAPHY

The study areas (Figure 1) were, 1) the west side of the Avalon Peninsula, west of longitude 54°00’ and north of latitude 47°00’. This covers the southeast part of the Ship Cove map area (NTS map sheet 1M/1; Figure 2). In the NTS 1M/1 map area, elevation increases sharply from the coast, to a plateau at 150 m to 180 m above sea level (asl). Three areas in the southeast part of the map area reach over 225 m asl. There are a few short, steep-walled valleys near the coast but beyond these, the terrain can be characterized as gently rolling. 2) The Isthmus of the Avalon Peninsula, extending from latitude 48°00’ in the north to latitude 47°30’ in the south. This area covers two 1:50 000-scale map areas (Dildo, NTS map sheet 1N/12; and Sunnyside, NTS map sheet 1N/13; Figure 3). The area has a rugged landscape with many peaks above 150 m asl. Two areas southwest of Goobies are above 320 m and Centre Hill, 4 km west of Deer Harbour, rises to 345 m asl. The central part of the study area, from the Doe Hills to the northeast end of the map area, is characterized by barren, irregular and rough topography with numerous bedrock outcrops. The northeast

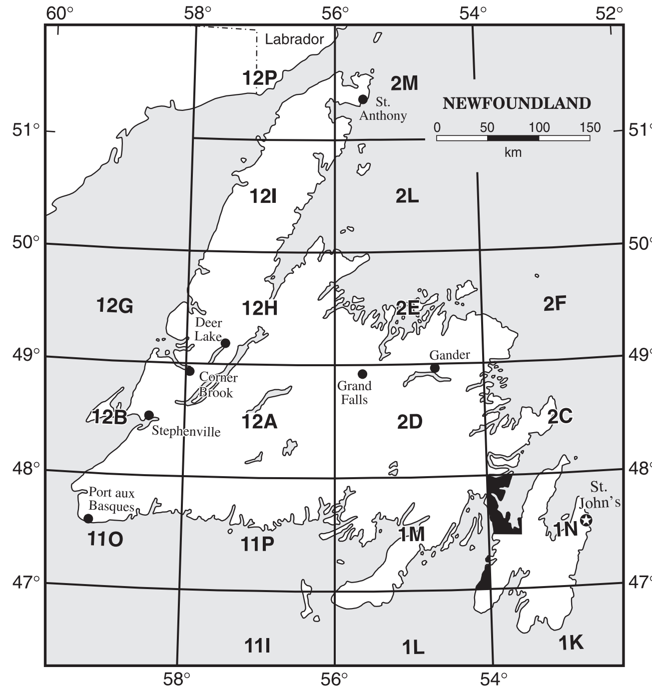

Figure 1. *Location of study areas.*

shoreline is rugged, and indented by numerous bays, some extending inland more than 5 km, at Bull Arm, Deer Harbour, and St. Jones Harbour.

PREVIOUS WORK

The Avalon Peninsula was covered by a series of local ice caps, the largest centred over St. Mary’s Bay. During deglaciation, these disintegrated into smaller dispersal centres along the major sub-peninsulas of the Avalon (Summers, 1949; Henderson, 1972). Glaciofluvial deposits associated with melting of the ice caps are found within the major valleys or offshore (Henderson, 1972).

Catto (1998a) interpreted the ice-flow history of the Avalon Peninsula mostly from striations and glacial landforms, and recognized three phases of glaciation. Phase One marked the accumulation of ice centres along the axes of the major peninsulas, and expansion seaward. During Phase Two, lowering sea level allowed the development of an ice centre in St. Mary’s Bay that expanded north, covering most of the Avalon Peninsula. Phase Three was marked by the collapse of the St. Mary’s Bay ice centre, rapid drawdown of ice into St. Mary’s and Conception bays, and the persistence of ice flowing through Trinity Bay. Ice became centred again on the main peninsulas, some of which actively retreated while others stagnated.

McKillop (1955) released a preliminary report on a survey of beaches throughout the area, provided detailed

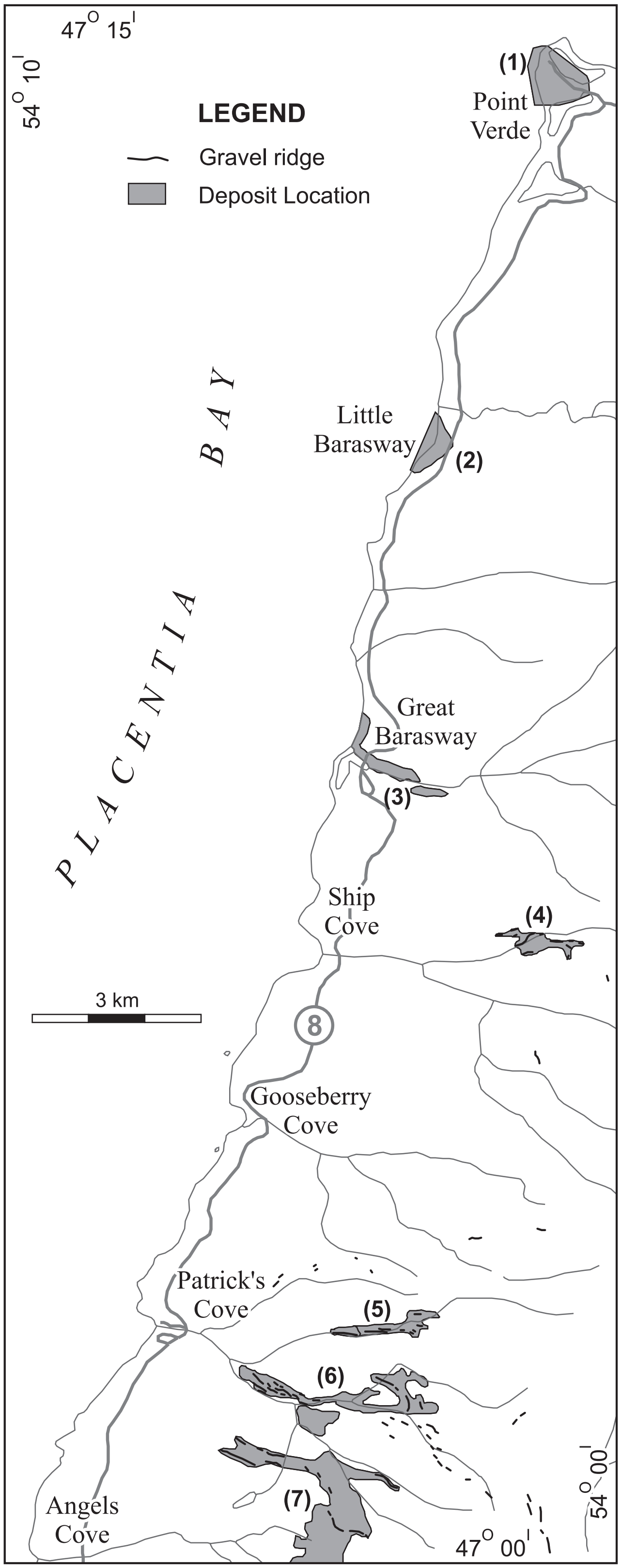

Figure 2. *Granular aggregate deposits in the eastern part of the Ship Cove map area (NTS 1M/1).*

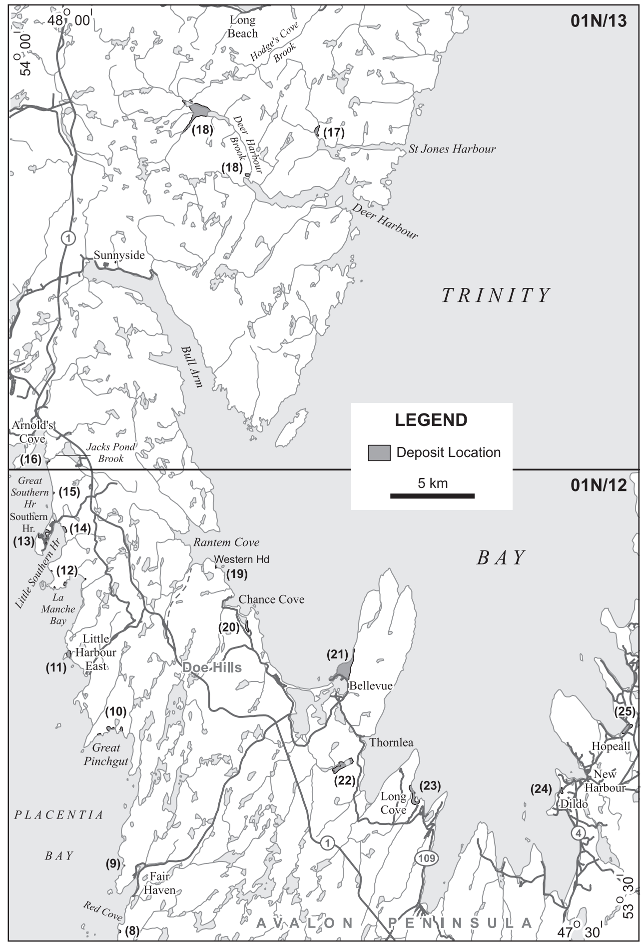

Figure 3. *Granular aggregate deposits in the Dildo and Sunnyside map areas (NTS 1N/12 and 1N/13).*

description of most beaches, including type of beach (bar or strand), their dimensions, size of material, lithology, and the sphericity and rounding of material. McKillop (*op. cit.*) also provided recommendations for the types of local or general use to which these resources may be applied. In recent years, beach removal has been restricted or banned entirely, due to erosion and damage to roads and property in back beach areas.

