SUNSHINE COAST AGGREGATE POTENTIAL MAPPING PROJECT
(BCGS Open File 2002-14)

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INTRODUCTION

As the market for natural and crushed stone aggregate in British Columbia continues to grow and existing reserves are consumed, the importance of aggregate exploration, land-use planning and resource inventory escalates. At present, much of the demand for aggregate in southwestern British Columbia is satisfied by operations located along the Sunshine Coast. Though there are a few aggregate studies available that cover parts of this region (i.e. Leaming 1968; McCammon 1975,1977; Buchanan and Bergman 1993; Lukawesky 1999; Savinkoff 2001), the reports are either outdated or are too general to meet the needs of land use planners, industry and broad governmental interests. In response to this, the Geological Survey Branch of the Ministry of Energy and Mines has undertaken an aggregate potential mapping project in the region. The project's goals follow those of earlier studies conducted by the Branch such as the Prince George (Bobrowsky *et al.*, 1996a), Okanagan (Bobrowsky *et al.*, 1998), Nanaimo (Massey *et al.*, 1998), Sea-to-Sky (Dixon-Warren *et al.*, 2000; Hickin *et al.*, 2001a) and North Coast (Hickin *et al*. 2001b) projects (Fig. 1).

As in the aforementioned projects, the Corporate Resource Inventory Initiative (CRII) provided the primary funding for the delivery of the project, while collaboration between British Columbia Assets and Lands Corporation (BCAL), Ministry of Transportation (MOT), and the Land Use Coordination Office (LUCO) of the Ministry of Sustainable Resource Management (MSRM) formed the basis of the logistical support. For further background information about the project an a general overview of the Quaternary history, the reader is referred to Bichler *et al*. (2002).

This report is meant to accompany the digital data for the Sunshine Coast Aggregate Potential Mapping (SCAPM) Project. Herein, a description of mapping, fieldwork and polygon ranking procedures is given. Instructions for the use of the data are contained within the INSTRUCTIONS.pdf file, found on the CD-ROM.

OBJECTIVES

The objectives of the SCAPM Project were formulated in conjunction with all of the organizations involved while keeping the state of industry, regional planning, environment, and budget constraints in mind. Deemed necessary was the creation of thematic maps that would act as a first approximation of aggregate potential along coastal and heavily populated areas. The four primary objectives list as follows:

1. Compile existing and readily available geological and geotechnical information pertaining to the study area;
2. Examine and record characteristics of known and exploited aggregate deposits;
3. Generate a complete coverage of Level III aggregate potential maps for the study area at a scale of 1:50,000; and
4. Compile all data collected and generated into an interactive geographical information system (GIS) that will be released to government agencies, industry and to the general public.

AGGREGATE POTENTIAL MAPS

The primary objective of a resource potential map is to delineate areas that exhibit favorable characteristics for hosting the resource in question. Varying from project to project are the attributes and procedures used to assess the resource and to divide the study area accordingly. So that some minimum level of data-reliability is set, a regulatory body often suggests mapping standards.

In the case of aggregate potential mapping in British Columbia, there are five levels of mapping considered (Table 1) based on a system developed for the Alberta Geological Survey by Edwards (1996) and discussed in greater detail by Bobrowsky *et al*. (1996b) and Massey *et al.* (2002). Of the five, Level I mapping is the most detailed and reliable, as it is conducted at large scales and employs both qualitative and quantitative analytical measures. It is also clearly the most expensive. At the other end of the spectrum are Level V maps that are purely qualitative in nature and are mapped at small scales. Such maps are inexpensive to produce but, as a consequence, carry the least amount of reliability. During the preliminary stages of the project, it was decided that a Level III approach would best suit the region's needs.

STUDY AREA

The study area comprises approximately 310,000 hectares of land surface located along the Sunshine Coast, northwest of Vancouver, British Columbia (Fig. 1). It lies entirely within the Sunshine Coast Forest District and crosses the regional districts of Sunshine Coast, Powell River and Comox-Strathcona, as well as the Lower Mainland and Vancouver Island Land and Resource Management Plan (LRMP) regions. Major communities within the region are Gibsons, Sechelt and Powell River.

The study area is a three-kilometre wide zone extending landward from the coast, stretching from Gibsons to as far north as the head of Bute Inlet. Exceptions to this include the area between Malaspina Peninsula and Saltery Bay, where a 5-kilometre buffer is used, and the inclusion of Sechelt Peninsula and Gambier, Texada, Nelson, Read, Cortes and West Redonda islands, in their entirety. Excluded from the total area are ecological reserves, parks and other protected areas that are greater than 500 hectares. The study area covers portions of NTS map sheets 92F/8-10, 92F/15-16, 92G/5-6, 92G/11-13, 92J/4, 92K1-3 and 92K/6-9.

