Sunshine Coast Aggregate Potential Mapping Project

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INTRODUCTION

The Sunshine Coast has long been a major producer of aggregate products that are readily consumed by the expanding markets of southwestern British Columbia and those south of the border. As part of an ongoing initiative of resource inventory, the Geological Survey Branch of the Ministry of Energy and Mines has undertaken an aggregate potential mapping project along the Sunshine Coast during the 2001 field season. 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), and Sea-to-Sky (Dixon-Warren *et al.*, 2000; Hickin *et al.*, 2001) projects (Figure 1). Funding and support is provided by the Corporate Resource Inventory Initiative (CRII) with additional logistical support from a variety of organizations including 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.

The desirable outcome of the project is a regional, reconnaissance style survey that will act as a first approximation of aggregate resources within the region. The project will outline exploited and known aggregate resources as well as potential new deposits, in a qualitative manner using distinct landforms.

The basis of the Sunshine Coast Aggregate Potential Mapping Project comes from four major objectives:

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.

The purpose of this paper is to describe the methods and progress of this project, provide a summary of the results to date, and to outline the anticipated data that will be released early in 2002.

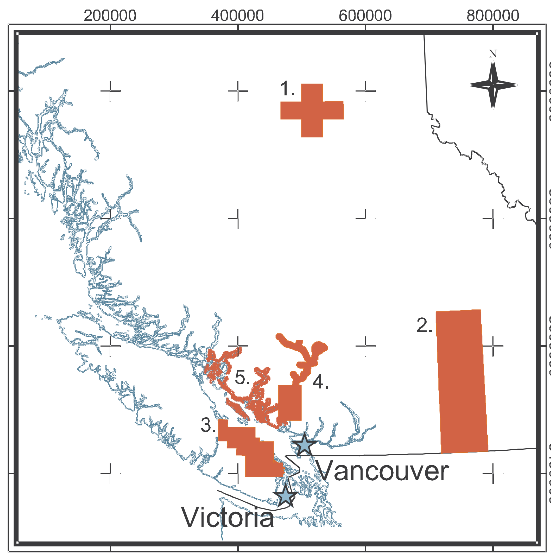

Figure 1. The five aggregate potential mapping projects conducted by the Geological Survey Branch during the past six years. Projects are numbered in accordance to the order in which they were conducted.

STUDY AREA

The study area is located in southwestern British Columbia, northwest of Vancouver (Figure 1), and lies entirely within the Sunshine Coast Forest District. The major communities within the study area are Gibsons, Sechelt and Powell River. It is concentrated along the coastline, stretching from Gibsons as far north as the head of Bute Inlet (Figure 2), with the coastline and a variable buffer extending landward, defining the boundaries of the study area. For the most part this buffer is 3 kilometres wide with exceptions being: between Malaspina Peninsula and Saltery Bay where a 5-kilometre buffer is used; all of Sechelt Peninsula; and Gambier, Texada, Nelson, Read, Cortes and West Redonda islands, which are included in their entirety. Subtracted from the total area are ecological reserves, parks and other protected areas that are greater than 500 hectares. This yields a total study area of approximately 310,000 hectares in 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.

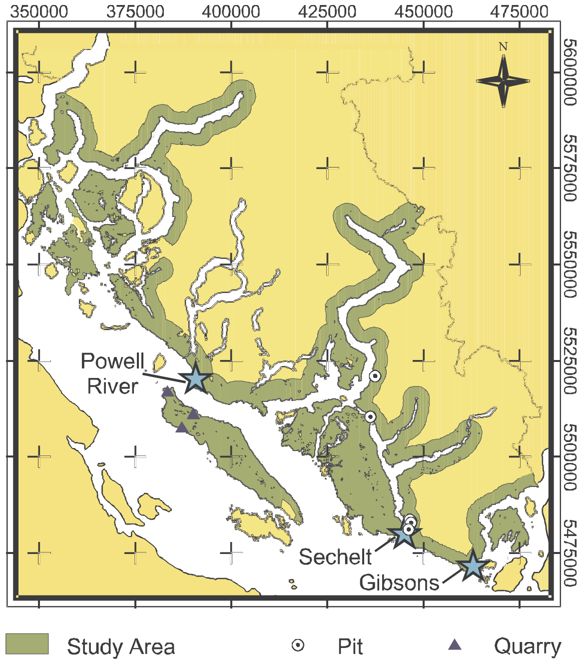

Figure 2. Location of the Sunshine Coast study area and the major aggregate producers and quarries in the region. Natural aggregate pits are indicated by light circles and quarries by dark triangles.