Surficial geological maps at a 1:50 000 scale (Batterson *et al.*, 2003a, b; Catto, 1986) and 1:250 000 scale (Liverman and Taylor, 1989, 1994) showed deposit types, and ice-flow features. An aggregate-resource study was conducted by the Department of Mines and Energy from 1978 to 1982 (Environmental Geology Section, 1983a, b, c, d; Kirby *et al.*, 1983) that outlined areas of potential aggregate within a 6-km-wide corridor along all roads in Newfoundland and Labrador. In addition to these data, geotechnical bedrock maps were compiled at a scale of 1:250 000 (Bragg, 1985). Bragg (1994a, b and c) released site location maps at 1:50

000 scale showing rock types and petrographic numbers followed by information on the petrographic quality of different rock types to determine their potential as construction aggregate (Bragg, 1995).

MAPPING AND ANALYTICAL METHODS

Assessing the potential use and value of granular aggregates can be complex, especially when a variety of different material types occur within any given aggregate deposit. Interpretation of airphotos (1:50 000-scale black-and-white, 1:20 000-scale black-and-white, and 1:12 500-scale colour photographs) is the first stage in locating potential deposits. Airphoto interpretation is used to produce preliminary landform classification maps that show the distribution and nature of the various deposits found within an area. Commonly they show a variety of till, and sand and gravel deposits, the latter being deposited by fluvial, glaciofluvial or coastal processes. Granular aggregate maps are a derivative of landform classification maps, supplemented by ground checking and sampling. These maps subdivide potential aggregate deposits into high, moderate, or low potential for aggregate production. The size of the deposit can be determined if its aerial extent and average thickness are known or can be estimated. Thickness values are approximations, based on the face heights of pits developed in the deposit, roadside exposures or features of the general landscape, such as the height of ridges or terraces above the surrounding terrain. From all data, individual deposits may be assigned one of four zones, with Zone 1 being the area of highest potential (Kirby *et al.*, 1983).

In addition to the data collected from aerial photographs, information on the various sediment types (Table 1) was obtained in the field by examining natural exposures (*e.g.*, stream cuts, shorelines, and gullies), or man-made exposures (*e.g.*, roadcuts, and pit and quarry excavations). Where exposures were not available, samples were collected from 1-m-deep hand-dug pits. In some places, hand-dug pits were not practical because of boulders or a thick, cemented B-horizon, making it difficult to see the undisturbed parent material. Lack of exposures meant that deposit thickness was difficult to assess. The scarcity of vertical sections, combined with the presence of a concealing surface mat of organic material in many places, made positive interpretation of the nature and extent of the glacial sediments heavily dependent upon evaluation of the geomorphology. Thus, in most instances, surface form was an important aspect in recognition of the unit mapped. Obvious landform boundaries were the basis of much delineation. Other features recorded in the field were sediment thickness, stoniness, presence of compact layers and the presence of vegetation. Approximately 15 kg of material were collected for field sieving at each site. Field sieving and petrographic analyses were performed on most samples containing >8 mm size material. A split (70 to 140 g) of the sand–silt–clay fraction (<8 mm) was retained for laboratory sieve analysis, which involved drying and splitting the sample to a manageable size (70 to 140 g) and wet and/or dry sieving of each sample following the procedures outlined by Ricketts (1987). This data was used to outline zones of aggregate potential on aggregate-resource maps.

Table 1. Composite soil description (Carter, 1983)

Description	Composition
Slightly sandy gravel	>95% gravel
Sandy gravel	5 to 20% sand
Very sandy gravel	> 20% sand
Sand/gravel	About equal
Very gravelly sand	>20% gravel
Gravelly sand	5 to 20% gravel
Slightly gravely sand	> 95% sand

AGGREGATE POTENTIAL

Till is widespread over most of the area, varying in composition, commonly in relation to underlying bedrock. Generally, tills have a higher silt–clay content than sands and gravels, which renders the majority of these deposits unsuitable for most construction purposes, unless washed to remove the silt. Potential quarry sites for low silt–clay tills will be outlined on 1:50 000-scale maps to be open-file released in 2010.

Glaciofluvial deposits, such as eskers, terraces and deltas, are generally the most suitable deposits for aggregate material. Generally, these deposits are clean, low silt–clay content, gravel-dominated sediment, resulting from deposition by meltwater from glaciers.

Some eskers in the study area form multiple ridges where they diverge at one or more places to form esker complexes. Most ridges contain gaps of varying lengths, where material either was not deposited or has been removed by erosion. Gaps may be no more than a few metres, or they maybe tens of metres or kilometres. Ridges generally vary in height up to 5 m, with one esker reaching a height of 8 m.

Deposits outlined vary greatly in quantity from 3000 to 2 000 000 m^3 based on estimated amounts determined from aerial-photograph interpretation and limited field investigations. Several deposits are within one kilometre of major roads. Other deposits are less accessible, or are too small to outline as potential resource areas. Three hundred and twenty-seven sites were investigated, and 150 samples were collected for grain-size analyses. Most samples were collected from shoreline exposures and 1-m-deep hand-dug pits. In most deposits, sample analysis indicate clean, coarse aggregates showing less than one percent silt–clay and variable sand–gravel concentrations. Deposits listed below range from gravelly sands to cobble–boulder gravels. These deposits are mostly suitable for coarse-grained aggregate uses. Fine-grained aggregates (sand) are less common.

Petrographic analyses were completed on 134 pebble samples, and show a range of petrographic numbers from 110 to 252. Although reserves are large in some areas, the presence of varying amounts of weathered shale, siltstone, and sandstone decreases the petrographic quality. Petrographic classification and petrographic quality were determined by using a list of petrographic factors for rock types in Newfoundland (Table 2).

Table 2. Petrographic classification (Bragg, 1995)

Classification	
Good (P.N. 100-135)	-excellent for major asphalt/ concrete construction
Fair (P.N. 136-300)	-may be used in minor construction (gravel roads, house foundations, minor retaining walls, low-traffic asphalt roads) if it passes other required specifications
Poor (P.N. 301-600)	-should only be used as fill material
Deleterious (P.N. 601-1000)	-unsuitable for aggregate use

NTS MAP AREA 1M/1

Till is visible along numerous coastal exposures and forms a blanket over most of the map area. With the exception of large deposits at Point Verde and Little Barasway, and a few pockets in other coastal areas, gravel deposits are more common in inland areas in the form of ridges and hummocks. These are most prominent in the central and south part of the map area.

1. Point Verde

Point Verde is located in the northeast corner of NTS map area 1M/1 on the south side of Placentia Sound (Figure 2). Henderson (1972) described Point Verde as “the largest mass of stratified drift on the Avalon Peninsula, deposited in the sea in an exposed position. The mass of drift is in the form of a blunt crescent, 1 km long from tip to tip, that rises gradually southwestward from the lagoon and ends in west and south-facing sand and gravel bluffs that rise 12 to 15 m. There are several kames at the broad southern end, and one or two kettles at the eastern part” (p. 83). This deposit covers a 300 000 m^2 area and contains 2 000 000 m^3 of sand and gravel.

Removal of quarry materials has been occurring for several decades in the Point Verde deposit. The deposit was not investigated in 2009. Aggregate data used to summarize aggregate quality was collected during previous sampling projects (Environmental Geology Section 1983a, b). Grain-size analyses of eight samples indicate it contains 42.2 percent gravel, 57.3 percent sand and 0.5 percent silt–clay (Table 3). Petrographic numbers of five samples are 121, 145, 160, 160, and 252.

2. Little Barasway

The Little Barasway deposit is located 6.5 km south of Point Verde (Figure 2). Henderson (1972) described the Little Barasway deposit as being similar to the Point Verde deposit – “south of Little Barasway River, the deposits behind the bluff are probably delta topsets that grew rapidly thicker as the proglacial delta was built seaward by outwash from the adjacent ice. The abundance of meltwater is indicated by channel scouring in the sand and by the torrentially bedded gravel to the south” (p. 84). The deposit covers an area of more than 180 000 m^2 and may contain 200 000 m^3 of gravel and sand. Four samples, collected from 6–8-m-high coastal exposures show sand lenses and up to 4 m of gravel overlying till. Grain-size analyses of sample material indicate it contains 45.8 percent gravel, 52.3 percent sand and 1.9 percent silt–clay (Table 3).

