

**LOWER MAINLAND AGGREGATES
DEMAND STUDY**

VOLUME I

AGGREGATE SUPPLY AND CONSUMPTION

Prepared for:

B.C. Ministry of Employment and Investment
4th Floor - 1810 Blanshard Street
Victoria, B.C.
V8V 1X4

Attention: Mr. James E. Lewis, Economist

Under Contract 96-319

Prepared by:

Levelton Engineering Ltd.
#150 - 12791 Clarke Place
Richmond, Bc V6V 2H9

Principal: P.T. Seabrook, P. Eng.

In Cooperation with:

Coriolis Consulting Corp.
1505 - 1130 West Pender Street
Vancouver, BC V6E 4A4

Principal: Mr. J. Wollenberg

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SUMMARY

FOREWORD

The B.C. Ministry of Employment and Investment recognizes that aggregate is both a strategic and vital resource for the construction industry. In fact, on a province-wide basis, it is the highest volume industrial mineral commodity produced. MoEI is also aware that this is a non-renewable resource and that the available volume of this resource in supply proximity to the Lower Mainland is dwindling. This supply limitation will reflect as a cost increase for future construction. The development of new supply deposits will be restrained by a combination of land held in the Agricultural Land Reserve and other restrictive zoning, environmental factors, and public resistance to the common noise, dust and traffic nuisance related to aggregate production.

A previous Study for the MoEI suggested that the aggregate supply industry was poorly administered in that it was subject to regulations from many, possibly 8, governmental groups and that it had no demand-side planning.

This Study was undertaken to:

- forecast aggregate consumption;
- develop and understanding of resource constraints;
- contribute ideas for a smoother management process;
- assist governments in strategic planning of aggregate supply and demand to mate with urban development.

The Study therefore had two components - an engineering assessment and an economic modelling - and is presented as two reports. The engineering was completed by Levelton Engineering Ltd. and is presented in Volume I; the modelling by Coriolis Consulting Corp. is presented in Volume II. The two components are designed to be an integrated demand study.

AGGREGATE SUPPLY TO THE LOWER MAINLAND

The study area encompasses the entire Lower Mainland but can logically be subdivided into two component areas, the Fraser Valley and eastern portions of the GVRD that are supplied by local land-based deposits, and the western portion of the GVRD, which is supplied largely via waterborne transportation from coastal deposits north of the Lower Mainland.

Waterborne aggregate supplies remain plentiful. However, inland pits and quarries, within reasonable proximity to city and town centres, are critical to maintain reasonable costs for infrastructure and urban growth and maintenance further inland. Without these local sources, costs escalate rapidly in proportion to increased transport distance to demand delivery points.

It was determined that aggregate production could be divided into the following species; their relative volumes are indicated.

Species	Processing	1995 Production, Tonnes x 1000	Production, % of Total
Premium aggregate	crush, wash, screen (e.g. concrete aggregate)	4,800	19
Road and asphalt	crush, screen, blend some shotrock	7,000	28
Bulk fill	largely unprocessed; may be screened to reject oversize	3,400	14
Shotrock	blasted from quarry and screened	3,400	14
Dredge sand	none, fill only	4,000	17
Miscellaneous not directly accounted		2,000 estimate	8
Totals		25,000	

The 25,000,000 tonnes annual production represents about 12 tonnes per person per year. Of this, 66% is sourced within the GVRD.

In recent years, there has been an increasing use of crushed quarry rock as a supplement to natural aggregate. This use is driven by both a shortage of rock in many pits and specifications requiring more rock for better quality end products. Quarry rock is a significant cost premium.

The above species were used in the development of unit aggregate usage for various types of construction. These units then became part of the forecasting model by Coriolis.

A list of all the groups contacted for this Study is included in Appendix A, Volume I. This is an extensive list which represents all categories of stakeholders, both public and private.

Some stakeholders were unable to provide information in a form appropriate for this study. For example, aggregate consumption by municipalities is tracked in a number of ways and in many municipalities is not well recorded in a useful format. As a result, only a few representative municipalities were able to supply the information required. Municipalities, as a group, are the highest aggregate usage sector; their needs are for combined road maintenance, rehabilitation and new construction.

The City of Vancouver is a good example of satisfactory data collection and presentation techniques and should serve as a model for the remainder of the study area.

Collection of production data was achieved through discussion with the aggregate producers. With the exception of only one supplier, this information was very forthcoming. Regulatory agencies, including the Ministry and Crown Lands, and some municipalities, could not independently verify annual aggregate production volumes.

As indicated in the above table, dredge sand from the Fraser River is a major component of aggregate supply in the GVRD. It is really a separate component from pit aggregate sourcing. Consultation with the Canadian Coast Guard indicates that the available volume has dropped from historic levels (5,000,000 m³ per year to 3,500,000 m³) leading to an increased demand (with increased costs) for pit supply. Administration and control of dredging is far more comprehensive than that of land based operations.

THE AVAILABLE AGGREGATE RESOURCE

This study has determined that there are extensive reserves in coastal deposits, certainly greater than 25 years with present demand from the current sources, with the potential for additional sources in the Jervis Inlet area. However, supply to the Fraser Valley has reached a critical level with:

- seven years reserves remaining south of the Fraser River;

- ten years reserves remaining north of the River;

although these reserves are significantly dictated by municipal restraint on new pit openings.

The study has identified, consistent with the previous findings referenced in Introduction, that there are major constraints to the development of new pits or quarries or the expansion of existing sources. Fundamentally, aggregate sourcing is not welcome by the public in even remote proximity to populated areas, specifically those in the Fraser Valley. In fact, aggregate producers are of the opinion that no new pits will be opened in the study area.

Objections arise from both the noise and dust of the gravel processing and the truck haulage through urban roads. Interestingly, aggregate truck traffic is synonymous with any construction activity, including rehabilitation, and increases as haulage distances increase so forcing more remote sourcing means truck traffic.

Constraints include, in addition to the above:

- a perception (partly earned) that gravel pits are poor neighbours and result in improper ultimate land use;
- Agricultural Land Reserve infringement
- the need to deal with multilevels of government and multigroups within governments to get an aggregate sourcing permit, a process which takes years.

The fact that planned and responsible aggregate sourcing can be an integral component of effective long term land use is not recognized by planners.

Land use decisions which plan for the optimum use of mineral aggregates, are critical for reducing the long term costs in supplying aggregate, particularly since urban growth in the Lower Mainland without land-use/resource planning leads to sterilization of these resources. In the longer term, land use where aggregate resources once occurred can be redefined since aggregate operations are a temporary land use.

The study notes that both the Municipal Act and the Regional District's Growth Strategies Act require that aggregate sourcing be addressed in urban planning. Little evidence of such planning was identified here.

Factors impacting on demand

The Lower Mainland has historically been blessed with an abundant supply of high quality aggregate, relatively easy to process and transport. This availability has perhaps influenced the lack of planning for this resource. Today, many prime pits are depleted and transportation difficulties have added restraints.

The public has a stake in the proper planning of future aggregate use because the largest component of demand is for infrastructures. This component accounts for perhaps 75% of the total demand.

Included with the study's scope was consideration of future technological factors which would impact on demands. It was determined that:

- recycling is driven largely by public demand; industry's interest is entirely economic. The only current significant use is in recycled hot mix asphalt pavement in which roughly 1000,000 tonnes are removed from the overall demand, but at a small premium cost for the resulting mix. This is only 0.4% of the total demand;
- new use such as high performance concrete, will reduce the size of structural members but will demand higher quality aggregates and special production. However, this demand will not exceed 5% of the concrete or 1% of the aggregate market for the foreseeable future;
- on-site demolition use will increase in the GVRD, but its impact will be less than 0.7%.

It was anticipated that mega projects created a significant spike in demand curve. However, even the largest, the Vancouver International Airport Expansion at 2 million tonnes in its peak demand

year, was only 8% of the total demand. It was determined that most construction years had some mega project demand so there is a tendency to smooth out the spikes.

It was determined that aggregate demand growth was roughly proportional to population growth. The historic Lower Mainland demand is shown in the attached graph.

INDUSTRY PERSPECTIVE AND CONSTRAINTS

The aggregate production industry is a disparate mix of family/private and large corporate firms which until recently had no central voice. Even now, it is not homogenous. However, all operators share the following common concerns and frustrations:

- there are far too many regulators and agencies involved, up to 8 for a given application. The approval process is cascading and non-linear and can take 3 to 5 years to fulfil;
- there are overlapping and conflicting requirements;
- the industry has a poor image in the public eye (admittedly partly earned) and is not recognized as an important component in construction;
- there are increasing tax surcharges;
- some municipalities in the Fraser Valley have used pit operation restraints as part of a political agenda.

Levelton's position is that pits should be operated such that reclamation and therefore ultimate land use drives the excavation plan.

Most operators state that they would be more comfortable with regulation by one agency with a global perspective. This regulation would logically be through the Provincial Government who can adopt a more global perspective but, unfortunately, the negative impacts of aggregate production occur at the municipal level.

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ACRONYMS USED IN THIS REPORT

- ALC Agricultural Land Commission
- ALR Agricultural Land Reserve
- BIERC Burrard Inlet Environmental Review Committee
- DFO Department of Fisheries and Oceans
- FRHC Fraser River Harbour Commission
- FVRD Fraser River Regional District
- GVRD Greater Vancouver Regional District
- MoEI Ministry of Employment and Investment
- MoELP Ministry of Environment, Lands and Petroleum Resources
- MoMA Ministry of Municipal Affairs
- MoTH Ministry of Transportation and Highways
- PWC Public Works Canada

1.0 INTRODUCTION

The majority of mineral aggregates, with dredged materials the exception, are produced from non-renewable resources. Sand and gravel deposits in the area of the Lower Mainland and Fraser Valley are Quaternary Sediments laid down in the past 10,000 years since glaciation ice receded from the area. These have constituted the majority of aggregate sourcing since the commencement of construction in the Lower Mainland.

Aggregate is a vital resource used in residential, commercial and industrial building construction and in infrastructure projects. Historically, the Lower Mainland has had an abundant supply of sand and gravel of good quality and relatively low price; the price was dictated by cost of processing and proximity of the deposits to the market. Further development plus demands on supply, processing and transportation systems will inevitably lead to rising costs. Future development may also sterilize valuable resources such that they may remain unused forever. Long range-planning is necessary to help ensure that high-quality, economical supplies of aggregate are available in the future while protecting the public from unwanted environmental and safety concerns of gravel extraction.

The Ministry of Energy, Mines and Petroleum Resources (subsequently the MoEI) recognizes the depletion of historic sources and the lack of planning for replacement study. They are also aware that the aggregate supply industry is subject to regulation and administration that are neither consistent nor based on demand-side planning. In order to define and quantify the situation, the Ministry commissioned this study. It was directed by James E. Lewis, Economist, Land Management and Policy Branch, Mineral Resources Division.

The contract for this work was awarded to Levelton Associates in cooperation with Coriolis Consulting Corp. Levelton Associates' involvement focuses on the materials aspects of the study, Coriolis on the modelling.

This study presents an overview of the state of the mineral aggregate industry in the Lower Mainland. Focus is on historical supply and consumption from which forecasts will be made to predict future consumption to help the Provincial Government design a planning strategy for the best use of the resource.

