

**GEOLOGICAL
SURVEY
OF
CANADA**

**DEPARTMENT OF ENERGY,
MINES AND RESOURCES**



PAPER 66-60

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**SAND AND GRAVEL IN THE
STRAIT OF GEORGIA AREA**

(Report, 38 figures and 3 plates)

S. F. Leaming



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OF CANADA

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STRAIT OF GEORGIA AREA

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DEPARTMENT OF ENERGY, MINES AND RESOURCES

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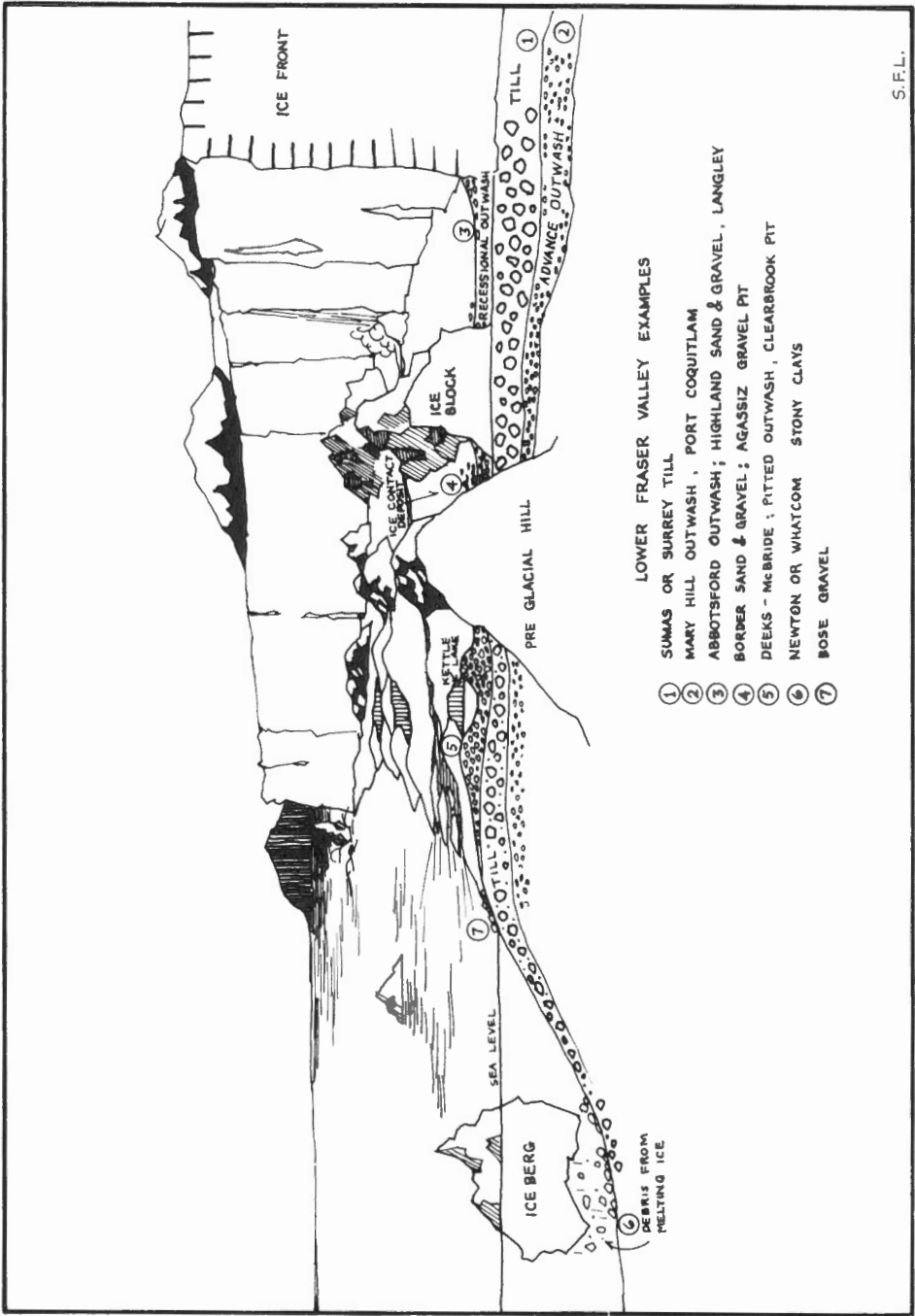
ABSTRACT

Sand and gravel deposits in the Strait of Georgia area constitute units in the succession of unconsolidated deposits formed during the Pleistocene and Recent epoch of earth history. This succession includes drift of at least three glaciations, non-glacial sediments of an interglacial epoch and sediments of post-glacial origin.

The most important formations are those associated with the Fraser glaciation. These include Capilano sediments, Abbotsford, Huntingdon and Mary Hill outwash. Of less importance are post-glacial deposits of Salish sediments, interglacial Quadra sediments, and older drift.

Maps showing the surficial geology of most of the area have been prepared by other officers of the Geological Survey of Canada and form the basis for this report. These maps are available to the public and should be considered essential supplementary information on specific problems relating to the distribution of sand and gravel in the area.

About 400 pits were examined and described.



Frontispiece. Hypothetical section showing recessional stage of glaciation.

SAND AND GRAVEL IN THE STRAIT OF GEORGIA AREA, BRITISH COLUMBIA

INTRODUCTION

The area discussed includes the lowlands on both sides of the Strait of Georgia, some of the valleys extending into the adjoining mountainous regions, and some of the islands in the the strait. On the mainland it centres around Vancouver but extends east to Chilliwack and northwest to Powell River. On Vancouver Island it extends from Victoria to Oyster River. The area covered and the principal Geological Survey of Canada references are shown on Figure 1.