METHODOLOGY

The methodology employed during this project follows that used in previous aggregate potential studies undertaken by the Geological Survey Branch in other areas of the Province. This section will deal with specifics of the project that differ from earlier work and will address the attributes ranked on an individual basis. For a more general discussion, the reader is referred to Bichler et al. (2002).

Terrain Mapping and Surficial Geology Attributes

The primary units of the aggregate potential map are terrain polygons that were identified during terrain mapping. Mapping procedures follow the guidelines set by the

TABLE 1: SUMMARY OF AGGREGATE POTENTIAL MAPPING LEVELS

	I	II	III	IV	V
Mapping Scale	1:100 to 1:10,000	1:10,000 to 1:50,000	1:50,000 to 1:100,000	1:100,000 to 1:250,000	1:250,000 to 1:500,000
Surficial Geology Data	yes	yes	yes	yes	Yes
Field Verification of Mapping	yes	minimal	no	no	No
Airphoto Interpretation	new, detailed	new and pre-existing	as required	minimal	None
Drill Hole Data	yes	yes	yes	no	No
Use of Existing Geotechnical Data	yes	yes	minimal	no	No
Field Testing (i.e. Drilling, Trenching, Geophysics)	yes	minimal	no	no	No
Material Testing	yes	minimal	no	no	No
Literature Review	detailed studies included	detailed studies included	regional studies	basic to regional studies	minimal
Verification of Aggregate Pit Locations	yes	yes	yes	minimal	No
Geological Mapping of Aggregate Pits	yes	yes	yes	minimal	No
Product Reliability	very high	high	moderate	low	very low
Average Cost per Map Sheet	> $50,000	$20,000 to $50,000	$10,000 to $25,000	$5,000 to $15,000	$1,000 to $10,000
Suitability of Maps	site construction purposes	city planning to municipal planning	municipal to regional planning	broad regional planning	provincial planning

Resource Inventory Committee (1996) and Howes and Kenk (1997). Polygons were mapped on base maps, created from 1:20,000 scale Terrain Resource Information Management (TRIM) data, at a scale of 1:50,000 using black and white, vertical airphotos (1:35,000 and 1:40,000 scales). Once mapping was completed, the information was digitized using a method that combines traditional means with scan technology to provide a high quality digital product. J.M. Ryder and Associates Inc. conducted the terrain mapping while Latitude Geographics Group Ltd. performed the digitizing.

