APPENDIX 1:

GENERAL SESSION: PROGRAM AND ABSTRACTS, THURSDAY MARCH 30, 1995

IC 1996-6

Fraser Room,
Executive Inn, Richmond

Schedule

8:30-8:35 **Opening Remarks**

8:35-8:40 **Introduction**

Paul Matysek (Manager - Environmental Geology Section, MEMPR)

8:40-9:00 **Geologic and Societal Aspects of Natural Aggregate Resources and Their Development in Canada and the United States**

Bill Langer (Senior Aggregate Geologist - USGS)

9:00-9:20 **Economics of the Aggregate Market**

Richard Poulin (Professor - Mining and Mineral Process Engineering, The University of British Columbia)

9:20-9:40 **Construction Aggregates: National and Regional Trends**

Oliver Vagt (Analyst - Industrial Minerals Division, Natural Resources Canada)

9:40-10:00 **Discussion**

10:00-10:20 COFFEE

10:20-10:40 **The Geology of Aggregate Deposits in British Columbia**

Peter Bobrowsky (Senior Quaternary Geologist - MEMPR)

10:40-11:00 **A Status Report for the Supply of Aggregates in British Columbia**

Barry Irvine (Aggregate Producer - Construction Aggregates Ltd.)

11:00-11:20 **Planning for Aggregate Resource Extraction: Putting the Inventory into a Context**

Doug Baker (Professor - Natural Resources and Environmental Studies, The University of Northern British Columbia)

11:20-11:40 **Aggregate Resources of the Greater Vancouver and Lower Mainland Market, B.C.: Problems and Future Outlook**

Dan Hora (Industrial Mineral Specialist - MEMPR)

11:40-12:00 **Discussion**

12:00-1:00	LUNCH
1:00-1:20	**Successful Integration of Aggregate Data in Land-Use Planning: a California case study** *David Beeby* (Assistant State Geologist - California Geological Survey)
1:20-1:40	**Aggregate Resource Management in Ontario** *Ray Pichette* (Director of Aggregate Resources - Ontario Ministry of Natural Resources)
1:40-2:00	**Ensuring Ongoing Economic Sources of Highway Construction Aggregate Through a Gravel Resource Management Program** *Stephen Lee* (Manager - Properties Branch, MoTH)
2:00-2:20	**A Planner's Perspective on Local Aggregate Issues** *Don Buchanan* (Planner - Coquitlam)
2:20-2:40	**Discussion**
2:40-3:00	COFFEE
3:00-3:20	**Mineral Aggregate Map Case Study, Alberta** *Dixon Edwards* (Senior Aggregate Geologist - Alberta Energy)
3:20-3:40	**Three-Part Surficial Aggregate Assessment** *James Bliss* (Senior Aggregate Geologist - USGS)
3:40-4:00	**Modeling Aggregate Resource Potential, Vancouver Island, BC** *Gavin Manson* (Graduate Student - School of Earth and Ocean Sciences, The University of Victoria)
4:00-4:20	**Discussion**
4:20-4:30	**Closing Remarks**

Aggregate Forum — Developing an Inventory that Works for You!

Paul Matysek and Peter Bobrowsky
Ministry of Energy, Mines and Petroleum Resources
Victoria, British Columbia

Aggregate resources represent a finite, non-renewable commodity which is essential in the construction of roads, industrial development, building structures, airports, railways and dams and is recognized as an important component of any comprehensive landuse or resource management program. In British Columbia there are about 6,000 sand and gravel pits, of which 2,600 are active operations producing output valued at over $170 million annually and directly employing 4,000 to 5,000 people. The total annual production of sand and gravel in the province approximates 50 million tonnes, of which half is from pits located in the Lower Mainland and along the coast. Many communities and municipalities are currently or will shortly experience aggregate shortages as local reserves are depleted or sterilized. Management of aggregate resources in the province is accomplished in the absence of a current pit and deposit inventory, forecast estimates or knowledge of aggregate potential.

In 1994, the Ministry's Geological Survey Branch initiated a program focused on provincial aggregate resources (Bobrowsky et al., 1995). The goal of this new effort is to establish an inventory of both natural and crushed aggregate pits in British Columbia. A long-term aim of this program is to provide products which will assist planners and decision makers as well as industry producers in their management and use of this finite resource. We believe the success of future decisions regarding the availability, sustainability and possible sterilization of aggregate resources rests on the quality and availability of an aggregate inventory. Aggregate inventory information is incomplete and widely scattered. To improve the reliability of provincial evaluation and landuse decisions regarding aggregate resources, several short term objectives were targeted in the aggregate program:

- Establish a digital database inventory of all aggregate pits (active and abandoned, as well as public and private) in British Columbia.
- Improve information transfer and data management between interested provincial ministries and external parties which are actively involved with aggregate resources.
- Develop acceptable methods for identifying and classifying aggregate resources.

To ensure that the Ministry's program is effectively targeted and implemented an open forum and workshop was conceived to provide input from key aggregate stakeholders. Co-sponsored with the Ministry of Transportation and Highways, the first day will consist of presentations by several keynote speakers and a facilitated question period for the audience. The speakers will address the importance and economics of aggregate; geological and social aspects; landuse concerns and data needs; as well as aggregate potential mapping methods. Day two will consist of a closed workshop for specialists in the field of aggregate mapping and key stakeholders. Participants will review the unique needs of British Columbia aggregate clients and develop suitable methodologies for aggregate resource inventory and potential mapping.

Reference

Bobrowsky, P.T., Kilby, C.E., Manson, G. and Matysek, P.F. (1995): British Columbia Aggregate Inventory Project; *in* Geological Fieldwork 1994, Grant, B. and Newell, J.M., Editors, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Paper 1995-1, pages 361-364.

Geologic and Societal Aspects of Natural Aggregate Resources and their Development in Canada and the United States

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US Geological Survey
Denver, Colorado

Crushed stone and sand and gravel are the major sources of natural aggregate. Crushed stone is derived from rock, boulders and cobbles that are blasted and mined from bedrock and subsequently crushed and processed into aggregate. Sand and gravel commonly result from natural erosion of bedrock and surficial deposits including the transportation and deposition of the eroded particles. Sources of sand and gravel aggregate commonly occur as channel, terrace, glaciofluvial and alluvial fan deposits.

Aggregate is produced in every Canadian province and in every state in the United States. Annual per capita consumption of aggregate is about 13 tons in Canada and 9 tons in the United States. Crushed stone and sand and gravel are most often used by the construction industry. For example, an average 1,500-square-foot home, when considering its proportional share of new streets, schools, churches, municipal construction projects and shopping centers, requires about 330 tons of aggregate. Crushed stone and sand and gravel are also important elements in many non-construction industries. Sand and gravel (or sand alone) can be used for industrial purposes such as foundry operations, glass manufacturing, abrasives and filtration beds of water-treatment facilities. Crushed stone is used as a source of calcium in fertilizers, as a metallurgic fluxstone and as the major ingredient in the manufacture of cement and lime. It may also be used in filtration systems and in the manufacture of glass.

Because natural aggregate is a bulky, heavy material with no special or unique properties it is considered to have a low unit value. However, it has a high place value since a large part of its worth comes from its geographic location. Aggregates commonly are available near the point of use at a low cost. However, even though suitable crushed stone and sand and gravel are widely distributed throughout much of Canada and the United States, availability is not universal because many large areas lack sand and gravel deposits. Potential sources of crushed stone may be lacking or covered by a significant thickness of overburden to make mining uneconomical.

Generally, aggregates should be free of undesirable substances such as silt, clay, mica and organic materials. They should be able to resist weathering and mechanical breakdown resulting from the actions of mixers, mechanical equipment and traffic. Aggregates used in portland cement concrete or bituminous mixes should also have favorable chemical properties. Some aggregates contain minerals that chemically react with, or otherwise adversely affect the concrete or bituminous mixes. Consequently, strict specifications are set for certain uses. As new high-performance materials are developed, even more stringent specifications will render some of today's aggregate resources unsuitable.

Aggregate cannot be produced without disturbing the natural environment. An obvious impact of aggregate production is the creation of pits, quarries, or mines. Reclamation of the mined-out areas is of critical importance to communities near the aggregate deposits. Aggregate extraction does not have to be viewed as the final use of the land. Reclaimed pits or quarries have been used for residential, industrial, and commercial developments, parks, golf courses, lakes, recreation areas, storm-water management, farmland, and landfills. The most acceptable solution for the community, and perhaps the most economical for the producer, is to plan the rehabilitation of the area prior to mining. This method would allow mining to progress while concurrent reclamation is performed on mined-out areas. The primary goal is to return the land to beneficial use.

Aggregate development may create other temporary environmental impacts such as increased airborne particulates, increased sediment loads in streams and lakes, and increased noise levels, and permanent impacts such as gross changes to the landscape. Increased truck traffic is both an environmental concern (dust and high exhaust emissions) and a safety concern. Even though measures can be taken to eliminate or greatly reduce the impact of aggregate extraction, communities frequently consider aggregate operations a nuisance, and wish to restrict them. Neighborhoods have their own ideas on how to use the land, and public opposition to aggregate mining commonly is very strong. For these and other reasons, the many levels of government may have regulations that must be followed before aggregate development can begin.

Natural aggregate, especially sand and gravel, commonly occurs in areas that are also favorable for other land uses. Prime aggregate resources are precluded from development if permanent structures such as parking lots, houses and other buildings are constructed over them. Once the land is developed for a use other than aggregate extraction, it is unlikely the aggregate will ever be mined. This results in a situation referred to as aggregate sterilization. Numerous examples of the inability to extract aggregate due to zoning, conflicting land use and sterilization exist throughout Canada and the United States.

The net result of this resistance to aggregate development is that aggregate operations are displaced farther away from the market areas that they serve. In the 1960's, little aggregate was shipped from county to county, even less across province or state lines, and practically none from one country to another. Today, aggregate is shipped many tens of kilometres by truck, hundreds of kilometres by rail or barge and thousands of kilometres by ocean-going freighters. The transportation adds substantially to overall cost of aggregate and because more than half the aggregate produced is for public works, the taxpayers absorb the added cost.

One method of ensuring a continuous economical supply of quality aggregate is to identify and characterize existing aggregate resources. This includes determining the distribution and thickness of aggregate resources as well as describing their physical and chemical properties. This can be accomplished through a variety of field mapping, remote sensing and geophysical techniques, and through the use of analog and computer resource-assessment models. The next step to ensuring adequate, long-term aggregate supplies is to protect identified aggregate resources. This is particularly important not only where supply is limited, but also in high-demand areas, even if the sources of aggregate are abundant. Various short-term and long-term techniques can be used to preserve aggregates.

Planning for and developing adequate supplies of aggregate can be a complicated process that entails balancing the needs of a region with the needs of the local communities. It requires enlightened planning, resource protection and regulation. Basic data related to aggregate resources can provide a basis for decisions related to the locations, volumes and quality of aggregates in the planning area. Plans based on this kind of information can contain provisions that balance the needs for aggregate with those for the protection of the environment and the right of the public to be free of the problems associated with aggregate mining.

Economics of the Aggregate Market

Richard Poulin
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Crushed stone together with sand and gravel constitute the two main sources of natural aggregates, the vast majority of which are used in the construction industry. Together they constitute the largest, by tonnage, non-fuel mineral commodities currently produced in North America. Further exploitation of this type of resource, however, has been significantly restricted by increasing urbanization and growing public concerns over environmental issues. The growth of populated areas has put pressure on aggregate producers who are expected to maintain supply whilst being inconspicuous. However, production economics require that quarry sites and their related producing facilities be located in or near population centres. Herein lies the paradox of this industry: a constant, predictable need for products and the community's desire that mining operations be conducted far from its boundaries.