Petrographic analyses of one sample consist of fresh to slightly weathered sandstone (48 percent), fresh to slightly weathered siltstone (37 percent), fresh to slightly weathered volcanic rocks (14 percent) and fresh, hard gabbro (1 percent). The sample has a petrographic number of 131.

Large volume of material, low silt–clay content, good petrographic quality, and road access indicate this deposit has high potential for quarry materials.

3. Great Barasway

The Great Barasway deposit is located 5 km south of Little Barasway (Figure 2). It covers a 500 000 m^2 area and may contain over 700 000 m^3 of sand and gravel. This deposit has variable grain sizes ranging from boulder gravel to sandy gravel and sand (Plate 1) that overly till. On the north side of Great Barasway, a 30-m shoreline exposure show silty till overlain by 3 m of sand and silty sand, overlain by 4 m of boulder–sandy gravel. On the north side of the river valley, 1 km east of the highway, 0.8 m of gravel over 1.5 m of till was noted, along with bedrock outcrop at two sites. On the south side of the river, a 1-m-deep, hand-dug

Table 3. Summary of sand and gravel samples collected in NTS areas 1M/1, 1N/12 and 1N/13

Deposit	Estimated m^3	No. of Samples Analyzed	Mean Grain-size Analyses % Gravel (+5 mm)	% Sand .078mm (-5 mm)	% Sl-Cl (-.078)	Petrographic Numbers (PN)
1. Point Verde	2 000 000	8	42.2	57.3	0.5	121, 145, 160, 160, 252
2. Little Barasway	200 000	4	45.8	52.3	1.9	131
3. Great Barasway	700 000	6	59.0	38.6	2.4	110, 116, 152, 180
4. Ship Cove	25 000	1	77.7	21.9	0.4	132, 165
5. Patrick's Cove North	125 000	1	92.3	7.4	0.3	179
6. Patrick's Cove South	200 000	3	83.2	16.6	0.2	118, 126, 136
7. Angels Cove	100 000	5	73.8	25.4	0.8	136, 139, 175, 178
8. Red Cove	3 000	1	68.3	31.6	0.1	137
9. Fair Haven	3 200	1	62.4	35.2	2.4	116
10. Great Pinchgut	150 000	4	60.5	39.3	0.2	116, 122, 136, 164
11. Little Harbour East	100 000	2	62.1	37.6	0.3	161, 161
12. La Manche	10 000	2	63.9	35.8	0.3	148, 173, 174
13. Southern Harbour	?	1	64.4	35.2	0.4	264
14. Little Southern Harbour	4 000	1	48.7	51.3	0.0	139
15. Great Southern Harbour	50 000	1	72.0	27.9	0.1	189
16. Jack's Pond Brook	40 000	4	58.3	41.5	0.2	120, 200, 224, 280
17. St. Jones Harbour	30 000	1	78.1	21.6	0.3	168
18. Deer Harbour	150 000	1	54.8	45.0	0.2	151
19. Rantem Cove	6 000	1	48.6	51.1	0.3	251
20. Chance Cove	30 000	2	43.8	55.8	0.4	139
21. Bellevue	15 000	1	75.9	24.0	0.1	292, 297
22. Thornlea	50 000	3	29.1	67.4	3.5	119, 167
23. Long Cove	30 000	4	55.3	43.0	1.7	148, 159, 178, 187
24. Dildo	20 000	1	53.6	45.9	0.5	125
25. Hopeall	100 000	2	68.4	30.3	1.3	111, 122

Note: Estimated quantities in table are based on airphoto analysis, and field investigations along roadcuts, shallow hand-dug pits and natural exposures. Grain-size results and petrographic numbers (PN) are based on a compilation of sample data for each deposit

pit revealed cobble gravel at the top of a poorly drained terrace. Grain-size data determined from this site is unreliable because of a cemented oxide layer, water penetration at the base of the pit, and high boulder content. Grain-size analyses of sample material collected throughout this deposit area indicate it contains 59 percent gravel, 38.6 percent sand and 2.4 percent silt–clay (Table 3).

Petrographic analyses of samples collected in the Great Barasway area contain fresh to moderately weathered sandstone (54 percent), fresh to moderately weathered siltstone (38 percent), fresh, hard volcanic rocks (5 percent), gabbro (2 percent), and granite (1 percent). Petrographic numbers of four samples are 110, 116, 152, and 180.

This deposit is easily accessible and petrographic quality is good to fair. However, variable grain-size data combined with silty till and bedrock exposures require more work in this area to outline potential quarry sites.

4. Ship Cove

The Ship Cove deposit is located 2.5 km east of Route 8 (Figure 2). It consists of a gravel ridge complex and eroded gravel dispersed over 300 000 m^2. The deposit contains approximately 25 000 m^3 of gravel and sand. Two samples were collected from 0.9- and 1.2-m-deep hand-dug pits at the top of 2- to 5-m-high ridges. Grain-size analyses of samples indicate it contains 77.7 percent gravel, 21.9 percent sand and 0.4 percent silt–clay (Table 3). Petrographic analyses of two samples indicate this deposit is composed of fresh to moderately weathered sandstone (40 percent), fresh to moderately weathered siltstone (38 percent), fresh to slightly weathered volcanic pebbles (21 percent) and fresh, hard granite (1 percent). Petrographic numbers of two samples are 132 and 165.

Low silt–clay content and acceptable petrographic quality indicate this is a good-quality deposit. However, the dis-

Plate 1. *Boulder–gravel over sand along shoreline exposure in deposit 3 at Great Barasway.*

tance of the deposit from roads, coarse aggregate and small volume of material make this deposit unsuitable for quarry development.

5. Patrick's Cove North

The Patrick's Cove North deposit is located 2.5 km east of Patrick's Cove (Figure 2). This deposit consists of segmented gravel ridges and hummocks over a 350 000 m^2 area. The deposit may be up to 8 m thick at the west end, and up to 4 m thick at the east end where bedrock outcrop intrusions were noted in two locations and contains about 125 000 m^3 of gravel and sand. Grain-size analyses of one sample, collected from a 1.2-m-deep hand-dug pit, indicate it contains 92.3 percent gravel, 7.4 percent sand and 0.3 percent silt–clay (Table 3). Petrographic analyses of one sample indicate the deposit contains fresh, medium-hard siltstone (42 percent), fresh, medium-hard sandstone (29 percent), and fresh to moderately weathered volcanic pebbles (29 percent). The sample has a petrographic number of 179.

The distance from roads, coarse texture, widely distributed gravel ridges within the deposit area and bedrock outcrop at the east end of the deposit reduce potential for quarry development.

6. Patrick's Cove South

The Patrick's Cove South deposit is located 1 km southeast of Patrick's Cove (Figure 2). It is a large complex of gravel ridges, eroded gravel, and hummocks covering a 1 km^2 area and contains in excess of 200 000 m^3 of gravel and sand. Discontinuous gravel ridges extend for another 4 km southeast from this deposit, although they were unsampled. The largest part of this deposit is located in its west end (Plate 3), close to Patrick's Cove, where gravel is estimated to be 8–14 m thick. Near the east end of the deposit, gravel ridges are 3–8 m high. Grain-size analyses of three samples, collected from three hand-dug pits, 0.8 to 1 m deep (Plate 2), indicate it contains 83.2 percent gravel, 16.6 percent sand and 0.2 percent silt–clay (Table 3). Petrographic analyses of three samples indicate this deposit is composed of sandstone (42 percent), siltstone (37 percent), volcanics (19 percent), and quartz (2 percent). Petrographic numbers of three samples are 118, 126, and 136.

Plate 2. *Gravel in 0.9-m-deep hand-dug pit at top of 8- to 14-m-high ridge in deposit 6, located 0.7 km east of Patrick's Cove.*

Low silt–clay content, good petrographic quality, large volume of material, and relatively close proximity to a road transportation network make this deposit suitable for a multi-year quarry operation.