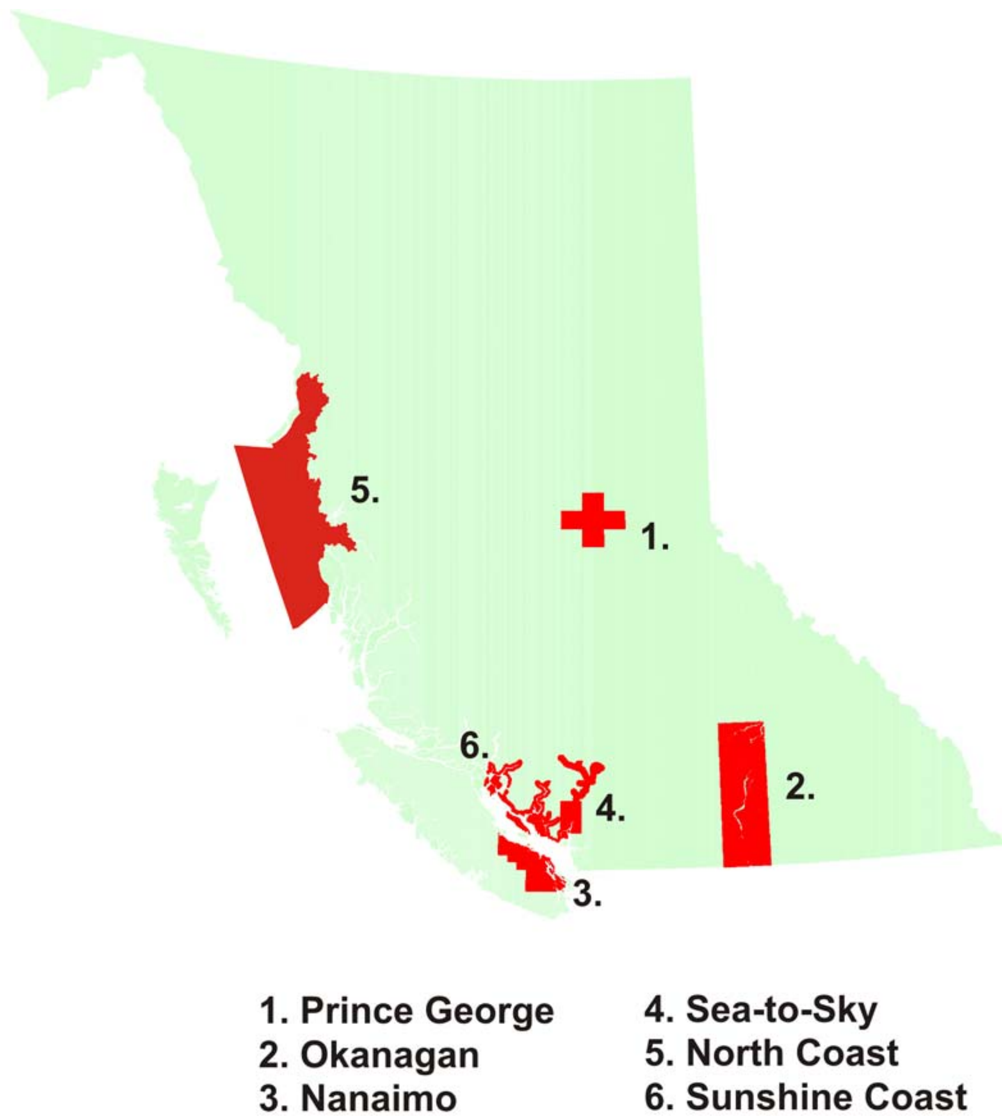

Figure 1: Locations of previous aggregate potential mapping projects conducted within British Columbia by the Geological Survey Branch. Projects are listed in the order in which they were completed.

The result is a detailed terrain map, within the study boundaries, that is divided based on surficial geology. Polygons delineate areas that have more or less homogenous characteristics. Each polygon is assigned a unique identifier and a symbol that summarizes its geological attributes, including: texture, surficial material, landform expression and stratification. For a detailed description of the mapping and coding system see Howes and Kenk (1997).

Before the ranking of these attributes can begin, the relative abundance of units found within complex terrain polygons must be determined. For this, a matrix was created (Fig. 2*a*) that analyzes the form of the terrain symbol and yields a coefficient that