Since it is the most fundamental component of construction, aggregate is employed wherever any type of building or public works construction activity occurs. As a result, the aggregate industry is one of the most dispersed raw material producing industries. The geographical dispersion of plant location is a function of the cost of transporting the processed aggregate to the point at which it will be used. Urban sprawl means that existing aggregate producers face higher environmental costs. For some producers these costs can render a site economically non-viable and production moves to sites away from the urban area. Because transport plays a central role in determining aggregate prices, such a change places remaining producers in the urban area at a competitive advantage. However, since these also face higher environmental costs, they may not profit from the removal of some competitors to locations at the fringe of the urban area. The use of competitive and high-volume delivery means, such as barge transport, allows penetration and/or expansion of market areas.

From the consumer's point of view, higher prices favour alternate sources of supply. From the producer's point of view, however, longer transport distances allow access to broader submarkets, thereby favouring larger-size operations with lower production costs. Regulation is an issue in regions with growing populations. This regulatory environment may cause exploitation schemes to evolve towards greater recycling, importing and marine production for example.

Demand for aggregates is a derived demand. Forecasting this demand can be done by econometric procedures based on general economic factors. The technique uses a function based on gross national product and population level, to which is added the effect of interest rates. The exclusion of the interest rate factor would only yield a general trend. There is a lag of two years before a change of interest rate affects demand. This is believed to correspond to the construction industry's reaction time. Price is excluded in the regression because the price elasticity of demand for aggregates is believed to be highly non-elastic in the short run. Aggregates represent a small part of overall construction costs and they cannot be easily substituted. It is, therefore, unlikely that changes in prices affect demand.

Land use conflicts involving aggregate producers are not new, concerns about sterilization of aggregate resources in the United States through uses that indefinitely render resources inaccessible have been reported as early as 1961. An alternative is sequential land use, such as resource extraction before the land is removed from the mineral base and used for other purposes. Multiple land use can also be considered, but require planning of aggregate extraction and establishing a quarry permitting mechanism that can generate consensus.

Construction Aggregates: National And Regional Trends

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This paper provides an overview of production and use of mineral aggregates in Canada. Beginning with a review of the relative importance of structural materials in the context of the Canadian minerals industry that provides information, by means of ten-year time series, on regional trends with respect to:

- volume and value of production (fob pit or quarry) of all construction aggregates;
- volume and value of production of sand and gravel (fob pit);
- the major established uses of sand and gravel in western Canada;
- long-term trends in the unit values of sand and gravel (in current and constant dollars); and
- linkages between shipments of sand and gravel and certain key economic indicators.

Finally, we comment on the implications of the above trends for: a) the management of mineral aggregate resources at both the national and regional level and b) the collection of statistical and other data on mineral aggregate production.

Construction aggregate, defined here as sand and gravel, crushed stone and miscellaneous stone, are grouped with structural materials, which collectively were valued at about $2.5 billion in 1994. This represents more than 17% of the value of the minerals industry, excluding fuels. Other commodities or products often categorized as 'structurals' include cement, gypsum, lime and other rock (or stone) and clay products that are used mainly for construction purposes.

The 'structurals', in particular, and to a certain extent industrial minerals as a whole, are often characterized by relatively low unit values compared to metallic minerals, which, in Canada, attract more attention because of their traditional importance in international trade, foreign exchange earnings and northern resource development.

Based on preliminary figures, the total value of all Canadian shipments of construction aggregates was about $1.2 billion in 1994, or about one-half of the value of all structural materials. Adjusted for inflation, the value of construction aggregates has expanded only about 8.5% over the 10 year period from 1984 to 1993 inclusive.

The total quantity of construction aggregates produced or shipped in Canada is currently about 300 million tonnes per year. Considering the period 1984-1994, the construction boom in Ontario in 1988-89 accounts for much of the peak.

Historically, the importance of the aggregates industry has tended to be understated in the national statistics. The publication of production statistics, generally in collaboration with the provinces, has related mainly to data provided by establishments operating licensed sites, and to a relatively much larger number of companies that require aggregates ancillary to other business activities. Provincial and federal cooperation is ongoing to improve reporting from all relevant establishments, companies and businesses. At the same time, however, there is a need to develop a method for estimating output in order to reduce the paper burden for companies and government.

Sand and gravel accounts for 70-75% of the volume of construction aggregates. Similarly, the peak years were in 1988-89, with declines in output and consumption since this peak period. Sand and gravel production is currently valued at about $800 million a year; this accounts for 60-65% of the value of all construction aggregates. In real terms, values have been expanded about 17% over the 10 year period from 1984-1994. This relatively small average annual increase of less than 2% understates the importance of aggregates, considering the final in-place costs associated with new and repair infrastructure. Trade in construction aggregates is very small relative to the total volume of aggregates consumed in Canada, however, it is important in some regions.

Based on reported figures for 1993, the consumption of sand and gravel in western Canada is broken down as follows:

- road bed and surfacing (60%);
- concrete aggregate (13%);
- asphalt aggregate (7%);
- fill material (6%);
- other including rail road ballast, ice control, mortar sand, backfill and other miscellaneous uses (14%).

The total value of all building and engineering construction in Canada is expected to be about $100 billion (1993), based on surveys by Statistics Canada. Surveys designed to estimate current year construction spending have been discontinued. Nation wide, the total value of construction is relatively stable in terms of real expenditures (1986 dollars). In 1993, total cumulative expenditures in all of Canada amounted to nearly $80 billion, with British Columbia accounting for about 15% of this amount.

Building and engineering construction in Canada ($85-100 billion per year including costs of repair) is very dependent on the domestic supply of aggregates. Combined with the fact that there has been a long-term trend away from rail and water transportation in some areas, toward a more flexible trucking mode, it is expected that regional resource planning, via sequential land use and rehabilitation, will become more important.

The Geology of Sand and Gravel Deposits in British Columbia

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Almost 75% of British Columbia is covered by unconsolidated surficial sediments; deposits that vary from less than a metre to several hundred metres in thickness. Most of the surficial sediments owe their origin to a number of processes which have been active during the last few million years (Quaternary), but a few isolated deposits of Tertiary age are also known. All of the processes are still active today, but their relative importance has changed with time, especially during the last 10,000 years (Holocene). For instance, since the last glaciation (Fraser Glaciation) the pre-eminent role of glaciers to actively erode, transport and deposit sand and gravel in British Columbia has been superseded by fluvial and mass-wasting processes.

During the Late Wisconsinan (25,000-10,000 years ago), much of the province was covered by a network of coalescing ice caps, valley, trunk, piedmont and cirque glaciers collectively termed the Cordilleran Ice Sheet. Isostatic depression of the land surface by the weight of the ice and a concomitant eustatic lowering of the sea level affected the configuration of the province's terrain. At this time, changes in base level resulting from isostasy and eustasy promoted sediment erosion and deposition. Subsequent climatic warming witnessed the decay of the ice sheet through active retreat and *in situ* melting. Sediment trapped in the ice consequently underwent active deposition beneath and adjacent to the melting glaciers; hence, deposits associated with deglaciation tend to reflect rapid and episodic events.

In many areas of British Columbia, thick accumulations of sand and gravel were deposited in front of advancing glaciers during the early stages of the Fraser Glaciation (*e.g.* Quadra Sand). Gravely facies correlative to this period provide significant sources of aggregate in many areas of southwestern B.C. (*e.g.* Saanichton gravel). At the end of the Fraser Glaciation, a number of deltas and river terraces developed in many of the isostatically depressed valleys. In the Fraser Lowland area, sand and gravel accumulations associated with the Fraser Glaciation include select facies of the Quadra Sand, Vashon Drift, Fort Langley Formation, Sumas Drift and Capilano sediments. Economically viable deposits of sand and gravel from this period are widespread and often exploited for aggregate purposes.

The character and distribution of unconsolidated sediments can be generalized by examining modern geological processes and the landforms resulting from such processes. Ground moraine, kame terraces and eskers which are common to the glacial environment consist of "predictable" assemblages of sediment that conform to a documented range of texture, sorting and internal structure. Similarly, the sedimentological and stratigraphic composition of channels, terraces and fans that occur in the fluvial environment, also contain deposits with predictable attributes. These and other geological environments (*e.g.* marine, lacustrine, aeolian) are the target of considerable research by earth scientists who specialize in surficial studies. This research includes the collective examination and analysis of the external morphology of landforms and internal properties of the deposits. Thus, the identification of unique landforms through air photographic interpretation provides the first level of analysis in the study of natural aggregate deposits, whereas the field description of subsurface exposures provides the second level of study.

Although many ideal landforms such as fan-deltas and glaciofluvial terraces often contain high quality materials for aggregate production, within deposit variations are common. The influence of local bedrock, topography and complex composite geological histories limit generalizations. Such parameters as sediment thickness, sorting and composition, although often predictable, still display site specific characteristics for each deposit which, therefore, require individual evaluation.

Landforms suitable for sand and gravel production occur in discrete areas of the province. In the mountainous regions of the province, natural aggregate occurs in the mid to lower valley environments. In the upper elevations, delta, fan and kame deposits hold the greatest promise for sand and gravel. Proximal ends of alluvial fans may support coarse rock particles with limited fine content. Raised glaciofluvial fan-deltas, although rare, mark the limits of tributary valley lake impoundment and often consist of coarse debris. Similarly, kame terraces, which represent the former margins of valley glaciers also contain poorly sorted mixtures of sand and gravel. In the lower valley environment, deltas, kames and eskers are secondary in abundance to dissected fluvial and glaciofluvial terraces. Terrace deposits, which represent former flood plains, contain sediments which are usually better sorted and graded than deltas, eskers and kames. Fluvial and glaciofluvial deposits are prominent landscape features in most valleys and at all elevations, but the sediments are always coarsest in their proximal reaches. In the coastal environments, glaciofluvial fan-deltas can occur up to 200 metres above sea level, depending on local isostatic depression, but generally are present within a few tens of metres above sea level. Productive glaciofluvial and fluvial deposits, show considerable range in elevation, but tend to be confined topographically to valley environments. In contrast, modern and raised ancient beach deposits show little vertical range but considerable lateral extent. The sediment in beach environments is often moderately well sorted and frequently coarser near the top and finer in the lower parts.

A Status Report for the Supply of Aggregates in British Columbia

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Construction Aggregates Ltd.
Vancouver, British Columbia

The supply of aggregates is key to the future growth of British Columbia. Aggregate is used in roads, asphalt, concrete, rail ballast, concrete products such as concrete pipe, block, pavers, manholes, etc. and as fill and backfill. Growth and improvement of the existing infrastructure are dependent on a low cost, reliable supply of quality aggregate. Although, the following comments are made with reference to the Lower Mainland construction market, they apply in varying degree to the rest of the province.

Construction in the Lower Mainland requires 20 to 24 million tonnes of aggregate per year with some estimates as high as 30 million tonnes. This figure includes fill and backfill not normally included in the definition of aggregate but originating from similar sources. Aggregate comes from the following general locations:

- Coastal pits on tidewater - 8 million tonnes per year
- North side of the Fraser River - 4 million tonnes per year
- Matsqui/Abbotsford and Chilliwack - 4 million tonnes per year
- Fraser River - 4 million tonnes per year (including 3 million tonnes of dredged sand)
- Quarries on Texada - 1 million tonnes per year
- Imports from the US - 1 million tonnes per year

Ownership of the land upon which these pits operate varies. Some are privately owned and operated, whereas others occur on Crown Land, First Nations Band Land, or on private land owned by someone other than the pit operator.

Cost of production also varies. For instance, pits on the north side of Fraser River have overburden at ratios up to 4 times that of the aggregate. In contrast, quarries generate the cost of blasting and additional crushing. Finally, operators of tidal deposits transfer the cost to barge product from 50 to 150 kilometres as well as the cost to off-load and handle material to customers sites or supply depots.