7. Angels Cove

The Angels Cove deposit is located in an area of extensive barrens, bog land, and numerous ponds (Figure 2). The deposit consists of esker ridges (Plate 4) and hummocky gravel that are dispersed over 2 km^2 near Angels Cove. The eskers are 1 to 8 m high and the hummocks reach 4 m high. The deposit contains approximately 100 000 m^3 of gravel and sand. Grain-size analyses of five samples, collected from 0.7- to 1-m-deep hand-dug pits, indicate it contains

Plate 3. *Gravel ridge in deposit 6, located 0.7 km east of Patrick's Cove.*

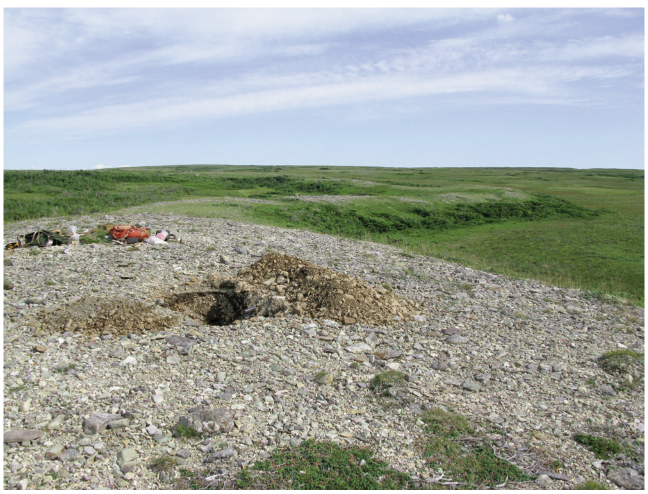

Plate 4. *Gravel in hand-dug pit at top of 4- to 8-m-high esker in deposit 7, located 2 km east of Angels Cove.*

73.8 percent gravel, 25.4 percent sand and 0.8 percent silt–clay (Table 3). Petrographic analyses of four samples collected in this area consist of fresh to moderately weathered siltstone (61 percent), fresh to moderately weathered sandstone (32 percent), quartz pebbles (3 percent), fresh, hard volcanic rocks (2 percent), and gabbro (1 percent). Petrographic numbers of four samples are 136, 139, 175, and 178.

Low silt–clay content, moderately good petrographic quality and the potentially large volume of material make this a good-quality deposit. However, because this segmented deposit has mostly thin units over a large area, and is a long distance from roads, it is unlikely the deposit will be developed as an aggregate source in the near future.

NTS MAP AREAS 1N/12 AND 13

Rock outcrop is common in the northeast and southwest part of the map area. Till is the dominant overburden type, generally thicker in the southeast and a smaller part in the northwest. Most gravel deposits are small and located near coastal areas. The largest two deposits are at the mouth of Deer Harbour and the mouth of Jack's Pond Brook.

8. Red Cove

The Red Cove deposit is located in the southwest corner of NTS map area 1N/12 (Figures 3 and 4). This shoreline deposit is 1500 m^2 and contains approximately 3000 m^3 of sand and gravel. The nearest road is 2.1 km to the north in the community of Fair Haven. Grain-size analyses of one sample, collected from a 1-m-high shoreline exposure, indicate it contains 68.3 percent gravel, 31.6 percent sand and 0.1 percent silt–clay (Table 3). Petrographic quality is fair, consisting of fresh, hard to moderately sandstone (57 percent), fresh to slightly weathered siltstone (38 percent), quartz pebbles (3 percent), and fresh to slightly weathered granite (2 percent). The sample has a petrographic number of 137.

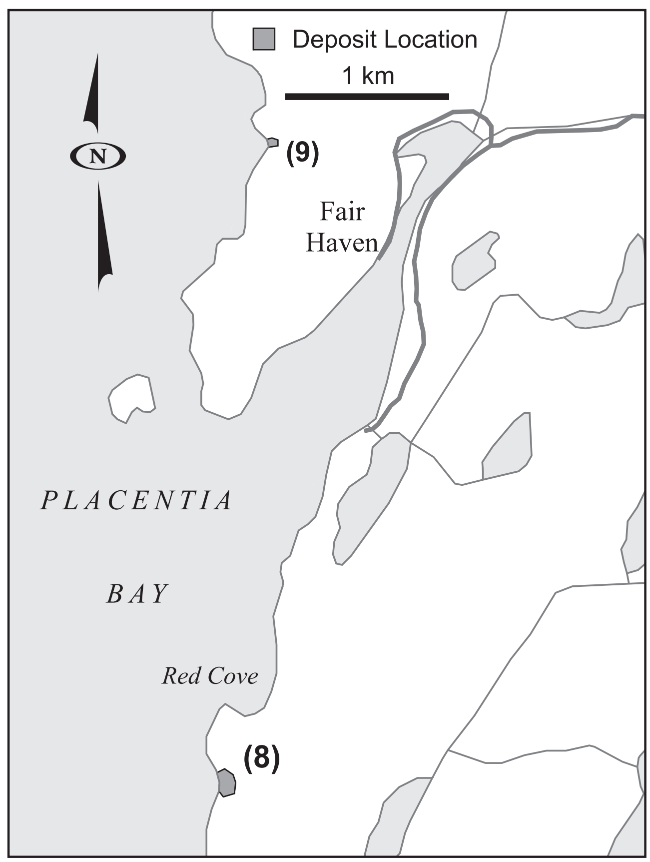

Figure 4. *Deposit locations near Red Cove and Fair Haven.*

Both grain-size and petrographic data indicate this deposit is suitable for quarry exploration. However, its small size and distance from a road will reduce its potential for quarry development.

9. Fair Haven

The Fair Haven deposit is almost 700 m west of Fair Haven in the southwest part of NTS map area 1N/12 (Figures 3 and 4). This shoreline deposit is 800 m^2 and contains approximately 3200 m^3 of sand and gravel. Grain-size analyses of one sample, collected from a 1-m-high shoreline exposure, indicate it contains 62.4 percent gravel, 35.2 percent sand and 2.4 percent silt–clay (Table 3). Petrographic quality consisted of fresh to moderately weathered, hard volcanic rocks (48 percent), fresh, hard tuff (28 percent), fresh, hard sandstone (13 percent), fresh, hard siltstone (9 percent), and fresh, hard arkose (2 percent). The sample has a petrographic number of 116.

Both grain-size and petrographic data indicate this deposit is suitable for quarry exploration. However, its small size and distance from a road will reduce its potential to be developed for commercial use.

10. Great Pinchgut

Three deposits were sampled in Great Pinchgut, on the east side of Placentia Bay in NTS map area 1N/12 (Figures 3 and 5). These deposits are 1200 to 20 000 m^2 and contain over 150 000 m^3 of sand and gravel. The nearest road is 3.2 km to the north, at Little Harbour East. Grain-size analyses of four samples, collected from shoreline exposure (Plate 5) ranging from 3 to 9 m high, indicate it contains 60.5 percent gravel, 39.3 percent sand and 0.2 percent silt–clay (Table 3). Petrographic analyses of 4 samples show an average of fresh to slightly weathered siltstone (60 percent), fresh to moderately weathered sandstone (28 percent), and fresh, hard volcanic pebbles (12 percent). Petrographic numbers of four samples are 116, 122, 136, and 164.

The Great Pinchgut deposits have a large volume of material, good grain-size quality, and good to fair petrographic quality. However, the distance from a road reduces its potential for quarry development.

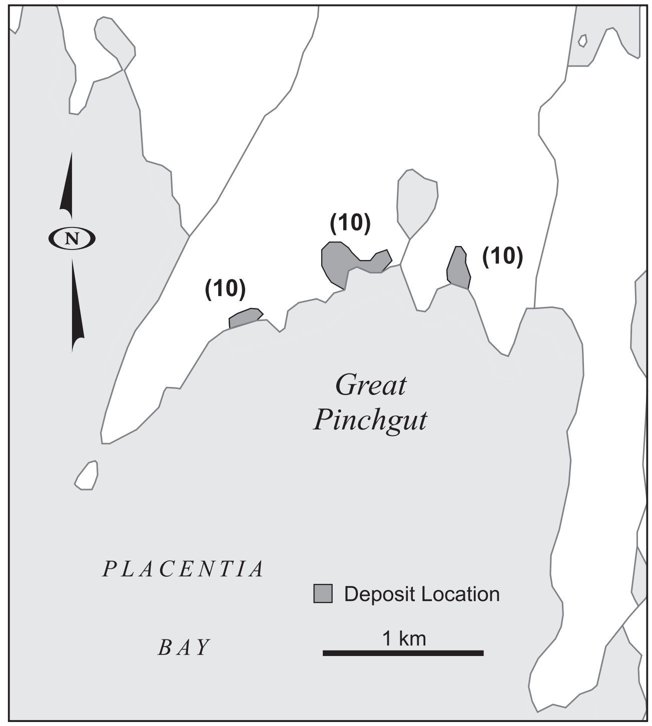

Figure 5. Deposit locations at Great Pinchgut.

Plate 5. *Gravel along 8-m-high shoreline exposure in deposit 10 at Great Pinchgut.*

11. Little Harbour East

The Little Harbour East deposit is located 1.2 km northeast of Little Harbour East on the west side of Placentia Bay (Figures 3 and 6). It is more than 20 000 m^2 and contains an estimated 100 000 m^3 of sand and gravel. Gravel samples were taken from 2.5-m- and 10-m-high shoreline exposures (Plate 6). On the northeast side of the deposit 2–6 m of exposed bedrock is overlain by 2–3 m of till which is overlain by 2.5 m of gravel. Till and bedrock were not exposed below a 10-m-gravel exposure on the south side of the deposit. Grain-size analyses of two samples indicate it contains 62.1 percent gravel, 37.6 percent sand and 0.3 percent silt–clay (Table 3). Petrographic analyses of two samples collected indicate this deposit contains fresh hard sandstone (54 percent), fresh to moderately weathered siltstone (45 percent), and granite (1 percent). Petrographic numbers of 161 were calculated for each of these two samples.