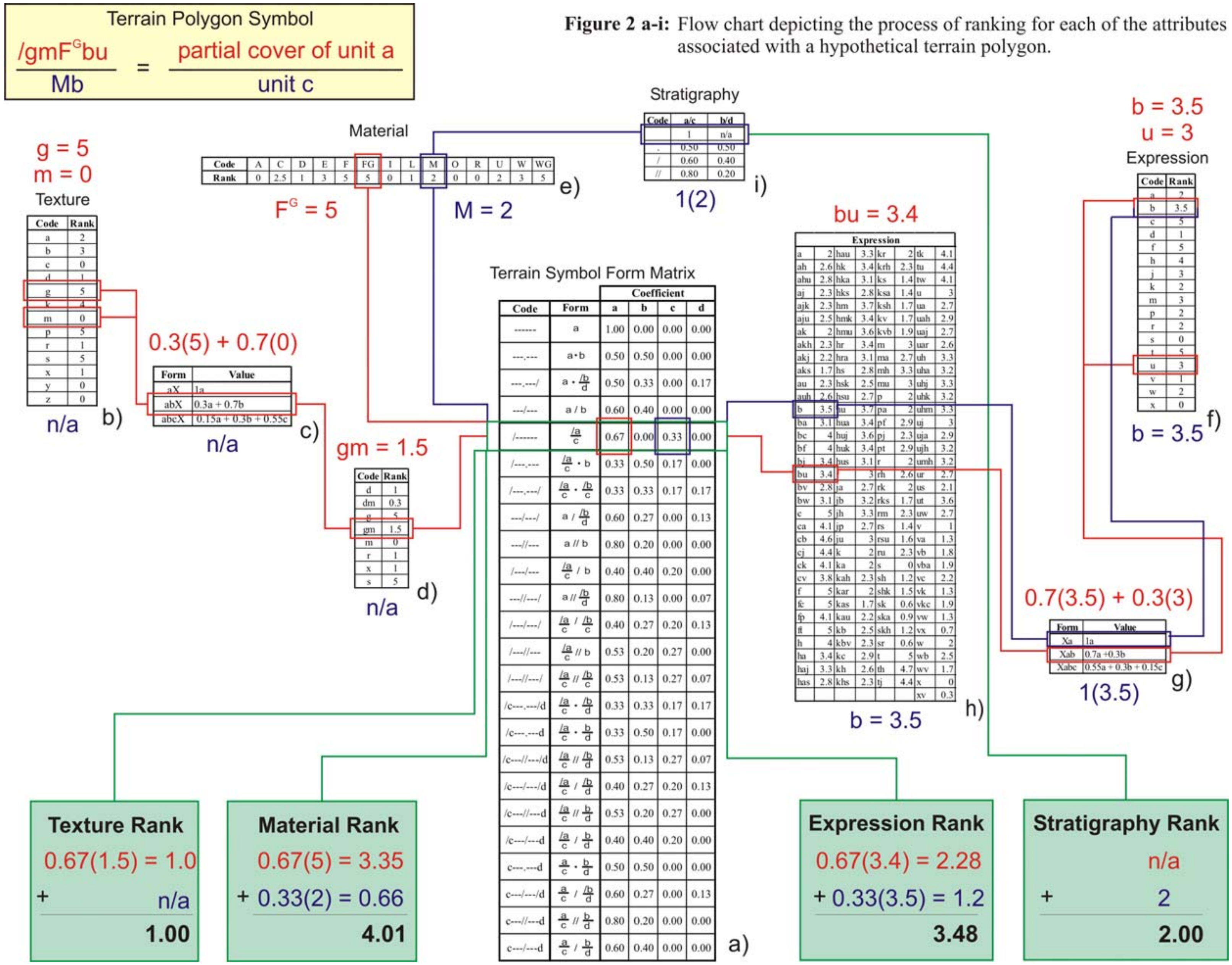

Figure 2 a-i: Flow chart depicting the process of ranking for each of the attributes associated with a hypothetical terrain polygon.

represents the relative abundance of the attribute within the polygon. The construct of the matrix is based on relationships described by Howes and Kenk (1997).

In the example (Fig. 2), a given terrain polygon consists of a partial cover of an undulating blanket of gravelly, muddy, glaciofluvial sediment that overlies a morainal blanket, the symbol form is (/a)/(c), where *a* represents attributes associated with the glaciofluvial unit and *c* the morainal unit. This yields a coefficient of 0.67 and 0.33 respectively (Fig. 2*a*) and means that 67 percent of the surface area is covered by a gravelly, muddy, glaciofluvial undulating blanket while the remaining 33 percent by a morainal blanket. The above example will be ranked for each of the attributes below.

Texture

Texture refers to the size, shape and sorting of clastic sediment of unconsolidated material. Textures are ranked on a scale of 0 to 5 (Fig. 2*b*) where the most desirable textures receive a value of 5 and least desirable a rank of 0. Textures of intermediate potential score in between. In the example given, only the glaciofluvial unit has been denoted with a texture description; gravel has a value of 5 and mud a value of 0. In such a case, a combined ranking is given using an appropriate formula for the number of textures reported (Fig. 2*c*). The outcome is a combined texture rank of 1.5. Figure 2*d* shows all of the texture rankings for the different combinations encountered in the terrain data. The last step is to apply the form coefficients and sum the unit texture rankings, thus the textural ranking for *unit a* is multiplied by 0.67 and added to the product of the textural ranking of *unit c* (in this case 0) and its coefficient (0.33). The end result is a polygon texture rank of 1.00.

Surficial Material

Surficial material is the type of unconsolidated sediment that can be found at surface and is classified by its genetic origin or, in other words, the process that deposited it. Figure 2*e* is a table of the classifications and their associated rank. Ranking is done on a scale of 1 to 5 where 5 is the most favorable for aggregate potential and 1 is the least favored. In the example, *unit a* is glaciofluvial (FG) and is considered very favorable and so recieves a rank of 5. *Unit c* is less favorable as it is moraine material and only receives a rank of 2. After applying the form coefficients from the matrix and adding them together, the polygon receives a rank of 4.01 for surficial material.

Surficial Expression

The ***expression*** attribute of the polygon describes the geometry of the deposit and may contain information about both its two-dimensional and three-dimensional distribution. It is ranked on a scale of 1 to 5 where 5 is the most favorable for aggregate potential and 1 is the least favored. Figure 2*f* shows how each of the individual expression terms are ranked. Like texture, a combination of expressions can be used to describe a single unit. In the example, *unit a* is denoted as having a blanket cover (3.5) as well as an undulating cover (3) while *unit c* is only a blanket cover (3.5). By using the appropriate formula in Figure 2*g*, the combined rank for *unit a* and *c* are 3.4 and 3.5 respectively. After applying the form matrix and adding the sums, an expression rank of 3.48 is generated for the entire polygon.

Stratigraphy

The stratigraphy ranking has been added to take into consideration the subsurface material. It uses the same initial ranking of materials that the surficial material ranking does but applies only a relation factor when a composite terrain symbol exists. In the example given, there is only one subsurface material present and so the relation factor is 1 (Fig. 2i) thus the stratigraphy rank is equal to the ranking of morainal material, 2. If no subsurface material is indicated, material immediately underlying the surface is assumed to be the same as the surficial material.