PHYSIOGRAPHY, CLIMATE AND VEGETATION

The Sunshine Coast falls within the Coastal Trough and the Coast Mountains physiographic regions (Holland, 1976). The Coastal Trough is a northwest-southeast structure that lies between the Coast Mountains to the east and the Insular Mountains to the west, stretching the entire length of British Columbia. The Coastal Mountains are an unbroken chain of rugged mountains that, as well, run the length of British Columbia. The study area is contained within a subdivision of the Coastal Trough known as the Georgia Depression, more specifically the Georgia Lowland, with parts of the study area found on the lower slopes of the Coastal Mountains. Adjacent to the study area is the Fraser Lowland, a subdivision of the Georgia Lowland that encloses Greater Vancouver. Except for the Fraser Lowland whose geomorphology is largely due to depositional processes, the Georgia Lowlands are characterized by an undulating Tertiary erosional surface that ascends gently from the Strait of Georgia towards the Coastal Mountains to a maximum elevation of approximately 1300 m asl (Holland, 1976). A relatively thin mantle of sediment covers it, as bedrock outcropping is very frequent.

The study area falls almost entirely within the Coastal Western Hemlock biogeoclimatic zone (Meidinger and Pojar, 1991). This region experiences relatively cool summers and mild winters, having an annual precipitation ranging from 1000 mm to 4400 mm of which, less than 15% occurs as snowfall. The most common tree is the western hemlock but other species such as the western red cedar, douglas fir, amabilis fir, yellow-cedar, lodgepole pine, red alder, black cottonwood and stika spruce are also encountered frequently.

PREVIOUS WORK

Aggregate resources along the Sunshine Coast have been the subjects of numerous studies. The earliest of these studies was that undertaken by Leaming (1968) who from 1961-1962 reviewed sand and gravel resources within the Strait of Georgia area. The resultant report outlines the distribution of unconsolidated sediments on both sides of the Strait as well as up major valleys and reviews available aggregate reserves and presents descriptions of extraction sites. McCammon carried out a similar study from 1974-1975 along the Sunshine Coast (McCammon, 1975; McCammon, 1977). Though the stratigraphy and surficial geology data produced from these studies remains essentially unchanged, the reserve estimates and descriptions of extraction operations are dated. More recently, MOT conducted an investigation into potential aggregate resources within a corridor along a section of Highway 101 between Lund and Powell River (Buchanan and Bergman, 1993), representing a small portion of the current study area.

QUATERNARY HISTORY

Like most of British Columbia, the majority of the unconsolidated surficial deposits along the Sunshine Coast owe their existence to multiple episodes of glaciation and deglaciation that occurred during the Pleistocene. In particular, it is the most recent cycle of glaciation and deglaciation that has produced the current landscape, and left behind the aggregate deposits that are the subject of this paper.

A change in vegetation approximately 29 ka BP, a result of a deteriorating climate, provides evidence for the onset of the last glacial cycle, the Fraser Glaciation (Clague, 1994). Ice normally restricted to high alpine areas began to expand into and advance down low elevation valleys and fjords. These valley glaciers eventually grew sufficient enough to overtop the confining topography and coalesce into a massive ice sheet known as the Cordilleran Ice Sheet. Outwash sediments associated with these advancing ice fronts are known locally as the Quadra Sands and are found in abundance throughout the Strait of Georgia at elevations up to 100 m asl (Ryder and Clague, 1989). These sediments are characterized as being cross stratified, well-sorted, fine to coarse-grained glaciofluvial sands containing minor amounts of gravel and silt (Armstrong and Clague, 1977).