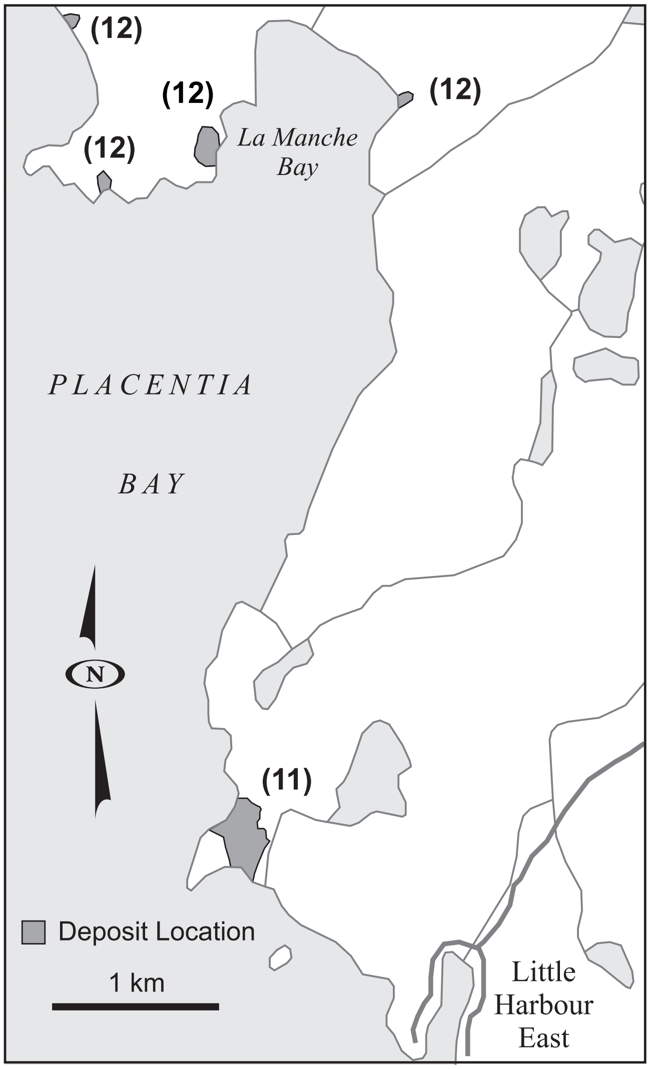

Figure 6. *Deposit locations near Little Harbour East and La Manche Bay.*

Plate 6. *Gravel along 10-m-high shoreline exposure in deposit 11 at Little Harbour East.*

Plate 7. *Pebble-sand along 6-m-high shoreline exposure in deposit 12 near La Manche.*

The large size of this deposit, good grain-size quality, and fair petrographic results may give this deposit potential for quarry development. It is uncertain if road access will be a problem or if it is feasible to construct a road to this deposit.

12. La Manche

Four deposits are located in the La Manche Bay and La Manche Head area. These deposits are 2400 to 6000 m^2 and contain 10 000 m^3 of sand and gravel (Figures 3 and 6). Samples were collected along shoreline exposures (Plate 7) at three of these deposits. One of these deposits is located near the end of a 1.7-m-long abandoned road leading to the abandoned mine site at La Manche. The other deposits are between 2.6 to 3.3 km from a road. Grain-size analyses of 2 samples, collected from a 2–5-m-high shoreline exposure, indicate it contains 63.9 percent gravel, 35.8 percent sand and 0.3 percent silt–clay (Table 3). Petrographic analyses of these samples consist of fresh to moderately weathered sandstone (48.2 percent), fresh to moderately weathered siltstone (48.1 percent) and fresh hard volcanic rocks (3.7 percent). Petrographic numbers of three samples are 148, 173, and 174.

Small size, and distance from a transportation network make these deposits unsuitable for quarry development.

13. Southern Harbour

The town of Southern Harbour is built on a large gravel terrace covering 270 000 m^2 (Figures 3 and 7). This deposit was not investigated during the 2009 field season. Data used to determine aggregate potential are based on

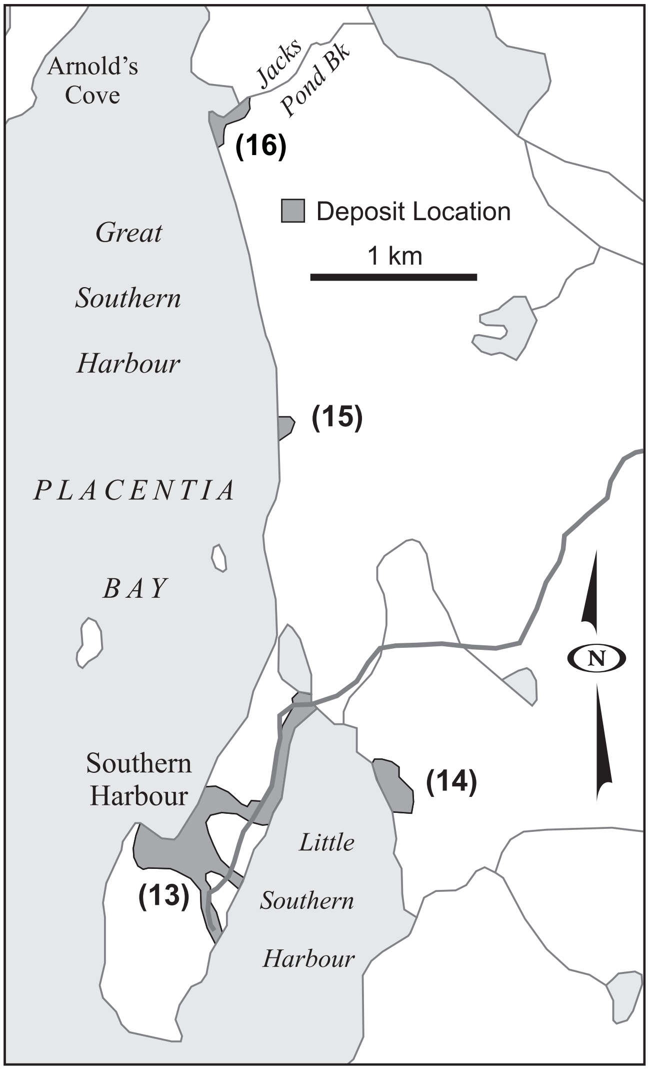

Figure 7. *Deposit locations near Little Southern Harbour, Southern Harbour, Great Southern Harbour and Jack's Pond Brook.*

sample and site data collected from previous aggregate-resource programs (Environmental Geology Section, 1983a, b). Shoreline exposures indicate this deposit is 1–2 m thick in the northeast, 8–10 m thick in the northwest, and tapers out to rock outcrop in most parts of the southwest. Grain-size analyses of one sample, collected from a 1.2-m-high road-side exposure, indicate it contains 64.4 percent gravel, 35.2 percent sand and 0.4 percent silt–clay (Table 3). Petrographic quality consisted of fresh to moderately weathered siltstone (66 percent), fresh to moderately weathered sandstone (15 percent), fresh to slightly weathered granite (12 percent), and volcanic rocks (7 percent). The sample has a petrographic number of 264.

Grain-size data indicate this deposit is suitable for coarse-quality materials. However, petrographic analyses indicate the material is poor for most aggregate uses, and residential development reduces potential for new quarry developments.

14. Little Southern Harbour

The Little Southern Harbour deposit is located on the east side of Little Southern Harbour in Placentia Bay, 450 m south of the Southern Harbour access road (Figures 3 and 7). This deposit is 2000 m^2 and contains 4000 m^3 of sand and gravel. Grain-size analyses of one sample, collected from a 2-m-high shoreline exposure, indicate it contains 48.7 percent gravel, 51.3 percent sand and no silt–clay (Table 3). Petrographic quality of this deposit is determined from fresh to slightly weathered sandstone (49 percent), fresh to slightly weathered siltstone (39 percent), fresh volcanic rocks (6 percent), granite (3 percent) and conglomerate (3 percent). The sample has a petrographic number of 139.

Although grain-size and petrographic data are adequate for this deposit, its small size makes it unsuitable for multi-year quarry development.

15. Great Southern Harbour

The Great Southern Harbour (Figures 3 and 7) deposit is located 1.4 km north of the Southern Harbour access road from the TCH. This deposit is about 5000 m^2 and contains 50 000 m^3 of sand and gravel. Grain-size analyses of one sample, collected from a 10-m-high shoreline exposure (Plate 8), indicate it contains 72 percent gravel, 27.9 percent sand and 0.1 percent silt–clay (Table 3). Petrographic analyses on one sample indicate this deposit contains fresh to moderately weathered sandstone (47 percent), fresh to slightly weathered siltstone (45 percent) and fresh, hard granite (8 percent). The sample has a petrographic number of 189.