A plan of the study area is presented as Figure 1. The area includes the Fraser Valley Regional District, Squamish-Lillooet and the Greater Vancouver Regional District. Areas such as the Sunshine Coast, Texada Island, Vancouver Island and Friday Harbour (United States) that supply aggregate to the study area are also considered.

Only aggregate that is consumed within the Lower Mainland is included in the demand here. Aggregate that is used internally within a construction project(s) (ie. Is excavated, then placed elsewhere on site or is transported from one site to another) is not included.

The study has two fundamental elements - engineering and economic forecasting. Results will be presented in this form.

Volume I - Aggregate Supply and Consumption (by Levelton).

Volume II - Development of a Model for Forecasting the Consumption of Aggregates (by Coriolis).

Volume III - Reference Material - these are copies of the reference material assembled during the study; they are intended for future MoEI use.

Volume IV - Provincial Management Process and Strategic Planning.

This report uses a number of acronyms. These are listed in the Table of Contents.

2.0 OBJECTIVES OF THE STUDY

The Ministry commissioned this study to achieve these objectives:

- “1. Forecast aggregate consumption (sand and gravel and crushed rock for construction purposes) as accurately as possible,
2. Encourage a more definitive understanding of current and future resource constraints,
3. Contribute ideas for improving the provincial management process and assist in the smooth functioning of the aggregate sector and
4. Assist in provincial, regional and municipal strategic planning regarding aggregate supply and demand and urban development.”

They further instructed that they required the modelling in such an interactive form that changes in demand patterns or the study's assumptions could be modified to update the demand forecasts. This study then forms a baseline for future modelling of aggregate supply and demand.

It was Levelton/Coriolis' interpretation of the above objectives that the Ministry wished to take a leadership role in modifying the management of this non-renewable resource so that future supplies of aggregate were available at reasonable cost to the study area. This management would develop the resource to the mutual but long term benefit of both the supply and consumption sides and of the public. The results of this study would provide the Ministry with the demand picture around which policy could be developed.

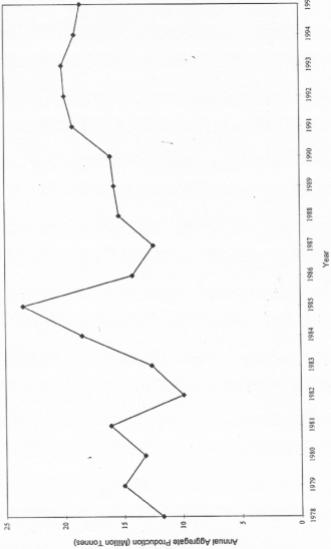
No comprehensive inventory of resource capability, consumption with specie separation and resource constraints, and no model for anticipating the impact on demand of changes in urban development is available. This study will provide the missing information and models.

The end result will be a forecast of consumption, an identification of sourcing restraints, a process for adjustment via modelling of demand:sourcing projections and, finally, a

commentary on avenues for provincial management and strategic planning. A substantial amount of reference information will be assembled for possible future use by the MoEI.

Finally, it is intended that this study form a baseline for future Lower Mainland Aggregate Resource Demand studies.

AGGREGATE PRODUCTION IN THE LOWER MAINLAND



3.0 ORGANIZATION OF THE STUDY

3.1 FORMAT

3.1.1 SPECIES OF AGGREGATE

This study is designed to provide estimates of past and current aggregate consumption as it relates to construction industry usage. It is the authors' position that aggregate demand cannot be considered without taking into account various species of aggregate. Sourcing, production and utilization will vary for the four species commonly required by the construction industry:

- Shotrock

This category includes limestone quarry rock used in the manufacture of cement along with the premium rock products such as railway ballast, clean crushed rock of various dimensions, rip rap, and crushed rock blended with sand for road base. These materials are subject to high levels of processing including crushing, screening and blending, and possibly washing.

- Premium Products

These products consist of washed, screened and blended aggregates such as fine and course concrete aggregate, masonry sand, drain rock and roofing (pea) gravel.

- Road Aggregates

The species of road aggregates includes screened pit run sand and gravel, blended base gravels and asphalt aggregate. These products may be crushed and are generally characterized as being well graded with less than 10 percent fines (primary silt sizes passing the 0.080 mm sieve).

Granular Fill

These materials consist of unprocessed bank run sands and gravels and dredged sand generally used as bulk fills. Typically, they are the lower cost materials because no processing is involved.

3.1.2 CONVERSION FACTORS

The aggregate industry generally uses metric tonnes as a basis for payment. Dredged materials from water bodies, however, are recorded in cubic metres. When estimating quantities of aggregate compacted in place, such as road gravels, the density of the materials has to be taken into account. Aggregate accounts for approximately 95 percent of asphaltic paving volumes and between 81 and 85 percent of concrete. Table 1 presents a summary of the conversion factors for various species used throughout the study.

TABLE 1

CONVERSION FACTORS

a) Primary

Species	Conversion (Tonnes/m ³)
Premium Aggregate	
Drain Rock	1.5
Concrete Aggregate	1.8
Concrete	2.4
Road Gravels	
Base and Subbase	1.8 (2.2 to 2.3 compacted)
Hot-mix Asphaltic Concrete	2.4
Dredged Sand	1.65 (1.8 compacted)

b) Supplementary

One cubic meter of concrete requires approximately	-	0.66 m ³ of course aggregate (stone)
	-	0.55 m ³ of fine aggregate (sand)
One tonne of hot mix asphalt requires approximately	-	0.52 m ³ of aggregate
One cubic foot	=	0.0283 m ³
One cubic yard	=	07646 m ³
One tonne	=	1000 kg
	=	2200 lbs

3.1.3 GROUPS CONTACTED

One of the objectives of this study is to gain an understanding of the state of the mineral aggregate industry as it exists today. In doing so it was necessary to contact a representative cross-section of stakeholders involved with the industry both from a supply and consumption perspective. A list of all the organizations contacted during this study is included in Appendix A.

3.2 METHODOLOGY

3.2.1 INDUSTRY SURVEY

A number of reports supplied by the Ministry were initially reviewed to gain an historical understanding of the mineral aggregate industry. Information summarized in these reports formed the basis from which relevant questions could be asked during interviews of producers. The report reviews and interviews were the main fact gathering procedures for this study. A bibliography of reports reviewed is included in Appendix B.

Organizations interviewed were selected to reflect the major components in the areas of supply, consumption and regulatory agencies.

A total of 13 aggregate producers were contacted and extensively interviewed to determine the total supply and species speciation of aggregate supplied to the Lower Mainland in 1995. Based on discussions with the Aggregate Producers Association and individual producers, it is the authors' opinion that the suppliers contacted represent greater than 90 percent of the mineral aggregate industry for the region.

In order to effectively estimate the consumption of various species of aggregate, a number of different approaches were used. To estimate quantities of ready-mix concrete used in various applications, the Canadian Portland Cement Association, B.C. Ready-Mix Association, ready-mix concrete suppliers in various regions, contractors and design engineers were contacted. In addition, the Portland Cement Association and the Washington Aggregates and Concrete Association in the United States were also interviewed to compare British Columbia concrete usage to that on a United States national and regional basis.

Statistical data supplied by the MoMA were invaluable in determining the amount of new road and sewer construction. To estimate quantities of aggregate used for this construction both municipal and consulting design engineers were interviewed.

The MoTH provided valuable information on their own aggregate sources in addition to current and projected consumption.

To determine the impacts of major projects, consultants and contractors involved in the design and construction of such projects were contacted.

The City of Vancouver maintains the most complete summary of aggregate usage of any Municipality interviewed. This information has provided the basis to determine past consumption and predict future needs for road maintenance and rehabilitation.

3.2.2 DATA ANALYSIS

The period for data collection was targeted as 1985 to 1995. Discussions within the project team and the Ministry revealed a consensus that this time period would allow a reasonable analysis of historic patterns of actual aggregate consumption in the Lower Mainland. These

data would form the basis of developing a model that correlates growth and construction activity with the consumption of aggregates.

It was initially proposed that data pertaining to the historic supply of the various species be obtained. Many producers, however, could not readily provide this information which resulted in modifying the methodology. Indications from the major suppliers of mineral aggregate were that similar percentages of aggregate species have been produced in the past. As a result this approach formed the basis of the historic percentages of species supplied. In addition to assessing the past and current supply trends, the following items were presented to the producers for discussion:

- Current operating reserves;
- Future plans for sourcing;
- Industry's perspective on constraints;
- Impacts of mega projects on supply and transportation systems;
- Transportation limitations and needs for economy of delivery;
- Consideration of impacts of new processing technology.

Historic construction growth and development patterns were analyzed within the study area for the same 10 year target period identified for supply of mineral aggregate. The historic trends analysis include the:

- Amount of residential (single and multifamily), office, retail and industrial development;
- Amount of infrastructure development as it pertains to rehabilitation and construction of new roads and services
- Population growth;

- Employment growth;
- Economic growth (as measured as the Gross Domestic Product of British Columbia);
- Identification of major construction projects which may have affected consumption of aggregate within the target period;
- consumption of portland cement.

The historic growth and development patterns are analyzed by sub-regions within the Lower Mainland.

3.2.3 TECHNOLOGICAL CHANGE

This study was to address the impact of technological change on future aggregate demand. Two components are:

- The impact of recycling as a cost and energy/resource conservation thrust;
- the improvements of materials engineering technology that would permit more efficient use of aggregates, for example the development of high strength concrete with corresponding reduction in structural member section size.

Levelton is involved in these technologies and conducted this part of the study largely from internal information. However, the City of Vancouver is a prime mover in recycling and their data were used as an indicator of the future trend.

4.0 SUPPLY

4.1 BACKGROUND INFORMATION

From a Provincial perspective, Statistics Canada reports the following 1994 gravel usage in B.C.:

	Tonnes x 10 ³	Percent of Total
Fill	5,040	13
Road Beds	15,340	42
Road deicing	220	<1
Concrete aggregate	6,820	18
Asphalt aggregate	3,230	8
Railroad ballast	330	1
Mine backfill	14	<1
Mortor sand	160	<1
Other	6,340	17
Total	38,500	

and the production of quarry rock as 7,200,000 tonnes. Of the above, about 60% goes to the Lower Mainland.

The above figures cannot be directly compared with data in this study because the definition of species is different.

Hora⁽¹³⁾ presents information relevant to this study. He states with regard to supply:

*

“In general terms, north of the Fraser River and along the coast, gravel availability is controlled primarily by geological factors and the physical presence of the deposits. South of the Fraser River, the limiting factors are availability of land and limitations of permitting procedures. The largest untapped resource, for example, is under the Abbotsford airport. The industry estimates that available resources on the south side of the Fraser River will be fully depleted in 5 to 10 years with no replacement reserved being planned. Since about 75% of aggregate consumption is used for public projects,

* Natural Resources Canada, Minerals and Metals Sector, Annual Report, Tables 7 and 9
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it will be the taxpayer who carries the burden or significantly higher transportation costs to bring the aggregate from more distant sources.”

and with regard to distribution:

“The distribution of production centres depends in general on the local market size and availability of the resource. As discovered during a 1980 survey, the market appears to bear transportation costs up to approximately 50 kilometres by truck and 150 kilometres by barge. For 1995, those transportation limits remain the same. What has changed are local production volumes with the same transportation pattern. Transportation costs, therefore, seems to be the main limiting factor in the Lower Mainland by dictating the size of production from individual production centres.”