Sometime after 25 ka BP, glaciers had reached the Fraser Lowland through valleys entering from the north and east, only to retreat by 19 ka BP (Clague, 1994). Along the Strait of Georgia, an ice lobe spread south well past the Georgia and Fraser Lowlands, achieving its greatest extent by approximately 14.5 ka BP (Mullineaux *et al.*, 1965). As ice overrode the area, sediments collectively known as Vashon Drift were deposited either ice-proximally or in direct contact with ice. These sediments consist of a complex of silty sandy till and sandy and gravelly glaciofluvial and glaciolacustrine sediments (Hicock and Armstrong, 1985).

After 14 ka BP, the regional climate began to warm and ice retreat followed, with parts of the Strait of Georgia being ice-free by 13 ka BP (Clague, 1980). The most predominant sediments deposited in the Georgia Lowland during this time are the Capilano Sediments. These are retreat-phase glaciofluvial, glaciomarine and marine sediments deposited on the seafloor, and as raised deltas and intertidal and beach sediments (Armstrong, 1981). Capilano sediments can be found in the region up to an elevation of 180 m asl, indicating a relative sea level much higher than that of present day (McCammon, 1977).

Following deglaciation, fluvial and mass wasting processes redistributed glacial sediments during a period of readjustment (Ryder and Clague, 1989). Eventually the system evolved into the modern-day scheme, with gravel, sand and silt sediments being deposited in modern fluvial, beach and bog environments; these deposits are known as the Salish Sediments.

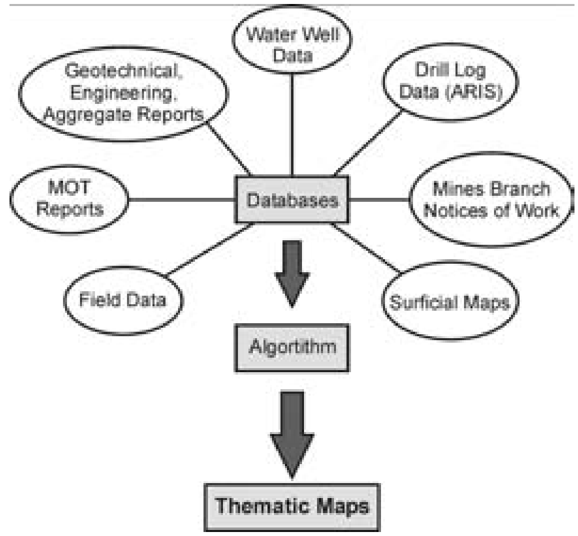

Figure 3. Flow chart depicting the process used for creating the thematic maps. Circles indicate sources of information while boxes represent products generated during the course of the project.

METHODOLOGY

For a number of years now, aggregate potential mapping projects have been implemented across Canada, using various methods (Bobrowsky *et al*., 1995). Within British Columbia, a system was developed based on the methodology established by the Alberta Geological Survey and is discussed in greater detail by Bobrowsky *et al*. (1996b) and Massey *et al.* (in press). This mapping system recognizes five levels of mapping intensity, and while the methods used at each of these levels is essentially the same, the resources that are utilized may vary. Of the five levels of mapping, Level III is favoured for applications of first approximation of aggregate potential within British Columbia (Bobrowsky *et al.*, 1996b).

Figure 3 is a flow chart summarizing the development of the final product for this project, the thematic maps, and the resources used to create it. The initial stage of the project involves the collection and compilation of data from many pre-existing sources into a series of linked databases. Geotechnical, engineering, and aggregate reports, surficial maps, water well data, drill log data, Mines Branch records (Notices of Work) and Ministry of Transportation records (public pits) are then queried for pertinent information such as: type of surficial material; thickness of overburden; aggregate content; and thickness, extent and quality of deposits. This type of information is not always readily available and may even be non-existent in areas.