Plate 8. *Gravel along 10-m-high shoreline exposure in deposit 15 at Great Southern Harbour.*

The size of this deposit and grain-size characteristics may make it suitable for quarry development. However, petrographic quality is less than ideal, and cost construction for road access will have to be considered.

16. Jack's Pond Brook

The Jack's Pond Brook deposit is located in Jack's Pond Provincial Park at the mouth of Jack's Pond Brook where it enters into Great Southern Harbour in Placentia Bay (Figures 3 and 7). This deposit is 6500 m^2 and contains 40 000 m^3 of sand and gravel. Grain-size analyses of four samples, collected from 5- to 7-m-high shoreline exposures, indicate it contains 58.3 percent gravel, 41.5 percent sand and 0.2 percent silt–clay (Table 3). Petrographic analyses of four samples indicate this deposit contains sandstone (47 percent), volcanic rocks (32 percent), siltstone (13 percent), granite (4 percent), gabbro (3 percent), and diorite (1 percent). Petrographic numbers of four samples are 120, 200, 224 and 280.

Grain-size data, size of deposit and road access are favourable for exploitation of this deposit. However, its location within a provincial park, makes it unsuitable for quarry development.

17. St. Jones Harbour

St. Jones Harbour is located in an area of rugged terrain in the northeast end of NTS map area 1N/13, 7 km south of Hodge's Cove on the west side of Trinity Bay (Figures 3 and 8). It is in a steep-sided narrow valley where the upper surface is 100 to 150 m high with peaks reaching 250 m high. The harbour is over 9 m deep along most of its 5 km length. The St. Jones Harbour deposit is 30 000 m^2 and contains approximately 30 000 m^3 of material above the water table. Samples were taken from a 1-m-high stream-cut exposure. It consists of a 1-m-thick boulder gravel unit consisting of 78.1 percent gravel, 21.6 percent sand and 0.3 percent silt–clay (Table 3), over gravelly sand with 10 percent silt–clay. Pebbles consisted of fresh to moderately weathered sandstone (73 percent), fresh to moderately weathered siltstone (16 percent), fresh, unweathered granite (6 percent), quartz (2 percent), fresh, unweathered volcanic rocks (2 percent) and fresh, unweathered diorite (1 percent). The sample has a petrographic number of 168.

The long distance from roads, high boulder content and the shallow thickness of the deposit make this deposit unsuitable for quarry development.

18. Deer Harbour

The Deer Harbour deposit is located north of the Isthmus of the Avalon Peninsula on the west side of Trinity Bay

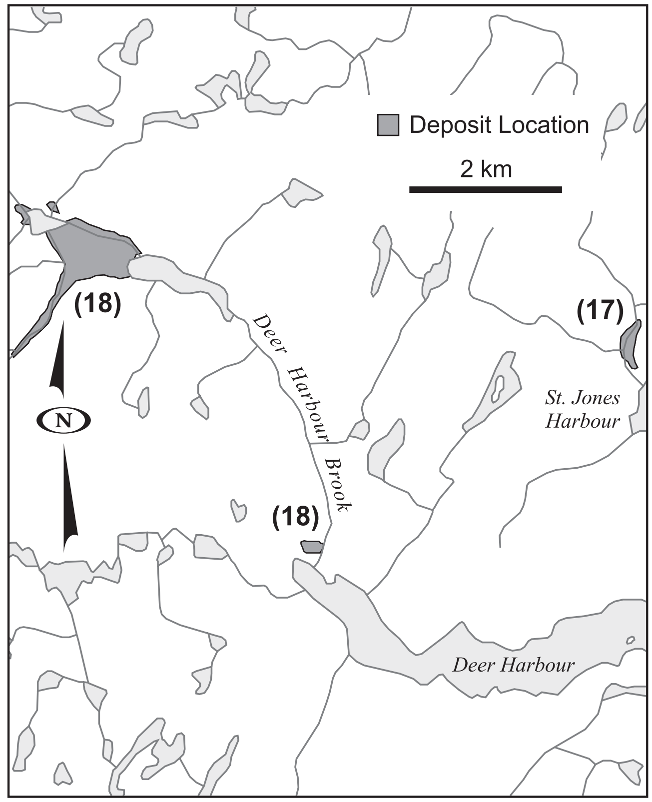

Figure 8. *Deposit locations near St. Jones Harbour and Deer Harbour.*

(Figures 3 and 8). Deer Harbour is over 300 m wide and 10 m deep for most of its 7 km length. There are two deposits located in this area. One deposit is located at the sheltered head of Deer Harbour near the mouth of a river flowing into Deer Harbour. This deposit is the largest investigated in the NTS 1N/12 and 13 map areas, covering approximately 17 000 m^2 and contains 150 000 m^3 of sand and gravel. Grain-size analyses of one sample, collected from a 1-m-deep hand-dug pit at the side of a terrace, indicate it contains 54.8 percent gravel, 45 percent sand and 0.2 percent silt–clay (Table 3). Pebbles of one sample collected from the Deer Harbour deposit near the mouth of the Deer Harbour River consisted of fresh to moderately weathered sandstone (61 percent), fresh, unweathered siltstone (24 percent), fresh, unweathered granite (11 percent) and slightly weathered volcanic rocks (4 percent). The sample has a petrographic number of 151. The second deposit, identified on aerial photographs, appears to be a large outwash deposit located 4.5 km to the northwest along the river flowing into Deer Harbour. This deposit has an aerial extent of more than 500 000 km^2 area. This deposit was not investigated during the field program, but it is located along the same river system as the Deer Harbour deposit and therefore, may have similar grain-size and petrographic characteristics.

The long distance from roads makes it uneconomically to open up this deposit for trucking aggregate to market areas. However, if reserves are proven large enough and because it is close to a sheltered deep harbour, barging of materials could be considered.

19. Rantem Cove

The Rantem Cove deposit is located 600 m southeast of Western Head (Figures 3 and 9). The nearest roads are 1.6 km east over rugged terrain, at Rantem Cove, and 1.9 km south at Chance Cove. The deposit is 1500 m^2 area and contains 6000 m^3 of sand and gravel. One sample was collected from a 4-m-high shoreline exposure, approximately 30 m long with rock outcrop at both ends. The top 1 m of this deposit consists of oxidized angular pebble gravel. Grain-size analyses indicate it contains 48.6 percent gravel, 51.1 percent sand and 0.3 percent silt–clay (Table 3). Petrographic analyses indicate this deposit contains fresh to intensely weathered sandstone (69 percent), fresh to intensely weathered siltstone (24 percent) and shale (7 percent). The sample has a petrographic number of 251.

Small size and road access make this deposit unsuitable for quarry development.

20. Chance Cove

The Chance Cove deposit is located in southeast end of the community (Figures 3 and 9). This deposit is 7500 m^2 and contains 30 000 m^3 of sand and gravel. Grain-size analyses of two samples, collected from a 1-m-high shoreline exposure and an 8-m-high abandoned quarry exposure, indicate it contains 43.8 percent gravel, 55.8 percent sand and 0.4 percent silt–clay (Table 3). Petrographic analyses indicate this deposit contains volcanic rocks (86 percent), siltstone (10 percent) and conglomerate (4 percent). The sample has a petrographic number of 139.

Proximity to a roads and acceptable grain-size and petrographic quality make this deposit suitable for quarry development. However, its location within the community will likely hamper development.

21. Bellevue

The Bellevue deposit is located on the north side of the community of Bellevue in Trinity Bay (Figures 3 and 10). It is 5000 m^2 and contains 15 000 m^3 of sand and gravel. One sample was collected in this area, from a 1- to 3-m-high shoreline exposures, consisting of boulder gravel. Grain-size analyses of sample material indicate it contains 75.9 percent gravel, 24.0 percent sand and 0.1 percent silt-clay (Table 3). Petrographic analyses indicate this deposit consists of fresh to moderately weathered sandstone (76 percent), fresh to highly weathered siltstone (20 percent) and volcanic rocks (4 percent). Petrographic numbers of these two samples are 292 and 297.