He also comments on the industry's challenges:

“British Columbia does not have a comprehensive aggregate resources management policy. In total, ten government agencies from municipal to federal level have regulations which, in one way or another, affect the aggregate industry. In urban areas particularly, a maze of regulatory requirements exists that operators of commercial gravel pits must potentially face. For example, there are as many as eight agencies that have potentially significant requirements that must be satisfied. Looking at the industry and regulation practices, it may be said that the aggregate production in B.C. is over-administered and under-regulated. The main problem is that current focus is on the consequences of mining and processing aggregate instead of the resource itself.

A major proportion of the province's population and population growth is in the Lower Mainland. The GVRD's growth plan with higher density housing is, however, not entirely coincident with municipal development scenarios. Neighbourhoods and communities usually see aggregate mining as a negative land use activity. Reclamation strategies integrated with long term growth plans can address this negative image by having community input defining the final land use. Such “opportunity landscape” can have recreation (park, golf course), environmental (wetland), residential or industrial value.

A “single window” regulatory process to deal with present overlap and fragmentation of responsibilities should be able to resolve the present problems and to ensure availability of aggregate at affordable prices in the Lower Mainland for many years to come.”

The location of current aggregate sources is shown in Figure 2.

4.2 DREDGING

4.2.1 FRASER RIVER

Dredge sand is a renewable resource.

Dredging of the Fraser River began in the 1880's and regular maintenance of the main shipping channel commenced in 1901. Between the years of 1947 and 1974, one to two million cubic metres of sand was removed from the Fraser River to maintain the shipping channels. Up until 1960, this work was carried out by PWC as in-house projects in which the dredgeate was ocean dumped. In 1961 some contract dredging began in addition to the in-house dredging. Between 1961 and 1974 dredged sand production averaged just over two million cubic metres annually. It has been estimated that 50% of this material was ocean dumped with the remainder being used for commercial/industrial purposes (Hay & Company, 1995).

Historically, dredging has been carried out to maintain shipping channels. In 1908 the ship draught requirement was 7.6 m as compared to 10.6 m by the early 1970's. The increased draught requirements resulted in the need to increase annual dredging. This was accomplished mainly by borrow dredging carried out by private contractors. Between 1975 and 1985 dredged sand production varied between 4 and 7.8 million cubic metres annually. The Richmond-Fraser Port Development has been the recipient of the largest single area deposit quantity of dredgeate in the past 15 years. It was used for land reclamation.

Borrow dredging for aggregate supply reduces the overall cost of channel maintenance. From 1980 to 1992, however, dredging activity has exceeded the River's regeneration capacity. Intense dredging through private borrow operations along with channel improvement dredging has lowered the bed elevation from 3 to 5 metres in most reaches. As a result, a reduction in

dredging is required to stabilize the river bed and to balance the amount of annual sand regeneration. The subsequent decline in dredging to accommodate these criteria along with recent, lower annual River discharges are reflected in Table 2.

TABLE 2
AVERAGE ANNUAL DREDGING OF SAND FROM THE LOWER FRASER RIVER

Period	Average Annual Volume (1000 m ³)
1980 to 1995	5,100
1988 to 1995	4,800
1993 to 1995	2,300 to 2,800

Typically, the main channel accounts for the majority of dredging which varies between 70 and 85 percent of the total dredgeate below the Patullo Bridge. Recent trends indicate marked reduction of dredging in the North Arm. The two PWC Dredges were laid up in 1988 and 1991 respectively. All dredging is now carried out under contract with two private dredging contractors. There is currently an oversupply of dredging capacity relative to the recent demand for dredging. Oversupply has resulted in driving down unit prices to the point where contractors find it difficult to maintain profit margins over the long term. It is expected that the present dredging capacity will be reduced by one-half within the next few years.

The locations of annual channel maintenance and borrow dredging are shown on the location plan Figure 3. Sand dredged above kilometre 14 measured from Sandheads is generally stockpiled at depots immediately adjacent to the dredged area. The depots are situated historically at the locations where sediment accumulates most rapidly. It is interesting to note that dredging increases the cross-section of the river channel which in turn reduces the water velocity, thereby reducing the sediment carrying capacity and enhancing deposition. After dredging, the channel then stabilizes itself by soughing of the banks and smoothing out the cross-section. Therefore, dredging encourages the condition it is desired to counter. Sand from below km 14 generally has a high silt content and is ocean dumped off Sand Heads. Dredgeate from the Surrey-Fraser Docks is usually dumped back into the main channel where it is dispersed downstream (the tholweg).

Table 3 refers to the total annual dredging and borrow as a percentage of aggregate consumption. Borrow dredging accounts for 22 to 82 percent of the total dredgeate in the Fraser River and its tributary channels. Current trends show that 3 to 4,000 tonnes of sand is used annually for consumption within the Lower Mainland. At the time of this study it was estimated that only a few tens of thousands cubic metres of dredged sand is stockpiled as inventory. In the late 1980's and early 1990's, borrow dredging accounted for over 30 percent of the total annual aggregate production in the Lower Mainland. This declined to less than 20 percent in 1991/92 and less than 15 percent in 1992/93.

TABLE 3
FRASER RIVER DREDGING VOLUMES BELOW PATULLO BRIDGE

Year	Total Dredged (1) (1,000 m³)	Total (2) Borrow (1,000 m³)	Percent Borrow	Total Borrow Tonnes	Borrow Dredging, Total of Lower Mainland Aggregate Production
1979/80	4,391	2,259	51	3,728	20
1980/81	4,261	2,765	65	4,562	25
1981/82	5,401	2,556	47	4,217	21
1982/83	3,922	983	25	1,622	14
1983/84	6,531	3,662	56	6,043	32
1984/85	7,214	4,336	60	7,154	28
1985/86	6,231	3,380	54	5,577	19
1986/87	4,596	1,802	39	2,973	17
1987/88	5,226	2,677	51	4,417	26
1988/89	6,092	3,000	49	4,950	25
1989/90	6,762	4,718	70	7,785	33
1990/91	5,132	3,322	65	5,481	33
1991/92	5,378	2,642	49	4,359	19
1992/93	2,267	1,923	85	3,173	14
1993/94	3,706 ⁽¹⁾	1,853	50	3,057	13
1994/95	2,452	1,226	50	2,023	9

(1) The Canadian Coast Guard uses a number of correction factors for the type of dredge, the percent of silt lost in the dredging operation and location in the river. The volumes of dredged material shown on Table 3 (except 1993/94) represent corrected values.

(2) Taken for construction purposes.

Some volume discrepancies may be present due to variations in the methods of data collection. In addition, the FRHC uses the calendar year while PWC collects data for the Fiscal year. (Personal communication - Mr. O. Isfeld, P.Eng. - Hay and Company Consultants Inc.).

Sand transportation from the depots is by truck. Soil deposit fees are not levied to the depot operators by the various municipalities. Soil removal fees, however, are charged against individual end users who contract to truck sand from deposit sites. These fees are levied to offset maintenance costs of roadways due to the truck traffic.

The future indications for dredging is towards a downsizing; the trend of the past few years will continue well into the future. Table 4 represents a projection of average annual demand for the GVRD. Appendix D presents background on maintenance dredging.

TABLE 4
PROJECTED AVERAGE ANNUAL DEMAND FOR DREDGE SAND FILL IN THE GVRD

Period	Richmond	Delta	Burnaby	Surrey	Major Projects	Total x 1000	
						m ³	Tonnes
1995 - 2000	1100	460	550	525	550	3185	5255
2001 - 2005	1200	500	550	600	1000	3850	6353

Adapted from Table 9-6 - Hay & Company Consultants Inc.⁽¹⁾

Future dredged material is estimated to account only for approximately 76% of the total demand ⁽¹⁾ presented in Table 2. In the past this demand has been almost fully satisfied by the dredgeate from the Fraser River. These future projections suggest that sand supplied from land based pits with access to tidal waters for barge transportation will have increased importance if the projected trend of decreased dredging continues and the demand for sand cannot be fulfilled by dredgeate. This trend, however, may be reversed if the current low Freshet cycle increases. The type of Freshet also has an affect on the sand load. For instance, if a large volume of water is discharged quickly, this will lead to increased scour and less deposition of sand. Conversely a moderate sustained discharge during freshet will allow more sand to be deposited. These uncertainties based on naturally occurring

conditions make it difficult to forecast future sand availability from dredging. In addition, increased dredging up river in the Chilliwack area will have an impact on downstream deposition.

Note: Numbers in () refer to the Bibliography in Appendix.

4.2.2 Marine - Local

Until the last decade, there was significant aggregate sourcing from marine deposits, typically by clam shell recovery from river estuaries. For purposes here, the majority was in Burrard Inlet - eg. Indian Arm areas and the mouth of the Capilano River. Historically, such sourcing was controlled by the National Harbours Board (Vancouver Port Corporation) and more recently by a committee of regulatory stakeholders, BIERC.

Removal of aggregate was both for the material itself and for maintenance of ship draft. Since river estuaries are regenerated by nature's upstream aluvial aggregate production, a perpetual source is available.

Such sourcing has been restricted in recent years due to a combination of supply and environmental restrains. The Corporation advised that, over the last 5 years, excavations has been limited to that required for their own construction only - eg. Centerm and Deltaport Docks. Quantities to Deltaport have been:

- Fill from First Narrows (Capilano) 400,000 m³
- Fill from Second Narrows 28,000 m³

In addition, there is occasional "maintenance" dredging of local dock fronts to maintain draft. In 1996, 30,000 m³ was taken from the Allied Shipyard area.

These aggregates are used as bulk granular fill in local coastal construction controlled by Corporation and are therefore not included in supply quantities here.

4.2.3 MARINE - COASTAL

The authors are not aware of any significant sourcing from other coastal areas outside the study area and the operation, shown on Figure 2. However, they have interviewed the District of Stewart who are in the process of developing the Bear River Estuary. Their target market is Pacific Rim and Alaskan buyers plus possibly the State of Washington. Their analysis shows no cost-effective supply to the Lower Mainland.

The District of Stewart is planning to produce the premium products - concrete sand and stone - for large barge shipment. The River has immediate reserves of 2,000,000 m³ followed by a regeneration of about 200,000 m³/year. For the District, this is both a revenue source for the local economy and a necessity because regeneration is filling their harbour creating both flood hazards and ship draft restrictions.

The District conducted, in 1995, a feasibility study ⁽²⁾ of their Port development. It focused on combined flood control and economic development as suggested above. Markets of South Alaska, South California and Hawaii were identified based, in part on the self-unloading deep sea vessel backhaul concept. Delivery to northern coastal B.C. was judged to be similar to their current costs. For southern (i.e. Lower Mainland) delivery, a \$17.00/tonne cost was estimated. This made Stewart non-competitive under current supply conditions.

The study noted some points relevant here:

- Stewart is the only deep sea terminal, other than Texada Island, with direct gravel sourcing.
- Part of the economic justification for gravel removal is the Federal Government's commitment to dredge deep sea harbours. The analogy of the gravel dredging for flood control dykes in the upper Fraser River (Chilliwack area) was presented.

It is concluded that remote coastal sourcing is not in the immediate future supply equation for the Lower Mainland.

There has occasionally been export of aggregate from B.C. coastal deposits to the USA, particularly Alaska and Washington. Quantities are not significant for purposes here.