Next, data collected in the field is added to the databases. The fieldwork component of the project involves visiting all active and inactive aggregate pits that fall within the study area boundaries, which includes commercial and public pits and quarries. The location of each of these mines is determined from previous aggregate studies, Notices of Work, Ministry of Transportation databases, a review of airphotos from the study area and terrain resource inventory management (TRIM) maps. At each field station a variety of observations are made, including:

- verification of mine location (GPS coordinates and elevation);
- type (pit, borrow or quarry);
- status (active, inactive, or reclaimed);
- dimensions of mine;
- surficial material, number of units present and their thickness;
- clast size, roundness, and lithology;
- grain size distribution and degree of sorting (very poor, poor, moderate, well, very well);
- degree of stratification (none, very poor, poor, moderate, well, very well); and;
- geologic interpretation

J.M. Ryder and Associates, Terrain Analysis Inc. completed detailed terrain mapping following the standards set by Howes and Kenk (1997), with the resulting polygons dividing the study area into discrete units. These polygons are then digitized and geo-referenced into a geographic information system (GIS), permitting the information stored in the previously mentioned databases to be linked to their associated polygons. This enables the evaluation of aggregate potential on a polygon-by-polygon basis as well as the ability to perform spatial data queries.

The final step in the generation of the aggregate potential map is to classify polygons (based on their attribute data) into groups that have varying degrees of potential for hosting aggregate resources. Based on select attributes, polygons are assigned a numerical value that is derived from an algorithm that yields an overall score. The construction of the algorithm allows particular attributes to be weighted according to their importance. As previously mentioned, the availability of information pertaining to aggregate potential varies from project to project and so therefore must the structure of the algorithm. The algorithm for this study is yet to be developed.

The desired outcome is a four-tiered classification whereby polygons are ranked in terms of potential by assigning a value of primary, secondary, tertiary, or unclassified. Polygons classified as primary are areas where the potential for aggregate resources is considered to be high. Unclassified polygons on the other hand are those with virtually no potential for aggregate resources, and include areas covered by ice or water. Polygons classified as secondary or tertiary fall in-between these end members.

Once the data capture and compilation stages, data evaluation, and the polygon rankings have been completed, these data are integrated into a GIS format for distribution to clients. ESRI's ArcView (v. 3.2) GIS software is used to produce various thematic maps that display a variety of information relevant to an aggregate potential study. The files used to create these maps, as well as the maps themselves, will be available in CD-ROM format, enabling users to interact with the data, changing the type of information displayed to suit their own needs, as well as be able to query the various databases.

RESULTS

As this project is still in it's early stages, results to report at this time are limited to the data capture and compilation stages. During the 2001 field season a total of 98 field stations were visited (*see* Figure 4). Most sites are located along the coast or near populated areas, rarely more than a couple of kilometres from open water or up a fjord. The primary reason for this is the distribution of surficial sediments within the study area and the added cost of transportation of aggregate products, a limiting factor in the economic viability of an aggregate deposit (Langer and Glanzman, 1993).

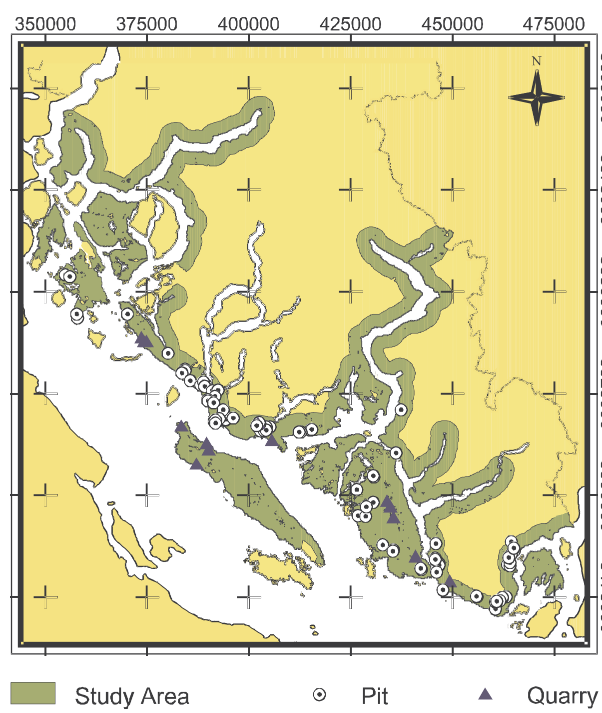

Figure 4. Distribution of the 98 field stations along the Sunshine Coast. Natural aggregate pits are indicated by light circles while quarries by dark triangles.