Reserves are known to vary in size, volume and content. Tidal pits tend to have extensive reserves. Pits on the north side of Fraser River have extensive reserves but are limited in annual production by the amount of overburden that has to be disposed. Deposits on the south side of the Fraser are rapidly being used and are expected to be fully depleted in 5 to 10 years with no replacement reserves planned. Material taken from Fraser River is limited by annual river deposition and requirements of the federal Department of Fisheries.

The challenges facing the industry are not in determining where deposits exist. This information is available through extensive studies completed by federal and provincial authorities. Rather, the industry faces the following challenges:

Ownership cost

- Pit operators face competition from property owners operating gravel operations as part of their property development. These developers are not bound by Ministry of Energy, Mines and Petroleum Resources requirements.
- Operators mining on Crown land are faced with increasing royalties and the obligation to reclaim the land, but share in none of the benefits of subsequent use of the land that privately owned pits often experience.

Soil Removal charges

- A majority of municipalities now levy soil removal fees. Amounts vary between municipality as do the methods of application. For example, some municipalities charge a fee each time the material is handled, whereas others charge only once.

Operating restrictions

- Gravel pits normally start operation at a distance from residential areas. With time, development moves closer and, as it does, demands for operating restrictions become more persistent. Noise, traffic, dust, runoff and hours of operation all become restrictive as development approaches. Finally, demands that operations be closed often result in premature closure and sterilization of reserves.

Zoning restrictions

- Recently, municipalities and regional districts have used restrictive zoning to prohibit gravel operations. Two recent cases involved restricting the use of crushers to existing operations where they can operate as 'non-complying' applications. New gravel pits will, in effect, not be allowed and "grand-fathered" operations will be forced to continue to operate with equipment presently on site. These bylaws resulted from pressure by residents not to allow gravel pits on land zoned for aggregate extraction.

Moratoriums

- Two municipalities no longer allow privately operated gravel pits.

What are the solutions?

1. Publicly acknowledge the importance of aggregate in the province. Support the industry when "new" neighbours apply pressure on operators.
2. Protect identified reserves with zoning that will keep residential areas away from pits until pits are nearing depletion.
3. Plan traffic patterns to allow transportation to and from pits on roads that do not transect residential areas.
4. Allow the sale of Crown land to gravel operators or allow them to share in the appreciation of the property that results from reclamation.
5. Standardize soil removal fees.

The Aggregate Producers of B.C. are active members of their communities. They require the assistance of all levels of government and public to maintain their ability to provide necessary materials for growth and improvement.

Planning for Aggregate Resource Extraction: Putting the Inventory into a Context

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Establishing an inventory to determine an aggregate resource base is only the first step in planning for the mining of sand, gravel and bedrock. Knowing the quality and quantity of a deposit is a vital first step in the planning stages for developing a working pit, however, determining the inventory is only one of several stages required to develop an aggregate source for commercial populations and a changing public environmental attitude. As such, the planning of aggregate resources requires integration with other land uses that may conflict with the guidance of a physical aggregate inventory. Once an inventory has been established, the subsequent planning stages consist of:

1. determine the "best use" of the deposit;
2. define the local land use pattern within the area;
3. identify priorities for development;
4. ensure that aggregate extraction is an interim land-use; and
5. integrate reclamation into the surrounding land uses.

Best Use of Deposit

Determining the "best use" of a deposit becomes a function of identifying competing uses for sand and gravel. Aggregate production may be only one potential use for sand and gravel, for example, other uses may include groundwater storage, or the historical character of a particular deposit. Moreover, high quality aggregates, such as those located in glaciofluvial deposits, may compete with other utility values.

Local Land Uses

The best quality deposits may never be used as a result of surrounding land uses. Aggregate production is only one land use in a myriad of land uses within a municipality or regional district. The problem is compounded by external factors associated with mining, including noise, dust, traffic and visual impacts. An inventory program needs to be integrated with the planning and future development of an area. As such, the inventory must be integrated with community plans and local economic development. Aggregates must be planned and integrated with other land uses.

Priorities for Development

The extraction of sand, gravel and bedrock needs to be incorporated with long term growth management strategies within municipalities. Land use patterns and trends need to be identified and integrated with the inventory of mineral resources deposits in order to reduce conflict between local residents and extractive operations. The co-ordination of long term development opportunities provides assurances for potential residents of an area and local pit operators. The economic importance of deposits can be identified and ranked with other future land uses.

Interim Land Use

Aggregate resources will gain a greater acceptance within the context of a community plan if it is seen as an interim land use. Well defined time lines for the development of major deposits will provide assurances for surrounding land users and operational targets for pit and quarry operators. In addition, future land uses can be identified from previous pit and quarry operations.

Integration of Reclamation

As well as identifying pit and quarry mining as an interim land use, it is important that the reclaimed landscape be integrated with surrounding land uses.

Neighbourhoods and communities have a vested interest in the environmental health of their local land resources. Often aggregate mining is seen as a negative land use activity. Reclamation strategies can address this negative image by having community input define the final land use. These "opportunity landscapes" become a product for the community and are the end land use for aggregate mining. Thus, aggregate extraction is only an interim land use, and the final reclaimed landscape results from a partnership between producers and the community.

Aggregate Resources of the Greater Vancouver and Lower Mainland Market, B.C.: Problems And Future Outlook

Z. D. Hora
Ministry of Energy, Mines and Petroleum Resources
Victoria, British Columbia

Introduction

Sand and gravel is, by volume, the largest mineral commodity used and produced in British Columbia. In 1994, about 41,837,000 tonnes were produced in the province, of which half was used in Vancouver and the Lower Mainland. In terms of value, sand and gravel is the most important industrial mineral commodity in the B.C. economy.

Quality of Sand and Gravel

Nature does not always provide deposits containing particles ideally sized and sorted for industrial requirements including pavement, road base, concrete and drainage fill. This is especially so for the most abundant surficial deposits, products of deglaciation, which are characteristically poorly sorted. As a result, most of the aggregate that enters the Lower Mainland area market is, to some degree, pre-processed. Smaller producers usually employ only simple screening, leaving the boulders as waste, and produce only a few types of construction aggregate or fill. Whereas larger operators have crushing, screening and washing facilities and are capable of supplying many types of aggregate product for a variety of uses.

Fortunately, the Lower Mainland gravel deposits do not contain appreciable amounts of deleterious components such as chert, glassy volcanic rocks and weathered rocks. In other areas, these attributes limit the use of natural aggregate by lowering the final quality of concrete. The only significant deleterious components of the sand and gravel deposits in the study area are silt and clay, both of which are easily removed by screening and washing.

Origin and Distribution of Deposits

Sand and gravel resources of the southern coastal region of British Columbia may be linked to various episodes of Wisconsinan glaciation. The distribution of sand and gravel deposits in the Fraser Lowland and along the coast is controlled by a number of factors. During the Quaternary, the province experienced several glacial-interglacial cycles. Major glaciations were accompanied by isostatic and eustatic changes in sea level of up to 200 m. As a result, low-lying areas were, at times, covered by the sea. Since the Fraser Lowland is bounded to the north and south by high mountain ranges, western glacier margins would have occupied the sea at certain times. During deglaciation, meltwater from the ice produced widespread and extensive deposits of sand and gravel along the coast, throughout the Fraser Lowland and adjacent areas. The interaction of waves and changing sea level positions, resulted in the widespread accumulation of gravely beach deposits up to a few metres thick at elevations between 0 - 200 m.

Local Geology

Gravel-bearing formations are present throughout most of the Lower Mainland in a variety of stratigraphical positions and lithological units. The largest accumulations of gravel include deltaic deposits in North Vancouver (Capilano age), a complex of units in the Coquitlam Valley, as well as Sumas and Fort Langley age sediments near Langley and Abbotsford. Alluvial fan sediments of the Chilliwack River (Salish age) cover a large area, but economical parts are restricted.

Deposit Characteristics

Deposits of sand and gravel vary in size, shape and granular composition. The producing deposits range from small fans a few hundred metres across and only several metres thick, to areas of more that 50 km^2 underlain by up to 50 m of gravel. Deposits south of Fraser River occur in generally flat terrain and contain well sorted gravel clasts, whereas deposits north of Fraser River and along the coast occur on sloping terrain, are unsorted and contain many boulders. Many deposits are covered by a layer of topsoil a few centimetres thick. If till is present, it is usually processed with the underlying gravel. In contrast, some of the mined deposits in the Fort Langley Formation are overlain by laminated marine silts with a stripping ratio of almost 1:1.

Availability of the resource is influenced not only by the physical presence of the deposits and the economic viability of product in the market area as a result of transportation costs, but also by conflicting interests that may sterilize existing deposits. For example, residential development favours areas underlain by gravel because of good drainage. Another limiting factor is public concern regarding noise, dust, water pollution and heavy traffic associated with aggregate extraction. Locally, even aesthetic aspects may play an important role in activating public pressure to eliminate existing production centres and to further restrict development of new deposits. Some of the deposits are several tens of metres thick and the gravel extends below the groundwater table. Municipal regulations, however, frequently limit gravel extraction above the groundwater table. Another problem facing the aggregate industry is that most of the gravel deposits south of Fraser River, and outside of the city limits, are located within the Agriculture Land Reserve (ALR). Application for exemption to operate a gravel pit must be approved by local authorities and the Land Commission and can, therefore, become a political issue. In the end, abundant aggregate resources are reduced by the above pressures which sterilize resources needed for residential, commercial, industrial and transportation development.

In general terms, north of Fraser River and along the coast, gravel availability is controlled primarily by geological factors and the physical presence of the deposits. South of Fraser River, the limiting factors are availability of land and limitations of permitting procedures.

Quarried And Crushed Aggregate

Crushed aggregate production at Pitt Lake, near Port Coquitlam, was phased out in the 1970s and the quarry at Watts Point, in Howe Sound, has been inactive for a number of years. In 1995, however, there are three major quarries producing approximately 2 million tonnes annually.

Data published by the US Geological Survey indicate that production costs of crushed quarried aggregate are 25 to 30 percent higher than those for sand and gravel. This means that the two products cannot be competitive if they come from local sources. However, it is quite possible that with increasing transportation costs for deposits more distant from the market, the price of crushed quarried rock in the lower mainland will again become competitive.

Limestone quarries on Texada Island, are producing large volumes of mine waste. Granite dykes form a significant part of the limestone deposits, and for the lime and cement industry the dyke material is deleterious.

Since selective mining of only limestone is frequently impractical, dykes are usually mined out and wasted. The limestone industry on Texada Island developed a crushed stone market for construction projects along the coast by processing such mine waste.

Aggregate Production And Use Distribution Patterns

The distribution of production centres depends in general on the local market size and availability of the resource. As has been discovered during our survey, the market appears to bear transportation costs up to approximately 50 kilometres by truck and 150 kilometres by barge. Transportation cost, therefore, seems to be the main limiting factor in the lower mainland by dictating the size of production from individual production centres. Only large deposits with large markets within economic transportation distances can afford several large producers concentrated in a relatively small area. Availability of transportation corridors is also an extremely important factor for marketability of aggregates in the lower mainland. The lack of available crossings on the Fraser River further constrains construction aggregate marketing from one side to the other.

For many years Greater Vancouver construction activities have relied on gravel imported from other areas. Since the major production centres in the Fraser Lowland and adjacent areas are distant from the urban core and trucking costs are prohibitive, the industry has developed production units along the coast and is barging aggregate to Vancouver to supply the local construction industry. Some deposits in the Howe Sound area have already been depleted, but about 50% of the deltaic deposits located along the shores of Jervis and

Sechelt Inlets have not been explored or developed. An additional area of aggregate potential are the shores of Indian Arm and Pitt Lake. A final possibility includes dredging gravel from the Strait of Georgia.