4.3 DEPOSITS

4.3.1 QUARRIES

Historically, limestone used in the production of cement products has been the principal use of quarried rock. Texada Island has been, and continues to be the main source of limestone for the Lower Mainland market area. Typically, the sand and gravel industry tends to locate close to market areas to reduce transportation costs. Waterborne access from Texada Island quarries allows lower transportation cost per tonne-mile because of the bulk carrying capabilities and ease of barging within the relatively sheltered waters of the Strait of Georgia. Markets for Texada limestone also include areas as far south as Seattle.

Granite dykes are prevalent throughout the limestone deposit on Texada. In some areas these dykes may form upwards of 30 percent of the deposit which, in the past, has been considered waste. It has been suggested that the cost to produce crushed aggregate from quarried rock may be as much as 30 to 50 percent higher (Hora ⁽¹³⁾) than conventional sand and gravel deposits. However, as production and ground transportation costs rise along with depletion of high quality inland aggregate sources of quarried rock blended with sand for use as construction aggregate is increasing. In 1980, the only operating quarries for construction aggregates were located on Texada Island. At the time of this study several quarries are operated mainly for the purpose of producing crushed aggregate (not limestone). These quarries, all situated with water access, are near Victoria, on the Pitt River, and the Fraser River at Cox Landing in Abbotsford.

The volume of crushed aggregate and limestone currently represents about 15 percent of the total annual aggregate produced for Lower Mainland markets and is expected to increase. However, the value of crushed aggregate represents a higher market share because quarried rock is used to produce premium products such as railway ballast, 75 mm and 20 mm road

base, clear crushed rock of various dimensions and rip rap that typically cannot be manufactured from other sources. Crushed rock is also desirable as course aggregate in high performance concrete - see Section 5.8.

4.3.2 COASTAL SOURCES

As noted in 4.3.1, limestone was the only species of quarried aggregate available to tidal waters. This material continues to be supplied from Texada Island. Texada quarries have operated for over 20 years. No other sources of limestone other than Texada Island are being pursued mainly because that source is strategically located, and the quality and vest reserves make this an economically viable mineral deposit for the foreseeable future.

In the past 10 years there have been several major sand and gravel sources developed on tidal waters. These areas include the Sechelt Peninsula and Jervis Inlet. All materials processed from these sources are barged into the Lower Mainland and off loaded to depots for final usage or for truck to transportation to their final destination. All of these sources will either maintain their current level of production or have plans for major expansions. Final usage of these aggregates varies from concrete aggregate to road base materials to bulk sand fill. The Sechelt area was the primary source of the bulk sand fill used for the Vancouver International Airport expansion.

The only significant source of processed sand and gravel delivered to Lower Mainland markets from the United States is the Friday Harbour facility operated by Lafarge. It has been estimated that up to 1.2 million tonnes was barged to Vancouver on an annual basis with about 60% of this being concrete aggregate and the remainder processed road subbase and base fills. This source will discontinue supply to the Lower Mainland in 1996 because of dwindling reserves.

4.3.3 FRASER VALLEY

Gravel pits have been operated in the Fraser Valley for over 50 years. The former District of Matsqui and District of Abbotsford, now amalgamated as the City of Abbotsford, continue to be the single largest source area outside of the Coquitlam River Valley. However, closure of gravel pits in recent years has by far exceeded opening of new gravel resources in the Abbotsford area.

There are only two gravel pits currently operating within the City of Surrey and none within the limits of the Township of Langley.

In an effort to place more local controls on gravel operation, the Township of Langley attempted in 1990 to pass a revised soil removal bylaw which was subsequently not approved by the MoMA or MoEI. The reasons given for the rejection are related to overlapping jurisdictions between Langley bylaws and the Mines Act. As a result the Township of Langley continues to use Bylaw No. 2642 entitled the "Prohibition of Soil Removal" approved by the Ministry of Municipal Affairs 1988. This bylaw essentially does not allow soil removal (including sand and gravel) except:

- In amounts of 20 cubic metres per hectare;
- On a parcel of land 0.81 hectares or less;
- When soil removal is reason for construction;
- Specified parcels of land included as Schedule "A".

Gravel operations south of the Fraser River are typically located within the ALR and applications for gravel removal fall under the jurisdiction of the Soil Conservation Act. The ALC views sand and gravel removal as an advantage where the agricultural capability of the land can be improved by removing rock, enhancement of drainage conditions suitable to agricultural use, and decreasing land slope. These requirements plus others imposed by local governments have served to isolate gravel removal to the south-west portion of the City of Abbotsford and sterilize significant resources.

Several gravel operations located in the District of Mission have historically supplied local needs only. However, the District of Maple Ridge has restricted opening of new gravel operations until the alignment of the main east-west transportation corridor north of the Fraser River has been determined. As a result, aggregate of all types is more frequently trucked into maple Ridge from Mission and Coquitlam.

The Upper Fraser Valley consisting of Chilliwack, Agassiz, Rosedale and Hope have until recently supplied sand and gravel products for local markets. The remaining gravel resources in Abbotsford are high in sand content and some areas have high overburden-to-gravel

stripping ratios. This has placed increasing demand on Upper Fraser Valley sources particularly the Fraser River gravel bars possessing high quality gravel. For example, the Chilliwack area is the main supplier of premium gravel for exposed aggregate concrete which is routinely trucked into Vancouver.

All transportation of gravel products is by truck with the exception of Mainland Sand and Gravel's quarry at Cox Landing where materials are barged to down-river depots for distribution. Because of the high volume of trucking associated with gravel pits, the public has historically opposed gravel mining permits.

The major supplier in the east end of the Valley is Hope Ready Mix. They serve a population of 10,000 with fill and road gravel as well as concrete. They advised that they were the sole concrete supplier east of Chilliwack to Boston Bar. Hot mix paving asphalt generally comes from the plants in the Abbotsford area.

Hope Ready Mix has its own pit with reserves for over 50 years. It is heavy to sand necessitating supplementary stone dredged from sand bars in the Fraser River (during the winter). Other suppliers also source from the River.

The current total annual demand of the Hope area is:

For concrete	10,000 m ³
For road gravel	6,000 m ³
For fill (sand and pit run)	12,000 m ³

There is no current growth; 1994 was a peak year with 1995 lower and 1996 projected as lower again.

Hope Ready Mix offered that there are increasing environmental restraints on river sourcing and that the permit costs have been increased significantly.

4.3.4 SQUAMISH - LILLOOET

Gravel supplies produced from Squamish to Pemberton, are used entirely within the region with no export to the Lower Mainland. Gravel supply volumes have not been determined as these do not affect the study.

4.3.5 LAND BASED AGGREGATE PRODUCTION

Table 5 presents the historical land based mineral aggregate production since 1978. A number of sources identified on the table were used to compile this information. Previous reports have noted production figures in the Lower Mainland that do not agree with some of the annual production values listed on this Table. Discussions with the MoEI indicates there may be some discrepancies in previous methods of gathering and reporting data.

TABLE 5
LOWER MAINLAND
LAND BASED MINERAL AGGREGATE PRODUCTION⁽¹⁾

Year	(Tonnes x 1000)
1978	11,684
1979	15,033
1980	13,329
1981	16,250
1982	9,853
1983	12,588
1984	18,524(2)
1985	23,205(2)
1986	14,219
1987	12,426
1988	15,291
1989	15,694
1990	16,052
1991	19,249
1992	19,962(3)
1993	20,121(3)
1994	19,051(3)
1995	18,520

Notes:

- (1) Does not include dredging.
- (2) Reported aggregate production in 1984 and 1985 increased significantly over previous and following years. This may have resulted from Expo 86 and related projects such as the Richmond Connector, Skytrain and Alex Fraser Bridge which were under construction at that time. There is also a possibility that MoTH reported aggregate production using different boundaries of production than used previously. In addition some 300,000 to 400,000 tonnes of aggregate was shipped to Everett, Washington during this period.
- (3) Estimated values
 - 1978 to 1988 Source: Thurber Engineering, Report to Ministry of Energy Mines and Petroleum Resources ⁽³⁾.
 - 1989 to 1994 Source: MoEI.
 - 1995 Source: Survey of Aggregate Producers by Levelton.

4.4 AGGREGATE SOURCING PERMIT REQUIREMENTS

Land based gravel extraction operations are subject to application review from these agencies:

- MoEI.

- MoELP;
 - Habitat Protection;
 - Crown Lands;
 - Water Management;
 - Waste Management.

- DFO.
- MoTH.
- ALC.
- Forest Commission.
- Regional Governments.
- Municipal Governments.

The industry advises that a three to five year period is required to obtain all necessary approvals to commence extraction. The permitting period increases with the number of agencies involved.

Interviews with agency representatives and aggregate producers indicate there is limited interactive communication between the approving agencies. This often leads to each agency presenting a wish list without regard for the project as a whole. Although MoEI is responsible for issuance of the permit, issuance does not generally occur until all other agencies have reported and approved the application. To the authors' knowledge there are no meetings between the approving agencies to discuss projects. As often occurs, because of this separatist approach, requirements for approvals can be quite onerous.

The responsibilities of each agency are presented below.

The MoEI process and responsibility is well defined in their pamphlet in Appendix C.

4.4.1 MoEI

MoEI issues the permit for gravel extraction. Their main concerns and focus of site inspections relate to health, safety and reclamation. Aggregate producers tend to respond favourably to

MoEI's authority. However, MoEI does not address land use issues which are typically the most contentious aspects of a gravel extraction permit.

The MoEI strongly endorses reclamation and does request ecological or groundwater studies before permitting, if it is an issue.

Study interviews suggest that MoEI maintains good control over health and safety issues. Past reclamation practices have, in some municipalities such as Langley, resulted in poorly reclaimed gravel pits that are not now productive. Along with other public issues such as noise, dust and truck traffic, past reclamation practices has lead to increased involvement of local governments.

4.4.2 MoELP AND OTHER MINISTRIES

4.4.2.1 Habitat Protection

MoELP provides input on habitat protection of fish and wildlife. This includes preservation of ecosystems for all forms of wildlife. At present there is no provincial legislation that provides for the protection of ground water resources.

MoELP through the Water Act also requires that approval be obtained for the use of surface water (for example in a wash plant) and the Waste Management Act would then require a permit for the discharge of effluent or waste to the land, air or water.

4.4.2.2 Ministry of Forests

The Ministry of Forests requires a permit only if timber is sold or removed from private property.

4.4.2.3 Crown Lands

This branch of MoELP regulates and approves tenure on crown land. There are two types of tenure, Licence of Operation (designed for shorter term use) and Lease, each with its own referral process. Crown lands are leased for a Land Rent Fee and a production-based royalty is paid to the Ministry for the extraction of mineral aggregate. Crown Lands is also responsible

for permitting gravel extraction in the upper reaches of the Fraser River near Chilliwack and Hope.

4.4.3 DFO

DFO regulates activities wherever fish stocks, particularly salmonoid species, may be affected. Habitat Protection and DFO have a close working relationship and often carry out concurrent inspections. Maintenance dredging guidelines for the Lower Fraser River are included in Appendix D.

4.4.4 FRHC

The FRHC is responsible for dredging in the Lower Fraser from Kanaka Creek to the mouth of the river. The commission liaises with the Canadian Coast Guard which monitors dredging and carries out impact studies, and with the DFO who is responsible for fish stocks.