Table 1 is a summary of the field stations visited. Of the 98 sites, 83 are natural aggregate pits and 15 are rock quarries. In addition, only 33 sites are currently being mined, the remaining 65 are either inactive or have been reclaimed or abandoned.

The size of extraction operations varies throughout the study area from borrow pits and small quarries only tens of square metres in area, to large-scale operations that cover square kilometres such as the Sechelt Pit (Construction Aggregates Ltd.) (*see* Photos 1 and 2). Of the pits that have shut down, approximately half have been abandoned and naturally reclaimed, with the remaining half either re-developed for residential, commercial or industrial use, or serve some other purpose to the local community (Photo 3). Past producing sites that have been re-developed, or that now serve some other purpose to the local community, are considered sterile with regards to aggregate potential.

The most common sediments extracted in the region are the Capilano Sediments, and is consistent with results from earlier aggregate studies by Leaming (1968) and McCammon (1977). As previously mentioned, these are retreat-phase sediments, consisting of glaciofluvial, glaciomarine and marine sediments deposited away from the glacier fronts. In most cases, pits are located in raised glaciofluvial deltas and consist of interbeded sand, sandy

TABLE 1
SUMMARYOF 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 1 shows the classification of field stations according to the type of mine and its status. Also included is a summary of the types of reclamation encountered; either the sites was abandoned and natural re-vegetation has ensued or the site has since been developed and now serves a secondary land-use.

Photo 1. An example of a small borrow pit located near the town of Gibsons where material is being extracted for road construction on private land.

Photo 2. A medium to large-scale aggregate pit located on Jervis Inlet called the Treat Creek Pit (Jack Cewe Ltd.).

Photo 3. Brookman Park; a reclaimed aggregate pit located next to Chapman Creek on the outskirts of Sechelt.

gravel, and gravel (Photo 4) at elevations up to 200 m asl. More rarely, Quadra Sand or Vashon till is being extracted.

Materials being quarried fall under two categories: granitic rock and limestone, with the greater volume being that of limestone. The granite quarries visited are very small in comparison to the massive limestone operations found on Texada Island (Photo 5) (over 6 million tons per year from three quarries). Stockpiles of waste rock at these limestone quarries are a very large potential source of crushed aggregate (in the order of tens of millions of tons).

In addition to field data, other major sources of information related to aggregate potential used in this project have included drill logs taken from the Geological Survey Branch's Assessment Report Index System (ARIS) and water well records from the British Columbia Ministry of Water, Land and Air Protection. Currently there are 455 drill logs and approximately 1300 water well records in the Sunshine Coast Potential Aggregate Mapping Project database.

Terrain mapping has been completed and is in the process of being digitized. In total, 3305 polygons have been delineated, covering an area of approximately 310,000 ha in portions of NTS 92F/8-10, 92F/15-16, 92G/5-6, 92G/11-13, 92J/4, 92K1-3 and 92K/6-9.

Photo 4. Typical sediments found along the Sunshine Coast in aggregate pits. They consist of interbeded sand, sandy gravel and gravel associated with a relict delta.

Photo 5. A photo of the main pit at the Blubber Bay Quarry; a limestone quarry located on Texada Island. This pit is approximately 160 m deep.

SUMMARY

As this project is in it's early stages, it is not possible at this time to comment on aggregate resource potential along the Sunshine Coast. However, some observations on the aggregate industry along the Sunshine Coast can be reported:

1. Glaciofluvial sediments, thought to belong to the Capilano Sediments, are primarily being mined;
2. Mined aggregate deposits lie predominantly below 200 metres asl; and
3. Aggregate pits tend to be near urban centers or near transportation routes such as major roads or waterways.

Once terrain polygons have been digitized, the compiled data will be spatially referenced to the polygons, and an algorithm will be run on this data to rank the polygons in terms of aggregate potential. The release of results from this project is anticipated in spring of 2002.

ACKNOWLEDGEMENTS

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