Successful Integration of Aggregate Data in Land-Use Planning: A California Case Study

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Four facts about California are important to an understanding of our Surface Mining and Reclamation Act of 1975. First, California is a mining state, with a rich mining heritage dating from the gold rush of 1849. That heritage continues to the present. Today over 1200 mines contribute to annual mineral production of $2.5 billion, ranking California the third largest non-fuel mineral producer of the 50 states in 1994. Second, we use considerable tonnage of construction aggregate in California. From some 750 gravel pits and quarries, California routinely leads the U.S. in sand and gravel production, with more than 93 million tons in 1994, valued at $465 million. Sand and gravel is the most important mineral commodity produced in California, not only because of value, but because it is essential to the maintenance of our societal infrastructure. Third, the gold rush also started a tradition of independent thinkers in the state who mistrusted centralized control in land-use decision making. Mining permits are approved at the local level--usually by one of our 58 counties, but also by any of our 470 incorporated cities. Fourth, our population is large (more than 33 million), highly urbanized, well educated, politically aware and environmentally conscious.

These four facts began combining to make mine permitting more difficult in the early-1960's as urban sprawl came into increasing conflict with traditional alluvial sand and gravel mining near metropolitan market regions. The construction aggregate industry foresaw the need for an objective regional database of mineral deposits so that local planners could direct new subdivisions away from remaining aggregate deposits, and lobbied our legislature for help. A select blue-ribbon task force was established by the Senate Natural Resources Committee to study the problem and make recommendations. The process was politicized as issues of local vs. state control, development vs. environment, sensitivity to local needs, proprietary data, competition and property rights were debated and addressed. After numerous impasses and 12-years of effort by the California aggregate industry, spearheaded by the Southern California Rock Products Association, perseverance was rewarded. The Surface Mining and Reclamation Act (SMARA) was passed into law in 1975, the first law of its kind in the U.S.

The original act has been extended and expanded 13 times by amendment through 1994 as clarification became necessary, successful programs were expanded and new public needs were addressed. In a stroke of genius, the legislature provided funding for the newly created program through the use of a portion of the Federal tax dollars collected from California mines operating on federal land within the state. This enabled the fledgling program to develop with some immunity from budget cuts. The initial $1.1 million annual allocation increased to $2 million in 1980, and in 1990, authority to charge fees was provided to fund a new reclamation compliance unit.

Relative to land-use planning, implementation of the SMARA is a shared responsibility between the California Department of Conservation's Division of Mines and Geology (DMG), the mining industry, the State Mining and Geology Board (SMGB) and the lead agencies of California. The passage of the SMARA Act in 1975 would have been impossible without recognizing and defining the roles of these four partners in the protection of aggregate resources.

The first article of SMARA states 'The legislature hereby finds and declares that the extraction of minerals is essential to the continued economic well-being of the state and to the needs of the society, and that the reclamation of mined lands is necessary to prevent or minimize adverse effects on the environment and to protect the public health and safety". This landmark statement was, at the time of its passage, unique in its recognition of the importance of mineral resources, giving them an equal footing with other natural resources. In addition to providing for the protection of aggregate (and other mineral resources) from development incompatibility with mining, SMARA established and defined criteria for the reclamation of surface mines, provided for reclamation compliance monitoring, and established requirements for financial assurances to assure reclamation could be completed. This paper will focus only on the first element of SMARA -- the protection of aggregate deposits.

Under the policy guidance of the SMGB, the State Geologist was mandated to classify specified lands within the state as to the presence or absence of significant mineral deposits.

Giving the state responsibility for the preparation of an accurate, objective, quantified mineral resource database precludes local special interests from influencing the classification. It also assures regional and state-wide consistency in the information provided to local government. This helps maintain a level competitive playing field between neighbouring mining companies in adjacent jurisdictions.

The SMGB restricted the initial focus of the act on construction aggregate in two major metropolitan markets -- The Los Angeles Basin, and the San Francisco Bay Area. After two small pilot studies and the development and refinement of both policy and technical issues, the first Mineral Land Classification Reports were released in 1978. A steady stream has followed, and today 91 reports have been completed and published, about half of which deal exclusively with construction aggregate. The aggregate reports cover more than 32,000 square miles of coastal and central California. In 1980 the act was amended to fund mapping beyond urban areas. Since that time, a similar sized area has been classified for other mineral commodities in the non-urban areas of the state, where potential federal land closures were being considered.

Local government was mandated by SMARA to recognize that classification data and establish appropriate mineral management policies to be incorporated into their general plans within one year of receipt of data from the State Geologist. Public hearings were held in the local jurisdictions impacted by the classification reports, and the SMGB designated certain mineral deposits classified by the State Geologist as Regionally Significant, giving them added legal protection. Over 100 billion tons of high-quality aggregate resources have been identified and designated by the SMGB.

Under SMARA, local government retains all land-use decision making authority relative to the granting of mining permits, but because local government generally lacks the technical staff expertise or regional perspective to evaluate the often conflicting testimony given by the pro and anti-mining interests, state prepared Mineral Land Classification reports give a stable base of information from which informed land-use decisions can be made. In some cases, DMG geologists are called upon by local government in mine-permit hearings to testify about aggregate resources under consideration. This ability to provide a non-special interest expert to assist decision makers with technical issues is a major strength of the SMARA process. SMARA geologists have been testifying at these hearings about four times per year. Almost every decision where State presence was requested was decided in favour of aggregate resource protection. Mine-permit decisions will probably always remain controversial. However, with the locally quantified resource inventories provided under SMARA, these decisions can be based on objective data, balanced against a perspective of long-term local resource needs rather than on emotion.

The primary user groups of Urban SMARA classification reports are lead agencies, closely followed by the aggregate industry. However, a variety of other users have emerged as report availability becomes better known. This includes bankers, other government agencies, mineral appraisers, lawyers, Realtors, geologic consultants, investors, landowners and students. Out-of-state and international mining companies have frequently used the reports to evaluate entry into the California aggregate market.

Aggregate classification reports have been well received by lead agencies, and the presence of an objective database where none previously existed has resulted in more informed land-use decisions. Lead agencies and individual aggregate producers, initially suspicious of the state program, are now requesting accelerated classification of their regions. In conclusion, the state efforts under SMARA appear to be working well in California.

Aggregate Resource Management in Ontario

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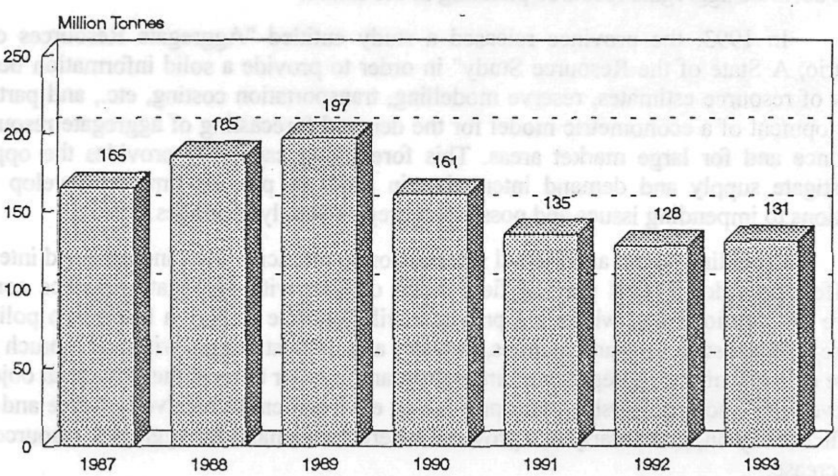
With some 11 million people in the province of the Ontario, the need to properly manage aggregate resources for the benefit of the public interest is a challenge, particularly in the high population urban areas of Southern Ontario. In 1993, some 131 million tonnes of aggregates were produced (82% from private land sources) and delivered to markets. Though significantly less than the 197 million tonnes produced for each of the years 1988 and 1989, the consumption per capita was still the highest in the country.

TOTAL AGGREGATE PRODUCTION IN ONTARIO 1987-1993



Aggregate resources management in Ontario has attempted to achieve its objective of "ensuring the availability, conservation and orderly development of aggregate resources with minimal adverse impacts on society and the environment". Strategically, an integrated resource management approach has been employed, focusing on three main topic areas: 1) resource conservation; 2) industry regulation; and 3) planning for aggregates.

Resource conservation is the area where public policy development has focused on reduce, reuse and recycle, substitute materials and alternative sources for aggregate resources. In 1991, the Ministry of Natural Resources released a comprehensive report entitled "Mineral Aggregate Conservation, Reuse and Recycling", on the state of construction and industrial wastes and by-products for reuse and recycling to aggregate products. It helped provide the foundation for government to encourage, and industry to plan for such conservation practices.

The program witnessed a major milestone in 1990 with the passage of the Aggregate Resources Act (industry regulation) which consolidated all relevant statutes dealing with aggregate resource management in the province. It effectively modernized and provided new policies and techniques to ensure compliance with environmental and social impact standards for extractive operations.

Planning for aggregates saw its formal beginning in Ontario with the Cabinet-approved Aggregate Resource Planning Policy (known as the 10-point policy) in 1982. In 1986, the Mineral Aggregate Resources Policy Statement (MARPS) was formally approved under the Planning Act of Ontario. As a result, it became a legal requirement of each municipality in the development of their Official Plans and Zoning By-laws to have due regard for the principles and policies of MARPS. Effective March 28, 1995, MARPS will be officially incorporated into the "Comprehensive Set of Policy Statements" intended to cover all matters of provincial interest required in municipal official plans. The program, known in Ontario as "Planning Reform", has the objective of empowering municipalities, protecting the environment and streamlining the planning process.

Though many significant improvements have occurred as a result of having new legislation and a solid planning policy, aggregate extraction is still not a welcome neighbour. The legacies and rehabilitation practices of the past provide an atmosphere of distrust with the general public. As a result, much effort has focused on improving rehabilitation standards and technology, and improved information gathering and data analysis. With the introduction of the Aggregate Resource Inventory Program (ARIP) in the late 1970s, formal mapping of primary, secondary and tertiary resources were compiled on a township basis to provide the necessary information for proper resource planning by both municipalities, industry and the province. Continued investment in the use of Geographic Information Systems (GIS) has provided opportunities to experiment in the areas of resource constraint mapping. Three townships have been completed to date that clearly illustrate significant reductions in resource availability as a result of pre-emptive social and environmental constraints. Proper transfer of this information to municipalities, industry and interest groups will hopefully help to provide the foundation for more accurate aggregate resource planning in the future.

In 1993, the province released a study entitled "Aggregate Resources of Southern Ontario, A State of the Resource Study" in order to provide a solid information benchmark in areas of resource estimates, reserve modelling, transportation costing, etc., and particularly the development of a econometric model for the demand forecasting of aggregate resources for the province and for large market areas. This forecasting capability provides the opportunity to investigate supply and demand interaction in order to provide time to develop appropriate solutions to impending issues and possible aggregate supply shortages.

Providing sound and factual information to municipalities, industry and interest groups, in effect provides a level playing field when dealing with aggregate resource concerns. The future in Ontario is one where the province will continue to play a leadership policy role and where partners such as municipalities, industry and interest groups will play a much greater role in the delivery of the aggregate resources program in order to meet the provincial objectives. It is believed that such partnerships will provide an environment to resolve resource and operational conflicts early on, particularly in a province where the demand for aggregate resources continues to increase.

Ensuring Ongoing Economic Sources of Highway Construction Aggregates Through a Gravel Resource Management Program

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MoTH Requirement for Gravel

There are 65,000 km of public road within the province of British Columbia, 45,000 km of which are provincial highways under the jurisdiction of the Ministry of Transportation and Highways (MoTH). This may be compared to the Province of Alberta that has approximately 20,000 km of provincial highways.