4.4.5 ALC

The majority of gravel extraction operations south of the Fraser River, particularly in Abbotsford and Langley, are located within the British Columbia ALR which is administered by the ALC. There are some existing gravel pits that began operations prior to the inception of the ALC which are not subject to current regulations. Permit applications under this agency are required to demonstrate that the agricultural capability of the land can be improved by gravel removal. This condition may be satisfied by a number of methods, such as decreasing the slope of the ground surface, removal of coarse gravels from the near surface, reducing irrigation requirements, reduction of erosion potential and backfilling with additional top soils.

ALC requirements for reclamation are more stringent than those of MoEI because reclamation focuses on the long term agricultural capability. The reclamation process begins with initial excavation of top soils that are removed and stockpiled separately according to their individual classification. These top soils are then replaced when excavation is complete. The ALC usually relies on the expertise of an Agrolgist to design the reclamation plan and carry out inspections.

Securities in the form of bonds are required at the time of application. These bonds are released when the reclamation plan is satisfactorily completed.

4.4.6 REGIONAL GOVERNMENTS

Regional Governments may set policies regarding gravel extraction in unorganized territories or Electoral Districts. The amalgamation of four regional districts in 1995 (Dewdney Allouette, Central Fraser Valley, Upper Fraser Valley and Fraser Cheam) into the FVRD has thus far resulted in an extensive array of bylaws in effect for different parts of the Regional District. For example, the former Dewdney Allouette Regional District prohibits gravel processing such as washing, screening or crushing within a pit. This in effect precludes a gravel pit from operating because processing is vital to meet most project specifications and must be carried out to make the operation economically viable. This bylaw is currently in effect for the former Dewdney Allouette Regional District but not the remainder of the FVRD. The Regional District has plans to modify these bylaws to a single standard.

Within the GVRD, the oldest and main source of sand and gravel is located in the District of Coquitlam. Operations date back in excess of 30 years. Although there have been no new permits issued recently, some expansion of existing permitted operations has been allowed. The area historically identified for gravel extraction has been zoned for this purpose. The District of Coquitlam has advised that very few public complaints regarding noise, dust or truck traffic are received. Contentious issues regarding the existing operations, however, are related to environmental impacts, particularly siltation of the Coquitlam River, and long term reclamation plans.

Regional Districts do not collect soil removal or deposit fees.

4.4.7 MUNICIPAL GOVERNMENTS

The Municipal Act has stated that municipalities shall identify in Official Community Plans:

877.(1)(c) "the approximate locations and area of sand and gravel deposits that are suitable for future sand and gravel extraction.

877.(1)(d) restrictions on the use of land that is subject to hazardous conditions or that is environmentally sensitive to development”.

The Act further states with respect to Community Plans:

8798.(1) “For the purpose of Section 920, a community plan may designate areas for one or more of the following:

(a) protection of the natural environment...”

The MoMA states that the authority given to Municipalities to administer a Soil Removal Bylaw may not extend to items such as hours of operation, but does provide some control of quarries under associated noise bylaws. Soil Removal Bylaws can establish fees for removal. Prohibition of soil removal from specific areas by the Municipality requires the approval of the Ministry and concurrence of the MoEI. The MoMA will consider such applications of an individual basis bearing in mind the requirements of the Growth Strategies Act that allows that planning must take into consideration that gravel is needed in areas of likely growth such as the Fraser Valley.

Local governments tend to be on the “front line” in the permitting of gravel extraction operations when dealing with public issues such as land use, truck traffic, noise and dust control. Municipalities are involved in the majority of land based operations because gravel sites are located mainly within municipal boundaries. Gravel operations located in Unorganized Territories such as the Eastern Fraser Valley and Coastal sources are permitted by MoELP and MoEI (see Figure 1). These Territories are in Regional Districts so they may have applicable zoning or soil removal bylaws.

Some municipalities place controls on gravel extraction by land use zoning such as prohibiting processing and designating only certain areas for gravel extraction. Controls such as soil removal and deposit bylaws allow fees to be levied. The stated purpose of these fees is to fund repair and maintenance of roads because increased truck traffic reduces their service life. Table 6 presents a summary of various controls and soil deposit and removal fees.

4.4.8 SUMMARY OF PERMIT REQUIREMENTS

Figure 4 shows the parties involved in an application for opening a gravel pit. For certain

special features of a particular land parcel there might even be other agencies (such as MoELP for groundwater considerations).

This approval process can take years as noted in 4.1 and 4.4.

TABLE 6

SUMMARY OF MUNICIPAL SOIL REMOVAL AND DEPOSIT FEES AND ISSUES RELATED TO NEW GRAVEL EXTRACTION PERMITS

Municipality	Soil Removal Fee (\$/m³)	Issues
City of Coquitlam	0.26	<ul style="list-style-type: none"> • Encroachment of development. • Environmental aspects must be addressed for all existing operations.
City of Surrey	0.50	<ul style="list-style-type: none"> • Encroachment of development • Limited resources remaining
District of Maple Ridge	0.20	<ul style="list-style-type: none"> • Encroachment of development. • New official community plan will identify area for resource extraction. • No export of gravel off-site until new highway corridor is established.
District of Mission	0.35	<ul style="list-style-type: none"> • Site must be in area designated for resource extraction. • Must identify need for use of the resource. • Processing must be in area zoned for resource processing.
Township of Langley	0.50	<ul style="list-style-type: none"> • Site must be in area designated for resource extraction or application may be made to add proposed site to existing list of areas.
City of Abbotsford	0.50	<ul style="list-style-type: none"> • Confined to south-east area and Sumas Mtn. • Processing must be carried out in areas zoned as industrial. • Can no longer import backfill materials.
District of Chilliwack	0.50	

4.5 INDUSTRY COMMENTS

Aggregate suppliers took advantage of these interview to express concerns over what they perceive to be the complex, inconsistent and intermixed governmental jurisdictions over their industry. Some aspects of their concerns were:

- Gravel excavation is not recognized as a temporary land use;
- While gravel excavation (including shotrock) is in the Land Act, rock such as limestone and dimension stone is in the Mineral Tenure Act;
- Municipalities basically do not want gravel pits because of proximity resident complaints regarding noise and truck traffic, primarily the latter. As a result Municipalities pass cascading bylaws to make gravel removal more restrictive;
- Working structures (eg. conveyors) are classified as "fixed" for development purposes and therefore face relevant permitting;
- Crown Land excavation permits are based on a 3 year tenure (with renewal) but a 15 year Residual Value Plan is required. These should marry;
- Up to 6 Ministries can become involved in an operation (possibly more - see 4.4). The industry wants only one, preferably the MoEI;
- There are conflicting bylaws requiring harmonization. For example a property line noise level limit of 50 dB by MoEI but 30 by some Municipalities;
- The Mines Act is not developed with gravel pits in mind;
- The Forest Practice Code is in conflict with the Mines Act in some areas;
- Mines regulations do not apply to MoTH's seasonal or intermittent pits (actually, only the requirement for a Permit is exempted).

MoEI advises that some of the above are overstated or self serving. Nonetheless, they remain as industry's concerns.

4.6 SUMMARY OF SUPPLY QUANTITIES

Table 7 is a breakdown by species of all aggregates produced for consumption in the Lower Mainland in 1995. Figure 5 presents the data graphically. This information was obtained mainly from interviews with producers (see Appendix A).

Data was cross checked by referring to previous studies (eg. (3) and (13) in Appendix B) and to Table 5.

TABLE 7

1995 AGGREGATE PRODUCTION

(TONNES X 1000)

	Premium Aggregate	Road Gravels	Bulk Fill	Shotrock	Dredged Sand	Total
GVRD	3,135	3,500	1,895	2,600	4,000	15,130
FVRD	1,655	3,450	1,485	800	400	7,790
Total	4,790	6,950	3,380	3,400	4,400	22,920
% of Total	21	30	15	15	19	

Assuming that up to a small amount of landbased supply sources are not accounted for, the total 1995 aggregate production is estimated **between 23 and 25 million tonnes**.

FVRD: Includes all production in the Fraser Valley Regional District.

GVRD: Includes all production in the GVRD and those areas on tidal waters that supply the GVRD.

Figure 7 presents the general sourcing of aggregate for various sectors of the study area.

5.0 DEMAND

5.1 IMPACT OF DEVELOPMENT

The following estimates of aggregate consumption for various forms of urban development are based on current construction techniques. It is the author's opinion that present day construction practices will provide a more suitable platform from which to project future consumption than historical methods. The following estimates of aggregate usage and current methods of construction have been selected to best represent the industry in 1996. Examples of the methods used to arrive at the unit aggregate values for various methods of construction are included in Appendix E.

5.1.1 RESIDENTIAL

- **Condominium Developments 46 - 51 tonnes/Unit**
 - ◇ three or four storey wood frame construction supported with a concrete parking structure.
- **Multifamily construction Townhouse 200 tonnes/Unit**
 - ◇ two or three storey wood frame construction with a concrete slab-on-grade;
 - ◇ 6 m wide internal access roads with curb and gutter on both sides
 - ◇ no sidewalks
- **Single Family Dwelling 340 tonnes per Residence**
 - ◇ 185 m² (2000 ft²) wood frame structure with a crawl space.

The amount of aggregate per unit of residential construction decreases with density and number of storeys as expected. Therefore less aggregate will be needed if the GVRD Livable Regions Plan is implemented.

5.1.2 COMMERCIAL/INDUSTRIAL

- Tilt-up concrete panel wall construction with concrete slab-on-grade. Unit conversions are based on an average area of 20,000 ft² (2150 m²); this requires 560 tonnes per 100 m².
- Highrise
 - à concrete structure 59 tonnes/1,000 ft² (107 m²);
 - à steel structure 13 tonnes/1,000 ft² (107 m²).

5.1.3 INSTITUTIONS

The majority of institutional construction is related to school facilities. Other construction involves additions to existing city halls, hospitals, and provincial government buildings. One exception is the recent LSP addition to Vancouver General Hospital which can be classified into highrise construction activity for aggregate consumption.

Table 8 presents the total school floor space constructed and estimates of aggregate used since 1986. It is the authors' opinion that schools represent the majority of institutional construction.

TABLE 8

TOTAL AREA OF SCHOOLS CONSTRUCTED AND TOTAL CONCRETE AGGREGATE CONSUMPTION

Year Opened	GVRD		FVRD		Total Concrete and Aggregate Consumption Study Area (Tonnes)
	Elementary (m ²)	Secondary (m ²)	Elementary (m ²)	Secondary (m ²)	
1986	5,491 (2)				2,471
1987	9,227 (3)				4,152
1988	6,403 (2)		7,520 (2)		6,265
1989	11,540 (4)		12,981 (4)		11,034
1990	27,041 (8)		3,622 (1)		13,798
1991	33,126 (10)	12,469 (1)			22,388
1992	21,155 (7)		10,466 (4)	13,018 (2)	22,040
1993	32,540 (13)	48,237 (2)		24,806 (2)	58,469
1994	18,335 (4)	22,081 (2)	10,416 (5)		26,187
1995	21,310 (8)	17,196 (2)	3,575 (2)	12,435 (1)	28,977
Total	186,168 (61)	99,983 (8)	48,580 (18)	50,259 (5)	

- Number in brackets refers to number of institutions.
- Howe Sound schools included in GVRD total.
- School Board offices included as elementary.
- Elementary/Junior Secondary schools included as elementary.