Area

The area ranking is based on percentiles of the areas of polygons present and is calculated from the surficial area of the digitized polygons using the ArcView software. It is meant to account for the fact that the larger the polygon size is, the more likely it is to find a "pocket" of sand and gravel. A scale from 1 to 5 is used where an increment of rank is equal to a change to the next 20th percentile. The largest 20 percent of the polygons receive a rank of 5 while the smallest 20 percent receive a rank of 1 (Table 2).

TABLE 2: SUMMARY OF AREA RANKING

Range	Rank
Area = 26 ha	1
26 ha > Area = 43 ha	2
43 ha > Area = 71 ha	3
71 ha > Area =129 ha	4
129 ha > Area	5

Water Well, ARIS Drill Logs and Geotechnical Borehole Data

Wherever available, data about the subsurface is collected from various organizations such as the MSRM, MEM, and MOT, as well as from private industry, including water well logs, logs of mineral exploration drill holes in Assessment Reports contained in the Assessment Report Indexing System (ARIS) and geotechnical boreholes. The amount of information that is applicable to aggregate potential varies from log to log but, for the information collected during this project, water well logs hold the most valuable information followed by geotechnical boreholes and ARIS drill logs.

Every drill hole in the study area was assessed in a qualitative manner, on an individual basis for the following: low aggregate potential material, high aggregate potential material and total unconsolidated material. In turn, these categories are subdivided into several attributes listed in subheadings below. Only some of these attributes have a direct bearing on aggregate potential and were ranked based on their thickness.

In order to obtain a ranking for a polygon, the thickness of attributes are first averaged for all holes found within a particular polygon. They are then ranked based on their relative thickness by dividing the average thickness by the maximum thickness in the study area and then multiplying by five. The product is then rounded to the next highest integer. This yields a scale of 1 to 5 where 1 and 5 represent the thinnest and thickest accumulations respectively.

Low Aggregate Potential Sediments

Sediments that are considered to be unlikely sources of good aggregate, as they will require extensive post-extraction treatment prior to commercial use, are classified into three categories according to their relative position to high aggregate potential sediments: overburden, interburden and non-burden. If the sediment is located above material that is considered to have a high aggregate potential, then the material is labeled ***overburden***; when sediment is found between two layers of high potential material it is classified as ***interburden***; and when it is found only beneath high potential material then it is non-burden. Only overburden and interburden are ranked, as non-burden has no bearing on aggregate potential in this exercise. Other classifications that do not appear in the ranking are bedrock and unknown (where no data is available).

High Aggregate Potential Sediments

High aggregate potential sediments are those that require the least amount of post-extraction treatment. They have been divided into three categories according to the log descriptions: quality A, B and C. ***Quality A*** sediments are generally clean, well sorted sands or gravels with minor amounts of other constituents. ***Quality B*** sediments contain more poorly sorted sediment but still contain no fine material such as silt and clay. Sediments that contain very minor silt and clay are classified as ***quality C***.

Unconsolidated Sediment Thickness

The total thickness of unconsolidated sediment is also ranked using the same procedure mentioned earlier. If a given drill hole intersects the bedrock-sediment interface then a ***maximum thickness*** of unconsolidated sediment overlying the bedrock is ranked. On the other hand, if the drill hole was of insufficient depth to penetrate bedrock, then a ***minimum thickness*** of unconsolidated sediment is ranked.

Stripping Ratio

Another attribute that is obtained from the drill hole logs is the ***stripping ratio***, which is the amount of overburden that must be removed divided by the amount of aggregate present. The idea behind this ratio is that if a source of aggregate lies underneath too thick of a cover of overburden then the cost of extraction outweighs the value of the aggregate. For the purpose of this study a cut-off value of one-third is used. This means that for every 3 metres of gravel there may be only 1 metre of overburden. If the stripping ratio is more than this, a rank of 0 is given for the stripping ratio ranking of the polygon. If it is equal to or less than this, then a rank of 5 is assigned.

Algorithm

Once all information was entered into databases and the relevant attributes ranked, an algorithm was developed that weighted each attribute according to its availability and importance to aggregate potential in the study area. The final algorithm is:

Polygon Rank = [5 x Material Rank] + [4 x Texture Rank] + [3 x Quality A Rank] + [2 x Quality B Rank] + [2 x Expression Rank] + [2 x Stratigraphy Rank] + [2 x Stripping Ratio Rank] + [Quality C Rank] + [Maximum Thickness Rank] + [Minimum Thickness Rank] + [Area Rank] - [Interburden Rank] - [3 x Overburden]

The algorithm resembles that used by Hickin *et al*. (2001) and diverges primarily as a result of differences in the ranking procedure. Once polygon ranks are obtained for all polygons, they are separated into three classifications: primary, secondary and tertiary aggregate potential.