Mountainous terrain and highly variable climate, including heavy precipitation and multiple freeze-thaw cycles, poses a relatively unique challenge to highway construction in this province. Through an ongoing process of research and testing, MoTH has established design standards that best address its needs. Highway construction in B.C. is based on a flexible pavement design with a substantial free draining base sufficient to mitigate frost action and strength loss through saturation and at the same time provides adequate support for the asphalt surface to withstand heavy truck loads. Typically a provincial highway will consist of 100 mm of asphaltic concrete, overlying a 300 mm course of crushed stone, over a variable sub-base of 300 - 1200 mm of select granular material. Thickness of the sub-base will generally depend on the nature of the sub-grade.

Highways constructed to such design criteria depend on readily available abundant sources of clean sound aggregates. MoTH requires approximately five million tonnes/year to maintain the existing infrastructure. During periods of new highway construction such as the Coquihalla highway in the mid 1980's, MoTH's annual usage exceeds 20 million tonnes.

Meeting MoTH Requirements and Managing MoTH Resources

The Ministry of Transportation and Highways currently has approximately 3000 gravel pits held under various forms of tenure. Eighty percent of the gravel used on MoTH highways comes from MoTH pits. In the Lower Mainland industry price competition and high operating, environmental and social costs encourage the Ministry to rely on commercial suppliers.

Until recently, the acquisition and operation of pits by MoTH was ad hoc, with sources acquired for projects usually following project planning, or even sometimes during the project construction. Prompted by depleting resources, increasing regulation and restrictions, and environmental and public concerns with MoTH gravel operations, MoTH implemented a formal Gravel Management Program (GMP) in 1990.

The purpose of the GMP was foremost to ensure that in this period of rapidly growing restrictions on gravel mining and growing scarcity of available resources, MoTH's interests would be protected. Those interests are to ensure that long term economic sources would remain available for the construction and maintenance of our highway system. Other gravel management program goals include ensuring the efficient and best use of these non-renewable resources and bringing existing Ministry operations into compliance with current legislation and standards of social acceptability.

MoTH's Gravel Management Program brings all functions related to the provision of gravel resources for ministry use under the authority of six regional gravel managers. They are responsible for:

- planning for ministry requirements
- inventorying existing resources
- exploring and evaluating new sources
- acquiring of new sources
- planning site development
- reclaiming depleted sources and disposition

All these activities are carried out in accordance with recently established Ministry Gravel Management Program policies and guidelines.

Protecting Resources to Meet MoTH's Future Needs

In the absence of any provincial agency mandated to protect and promote the interests of the industry which is vital to the support of our highway infrastructure, the industry is threatened by the loss of valuable resources through development and land use restrictions, and through over-regulation. Local governments are beginning to exercise more control over the private sector industry and limit the industry through permitting requirements, zoning restrictions and soil removal bylaws. Although MoTH is not required to comply with local government bylaws, it is our current policy to respect municipal bylaws where feasible.

Land use planners and regulating agencies in all levels of government must consider the impacts of their decisions on sand and gravel resources if we are to assure ongoing economic sources of gravel to meet industry requirements and minimize land use conflicts. An inventory of provincial sand and gravel resources is the first step towards the wise management of these vital non-renewable resources.

A Planner's Perspective on Local Aggregate Issues

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Introduction

This presentation will focus on experience within Coquitlam since the late 1960's dealing with issues involving the gravel pit development area along Pipeline Road in the Coquitlam River Valley. This will serve to illustrate the kinds of issues being dealt with by local government and also how addressing those issues relates to Official Community Plans (OCP's) and their implementation.

Early Issues

From the 1960's to the early 1980's the Coquitlam Council and staff dealt with many issues relating to gravel pit development and operations. Gravel trucks in residential areas was a major issue in the 1970's.

Another issue related to effects on fish in the Coquitlam River which had historic Salmon runs. Tied into that was the role of the city in enforcing operating standards and reclamation of gravel pits. Early rules involved no excavation between Pipeline Road and the Coquitlam River and not allowing excavation below the level of adjacent roads. The City used a private Engineering Consultant to enforce silt content standards for effluent from gravel pits. After the Coquitlam River Water Management Study of 1978 this effort was left to senior government to address through mining plans.

Other issues involved landslides from gravel pits affecting adjacent properties and Pipeline Road itself. There were also conflicts with residents who lived to the east Pipeline Road in the vicinity of the gravel pits.

Another whole set of issues related to court cases in soil removal permit fees. Council had imposed higher fees in order to provide funds for the building of the gravel truck route entirely within Coquitlam from Pipeline Road south to Lougheed and Barnet Highways. This led to an early important precedent in a case with Lafarge Concrete Ltd.

Towards Official Community Plan

An important background report was done by Thurber Engineering Ltd. on the future of the gravel industry which led to eight major conclusions on how to deal with the area. This report has provided a continuing reference and framework for ongoing activities since passage of the Official Community Plan (OCP) for Northwest Coquitlam in 1987.

Nature of an OCP

An OCP is a policy document. Bylaws passed by the Council and spending on public works should be consistent with the Official Community Plan. The process involves extensive public consultation and a formal public hearing.

One of the requirements of the Municipal Act is that the approximate location and area of sand and gravel deposits that are suitable for future sand and gravel extraction shall be included in the form of statements and map designations for the area covered by the plan. The sand and gravel excavation area in the Northwest Coquitlam OCP was based on the Thurber report.

Implementing An OCP

Bylaws and spending powers are key along with ongoing provision of information. The soil Removal Bylaw is particularly important. In the case of Northwest Coquitlam, the development agreement worked out initially with BC Enterprise Corporations, and later assigned to Wesbild, was a critical component. This provided the basis for a buffer area adjacent to gravel pits and dealt with major trunk drainage and services for the areas to the west of the interface.

Current Issues

The safety and the hazards presented by gravel pit development continue to be an issue. We now have residential development underway to the west of the southern portion of the "sand

and gravel extraction area". An intercepting drainage ditch system has been installed along the buffer for dealing with the overland drainage. Excavation within the gravel pits is an issue as well. Environmental protections, long term reclamation and use as well as ongoing litigation are also issues.

Conclusion

The former Lafarge gravel pit in Coquitlam represents the kind of long term use possible once mining activity ceases. This hundred acre area is now the Town Centre Park with a stadium and Olympic style running track plus attendant facilities. A lake left by Lafarge bears the Company name. The lake is surrounded by walkways and is used for recreational activity. Our vision is that the gravel pits along Pipeline Road will eventually provide for recreational open space, although the slopes and elevations continue to make this a considerable challenge.

Mineral Aggregate Map Case Study, Alberta

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The Alberta Geological Survey has operated a mineral aggregate inventory program (AI) since 1976. Since 99% of the aggregate produced in Alberta is sand and gravel, the program has concentrated on unconsolidated granular deposits. Information gathered through our mapping and inventory program is transferred to clients in a variety of publication formats and map scales. Our experience is that a number of factors are important in the information transfer process. Some of these factors include: reliability of resource estimates (scale related), selection of data for display, terminology, format, style and timeliness.

Reliability of resource estimates (scale related)

Most aggregate information published by the Alberta Geological Survey has been in the form of maps. There should be a correlation between the scale of the published map and the reliability of the data presented, *i.e.*: the more detailed the data gathering process and the accuracy of the interpretation the larger the scale that may be used. In order to explain this concept to our primary clients (planners and land managers) we use a V level system to describe map scale and resource reliability. Level V assumes reconnaissance data gathering with little or no field checking (*i.e.*, could be remote sensing data). Level 5 maps are suitable for preliminary or broad regional planning. The other extreme is level I which assumes data gathering from a closely spaced grid of test holes and samples. Level I maps are suitable for establishing accurate reserves and supporting construction projects.

More aggregate information is now being transferred in digital form for use as one thematic layer on a multi-use product. GIS technology makes it easy to reproduce a map at any scale. This makes it even more important to place restrictions on the scale at which particular information can be displayed. A specific concern we have now is in the incorporation of different data sets (differing reliability) into a single map product and the difficult in determining appropriate use and scale.

Selection of data for display

Ideally the client should indicate what data should be displayed on the map and in what form. Unfortunately many clients depend on the geologist to provide a product which will meet their needs. Selection of data for the final map starts with the design of the field program and extends into the selection and interpretation of the data. Our approach is to prepare a simple, focused product for our primary client. We publish all our maps and have many users other than our primary client. One result of our approach is that our maps can appear clear in the eyes of some users but lack data for geologists who would be capable of making their own interpretations from raw data. It is tempting to produce a map which can, in theory, be used by a variety of users but this can result in an unnecessarily complex final map product. If a dynamic inventory is maintained, an underlying philosophy should be developed at the early stages which clearly links the data gathering process with the purpose and nature of the final product.

Presentation (Terminology, Format, Style)

Terminology used in the map or report must be clearly explained and if possible terms used from the clients vocabulary and field of expertise. This can in some cases result in the use of terms or display of information in a manner foreign to other geologists or users other than the primary client. As many maps or reports are used in multiple ways it is important that disclaimers, qualifying remarks, and definitions of terms are included. Map format and style can make the difference between a client making use of a product or discarding it in frustration. The best person to ask about style and format requirements are the client. If the client cannot articulate his/her requirements then a range of sample products should be provided from which the client can choose the best presentation. In the case of a long term inventory program, it is critical to select the most appropriate scale, format and style and then maintain this approach for the entire program. The basic map product of the AI is a stand alone, 1:50,000 scale map with an extended legend produced as a blue-line copy.

Three -Part Surficial Aggregate Assessment

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One way to systematically assess surficial aggregate (sand and gravel) deposits is by using three broad and interrelated activities similar to those developed by Singer (1993). The parts are simple to state; but are not always easy to do. They are as follows: (1) consistently define boundaries of tracts known or suspected to contain aggregate deposits, using regional surficial geology; (2) classify aggregate deposits by type, using characteristics important to end users and pit operators; and (3) estimate areas of known or suspected deposits. Alternatively, the number, not area, of suspected deposits might be estimated. Assessment involves the integration of these data by using a number of tools. Assessment products can include maps that show tracts containing discovered and undiscovered aggregate resources. With a little additional effort an estimate of the probable amount of aggregate remaining in the assessed region can also be provided. Uncertainty assigned to part of a regional aggregate assessment can not be eliminated, only reduced; therefore, the total amount of remaining aggregate forecast must be reported as a distribution.

Tracts represent the best definition of the outer boundaries of areas containing both known and undiscovered aggregate deposits. All significant deposits, prospects, and occurrences may be shown as well. Tract boundaries are based on geology, not aggregate deposits. The removal of all known deposits during tract preparation should **not** change the tract boundaries. Areas within a tract that has been exhaustively explored for aggregate deposits should be shown. Several types of tracts may possibly be needed for different subtypes of aggregate deposits based on surficial geology differences and other criteria consistently applied. Ideally, tract boundaries are prepared without concern about current surface use. Changes in surface status may occur which may make an area again available for aggregate extraction. Urbanization or other types of surface sterilization may make some areas impossible to be evaluated.

Classification of aggregate deposits by types, using deposit characteristics important to end users and pit operators, can be achieved by using mineral deposit models like those in Bliss and Page (1994). Models are simply cumulative distributions of data for deposit characteristics from representative samples of a particular type of aggregate deposit. One major deficiency in the models developed to date is that the data are from deposits defined without regard to suitability for use in terms of geotechnical characteristics (percent fines, grain-size distribution, durability, reactivity). Except in alluvial fans, deposits without these data can be described by using the **same** distribution of deposit volumes, areas, and thickness (Bliss and Page, 1994; figs. 2, 4-6).

The need to classify aggregate pit material, even approximately, must be stressed. Many pits have material that is only suitable as a source of construction fill material, not aggregate. Substantial simplifications and savings in effort may be possible if assessments and models address only deposits that meet, or are readily upgraded to, specific geotechnical standards. Tract boundaries may be affected as well.