An average elementary school uses 700 to 1,000 m³ of concrete which equates 0.3 m³ of concrete per m² of school area (0.45 tonnes of aggregate/m²). This estimate is based on single storey steel frame construction over a crawl space.

Secondary schools use slightly more concrete per unit area than elementary schools because construction techniques differ. Typical recent secondary schools are constructed of concrete for the first floor with steel framing for the second floor. Elgin Secondary in Surrey was recently constructed using 4,000 m³ of concrete with an area of 10,235 m² which corresponds to an

aggregate consumption of 0.6 tonnes/m² for concrete. Scottsdale Secondary in Delta is under construction and is anticipated to use 1,800 m³ of concrete over an area of 6,000 m² (0.45 tonnes of aggregate/m²). Table 9 presents a summary. There is no readily available estimate of backfill quantities from school contractors.

TABLE 9
AVERAGE SCHOOL AREA AND CONCRETE AGGREGATE CONSUMPTION

Average Area of School (m ²)	GVRD	FVRD	Concrete Aggregate Consumption Tonnes/m ² of Floor Area
Elementary	2,050	2,700	0.45
Secondary	12,500	1,050	0.60

These values do not include aggregate used as backfill. The amount of backfill material depends on the size of footprint and depth of excavation which is difficult to estimate.

5.1.4 INFRASTRUCTURE

5.1.4.1 Municipal Roads

Most municipalities, with only a few exceptions, do not record the quantity of aggregate used in rehabilitation and maintenance of existing roads. Quantities of aggregate for new road construction are not available from municipalities because developers are the supplier. As a result, the method selected to determine the quantity of aggregate used in municipal road construction is to determine the total length of road constructed annually and estimate quantities of aggregate based on a typical road cross-section. Table 10 below shows the breakdown of roads by type of surface.

TABLE 10
PERCENTAGE OF ROADS BY TYPE OF SURFACE ROADS

Regional District	Percentage by Type of Surface		
	Asphalt	Concrete	Gravel
GVRD	87	7	6
FVRD	94	-	6

As shown in Table 10, the majority of roads within the study area are surfaced with hot-mix asphaltic concrete cement (HMAC). No new concrete surfaced roads have been constructed recently. Gravel surface roads are generally located in lesser developed areas and tend to be older. As a result, the typical road design is based on an asphalt surfaced road with the cross-section shown in Figure 6.

For estimating purposes, the unit conversion factors for the quantity of aggregate used in roads is taken from Table 1.

Road widths vary between 6 and 14 m depending upon the classification. Some roadways are constructed with sidewalks on one or both sides, some with curbs and gutters and some without. In consultation with several municipal and road design engineers, an average municipal road has been determined to be 9 m wide with concrete sidewalk and curb and gutter constructed on both sides. A bitumen content of 5 percent for the HMAC has been assumed. This means that 95 percent of the HMAC is composed of aggregate. Based on the above noted assumptions it is estimated that one kilometre of road contains 10,300 tonnes of mineral aggregate with the breakdown in Table 11.

TABLE 11
ROAD GRAVEL CONSUMPTION

Location	Road Gravels - Tonnes/km	% of Total
Road Structure	9,990	97.0
Sidewalk	200	2.0
Curb and Gutter	113	1.0
Total	10,303	100

The total length of new road construction within the study area is summarized in Table 12. The average length of new road construction on an annual basis for the past nine years of record is 165 km. Based on 10,300 tonnes of aggregate per kilometre, approximately 1.7 million tonnes of aggregate is used for new municipal road construction annually.

TABLE 12
MUNICIPAL ROADS
TOTAL LENGTH OF ROAD - KILOMETRES

Year	Regional District					Total	Total length of road added	GVRD as a percentage of total road
	CFV	⁽¹⁾ DA	FC	SL	GVRD			
1985	780	663	642	197	⁽²⁾ 7,877	10,159		77.0
1986	792	680	645	189	⁽²⁾ 8,027	10,333	174	77.7
1987	801	747	647	193	⁽²⁾ 8,132	10,520	187	77.3
1988	807	760	647	196	8,303	10,713	193	77.5
1989	815	774	651	199	8,397	10,836	123	77.5
1990	817	773	651	200	8,504	10,945	109	77.7
1991	833	793	653	202	⁽³⁾ 8,568	11,049	104	77.5
1992	845	815	740	209	8,585	11,194	145	75.7
1993	885	837	785	209	8,649	11,335	141	76.3
1994	869	849	787	209	8,929	11,643	308	76.7

CFV Central Fraser Valley }
 DA Dewdney Allouette }
 FC Fraser Cheam } FVRD
 SL Squamish Lillooet }
 GVRD

1995 statistics not available.

(1) Discrepancies in tabulating total length of roads for Mission and Maple Ridge resulted in a reduction of 58 km of road for Dewdney Allouette Regional District from reported statistics prior to 1993.

(2) Includes Langley - Langley joined GVRD in 1988.

(3) Using an estimate from 1992 date for Richmond (1991 data not reported).

Table 13 shows unit aggregate demand for roads and services (i.e. utilities) related to various new developments.

Table 14 shows a summary of aggregate consumption for maintenance and rehabilitation of existing roads. Most municipalities that were contacted did not compile data in this form and therefore detailed information was not available for this study. The volume of aggregate per kilometre of existing roads agree reasonable well between Port Coquitlam and the City of Vancouver, The higher quantities of gravel per kilometre for Pitt Meadows may reflect the rural nature and possibly poor soil conditions in the municipality. It is conceivable that poor subbase conditions will lead to increased maintenance requirements in Pitt Meadows.

TABLE 13

**AGGREGATE USED IN MUNICIPAL ROADS AND SERVICES
TRIBUTARY TO VARIOUS DEVELOPMENTS**

	Construction	Unit Demand
1	Total aggregate for road and service construction	18,500 tonnes/km
2	Single family residential - Vancouver - Fraser Valley	83 tonnes/unit 166 tonnes/unit
3	Commercial	63 tonnes/1000 ft ² (93 m ²)
4	Low rise multifamily	20 tonnes/unit

See Appendix E for sample calculations.

TABLE 14**AGGREGATE CONSUMPTION FOR REHABILITATION OF ROADS AND SERVICES
(1994/1995) (TONNES)**

Species	Port Coquitlam	Pitt Meadows	Vancouver	Burnaby	North Vancouver	Township of Langley	Abbotsford	Total 1000 tonnes
Road Gravels	31,467	24,000	204,267	32,000	31,000	125,314	69,625	448
Premium Aggregate	909	1,400	5,072	1,000		1,762	-	10
Bulk Fill	8,660	1,200	175,366	-	-	200	22,983	185
Total Aggregate	41,836	26,600	384,705	34,000		127,276	92,608	707
Volume for Rehabilitation	⁽¹⁾ 41,836	⁽¹⁾ 26,600	⁽²⁾ 342,387	⁽¹⁾ 34,000		⁽¹⁾ 127,276	84,434	656
Total Length of Roads (km)	220	82	2,086	840	175	817	954	5,174 km
Volume of Aggregate per km of existing road (tonnes)	190	324	164	40.5	177	156	88	136 Ave

(1) 100% rehabilitation. Port Coquitlam and Pitt Meadows construct new roads under separate contracts.

(2) 89% of total aggregate used for rehabilitation

From Table 14 it is noted that municipal use for rehabilitation is:

- predominantly road gravels;
- 93% of their aggregate needs;
- approximately 40% of new construction road use (Table 11) is needed for rehabilitation.

5.1.4.2 Underground Services

The total length of sewer and watermain constructed within the Lower Mainland for the target period is presented in Table 15. Estimates of the quantities of aggregate used as bedding and backfill materials for underground services are based on the following assumptions:

- 1) Sanitary and storm sewers are included in a single trench (2 m wide x 4 m deep).
- 2) Water main completed in a separate trench (1 m wide x 0.5 m deep).
- 3) B.C. Hydro & B.C. Tel trenches backfilled with native material.

4) Street lighting trenches backfilled with native material.

It is estimated that 8,100 tonnes of sand or sand and gravel are used for underground services per km of new road constructed. Over the past nine years the average annual length of services constructed is 490 km, giving an average of 3.4 million tonnes of aggregate per year.

TABLE 15
TOTAL SEWER AND WATERMAIN DISTANCE (KMS)

Regional District Year	Central Fraser Valley	Dewdney Allouet	Fraser-Cheam	Squamish Lillooet	GVRD	Total	Total Annual Increase
1985	926 ⁽¹⁾	821	689	325	14,561 ⁽¹⁾	17,322	
1986	951 ⁽¹⁾	842	691 ⁽²⁾	333	14,827 ⁽¹⁾	17,644	322
1987	1018 ⁽¹⁾	N/A	N/A	342	15,204 ⁽¹⁾	18,141	497
1988	1,071	914	698	343	15,668	18,694	553
1989	1,126	946	742	369	15,968	19,151	457
1990	1,155	942 ⁽³⁾	771	377	16,420	19,665	514
1991	1,197	994	753	379	16,861	30,184	519
1992	1,231	1,007	838	404	17,298 ⁽⁴⁾	20,778	594
1993	1,274	10,51	855	412	17,425	21,071	293
1994	1,336	1,093	887	415	17,999	21,730	659

- (1) Langley joined GVRD in 1988, 1985 to 1988 distances have been subtracted from CFVRD and added to GVRD.
 (2) Data from Harrison Hot Springs transposed on table - no increase in sewer - watermain distance at Harrison in 1986.
 (3) Pitt Meadows shows a decrease in total sewer and watermain distance from 137 km in 1989 to 119 km in 1990.
 (4) Anmore data discrepancies include 690 km and 3,320 kms of watermain for 1991 and 1992 respectively. These values have been adjusted to reflect actual watermain lengths of 7 km.

Reference: Ministry of Municipal Affairs Statistics

5.1.4.3 Ministry of Transportation and Highways

The MoTH has not compiled data that will allow a similar unit conversion quantity of aggregate per kilometre as used for municipal roads. Annual records of aggregate usage for rehabilitation and maintenance of existing highways in the Lower Mainland are available for the past four years are presented in Table 16.

TABLE 16

**MINISTRY OF TRANSPORTATION AND HIGHWAYS AGGREGATE CONSUMPTION (TONNES)
IN THE LOWER MAINLAND**

Fiscal Year	HMAC	Maintenance		Rehab. & Maint. MoTH	Rehab. & Maint. Contractor	Projects	Total
		Ministry Sources	Private Sources ⁽¹⁾				
1995/1996	14,000	18,000	17,000	49,000	N/A	1,000,000 ⁽²⁾	1,098,000 +
1994/1995	44,000	24,000	17,000	85,000	19,000	-	189,000
1993/1994	34,000	19,000	17,000	53,000 +	9,000	122,000	254,000
1992/1993	N/A	36,000	17,000	35,000 +	37,000	63,000	188,000 +

(1) Estimate

(2) Barnet Highway

N/A Not available

New highway construction will be discussed under impacts of large projects.

5.2 SPECIALTY PRODUCTS

There are a large number of specialty product manufacturers and suppliers who use aggregate but the total volume is small. The only significant demand identified is from dry-bag producers (such as “sack-crete” sold in hardware stores). The total annual aggregate demand here is about in the 50,000 to 60,000 m³ range, mostly sand.

One dry-bag supplier sources from the parent company’s waterborne supply. The other has a pit in the Clearbrook area with at least 10 years supply. This latter supplier anticipated future supply from further up the Valley dependent on Fraser River regeneration. Constant zoning pressure on the current supply was a concern.