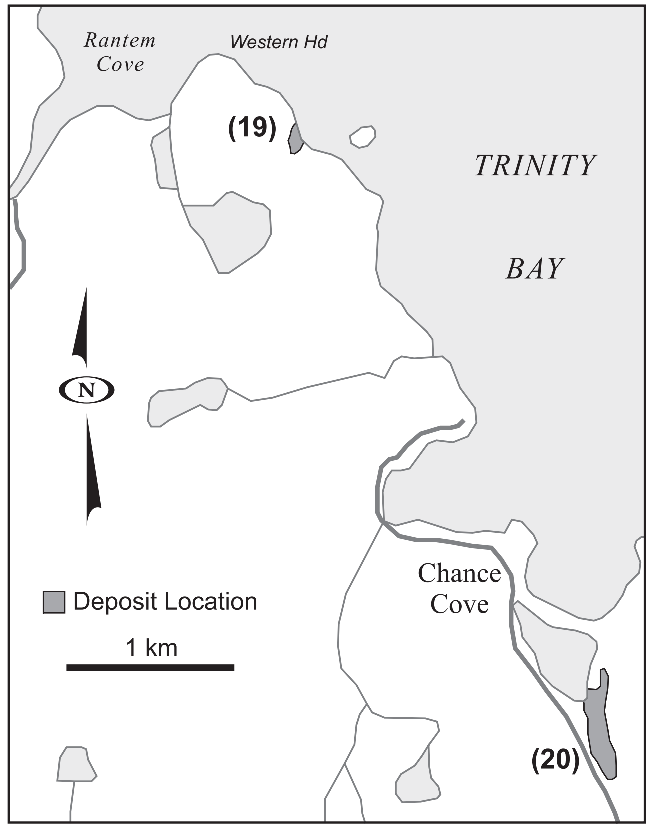

Figure 9. *Deposit locations near Rantem Cove and Chance Cove.*

Coarse texture, petrographic quality, generally shallow thickness, and residential development make this deposit unsuitable for quarry development.

22. Thornlea

The Thornlea deposit is located 500 m west of Route 201 and 1.3 km southwest of the community of Thornlea (Figures 3 and 10). The deposit consists of hummocky gravel intermixed with bog and rock outcrop over 30 000 m^2. It contains approximately 50 000 m^3 of sand and gravel. Grain-size analyses of two samples, collected from 1.2- and 1.3-m-deep hand-dug pits (Plate 9), indicate it contains 29.1 percent gravel, 67.4 percent sand and 3.5 percent silt–clay (Table 3). Petrographic quality based on analyses of two samples indicate this deposit contains fresh to moderately weathered sandstone (74 percent), fresh to moderately weathered siltstone (22 percent) and conglomerate (4 percent). Petrographic numbers of these two samples are 119 and 167.

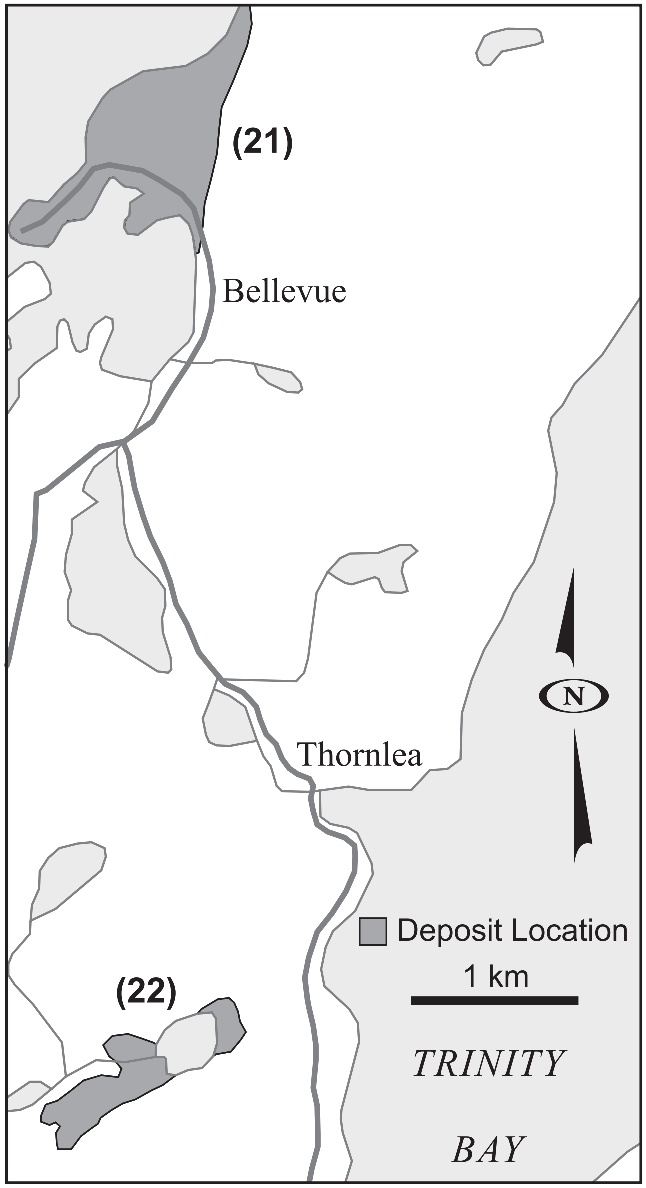

Figure 10. *Deposit locations near Bellevue and Thornlea.*

Plate 9. *Stratified sand and pebble gravel in 1.3-m-deep hand-dug pit in deposit 22 near Thornlea.*

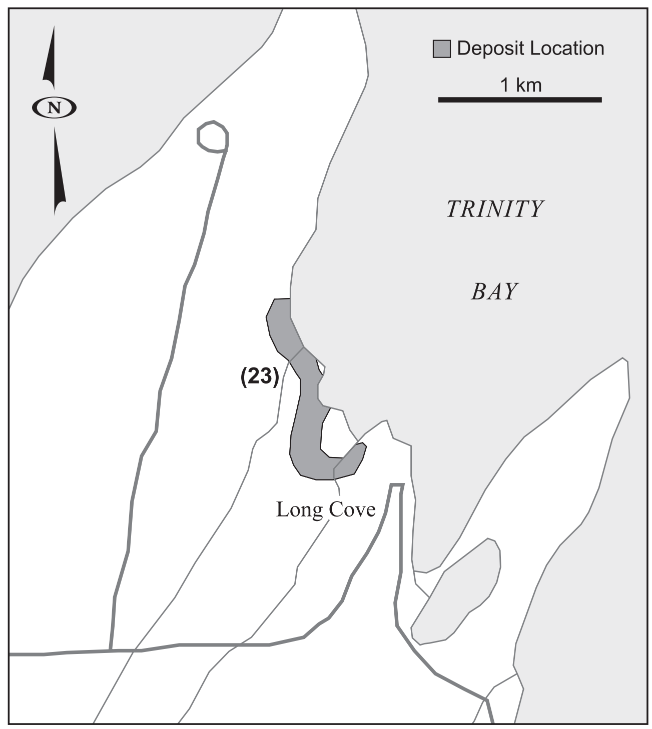

Figure 11. *Deposit location near Long Cove.*

Good grain-size quality and good to fair petrographic quality indicate this deposit has suitable quarry materials. However, the presence of sporadic bedrock in the deposit area and bog around the deposit will reduce the potential for quarry development.

23. Long Cove

The Long Cove deposit is located near the north end of Long Cove, approximately 300 m from Route 201 (Figures 3 and 11). This shoreline deposit is 20 000 m^2 and contains 30 000 m^3 of sand and gravel. Shoreline exposures vary from 1 to 4 m high. Bedrock outcrop and till are also exposed along the shoreline. Textures of samples from this deposit vary from sandy–pebble gravel to sandy–cobble gravel and gravel with low boulder content. Grain-size analyses of four samples indicate it contains 55.3 percent gravel, 43.0 percent sand and 1.7 percent silt–clay (Table 3).Petrographic analyses of four samples contains fresh to moderately weathered sandstone (46 percent), fresh to moderately weathered siltstone (34 percent), fresh to intensely weathered volcanic rocks (10 percent), fresh, hard arkose (6 percent) quartz pebbles (3 percent) and conglomerate (1 percent). Petrographic numbers of four samples were 148, 159, 178 and 187.

Low boulder content, high sand content, and proximity to a road make this deposit suitable for quarry development. However, the deposit is only 1 m thick over most of the area, and rock outcrop and till exposures within the deposit indicate there is a need for more detailed work to more accurately outline this deposit and determine its potential for quarry development.

24. Dildo

The Dildo deposit is located along an abandoned road between Dildo and New Harbour (Figures 3 and 12). The shoreline deposit is 18 000 m^2 and contains 20 000 m^3 of sand and gravel. Grain-size analyses of one sample, collected from a 1–2-m-high shoreline exposure, indicate it contains 53.6 percent gravel, 45.9 percent sand and 0.5 percent silt–clay (Table 3). Petrographic analyses of one sample collected in this area consist of fresh to moderately weathered sandstone (51 percent), and fresh to slightly weathered siltstone (49 percent). The sample has a petrographic number of 125.