A primary classification denotes areas that exhibit many characteristics favorable for hosting natural aggregate deposits and thus have the highest aggregate potential. Secondary polygons show some of these traits, but to a lesser extent than primary polygons, and so have only a modest aggregate potential. Polygons that display few or no characteristics that are favorable for aggregate deposits are classified as tertiary. Exceptions to this can be found in Table 3 where polygons that received a ranking that would normally put them into a classification inconsistent of their surficial geology, have been reassigned to a different classification. An example of this is polygon 1700 that is described as a colluvial veneer overlying a gravelly, glaciofluvial terrace. It received a total ranking that would place it into a secondary aggregate potential classification but it clearly should be primary.

Field Work

The fieldwork component of the study consists of on-site visits to all historic and active sand and gravel operations, as well as known rock quarries. At each location, data is collected concerning the location, size and deposit characteristics. A global positioning system (GPS) provides the means for an accurate location while a laser range finder allows for measurements to be made quickly and effectively.

Deposit characteristics are summarized on both qualitative and quantitative characteristics. Field observations are made on: grain size distribution; clast size range, angularity and lithology; sorting; stratification; structures; and stratigraphy. In addition, photographs are taken of the general site, the pit face and of the material being extracted. Upon returning from the field, all information collected is entered into databases, including photographs that are digitized, and later linked to the thematic atlas.

Pit Potential

The potential for further extraction from existing operations is qualitatively assessed and is called the ***pit potential***. It is based on the size and activity of aggregate operations present, a qualitative estimation of reserve life and the number of operations within the polygon. The pit potential is not part of the ranking procedure for aggregate potential and appears as a separate layer of high, moderate or low potential polygons.

TABLE 3: EXCEPTIONS TO THE ALGORITHM

Polygon Number	Generated Rank	Artificial Rank
1812	Tertiary	Secondary
2950	Tertiary	Secondary
3242	Tertiary	Secondary
290	Secondary	Tertiary
3016	Secondary	Tertiary
231	Secondary	Tertiary
2692	Secondary	Tertiary
1512	Secondary	Tertiary
1410	Secondary	Tertiary
1202	Secondary	Tertiary
1700	Secondary	Primary

Crushed Bedrock Potential

The potential for a source of crushed aggregate is assessed on the basis of bedrock types found within the study area and is termed the ***crushed bedrock potential***. Bedrock types were ranked on a scale of 1 to 4 based on their usefulness as a source of crushed aggregate following Bragg (1990) and Bragg *et al.* (1990) (Table 4). Regional geology maps, taken from Geological Survey Branch Open Files 1994-6 (Massey 1994) and 1994-17 (Bellefontaine and Alldrick 1994), were overlain with the study area and are included as a separate map layer with crushed bedrock potential polygons shown for the study area.

Thematic Atlas

The final stage of the project is the creation of the interactive thematic atlas. Built on ESRI's ArcView 3.2 platform, the thematic atlas is a collection of layered graphical data known as themes that are spatially referenced and linked to databases containing information collected throughout the course of the project. This data may be queried and displayed at the users will, using the standard tools found within ArcView. Complementing these utilities is a tool designed to allow the user to access reports and images associated with extraction sites, drill holes and polygons. It is called the LinkTool and has been built into the atlas using ArcView's programming language called Avenue. For more information, please refer to the INSTRUCTIONS.pdf file and the user manuals supplied with the program.