There has been a stable demand over the last few years. Occasional surges are the result of recreational demands such as golf courses.

5.3 IMPACT OF LARGE CONSTRUCTION PROJECTS

5.3.1 GENERAL

It was anticipated that large Lower Mainland construction projects would have a noticeable impact on the aggregate consumption curves and that would have to be factored into modelling on a one-off basis. Following is the results of a survey of major projects, in many of which Levelton has had direct involvement.

Major projects requiring large volumes occur on a relatively regular basis and tend to span a few years in duration. Because of the duration, the aggregate industry is generally able to adjust supply and transportation systems to the increased demand. Table 17 is a summary of major projects considered in this study.

TABLE 17
QUANTITIES IN MAJOR PROJECTS

Project	Construction Period	Main type of Aggregate	Total Volume Million Tonnes	
			Tonnes	Tonnes/Year
Richmond Landfill	1978 - 1982	Dredged sand	8	2
Expo 86	1983 - 1985	Sand and gravel	3	1.5
Alex Fraser Bridge	1983 - 1986	Dredged sand	1	0.3
Vancouver Airport	1992 - 1996	Sand	2.5	0.8
Deltaport	1995 - 1997	Crushed limestone	1.7	0.6
Annacis Island Sewage Treatment Plant	1995 - 1997	Premium aggregate	0.3	0.1
CN Intermodal Yard	1994 - 1995	Dredged sand	2.5	1.25
Barnet Highway	1995 - 1996	Road gravel	1.0	0.5

As noted in Table 17 the average annual demand for any single project is less than 2 million tonnes and generally less than 1.25 million tonnes per year which is in turn less than 5 percent of the annual Lower Mainland aggregate demand in any given year. These values may be slightly misleading and are discussed for the five major projects listed:

- Expo 86 had a significant impact on the aggregate industry. Large quantities of bulk fills were placed on the site, and a number of spin-off projects also resulted in aggregate usage. Table 5 shows the total aggregate production for 1978 to 1995. There is an anomaly in 1984 and 1985 when a disproportionate amount of sand-gravel was produced for these two years leading up to Expo. The following is a list of projects contributing to the increase in demand for 1984/85:
 - Richmond connector.
 - Skytrain.
 - General upgrading of roads.
 - Parking lot construction.
- Filling of the Richmond Landfill required the highest volume of aggregate. This project, however, coincided with the availability and need to dredge sand from the Fraser River. It also coincided with an increase in borrow dredging. At that time, because of the large number of dredges that were operating and the increased availability of sand, impact on the dredging industry was only moderate.
- Dredging to improve the channel of the Alex Fraser Bridge also coincided with increased borrow activities. The increased borrow is reflected in Table 3 for the years 1983, 1984 and 1985. This area is a perennial source of high quality sand and all this material was eventually used in upland areas.
- Filling of the CN Intermodal Yard in Surrey corresponded to the availability of dredgeate at the Surrey Fraser Docks. Dredging at the location often utilises the Thalweg, where sand is dumped back into the main channel for dispersion downstream. This type of maintenance dredging was often carried out on in-house contracts, but because of the resulting end use, borrow dredging was used to offset the cost for maintaining the channel in that area.
- The Vancouver International Airport required that most of the sand fill be placed quickly as preload during the initial construction phase. Although the total volume used was less than 10 percent of the annual production for the Lower Mainland, the time to supply the sand created a significant strain on the supply and transportation systems. Refer also to 5.3.2.1.

The surge in aggregate demand for major projects has been supplied by dredged sand. These projects have typically coincided with a need to dredge at a particular location where sand and equipment has been readily available. These projects therefore have not significantly effected the traditional pit supply industry.

As previously noted, the Vancouver International Airport expansion placed a significant strain on the supply of aggregate within the Lower Mainland. This strain has not been realized from other mega projects because of a number of factors such as the smaller aggregate demand, the type of project, period of construction and the type of aggregates required. The largest demand at the Airport was for bulk fill to be delivered over a relatively short period of time, the demand was buffered somewhat because a large supply was available from coastal sources. This, however, placed a strain on the transportation system, such as barges and tugboats to transport sand fill to the site and loading equipment and trucks to move the material on site. This had the effect of reducing the availability of these transportation systems to other areas of the Lower Mainland. Other projects such as Deltaport have not affected the supply side significantly because the two major aggregate species required (road gravels and shotrock) do not strain supplies as much as a single large species demand.

Major projects consistently occur within the Lower Mainland. Projects which require significant site grading and paving have the largest aggregate demand. With the exception of the Vancouver International Airport expansion and Expo 86, adjustments in demand and transportation of aggregate can be readily accommodated. In recent years, large projects within the GVRD have been accessed by waterborne transportation systems which are more capable of adjusting to increased demand than ground transportation systems. Conceivably, large aggregate demand projects in the Fraser Valley would have a significant effect on the supply and transportation systems without waterborne access.

Land based supplies and transportation can become strained by major projects. The dredging industry, however, is more dependent on large contracts mainly because of the current size of the industry and the recent downtrend in dredging from the Lower Fraser River. Where large projects may require 5 to 10 percent of the total annual aggregate demand in the Lower Mainland, individual large contracts for dredge sand may require up to 40 percent of the annual dredged sand volume.

5.3.2 CURRENT PROJECTS

The following projects are known to use significant volumes of aggregate and were selected as representative of major demands.

5.3.2.1 Vancouver International Airport

The expansion of the Airport was commenced in 1992 and will be completed late in 1996. It represents an unprecedented demand on the aggregate supply due, primarily, to the pre-load construction system. The Airport is actually a number of separate projects with consumptions totalling 2.5 million m³ and separations shown in Tables 18 and 19.

There are a number of unique Airport features relevant here:

- Supply was largely by barge through a site - constructed off-loading facility.
- The volume of same fill ** was so large that it taxed the capability of the entire coastal sourcing - three suppliers were involved. Most pits are heavy to sand so they welcomed the opportunity to move this fraction, but the Airport absorbed all available stockpiles and some suppliers had to bland products to meet Airport requirements.
- The Airport is an example of ultimate aggregate utilization. Sand was used initially as pre-load to consolidate the Lulu Island alluvial silt, then as either fill under the runway and other structures, or as-is in fine aggregate for cement treated base, or washed to produce fine aggregate for the concrete paving.
- Crushed Texada Island Limestone was used as concrete course aggregate in lieu of the normal natural aggregate. This is the first major use of this source in concrete and probably represents a trend. Its use here was dictated by both direct barge access of the site and its superior performance in paving concrete.

TABLE 18
VANCOUVER INTERNATIONAL AIRPORT EXPANSION
AGGREGATE DEMAND

Type	Project Volume, Tonnes			
	Runway Total	Terminal Building	Other	
Concrete				
Coarse Aggregate	** 319,000	51,000	8,800	378,800
Fine Aggregate		32,500	5,400	37,900
Drain Rock and Fill	** 45,000	3,600	1,000	48,000
Asphalt Aggregate	37,800	5,400	7,200	50,400
Dredge Aggregate	297,000	-	-	297,000
Sand Fill	32,238	-	-	32,2000
Granular Base	234,000	43,200	36,000	313,200
Pre-load Sand and Fill	2,868,000	-	-	2,868,000

Note: Runway pre-load fill subsequently used elsewhere on project.

** Crushed limestone

TABLE 19
VANCOUVER INTERNATIONAL AIRPORT
AGGREGATE DEMAND RECLASSIFIED TO SPECIES HERE

Species	Demand, Tonnes
Quarry	379,000
Premium	97,700
Road Gravel	365,000
Fill	2,900,000
Dredge	297,000

5.3.2.2 Deltaport container Terminal Project

The Deltaport expansion began in 1995 and is scheduled for completion in 1997. In recent history, it is second in the volume of aggregates required only to the Vancouver Airport expansion. Table 20 shows a breakdown of aggregate usage.

TABLE 20
DELTAPORT AGGREGATE CONSUMPTION

Usage	Species (tonnes x 1000)		
	Premium Aggregate	Road Gravel	Shotrock
Gravel mattress, shore protection and caisson ballast			1,360
Asphalt pavement		100	
Base and subbase		230	
Structures	100		
Total All species			1,7690

The shotrock, base and subbase fills were supplied by coastal sources and have been barged to the project site. Hot mix asphalt will be trucked to site from local plants.

In excess of one million cubic metres of dredged sand was used as general site fill. This dredged material was obtained directly offshore specifically for this project and is not included in the volumes considered here.

5.3.2.3 Highway 1 High Occupancy Vehicle (HOV) Lanes - MoTH

Construction of the Highway 1 HOV lanes began in 1996 and is scheduled for completion in 1997. Bulk fills, road base and subbase fills are supplied by contract from local private sources. MoTH will not be supplying aggregates from its own sources. The following table presents the estimated quantities of aggregates required.

TABLE 21

PROJECTED AGGREGATE CONSUMPTION FOR HIGHWAY 1 HOV LANES

Usage	Species (1000 tonnes)		
	Premium Aggregate	Road Gravels	Bulk Fill
Concrete overpasses	5 ⁽¹⁾		
Subbase sand fill			210
Base course		310	
Asphalt		80	

(1) Estimated

The total aggregate required for this project is estimated at 600,000 tonnes to be supplied over a two year period. MoTH estimates that they would use 600,000 tonnes of aggregate in an average year within the Lower Mainland.

5.4 CITY OF VANCOUVER

(AGGREGATE HANDLING AND ASPHALT AND CONCRETE RECYCLING PLANT)

An extended discussion of the City of Vancouver's position will be presented because, as shown in Table 14, they are a major player in aggregate demand. Table 22 shows their annual requirements.

The City is planning to move from their existing facility on False Creek to a new operation on the Fraser River. The City provided a copy of their economic evaluation of the scope of the new operation⁽¹⁴⁾ from which the following is drawn:

- aggregate handling with barge supply;
- equipment to crush and screen concrete and asphalt;
- a hot mix asphalt plant,

plus support facilities.

The City acquires 400,000 tonnes of aggregate annually. From this about 90,000 tonnes go into hot mix asphalt manufacturing. An additional 15,000 tonnes of hot mix are purchased giving a total hot mix tonnage of 105,000. Of this, they plan on initially incorporating 20% recycled pavement with future increases.

The City estimates about 200,000 tonnes of potentially recyclable material is available from excavations. Of this 95,000 are delivered to (private) recycling depots and the balance disposed of as landfills. A key element of the City's economic evaluation was therefore the integration of recycled pavement, concrete and granular excavation back into their mainstream aggregate supply.

The Sanitation Department now purchases an additional 65,000 tonnes of recycled aggregate for landfill roadway construction.

The City estimates that the direct incremental cost premium to use recycled aggregate is \$1.70/tonne, 1994 values. However, there are other benefits.

The significance of the above information to this study is the potential that recycling may play in aggregate supply, particularly given the commitment of a large user such as the City. However, the City's total impact on the aggregate demand by using all their available recycled material is only 8%. Their evaluation ⁽¹⁴⁾ notes the possibility of less conventional hot mix private supply in Vancouver as existing plan are moved out (to the Fraser Valley) and also the future possibility of other Municipalities participating in the City's facility.