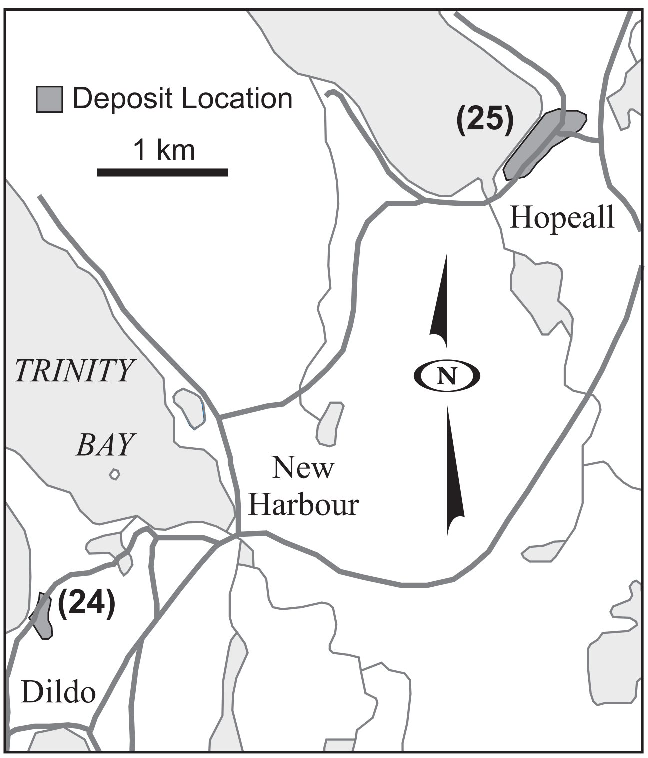

Figure 12. *Deposit locations near Dildo and Hopeall.*

Low silt-clay content, good petrographic quality and proximity to a transportation road network make this deposit an excellent source for high-quality aggregate material. However, its small size is unsuitable for a multi-year quarry operation.

25. Hopeall

The Hopeall deposit is located in the community of Hopeall on the east side of Trinity Bay (Figures 3 and 12). This deposit is 70 000 m^2 and contains 100 000 m^3 of sand and gravel. Boulder gravel and till exposures were noted within this area. Grain-size analyses of two samples, collected from a 2-m quarry exposure and a 3-m roadside exposure, indicate it contains 68.4 percent gravel, 30.3 percent sand and 1.3 percent silt–clay (Table 3). Petrographic analyses of two samples collected in this area have fresh, hard siltstone (57 percent) and fresh to slightly weathered sandstone (43 percent). Petrographic numbers of two samples are 111 and 122.

Low silt-clay content, good petrographic quality and proximity to roads make this deposit an excellent source for high-quality aggregate material. However, till exposures, high boulder content and residential development reduce its potential for quarry development.

SUMMARY

Deposits sampled vary from very gravelly sand to very sandy gravel and boulder–sandy gravel, and range in quantity from 3000 m^3 to 2 000 000 m^3. In NTS map area 1M/1 there are several areas where large deposits of sand and gravel were located. The largest is at Point Verde, which has been quarried for several decades. Other deposits are in the form of long narrow ridges or gravel hummocks. In some of these, the ridges and hummocks have wide gaps between them, which makes it more difficult to set up a quarry operation, and the distance of these deposits from a road will increase cost of operation. The deposit with the greatest potential for new quarry development in this area is located east of Patrick's Cove. It is less than 1 km from the road, has good petrographic and grain-size quality and is large enough to support a multi-year quarry operation.

Sand and gravel aggregate was identified at many shoreline locations throughout NTS map areas 1N/12 and 13. Most of these deposits are small and are not suitable for commercial quarry activity. Deposits at Great Pinchgut, Little Harbour East and Deer Harbour have sufficient quantities of material to support quarry operations, but the distance of these sites from roads make them unsuitable for development. There is a large deposit at Hopeall but variable grain size, high coarse gravel content and residential zones in the area make it unsuitable for a quarry operation.

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REFERENCES

Batterson, M.J., Taylor, D. and Catto, N.R.
2003a: Landforms and surficial geology of the Dildo map sheet (NTS 01N/12). Newfoundland Department of Mines and Energy, Geological Survey, Map 2003-14, Open File 001N/13/0727.

2003b: Landforms and surficial geology of the Sunnyside map sheet (NTS 01N/13). Newfoundland Department of Mines and Energy, Geological Survey, Map 2003-15, Open File 001N/13/0728.

Bragg, D.J.
1995: Petrographic examination of construction aggregate. *In* Current Research. Newfoundland Department of Mines and Energy, Geological Survey, Report 95-1, pages 77-89.

1994a: Site location map with rock types and petrographic numbers for the Ship Cove map area. Scale 1:50 000. Newfoundland Department of Mines and Energy, Geological Survey Branch, Map 94-128.

1994b: Site location map with rock types and petrographic numbers for the Dildo map area. Scale 1:50 000. Newfoundland Department of Mines and Energy, Geological Survey Branch, Map 94-143.

1994c: Site location map with rock types and petrographic numbers for the Sunnyside map area. Scale 1:50 000. Newfoundland Department of Mines and Energy, Geological Survey Branch, Map 94-144.

1985: (map 1N); Geotechnical bedrock compilation maps of Newfoundland. Scale 1:250,000 (supplemental Report 83-2). Newfoundland Department of Mines and Energy, Mineral Development Division, Open File Nfld (1485).

Canadian Standards Association
1973: CSA standard A23.2.30, Rexdale, Ontario, pages 207-209.

Carter, M.
1983: Geotechnical Engineering Handbook. University of Wales Institute of Science and Technology. Pentech Press, London and Plymouth.

Carter, P.D.
1981: The Economics of Mineral Aggregate Production and Consumption in Newfoundland and Labrador. Newfoundland Department of Mines and Energy, St. John's, Newfoundland.

Catto, N.R.
1998a: The pattern of glaciation on the Avalon Peninsula of Newfoundland. Geographie physique et Quaternaire, Volume 52, No 1, pages 23-45.

1998b: Landforms and surficial geology of the Ship Cove map sheet (NTS 1M/01). Newfoundland Department of Mines and Energy, Geological Survey, Map 98-62, Open File 001M/01/0384.

Department of Transportation
1999: Specifications Book (third edition). Government of Newfoundland and Labrador, Department of Works, Services, and Transportation, Highway Design Division, St. John's.

Environmental Geological Section
1983a: Site data and 1:50,000 scale maps. Field maps for all surficial and glacial mapping and aggregate resource mapping projects. Newfoundland Department of Mines and Energy, Mineral Development Division, Open file NFLD (1267).

1983b: 1:50,000 scale aggregate resource maps outlining zones of aggregate potential within a 6-km-wide corridor in Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, Open File NFLD/1300, Map 82-080.

1983c: 1:50,000 scale aggregate resource maps outlining zones of aggregate potential within a 6-km-wide corridor in Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, Open File NFLD/1300, Map 82-101.

1983d: 1:50,000 scale aggregate resource maps outlining zones of aggregate potential within a 6-km-wide corridor in Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, Open File NFLD/1300, Map 82-102.

Henderson, E.P.
1972: Surfical geology of the Avalon Peninsula, Newfoundland. Geological Survey of Canada, Memoir 368.

Kirby, F.T., Ricketts, R.J. and Vanderveer, D.G.
1983: Inventory of aggregate resources of Newfoundland and Labrador. Newfoundland Department of

Mines and Energy, Mineral Development Division, Report 83-2, 36 pages.

Liverman, D. and Taylor, D.
1989: Surfical geology map of the St. John's map area, scale 1:250,000. Newfoundland Department of Mines and Energy, Geological Survey. Open File NFLD/1907, map 89-154.

1994: Surficial geology map of the St. John=s (1N) and Trepassy (1K) map areas (digital), 1:250,000 scale. Newfoundland Department of Mines and Energy, Geological Survey. Open File NFLD/2422, map 94-230.

McKillop, J.H.
1955: Beaches in eastern Newfoundland. Preliminary report. Geological Survey of Newfoundland, Open File NFLD 87, 116 pages.

Ontario Ministry of Transportation
1994: Procedures for petrographic analysis of coarse aggregate. Ministry of Transportation, Ontario, Laboratory Testing Manual, Volume 2, LS-609, 18 pages.

Ricketts, M.J.
1987: Coastal Labrador aggregate resources. Newfoundland Department of Mines and Energy, Mineral Development division, St. John's, Mineral Resource Report 5, 50 pages.

Ricketts, M.J. and Vatcher, S.V.
1996: Granular aggregate-resource mapping in the Roddickton-Main Brook area, Great Northern Peninsula, Newfoundland. *In* Current Research. Newfoundland Department of Natural Resources, Geological Survey, Report 96-1, pages 41-53.

Rutka, A
1976: Economic use of mineral aggregate in road construction (Draft Report). Ontario Ministry of Transportation and Communications. Prepared for Presentation to the Mineral Aggregate Working Party, March 17, 1976.

Smith, M.R and Collis, L.
1993: Aggregates: Sand, gravel and crushed rock aggregate for construction purposes (2nd edition). Published by the Geological Society of London, Geological Society Engineering Geology Special Publication No 9, 339 pages.

Summers, W.F.
1949: Physical geography of the Avalon Peninsula of Newfoundland. M.Sc. thesis, McGill University, Montreal, Québec.

Vanderveer, D.G.
1982: Municipal planning and aggregate resources-a brief synopsis. Newfoundland Department of Mines and Energy, Mineral Development Division, Unpublished report, 2 pages.