Surficial aggregate deposits resemble uneven blankets--most of the variability in volume is related to the variability in area, not thickness. If the area of a deposit can be estimated, volume can also be estimated by using a simple regression equation (Bliss and Page, 1994; eq. 2). Estimates of the area of extension can be made for known deposits and for recognized but unworked deposits. Better estimates of volume are possible with thickness data. An estimate of the number (or surface area) is more difficult when the aggregate deposits are not currently recognized. Undiscovered deposits should be expected to occur unless a tract has been exhaustively searched. A guide for estimating area was developed for fine-grained aggregate deposits that meet, or can be upgraded to meet, ASTM standard C-33 in the coastal plain of Georgia. The area of deposits there has been calculated as a percentage of area of a county (between 50,000 and 300,000 ha) and modeled. In that regionally extensive tract, 80 percent of the counties have deposits underlying between 0.0019 and 0.16 percent of their surface areas. That model suggests that estimates of sum of deposit areas should not total more than one percent of the delineated tract area for this deposit type.

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Modeling Aggregate Resource Potential, Vancouver Island, British Columbia

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Rapid urban growth in certain areas of British Columbia, particularly the Lower Mainland, has led to problems in managing aggregate resources. Failure to include aggregate potential in land-use planning may lead to sterilization of deposits and shortages in the supply of local aggregate. The development of a quick, inexpensive and accurate method of defining new potential sources of aggregate will help to ensure the continuing supply of local aggregate far into the future. The first step in developing such a method is to develop a model for aggregate deposits. This paper reviews progress in modeling aggregate potential for Vancouver Island, British Columbia.

Gravel pits on Vancouver Island can be broadly divided into two types, publicly or privately owned. The locations of privately owned sand and gravel pits in B.C. are on record with the Ministry of Energy, Mines and Petroleum Resources. The records comprise a digital database inventory now being compiled that can be used to generate maps (1:50,000 scale) of pit locations for Vancouver Island. Maps of pit locations were then overlain onto terrain-landform maps also available at 1:50,000 scale (produced by the Ministry of Environment, Lands and Parks). The landform hosting individual pits was determined. Landforms identified were simplified into the following categories: glaciofluvial (undifferentiated), glaciofluvial fan, glaciofluvial plain, glaciofluvial terrace, fluvial (undifferentiated), fluvial fan, fluvial terrace, marine, moraine, colluvial and organic. The polygon for each landform hosting a pit was digitized by hand to determine the surface area.

Locations and volumes for most publicly owned pits in British Columbia are stored in databases in the Ministry of Transportation and Highways. Locations and volumes of public pits located in landforms hosting privately owned pits were obtained and tabulated according to the landform within which they occur. A total of 150 private pits were identified; hosted in 86 separate landforms. Twenty-three publicly owned pits with deposit volume and location information were also found to be hosted by these landforms.

Glaciofluvial (undifferentiated) landforms host 49 public and private pits, the most of the 11 landform categories. Other landforms that are important in hosting pits are glaciofluvial fans (29 pits), marine landforms (20 pits), and fluvial fans (19 pits). In terms of surface area, marine landforms have the largest total surface area (11 285 ha), followed by morainal (9498 ha) and glaciofluvial (undifferentiated) (8933 ha) landforms. For the same categories, the mean surface area is largest for morainal (1055 ha), colluvial (972 ha) and marine (752 ha) landforms. However, the importance of each landform category in terms of volume of sand and gravel deposits differs. In this case, glaciofluvial (undifferentiated) landforms contain the largest total volume of sand and gravel deposits (2,575,250 m^3) followed by fluvial fan (1,364,993 m^3) and glaciofluvial fan (1,004,786 m^3) categories. Mean deposit volumes are largest in marine (550,000 m^3), fluvial fan (352,500 m^3) and glaciofluvial (undifferentiated) (319,406 m^3) landforms. However, given the large standard deviation in both surface area (656 ha) and volume (385,350 m^3) statistics, there is no significant difference (a=0.05) in either mean landform surface area or deposit volume for the different landforms on Vancouver Island.

The distribution of both the volume of deposits and area of landforms hosting the deposits were found to be not significantly different (a=0.05) from lognormal. However, there is no correlation between volume and area. Previous studies using data from areas other than B.C. have shown surface area and volume to be strongly correlated. If correct, our poor correlation may indicate biased sampling procedures for area.

The method of analysis employed in the area-volume correlation relied only the landforms hosting both private and public pits. Volumes were determined from publicly owned pits and areas were determined from the landform hosting those pits. However, we did not use all the landforms which host since volume data was incomplete. A comparison of the mean surface area of the landforms used (664 ha) against those not used (527 ha) demonstrates that smaller landforms were omitted in the correlation analysis.

One factor contributing to the poor correlation could be that polygon landforms on terrain maps do not define deposits, but rather support partial host deposits. As such it may not be meaningful to relate landform surface area to deposit volume. A better relationship may occur between the total volume of all deposits in a landform and landform surface area.

The results of this study are of interest because the landforms that appear most important as deposit hosts on Vancouver Island are not necessarily those that are important elsewhere. In particular, the importance of marine deposits in coastal environments which are absent elsewhere, demonstrates that local testing and refining of generalized sand and gravel deposit models is important. The lack of correlation between deposit volume and landform surface area suggests that this may not be a useful comparison. The method used in this study may be important in future studies, however, larger sample sizes are clearly necessary to define the surface area-volume correlation.

APPENDIX 2:

REPORTS FROM WORKSHOP GROUPS, FRIDAY MARCH 31, 1995

Fraser Room, Rooms A and B, Executive Inn, Richmond

Schedule

9:00 - 9:15	**Introduction and organization of the day**
9:15 - 12:00	**Break into WORKING GROUPS**
10:30	**COFFEE**
12:00 - 1:30	**LUNCH**
	(facilitators and reporters to prepare reports)
1:30 - 3:00	**Reassemble in Fraser Room.** (Working groups to report)
	(15 min report, 15 min general discussion).
3:00 - 3:15	**COFFEE**
3:15 - 4:30	**Concluding discussion**

Workshop Group 1:

Aggregate Resource Inventory

Facilitator:	Paul Matysek, MEMPR
Reporter:	Brian Bowman, UNBC
Other Members:	David Beeby, CGS, California
	Ed Beswick, MEMPR
	R.G. Buchanan, MoTH
	Robert Gowan, DIAND
	Barry Irvine, Construction Aggregates
	Jason Jackson, MoTH
	Bill Langer, USGS
	Alex Matheson, MEMPR
	Richard Poulin, UBC
	Greg Reid, Golder Associates
	Dave Smith, Thurber Engineering
	Len Thony, MoTH

1) Clients for an aggregate inventory:

- Ministry of Energy, Mines and Petroleum Resources
- Ministry of Transportation and Highways
- Ministry of Environment, Lands and Parks
- Ministry of Municipal Affairs
- First Nations
- Municipalities
- Regional Districts
- Private Industry (Producers, Developers, Construction)
- Realtors
- Bankers
- Consultants
- Universities/Colleges

2) The primary uses for the inventory will be for:

a) Planning - at local, regional and provincial levels
b) Preparation of aggregate potential maps
c) Regulatory agencies

3) Major considerations in developing the inventory:

a) User demand - must be enough demand to make the data worthwhile to collect and maintain
b) Costs of initial compilation and of maintenance
c) Time expenditure
d) Updating - inventory must be easy to maintain with periodic updates
e) Value
f) Format - digital, hardcopy maps (scale)
g) Availability/distribution

4) Inventory should contain the following information:

	Available	Needed
Location	*	
Sand & gravel or crushed stone		*
Highest past use	*	
Employment data	*	
Reserve estimate	*	
Reserve resources	*	
Date of record	*	
Information source	*	
Reference identification #	*	
Ownership	*	
Overburden thickness		*
Status (inactive/active/closed/reclaimed)		*

The following factors were also considered but rejected at this time:

Pit Geometry
Deleterious materials
Percent oversized material
Thickness
Proximity to rail or road
Elevation
Crown Land Lease
Ground water depth and flow
Mining techniques
Land use
Landform/terrain unit
Use of materials

5) Key Points for developing the inventory:

a) One inventory - one agency. Work towards integration of all inventory data into one database via agreements between agencies
b) Public Relations: to facilitate information gathering and dispersal. Relate with other agencies; data providers; consumers
c) Prioritize collection of data. To meet the need for aggregate management where encroaching development or competing uses may reduce future potential. Certain areas may have to be set aside for future detailed consideration
d) Continued communication with other jurisdictions such as Alberta, Ontario and California
e) Pilot project needed immediately
f) Do not develop a database with a considerable number of blank fields

Workshop Group 2:

Aggregate Potential Mapping

Facilitator:	Peter Bobrowsky, MEMPR
Reporter:	Doug Baker, UNBC
Other Members:	Bruce Crawford, MoTH
	Sheldon Harrington, MoTH
	Dan Hora, MEMPR
	Bryan James, MoTH
	Steve Likeness, MoTH
	Sandy Martin UBC
	Ray Pichette, Ontario
	David Servage, Terus Construction
	Ted Simmons, Butler Bros.
	Don Stewart, Planning Initiatives
	Gerald Tooley, Yukon
	Doug VanDine, Consultant
	Terry Vaughn-Thomas, Consultant

Introduction

Basic inventory information (Workshop Group One) currently being compiled by MEMPR can be supplemented with geological, geotechnical and hydrogeological data, statistically manipulated (Workshop Group Three) and subsequently displayed in a map format as Aggregate Potential Maps. The intent of the aggregate potential maps is to illustrate existing aggregate pits and deposits, delineate potential deposits and provide an objective first approximation as to the relative likelihood of aggregate utility. Further testing is imperative for the map users. Map products can theoretically vary in scale from 1:1,000,000 to 1:1,000 depending on the project objectives.

Key Points:

- Aggregate database must be centralized. Currently information is widely distributed and 'piece meal' within several provincial ministries, branches and local government offices.
- All information generated in an 'Aggregate Program' must be made easily accessible to all users of the database including various governments, industry and the public.
- A complete database should be cost-recoverable, since compilation of the database may require buying and selling of partial and disparate databases.

Aggregate Potential Mapping

Background

The Alberta Geological Survey (AGS) has established a precedence in this regard and their mapping scheme provides a good model from which to initiate a similar program in British Columbia. Briefly, the AGS recognize five levels of aggregate potential information which can be illustrated in map form (I - detailed to V - general).

The preferred level of mapping in British Columbia is Level III; however, in certain cases Levels IV and V may be sufficient.

Partnerships

Actual map production for high priority areas in the province will require cooperative efforts from several interested parties to develop a basic inventory. The Ministry of Energy, Mines and Petroleum Resources (MEMPR) should take the lead role in the program, with significant support from the Ministry of Transportation and Highways (MoTH), and lesser effort from the Ministry of Forests (MOF), aggregate producers and municipalities.

Clients/Users of Maps

All of the parties identified as being integral in the production of Aggregate Potential Maps were also recognized as playing important roles as users of the data. Others can be added to this list of information clients. Map level of information which is preferred for each client is given in the brackets. In no particular order, identified clients include:

- producers (III)
- MoTH (III-V)
- MOF (III-V)
- planners - municipalities, regional districts, First Nations (II-III)
- land developers/Realtors (III-V)
- consultants (III)
- MEMPR (III-V)

Map Requirements

Discussion identified a suite of characters which should be used in a complete Level I style of map. These include:

- water level-water wells
- petrography
- gradation
- deposit type
- deposit depth
- exposures
- pits (active and inactive)

Realistically, information for many of these parameters either does not exist or cannot be collected for integration into an aggregate potential map.