TABLE 22
CITY OF VANCOUVER
PURCHASE OF MINERAL AGGREGATES (TONNES)

	Species			Total
	Premium Aggregate	Road Gravels	Bulk Fill	
1989	8,145	174,162	166,771	349,078
1990	7,674	170,500	166,753	344,927
1991	2,546	158,600	131,508	292,654
1992	5,541	182,490	133,417	321,448
1993	4,289	187,378	160,972	352,639
1994	5,582	190,297	176,620	372,499
1995	5,072	204,267	175,366	384,705

- Adapted from City of Vancouver statistics.
- Estimate 11 percent of aggregate for new road construction; balance for maintenance.

5.5 MARKET AREAS - LOWER MAINLAND AGGREGATE STUDY

The following subregions have been identified as the market areas used for this study. These regions were divided mainly from Hora (1980)⁽¹³⁾ and agree closely to market demarkations used by the major producers with the one exception that Surrey was historically split between the north and south, but for purposes of forecasting, has been included in the GVRD. Figure 7 is a map of the market area.

1. GVRD

Within reach of docking facilities along shoreline of Burrard Inlet and on Fraser River and is supplied by barges from coastal pits includes the following municipalities:

West Vancouver
 North Vancouver
 Vancouver
 Richmond
 Delta

2. GVRD
Coquitlam valley supplies municipalities of:

- Burnaby
- New Westminster
- Coquitlam
- Port Coquitlam
- Port Moody
- North Surrey
- Pitt Meadows

3. Fraser Valley - South of Fraser River

- South Surrey
- Langley
- Abbotsford

4. Fraser Valley - North of Fraser River

- Maple Ridge
- Mission

5. Chilliwack/Kent

- Chilliwack Harrison
- Agassiz
- Rosedale
- Hope
- Harrison

On Figure 7 is superimposed a line roughly separating supply by barge (coastal) from that by truck (valley). This line is known to be dictated entirely by price and is currently moving eastward as land supply increases in cost.

5.6 PORTLAND CEMENT CONSUMPTION

The construction industry has often used the consumption of portland cement as an indicator of construction volume. Since all use of cement involves aggregate, and since over 90% of this is in concrete, cement consumption is a reliable method of estimating aggregate demand.

The Canadian Portland Cement Association provided information on the historic and short term projected cement consumption for the Province. This is presented in appendix F. They also provided construction activity forecasts which they directly relate to cement consumption as suggested above; these were considered in Section 5.9.

The two local cement companies advised that shipments to the study area were about 65% of their provincial totals, slightly more than population proportionality. From this, and the data in Appendix F, Table 23 was prepared. A 10% increase in demand is projected over the next few years.

TABLE 23
CONCRETE AGGREGATE CONSUMPTION IN LOWER MAINLAND
PAST AND PROJECTED

Year	Aggregate Used in Concrete, 1000 Tonnes
1985	5,510
1986	5,600
1987	6,140
1988	6,900
1989	9,020
1990	9,550
1991	9,150
1992	9,910
1993	10,100
1994	10,570
1995	10,300
1996	10,440
1997	11,060
1998	11,630
1999	11,450

- Data calculated from B.C. cement consumption (Appendix F) x 0.65 for Lower Mainland.
- Assume average 250 kg/m³ of cement in 1 m³ concrete.
- Conversion to aggregate tonnage from Table 1.

5.7 INFORMATION FROM LARGE CONTRACTORS

A number of large contractors were included in the survey. They generally offered similar comments summarized below:

- There is no current aggregate supply restraint. They have noted new sources and the addition of crushed quarry rock as coarse aggregate. However, the quality is satisfactory.
- There has been a recent increase in cost. For contractors, this is a pass-on item.
- They assume that the supply industry will simply "go further afield and charge more".

One contractor anticipated that some operator will open a large quarry in the north coast and bulk-carry to the Lower Mainland.

There was a general feeling that construction volume will reduce in the near future. This is somewhat a variance to Table 23 projections.

5.8 IMPACT OF TECHNOLOGICAL DEVELOPMENT ON AGGREGATE DEMAND

5.8.1 BACKGROUND

The authors were aware that there is economic and environmental pressure to recycle, particularly for non-renewable resources. If this concept is advanced, it could have an impact on aggregate demand.

The possibility of recycling aggregate from demolition has been extensively researched and to a degree implemented, primarily in Europe and populated parts of Asia, where supply side economics and/or government regulations make this attractive. In North America where the materials:labour ratio is much lower, there has not been the same driving forces but there has been isolated developments of the concept. Some research and implementation has been done by groups such as the U.S. Corp. of Engineers and more recently by the American Concrete Institute and there is a volume of technical literature.

Locally, the technology impact has taken these forms:

- Crushing of removal asphalt paving and using it as a raw material, typically at 20% of the total aggregate. The existing original asphalt oil is rejuvenated by additives. This has been a well developed concept in the GVRD. A large pile of removal older pavement exists at the Mitchell Island plant of Columbia Bitulithic Paving. The City of Vancouver has been a leader in recycling as described in 5.4. They do so despite a current premium cost. Volumes of their recycling are currently less than 200,000 tonnes.

- The use of quarry rock to supplement the crushed rock fraction or rock deficiency of secondary gravel deposits. This is a natural evolution because of both the generally over-sanded nature of Lower Mainland pits and need to increase crushed fractions for improved performance in higher quality concrete and asphalt paving. The crushed portion of these blends comes at a cost premium of 30 to 50%; typically blending would be 15 to 30% by weight of the natural aggregate.

- Crushing of demolition concrete and use of this as granular fill. For example, this was recently done as:
 - recycling removal concrete pavement during the Vancouver International Airport Runway extension;
 - crushing a Richmond warehouse concrete frame on site during demolition;

and using the resulting product as bulk fill. Use of recycled concrete aggregate has not been attempted locally because of premium costs and lower resulting concrete quality.

5.8.2 THE FUTURE FOR RECYCLING

It is indicated in 5.8.1 that there is potential for recycling and some of it occurring but the current impact on demand is an insignificant 1%. Not included here would be on-site recycling which does not impact the supply/demand equation. The controlling factors are:

- economics. Recycled material is still an economic premium except where factors such as transportation, access or waste disposal control;
- the resulting products (with partial replacement of natural with recycled aggregate) has generally poorer workability and/or durability than products with virgin aggregates.

And, unless there is a Government mandate and cost incentive to recycle, it will not increase markedly in the immediate future.

Note that today removal asphalt paving, excavation, and demolition concrete is not wasted but finds a home a bulk fill so it replaces a lot cost aggregate. To a degree, it could replace the current and anticipated reduction in availability of bulk fill dredge sand (see Section 4.2).

A further example is the potential for high strength concrete. With modern chemical admixtures and selective aggregate sourcing, Levelton can now produce locally 100 MPa concrete increasing with previous limit to say 60 MPa. This could result in smaller structural sections or longer spans with a net reduction aggregate required for a particular structure, perhaps a 20% reduction.

However, the number of structures where this higher strength can be effectively used is perhaps 5% of construction and, given the volume of aggregate in concrete, Table 23, the overall impact in demand is in the order of ½% of the total demand.

So, for purposes of this study, technological development will not have a significant impact on the total aggregate demand within the Lower Mainland.

A more optimistic view would be obtained from areas where natural deposits are more depleted than here - see Section 6.0. Appendix F contains information from Oregon anticipating recycling currently accounting for 4% of aggregate demand.

5.9 FUTURE DEMANDS

During interviews, most sources were asked about potential future projects that would also have significant demand. The following were identified:***

Convention Centre - the demand would depend on the scheme selected, but 100,000 m³ total of the range of species over 1997/1998 would be a crude estimate.

Foreshore, False Creek - demand here would be primarily shotrock for rip rap.

Vancouver International Airport - Phase II Expansion - there is currently planning for further expansion to the Terminal Building and aprons. However, the large Phase I volume for a runway would not be required. An estimate would be 200,000 m³ for 1998/1999.

Coal Harbour - proponents are seeking a source for 200,000 m³ of bulk fill.

Expo Lands - anticipated demand would be primarily for highrise structures which do not have high volumes, say 100,000 m³ from 1997 to 2000.

Centerm Docks - although a large construction project, this will only require 20,000 m³ of imported aggregate. The major aggregate volume will be excavation material from other projects or the site itself (see also 4.1.2).

One cement supplier, when questioned, stated "...there are always one or two major projects on-going, and, any such projects extends over a few years, so there is not a major fluctuation in total year-to-year demand." This is borne out by the relatively small change in cement sales - see Section 5.6.

For purposes of this study, the survey has not identified any factors that would have a major or controlling influence on demand. Therefore, traditional increases, as suggested by projected cement consumption in Appendix F and Table 23, should apply. These are generally proportional to population increases.

Future projections will be examined further in Volume II of this study.

6.0 AGGREGATE RESERVES

Estimates of aggregate reserve for various sub-regions within the study area are included in Table 24. These estimates are based on information obtained from interviews with suppliers and represent resources that are currently permitted or may be mined by an amendment to an existing permit. The time to deplete the resource is based on existing production levels, pricing and processing technology.

In general, the reserves of shotrock for all purposes is not a concern within the projected time period of this study. There are an infinite supply of hills/mountains that can be drilled, blasted and crushed. Most shotrock sources are readily accessible to waterborne access. Increased production of shotrock will occur in the Fraser Valley where land based quarries in combination with depots on the Fraser River will have increased importance.

Based on the gravel reserves presented in Table 24, aggregate supplies within the GVRD and from coastal sources supplying the Lower Mainland are adequate for the projection period to 2021. Good quality sand and gravel is available from coastal sources. The Coquitlam River area deposits, although containing huge reserves, tend towards increasing sand contents and lower economic returns. These sources may be open to increased competition from waterborne access because of lower transportation costs of barging.

Known reserves within the Central Fraser Valley, supplied from sources here identified as south of the Fraser River, are at a critical level. It is estimated that only seven years of sand and gravel remain at current levels of consumption. In the Abbotsford area, sand content of the remaining reserves is estimated to be higher than past production. In addition, higher stripping ratios (ratio of aggregate to unusable overburden) are becoming more common. The City of Abbotsford has isolated aggregate production to the southwest corner of the City and Sumas Mountain. There are significant resources located south of the Abbotsford Airport. These are situated within an area of good quality agricultural land that is intensely farmed. Indications from the City of Abbotsford lead us to believe this area will not be mined in the foreseeable future. The City has recently requested proposals to prepare an aggregate resource and mining reclamation plan for the east side of Sumas Mountain within the current city limits.

Known reserves north of the Fraser River are also at critical level. Large resources are known to exist in Mission and Maple Ridge but as yet no comprehensive planning to utilize these sources has been formulated. The District of Maple Ridge is currently not allowing new gravel extraction permits until the proposed east-west transportation corridor has been identified by the MoTH. The Mission and Maple Ridge area represent the most significant potential resources of sand and gravel for the Fraser Valley. It is highly desirable, and responsible from a resource management perspective, that these potential sources be quantified and planning proceed to best utilize these materials before development sterilizes these deposits.

TABLE 24
ESTIMATED SAND AND GRAVEL AGGREGATE RESERVES

Area	Known Reserves Tonnes x 1000	Estimated time to Deplete Supplies at Current Production (Years)
Coastal Sources	400,000	40 +
GVRD	200,000	30 - 40
Fraser Valley Ministry of Transportation and Highways	8,300	20+
South of Fraser River	30,000	7
North of Fraser River	35,000	10