TABLE 4: SUMMARY OF BEDROCK TYPE RANKING

Map Code	Description	Rank
EKd	diorite; includes Goat Lake Pluton and West Redonda Diorite	4
EKgb	gabbro	4
EKgd	variably foliated granodiorite; includes Quatam, Sakinaw Lake, Malaspina and Quarry Bay Plutons	4
EKgn	granitoid gneiss	4
EKqd	foliated and chloritized hornblende-biotite quartz diorite, granodiorite and diorite; minor massive diorite and greenstone; includes Firvale and Atnarko Plutons	3
JI	granodiorite, quartz diorite, quartz monzonite, diorite, agmatite, feldspar porphyry, minor gabbro and aplite	4
JKd	variably foliated diorite (includes Pemberton Diorite) and dioritic complex, incorporating inclusions and screens of other rock types	4
JKgb	gabbro	4
JKgd	variably foliated granodiorite; lesser quartz diorite; includes Paradise River Pluton	4
JKqd	quartz diorite, variably foliated; lesser granodiorite; includes minor gneissic diorite and inclusions and screens of other rock types; includes Burnett Bay and Lillooet River Intrusion	4
JKqm	quartz monzonite, varably foliated; includes Paradise River Pluton	4
JKt	tonalite	4
Kg	hornblende-biotite granodiorite, quartz monzonite, tonalite, quartz porphyry, hornblende-feldspar porphyry	4
KTgd	equigranular granodiorite	4
KTqpm	porphyritic quartz monzonite	4
LJd	diorite; includes Malibu Diorite	4
LJgd	granodiorite	4
LJqd	quartz diorite; includes Cloudburst, Ashlu Creek and Ward Point Plutons	4
lKG	undifferentiated Gambier Group volcanic and sedimentary rocks include thick bedded basaltic andesite, dacitic and rhyolitic tuffs, flows and volcanic breccia, greenstone, pillowed basalt, argillite, greywacke, shale, siltstone, basal conglomerate with plutonic clasts and arkose; includes Monarch Volcanics, Fire Lake Volcanics and Goat Mountain, Britannia, Helm, Empetrum, Cheakamus, Brokenback Hill and Peninsula Formations	2
lmJBI	tuffaceous sandstone, tuffaceous siltstone, argillite, graphitic siltstone with minor interbedded carbonate, lapilli tuff, andesite flows and/or sills	2
MKgd	variably foliated granodiorite; lesser quartz diorite; includes Fish Egg, Smith Inlet, Belize Inlet, Draney Inlet, Sandell, McFee Bay, Rivers Inlet, Amback, Kwatna, Doos Creek, Kingcome, Namu, Big Julie, Castle Towers, Meslillooet, Pinecone, Vickers Creek Plutons, Princess Royal Reach Granodiorite, Howe Sound Pluton, Princesss Louisa Granodiorite, Thomas Lake, Mount Clarke and Mount Mason Plutons	3
MKqd	variably foliated quartz diorite; lesser granodiorite; includes Malaspina, Howe Sound, East Sechelt and Spuzzum Plutons	3
Mm	metamorphic rocks of uncertain protolith affinity; includes amphibolite, gneiss and migmatite	2
MPn	interbedded chert-argillite, sandstone-argillite rhythmites, crinoidal limestone	3
PMgn	predominantly felsic orthogneiss; granitoid gneiss, local agmatite, migmatite, amphibolite and schist	2
TrK	pillow basalt, volcanic breccia, greenstone, minor limestone	3
TrKQ	interleaved basalt, pillow basalt, greenstone and limestone	3
TrQ	massive light grey, fine to coarse grained bioclastic limestone, minor pillow lava	4
uKN	sandstone, mudstone, carbonaceous siltstone, conglomerate and coal	1
uKv	basaltic volcanic breccia with diorite fragments	3
uTrK	Basalt pillowed flows, pillow breccia, hyaloclastite tuff and breccia, massive amygdaloidal flows, minor tuffs, interflow sediment and limestone lenses (Carnian).	3
uTrq	thick bedded, grey to black, micritic and stylolitic limestone, medium to thin bedded limestone and calcareous siltstone, minor oolitic and bioclastic limestone, garnet-epidote-diopside skarn. (Carnian)	4

SUMMARY OF RESULTS

Terrain mapping resulted in the division of the study area into 3,305 polygons based on surficial geology (not including polygons designated as water). The maximum and minimum polygon sizes are 2,854 hectares and 1 hectare respectively, with a mean value of approximately 94 hectares. The sum total of polygons yields a study area of 309,523 hectares.

Information from 1,462 drill holes, within 153 polygons, was collected. They yield a total of 77,749 metres of drill data (Table 5). Of this, 5,585 metres are ranked as high potential aggregate material, 13,212 metres as low potential sediments and the remaining is either unclassified or bedrock.

Table 6 summarizes the aggregate potential classifications for all polygons. Approximately 7 percent of the total study area is ranked as having a primary aggregate potential, 6 percent secondary and 87 percent tertiary. Of this area, only 14 percent of those polygons classified as primary and 8 percent of the secondary polygons contain active or historic pits. This means that there is approximately 11,000 hectares of land lying in polygons that have high potential for hosting aggregate deposits and have yet to be exploited, as well as an additional 11,000 hectares under the secondary ranking (Table 6).

A total of 98 field sites in 63 polygons were visited: 83 sand and gravel operations and 15 rock quarries (Table 7). Approximately one-third of the stations were considered as being active operations while the rest were either inactive or have been reclaimed. Eight of the 63 polygons that contain pits are ranked as having a high pit potential, 12 are ranked as moderate and 43 have low pit potentials, where pits are found in either low quality sediments, have limited reserves or have been reclaimed.