Parameters for Ranking and Assessing Potential

Productive discussion by the participants resulted in the identification of several parameters which should be evaluated in ranking and assessing the aggregate potential of specific deposits. Individual parameters should be weighted (possible weighting factors given in brackets, 3 high to 1 low). In no particular order these include:

- thickness (3)
- sand and gravel content (%) (3)
- deposit type (3)
- overburden thickness (2)
- ground water (2)
- quality (2)
- bedrock (1)

Again, realistically, information pertinent to many of these parameters either does not exist, cannot be collected or is too expensive to obtain. The parameters used will, therefore, vary from area to area and will further limit inter-area comparisons.

Methodology for Ranking and Assessing Aggregate Potential

Following amalgamation of the inventory and supplementary data, three questions must be addressed in providing a final ranking and assessment of aggregate deposit potential:

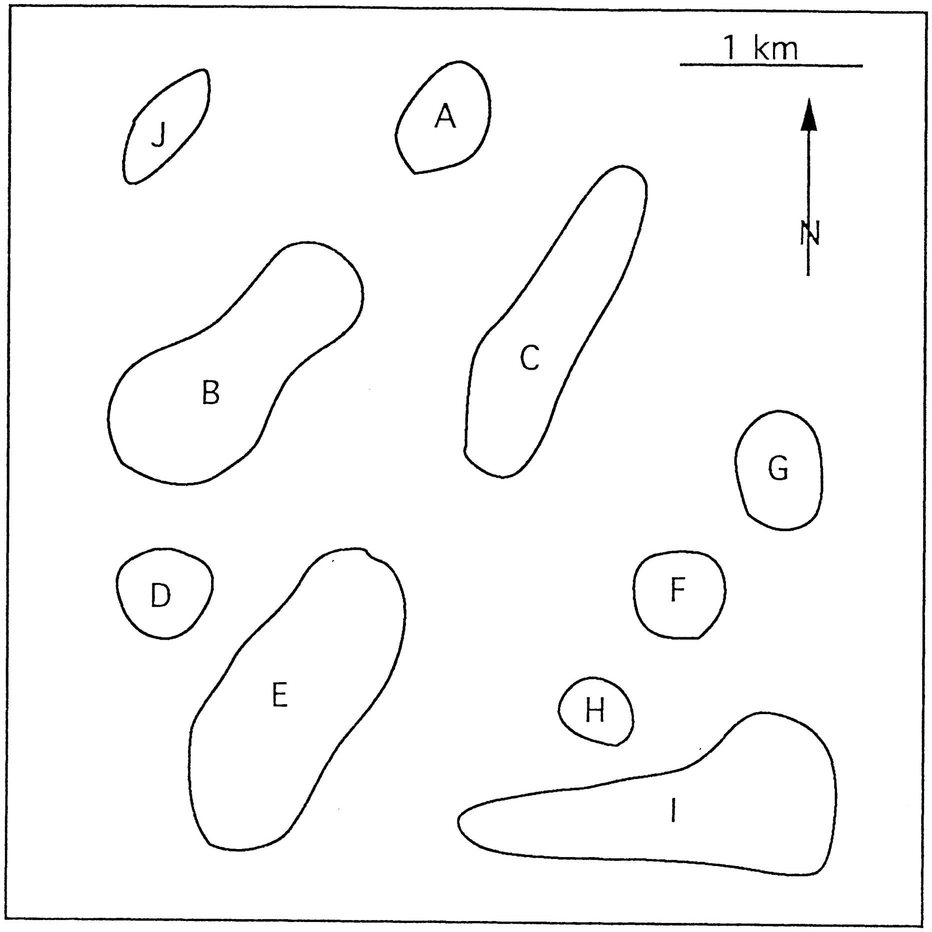
a) how do we rank the data?

b) how do we compare the parameters with respect to weighting?

c) how do we tally the ranking?

Assessment Matrices

Members of the Working Group proposed the use of assessment matrices. Each of the parameters used in any one area, for example, thickness, deposit type, sand and gravel content and quality would first be evaluated against its own matrix (Figure 1). The 3 x 3 matrix would consist of points accrued for probability [H (3), M (2) and L (1)] of occurrence along one axis measured against the H (3), M (2) and L (1) characteristics of the parameter.



POLYGON	% GRAVEL	RANK
A	20	6
B	40	5
C	5	9
D	10	8.5
E	15	7
F	85	1
G	80	2
H	70	3
I	10	8.5
J	65	4

Figure 1: Possible assessment matrix for deposit quality (gravel content).

THICKNESS	> 20 m (value = 3)	10-20 m (value = 2)	< 10 m (value = 1)
PROBABILITY			
High (value = 3)	A		
Medium (value = 2)			B
Low (value = 1)		C	
	Cell Sums	***Weighting***	***Total***
Polygon A=	3+3	x2	(=12)
Polygon B=	2+1	x2	(=6)
Polygon C=	1+2	x2	(=6)

DEPOSIT TYPE	Glaciofluvial (v = 3)	Alluvial (v = 2)	Marine (v = 1)
PROBABILITY			
High (v = 3)		A	C
Medium (v = 2)	B		
Low (v = 1)			
	Cell Sums	***Weighting***	***Total***
Polygon A=	2+3	x1	(=5)
Polygon B=	2+3	x1	(=5)
Polygon C=	3+1	x1	(=4)

% GRAVEL	> 65% (v = 3)	35-65% (v = 2)	< 35% (v = 1)
PROBABILITY			
High (v = 3)	B		C
Medium (v = 2)		A	
Low (v = 1)			
	Cell Sums	***Weighting***	***Total***
Polygon A=	2+2	x3	(=12)
Polygon B=	3+3	x3	(=18)
Polygon C=	3+1	x3	(=12)

FINAL VALUES

POLYGON	CATEGORY TOTALS	RANK
A	12+5+12=29	1.5
B	6+5+18=29	1.5
C	6+4+12=22	3

Figure 2: Example calculation of scores for three polygons (A, B and C) for the three parameters thickness, deposit type, and gravel content. Total scores are presented as weighted sums (using the possible scheme - thickness x 2; deposit type x 1; gravel content x 3).

PROBABILITY / THICKNESS	> 20 m (value = 3)	10-20 m (value = 2)	< 10 m (value = 1)
High (value = 3)	A		
Medium (value = 2)			B
Low (value = 1)		C	

	Multiplied Cells	*Weighting*	*Total*
Polygon A=	3x3	x2	(=18)
Polygon B=	2x1	x2	(=4)
Polygon C=	1x2	x2	(=4)

PROBABILITY / DEPOSIT TYPE	*Glaciofluvial (v = 3)*	*Alluvial (v = 2)*	*Marine (v = 1)*
High (v = 3)		A	C
Medium (v = 2)	B		
Low (v = 1)			

	Multiplied Cells	*Weighting*	*Total*
Polygon A=	3x2	x1	(=6)
Polygon B=	2x3	x1	(=6)
Polygon C=	1x3	x1	(=3)

PROBABILITY / % GRAVEL	*> 65% (v = 3)*	*35-65% (v = 2)*	*< 35% (v = 1)*
High (v = 3)	B		C
Medium (v = 2)		A	
Low (v = 1)			

	Multiplied Cells	*Weighting*	*Total*
Polygon A=	2x2	x3	(=12)
Polygon B=	3x3	x3	(=27)
Polygon C=	3x1	x3	(=9)

FINAL VALUES

POLYGON	CATEGORY TOTALS	RANK
A	18+6+12=36	2
B	4+6+27=37	1
C	4+3+9=16	3

Figure 3: Example calculation of scores for three polygons (A, B and C) for the three parameters thickness, deposit type, and gravel content. Total scores are presented as weighted multiplication (using the possible scheme - thickness x 2; deposit type x 1; gravel content x 3).

Polygons would be placed in appropriate cells within the nine possible choices of the matrix and an appropriate score calculated (Figure 1). A methodological question arises as to whether the x and y axes be summed or multiplied. In the examples the axes are summed (Figure 2) and multiplied (Figure 3) to obtain the scores for the various polygons.

Scores from each matrix could be weighted depending upon the importance of the parameter evaluated. Lastly, all weighted scores for an individual polygon would be summed for a final tally. Polygons could then be ranked from highest to lowest, providing a semi-quantitative method of assessing aggregate potential.

Workshop Group 3:

Quantitative Aggregate Resource Mapping

Facilitator:	Nick Massey, MEMPR
Reporter:	Jim Place, MoTH
Other Members:	Jim Bliss, USGS
	Dixon Edwards, Alberta
	Dave Handel, MoTH
	Chris Smith, MoTH
	Wayne Miller, MoTH
	Dave Proudfoot, Consultant
	Gavin Manson, UVic
	Dilsher Virk, Consultant
	Fred Shriner
	Oliver Vagt, NR Canada

1) Do we need quantitative aggregate potential maps?

Yes. Even though MoTH personnel are satisfied that the data they currently maintain is adequate to meet their mandate, they and other participants recognized that aggregate resource potential maps would be of value to a large number of clients.

2) Who are the likely clients for quantitative aggregate potential maps?

The group identified a large and varied group of clients and users of aggregate potential maps and other aggregate information. These include, but are not restricted to:

- Ministry of Transportation and Highways
- Municipalities
- Regional Districts
- Forest Companies
- Construction Industry
- Aggregate Producers

MoTH is an unique agency since it routinely obtains aggregate information internally, using its own personnel. It is, therefore, both an aggregate map client and an important source of data for map compilation. The remaining clients may support some aggregate data of their own, but primarily rely on external sources for most of their needs.

3) Scale of maps.

The scale of any maps should be client driven and could vary from project to project. For a municipality, the maps should be at the same scale as that normally used by that municipality for its other mapped data. For general maps, a scale of 1:50 000 was recognized as useful, or 1:20 000 where TRIM basemaps and aggregate data are readily available. The use of GIS technology in the compilation of the data, however, can allow for variable scale production so long as data integrity is not compromised.

4) What makes these maps "quantitative"?

The basic map would outline the terrain landforms that potentially host economic sand and gravel deposits. Above and beyond this, the target level of information would be at least equivalent to Level III in the Alberta scheme. However, there will be a varying distribution in the quality and type of data available within any project area ranging from levels I to V. This is unavoidable in the absence of new field studies. The variability should be clearly indicated on the map.

5) What data types should be included on the compilation of the maps?

There are several types of information that are required on a map:

a) Areas of potential aggregate resources. These polygons are essentially based on landforms or terrain units known to host, or have potential to host, sand and gravel of economic interest. The minimum size of the polygons will be scale dependent.

b) The areas should be classified according to the deposit type.

c) The volume/shape of the aggregate body should be calculated and indicated. This can be derived from various data sources including test pits, water wells, drill holes, geophysics, and so on. The individual data points need not be included in the final map, but the data could be made available as a separate database. The calculated volume should not be shown as an absolute value, but rather indicated categorically within a range (small, moderate, large, extensive; A, B, C, and so on). The reliability of the estimate should also be indicated on each map.

d) Where available, geotechnical data should be summarized. Grain size characteristics of the deposits is essential, as are indications of the quality of the aggregate.

e) Some clear indication of the reliability/uncertainty is essential, especially if problems of liability are to be avoided.

f) Sites of pits and quarries - derived from the basic inventory.

g) Compilation of all data in a GIS will allow for customization of the final product to suit the needs and requirements of the client.

6) Who should deliver the maps?

Several options were identified by the Working Group, with the following conclusions:

a) The project should be delivered by a single public agency.

b) The agency should be supervised by a multiagency/ministry advisory committee "with teeth".

c) The Geological Survey Branch was considered the most suited candidate for the task. The recommendation by participants was based on several considerations including the Ministry's active role in aggregate issues (*e.g.*, through Notices of Work, current inventory program), expertise in surficial mapping, and recognized economic neutrality in the use of aggregate resources.

7) Who should comprise the multiagency advisory committee?

The advisory committee should be made up of a combination of data suppliers and data users. However, the representation should be effective, that is, the members must be authorized to supply any data that is required by the project.

Minimally, representation should include:

- Ministry of Transportation and Highways
- Ministry of Forests
- Planners - municipal or regional district
- Consultants (producer, developer)

The advisory committee may meet once or twice at the initiation of the project, but then should only need to convene every several months or as required to assess project milestones.

8) An action plan is required for implementing the aggregate potential mapping project.

The group suggested the following outline of an action plan to initiate the aggregate resource potential mapping project:

- High-level agreement (MOU) between relevant agencies to access and share data. The MOU is critical to the success of the project; without which there is little guarantee of success.
- A pilot project needs to be established. The group recognized that there is some urgency to have the project begin and suggested the pilot project be completed within the next year. The process is summarized in the accompanying flow chart (Figure 4):
- Products should include: a) a map; hardcopy and digital versions; the map could be customized to the clients needs; b) a technical report describing the final map, the data types, the compilation procedure, and reliability of data and interpretation; and c) a second report with recommendations for future projects.
- Based on the outcome of the pilot study, the decision should be made whether to proceed to study other areas of the Province, priorize the areas, and seek funding.

9) The Lower Mainland was recognized as a separate and special issue.

The distribution of aggregate, high population density, and variable land-use strategies in the Lower Mainland are not readily resolvable by aggregate potential mapping. A pilot project should thus be located elsewhere in B.C. The group felt, however, that the Lower Mainland should not be ignored, but needs to be dealt with at the policy level, rather than the technical level. The effects of sterilization of aggregate resources in the Lower Mainland can serve as a valuable case study when dealing with other jurisdictions.

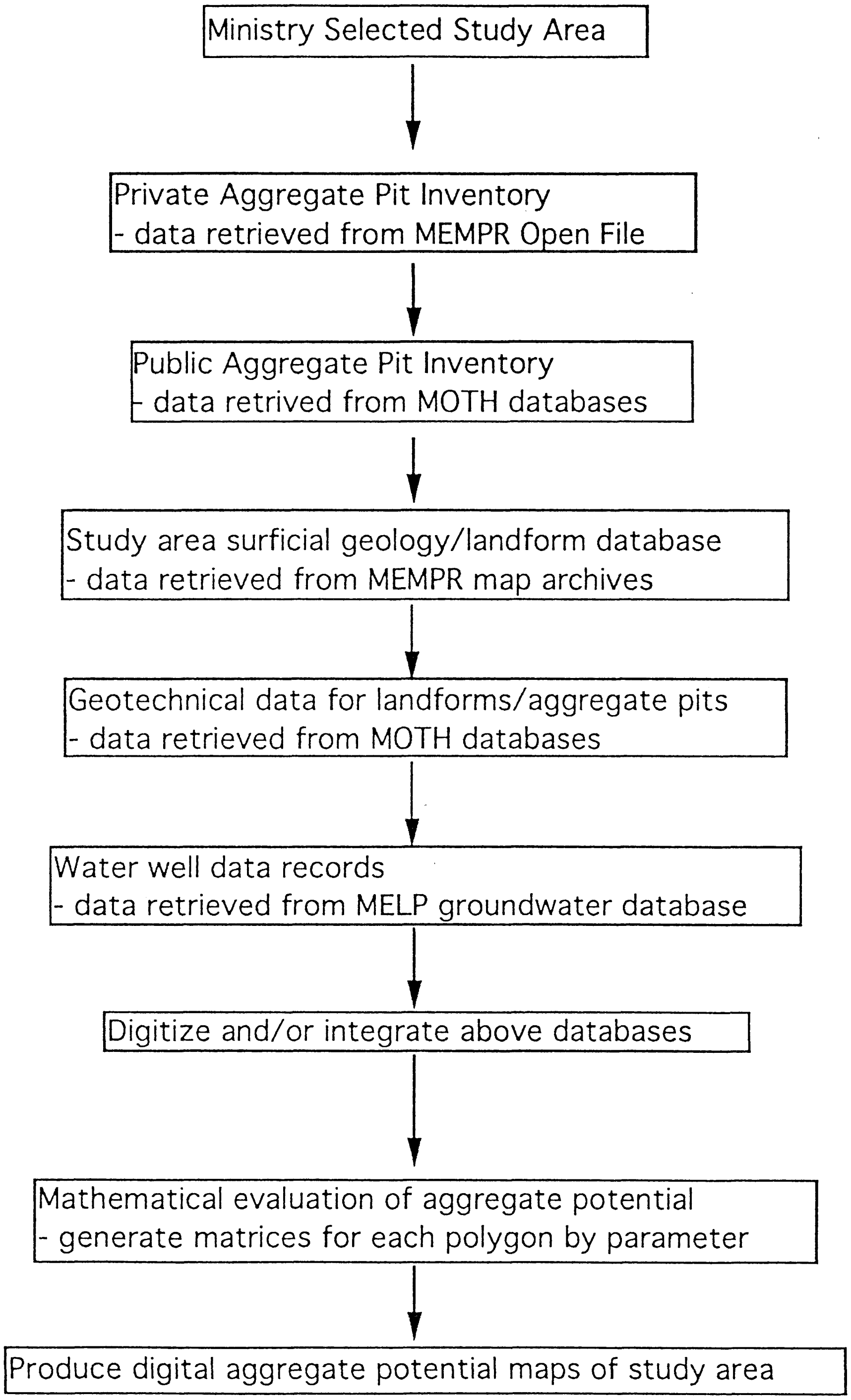


Figure 4: Proposed flow chart for production of pilot project aggregate potential maps.

APPENDIX 3:

AGGREGATE FORUM QUESTIONNAIRE

Participants in the forum were asked to complete a questionnaire as a means of capturing extra feedback. The questionnaire is reproduced here in with an accompanying brief analysis of the responses.

Questionnaire

This questionnaire is designed to help define the need for aggregate resource mapping in British Columbia. By answering the questions you will help the Ministry of Energy, Mines and Petroleum Resources to determine the users, value and current demand for aggregate resource data.

Your response is very important to us. Please check the appropriate boxes. You may make the response anonymously by tearing off the address sheet and submitting it separately.

Personal Background

I am employed by/as:

Min. of Transportation and Highways
Municipal or Regional Govt
Min. of Forests
Aggregate Producing Industry
Min. of Energy, Mines & Petrol. Res.
Engineering/Geotechnical Consult.
Other Provincial Govt
Federal Govt
Other - please specify

How do you use aggregate resource data?:

Aggregate Production
Aggregate Exploration
Land use planning - regional
Land use planning - municipal
Highway Construction
Other Construction
Other - please specify

Which area of B.C. are you primarily concerned with:

Lower Mainland
Fraser Valley
Southern Vancouver Island
Eastern Vancouver Island
Okanagan
All of B.C.
Other - please specify

Present use of Aggregate data

Do you or your organization use aggregate resource data of any sort in your work?

What sort of data do you use and where do you presently obtain such information?

Are these data sufficient for your needs? If not, how are they deficient?

Value of Aggregate Resource Inventory

The Ministry of Energy, Mines and Petroleum Resources is presently compiling an inventory of privately owned aggregate pits (past and present producers). The Ministry of Transportation and Highways is also compiling a similar inventory for pits in the public sector.

Would these inventories be of use to you and your organization?

What purposes would the inventories serve?

What data format would be most useful to you? Rate most (1) to least (4) useful:

digital database in a standard format (*e.g.*, dBase, Excel, FoxPro, *etc.*)

digital database with custom search/edit functions

hardcopy maps

digital maps

Value of Aggregate Resource Maps

Aggregate resource maps have been produced by in several jurisdictions in Canada and elsewhere in the world. The maps document the geological units that are known to be presently producing aggregate or could produce aggregate in the near future. Such maps may be descriptive, consisting of present resources, or they include some assessment of the aggregate potential. Potential can be expressed qualitatively (*e.g.*, high/medium/low, *etc.*) or quantitatively (*e.g.*, based on probabilistic estimates of the untested resources).

Do you think that aggregate resource maps are needed in your jurisdiction or area of interest?

Would your organization use aggregate resource maps if they were available?

How would you use aggregate resource maps?

What scale of aggregate resource mapping would be most applicable to your organization?

1: 5,000 (city lot scale)	1:10,000
1:20,000 (city block scale)	1:50,000 (municipality scale)
1:100,000	1:250,000 (regional scale)

What areas of B.C. should be prioritized for aggregate resource mapping? Rate highest (1) to lowest (6)

Lower Mainland

Fraser Valley

Southern Vancouver Island

Eastern Vancouver Island

Okanagan

Other - please specify

Format of Aggregate Resource maps

What sort of aggregate resource data do you need?

Presently known resources only

Qualitative assessment of potential aggregate resource (high/medium/low)

Quantitative (probabilistic) assessment of potential aggregate resource (tonnes of gravel)

Other - please specify

In what format would you find the data most useful?

hardcopy maps

digital maps

both

Which of the following geological information should aggregate resource maps include?

locations of pits (past producers)

locations of pits (present producers)

rock quarries (for crushed rock), past producers

rock quarries (for crushed rock), present producers

outlines of geological units presently producing sand and gravel

outlines of geological units presently producing crush rock

outlines of geological units assessed to be potential future producers of sand and gravel

outlines of geological units assessed to be potential future producers of crush rock

locations of test drill holes and water wells

drill hole results (overburden depth, thickness of aggregate, gravel/sand/fines ratios, *etc.*)

potential offshore resources, where applicable

other information - specify

Which of the following socio-economic information should aggregate resource maps include?

municipal boundaries

Agricultural Land Reserve

areas presently developed (residential, commercial, schools, *etc.*)

major transportation routes

other information - specify

Demand for Aggregate Resource Maps

What do you consider the major hurdles to implementing an aggregate resource mapping program in your jurisdiction? Rate (1) highest to (5) lowest:

Funding

Liability

Expertise

Political will

Other - specify

Would your organization be willing to contribute funds toward an aggregate resource mapping program in your jurisdiction?

Would your agency collaborate with another agency such as the B.C. Geological Survey Branch to produce aggregate resource maps for your jurisdiction by sharing of human resources for data collection, data entry, GIS applications, etc.?

Do you think aggregate resource maps should be produced by (rate from highest (1) to lowest (4)):

one agency alone

one agency under the guidance of a multi-agency coordination committee

a consortium of several agencies with a joint technical liaison committee

a number of unrelated agencies using identical standards

If a coordination, technical liaison or standards development team is created, who should be represented?

Provincial Government

Min. of Transportation and Highways

Min. of Energy, Mines & Petroleum Resources

Min. of Forests

Min. of Environment, Lands & Parks

Min. of Municipal Affairs

Federal Government

Municipal and Regional Governments

Universities

Aggregate Producers

Geotechnical and Engineering Consultants

Others - please specify

Other comments

QUESTIONNAIRE RES UI

Thirty-eight questionnaires were returned at summarized below.

- A majority of respondents said they used aggregate dat most said the existing data are insufficient for their needs
- 84% agreed that a provincial inventory of aggregate reso ce that it be in a standard database format (*e.g.*, dBase, Exc also identified a need for hardcopy maps.
- 92% of respondents thought that aggregate resource ma s useful to their work. About half of these would prefer th significant minority also suggesting 1:20 000 or 1:10 000. maps were needed; 50% quantitative maps.
- Funding and lack of political will were identified as the two production of aggregate potential maps. Although the majori production of the maps, few were willing to contribute funds.
- The majority favored the production of these maps by a sir agency supervisory/coordination committee.

The individual respondents were drawn from aggregate producers (3% planners (8%), MoTH (30%), MEMPR (10%) and others (10%).

APPENDIX 4:

AGGREGATE FORUM SPEAKERS CONTACT ADDRESSES