TABLE 5: SUMMARY OF DRILL HOLE DATA

		Thickness (m)	
Overburden		6,624	13,212
Interburden		4,463	
Non-burden		2,125	
Aggregate Quality	**A**	332	5,585
	B	3,823	
	C	1,430	
Unknown			1,772
Bedrock			57,180
Total			**77,749**

TABLE 6: SUMMARY OF POLYGON AGGREGATE POTENTIAL

	Total Polygons				Non-exploited Polygons			
Polygon Classification	**Polygons**	**%**	**Hectares**	**%**	**Polygons**	**%**	**Hectares**	**%**
Primary	194	6	20,466	7	166	5	11,317	4
Secondary	171	5	20,428	6	157	5	11,168	4
Tertiary	2,940	89	268,628	87	2919	90	262,954	92
Total	**3,305**	**100**	**309,522**	**100**	**3242**	**100**	**285,439**	**100**

TABLE 7: SUMMARY OF FIELD STATIONS

Mine Type	Active	Inactive	Reclaimed		Total
Sand and Gravel Pit	28	36	19	9 Naturally Revegetated	**83**
				10 Re-developed	
Quarry	5	9	1	1 Re-developed	**15**
Total	**33**	**45**	**20**		**98**

Table 8 is a summary of the field stations and their corresponding polygon's aggregate potential classification. The majority of sand and gravel pits are found within polygons classified as primary or secondary (84%), whereas rock quarries are found primarily within polygons classified as tertiary (67%). Surficial geology shows a greater distribution, with pits distributed primarily amongst glaciofluvial, glaciomarine and marine terrain polygons (31%, 23%, and 23% respectively) (Table 9). As well, all but 11 of the natural aggregate pits are found below 200 metres elevation.

TABLE 8: SUMMARY OF PIT POLYGON RANKING

Polygon Classification	Sand and Gravel Pits	%	Quarries	%
Primary	51	61	3	20
Secondary	19	23	2	13
Tertiary	13	16	10	67
Total	**83**	**100**	**15**	**100**

TABLE 9: SUMMARY OF PIT SURFICIAL MATERIAL

Surface Materials	Sand and Gravel Pits	%	Quarries	%	Total Stations	%
Glaciofluvial	26	31	2	13	28	29
Fluvial	4	5	1	7	5	5
Glaciomarine	19	23	1	7	20	20
Marine	19	23	2	13	21	21
Till	12	14	5	33	17	17
Colluvium	3	4	1	7	4	4
Anthropogenic	0	0	3	20	3	3
Total	**83**	**100**	**15**	**100**	**98**	**100**

DISCUSSION

The locations showing the highest potential for hosting natural aggregate deposits along the Sunshine Coast are primarily controlled by events following the glacial maximum in the region, when glaciers began to rapidly recede. As a consequence of higher sea levels and melting ice during this period, where rivers drained into the oceans, large deltas formed on what are now hill slopes of coastal areas and are found up to an elevation of approximately 200 metres above the modern sea level. These glaciofluvial deltas and fans are the primary targets of most natural aggregate extraction sites in the study area, the largest example of this being the Sechelt Pit, owned by Construction Aggregates Limited. In addition, glaciomarine sediments can be found up to this elevation, composing much of the area between Gibsons and Sechelt and Langdale and Powell River. Normally marine and glaciomarine deposits are undesirable materials with respect to aggregate potential but, along the Sunshine Coast, many of the smaller sand and gravel pits are in pockets of natural aggregate that occur as small raised deltas associated with these larger areas of glaciomarine deposits. An additional source of sand and gravel related to glaciomarine environments are coarse beach deposits that can be found sporadically throughout the region. Other areas where glaciofluvial sediments occur are in valley bottoms where outwash sediments can be found along side modern fluvial deposits.

Colluvial deposits dominate areas of secondary importance for aggregate potential. Cones and fans consisting of re-mobilized material are common along the steep-sided fjords such as Toba, Jervis and Salmon Inlets. These deposits are generally much smaller than glaciofluvial deposits, more poorly sorted and have a higher fine fraction. For these reasons, colluvial deposits are not ideal targets for sand and gravel exploration but may serve as an important source of aggregate where no other option exists. Other secondary deposits are those that consist of glaciofluvial, fluvial, glaciomarine or marine sediments that either make up only a small portion of the polygon or have a high fine fraction. For more a more generalized discussion of the Quaternary sediments and history of the study area, refer to Bichler *et al.* (2002).

USE OF DATA

With the large scope of this study and the limited funding available, it is necessary to rely on information collected by other agencies for the completion of the project. The data presented herein and in the digital files has been collected from a large variety of sources and is subject to the reliability of the original authors. All data assembled has been handled as if it were of high integrity and so quality control is limited to reproduction of the original data, newly collected data and to the application of the algorithm.

The study offers only a first approximation of aggregate potential and is not a substitution for independent exploration and assessment. It is meant to delineate areas that possess characteristics that are conducive for hosting natural aggregate deposits. The methodology and data acquisition described in this report are representative of a Level III mapping exercise.

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