Sand and gravel are vital commodities in modern society. Their greatest importance lies in the construction of transportation facilities such as roads, airfields and railways but they are also widely used in concrete for bridges, dams, foundations and buildings. Vast quantities are used annually and although the material is at present relatively accessible, abundant and low-priced, without good planning this will not necessarily continue to be true. With increasing urbanization, depletion of the supply is accelerating, both by increased consumption and by reduced availability through zoning regulations. As the more accessible reserves become depleted or unavailable, new sources at greater distances must be found thus involving greater transportation costs. It is in the common interest that the best use be made of these resources. This will involve planning by municipal authorities and foresight by private industry.

This report points out sources of information on the distribution of sand and gravel and attempts to give some idea of the available reserves. Sketch maps showing the location of all pits have been prepared and Figure 2 is an index map to the locations. The subject is part of the larger study of surficial geology and because few in the gravel industry have had any training in geology some principles are included. The technology of the industry is also briefly described.

The field work for the report was done from time to time during the summers of 1961 and 1962.

Information in this report is taken in part from maps and reports dealing with the surficial geology of the region previously published by the Geological Survey of Canada and indicated on Figure 1. Copies of these may be obtained from the Geological Survey of Canada, Vancouver, or from the Ottawa office at 601 Booth Street, Ottawa.

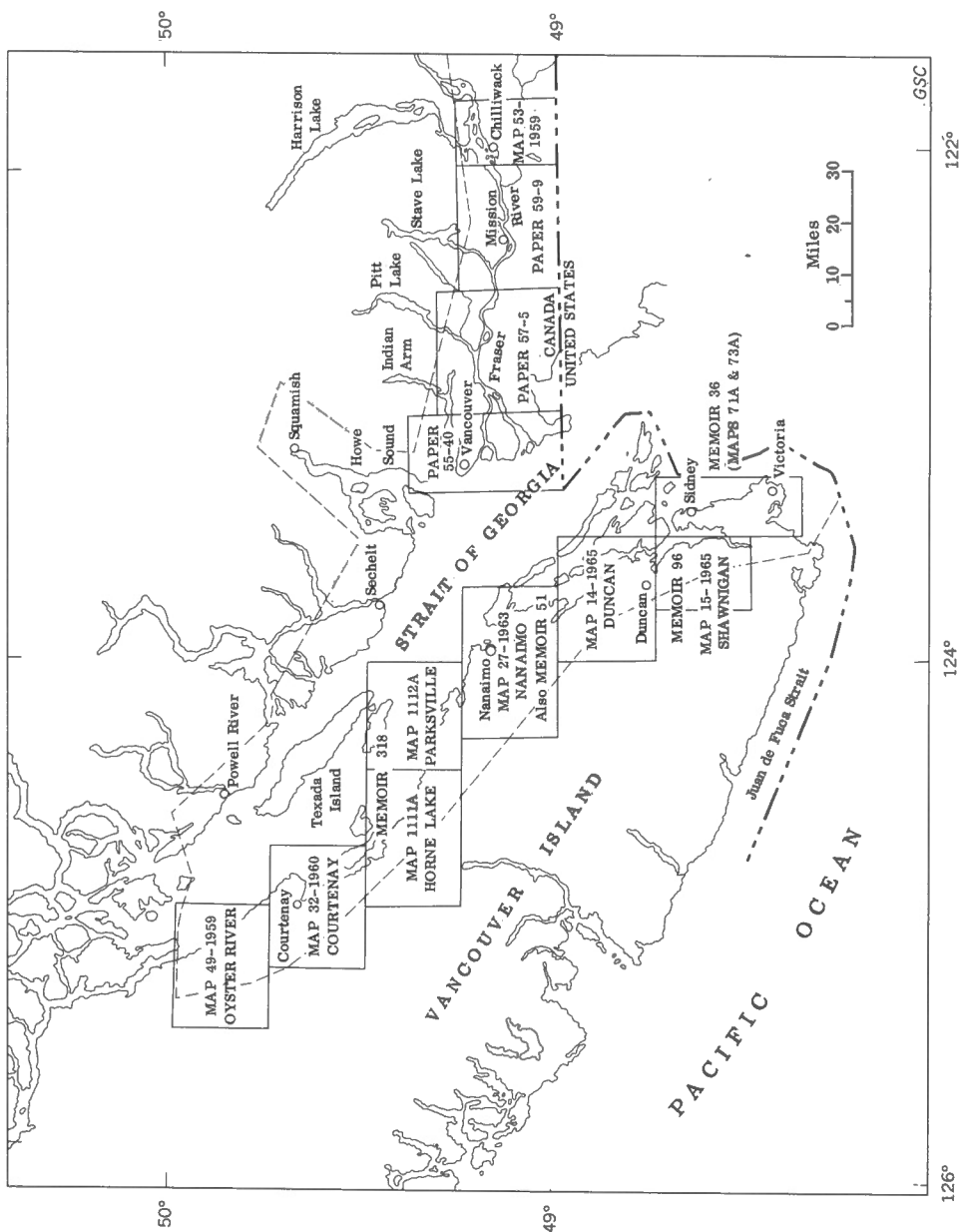


Figure 1. Index to areas studied and to earlier Geological Survey references.

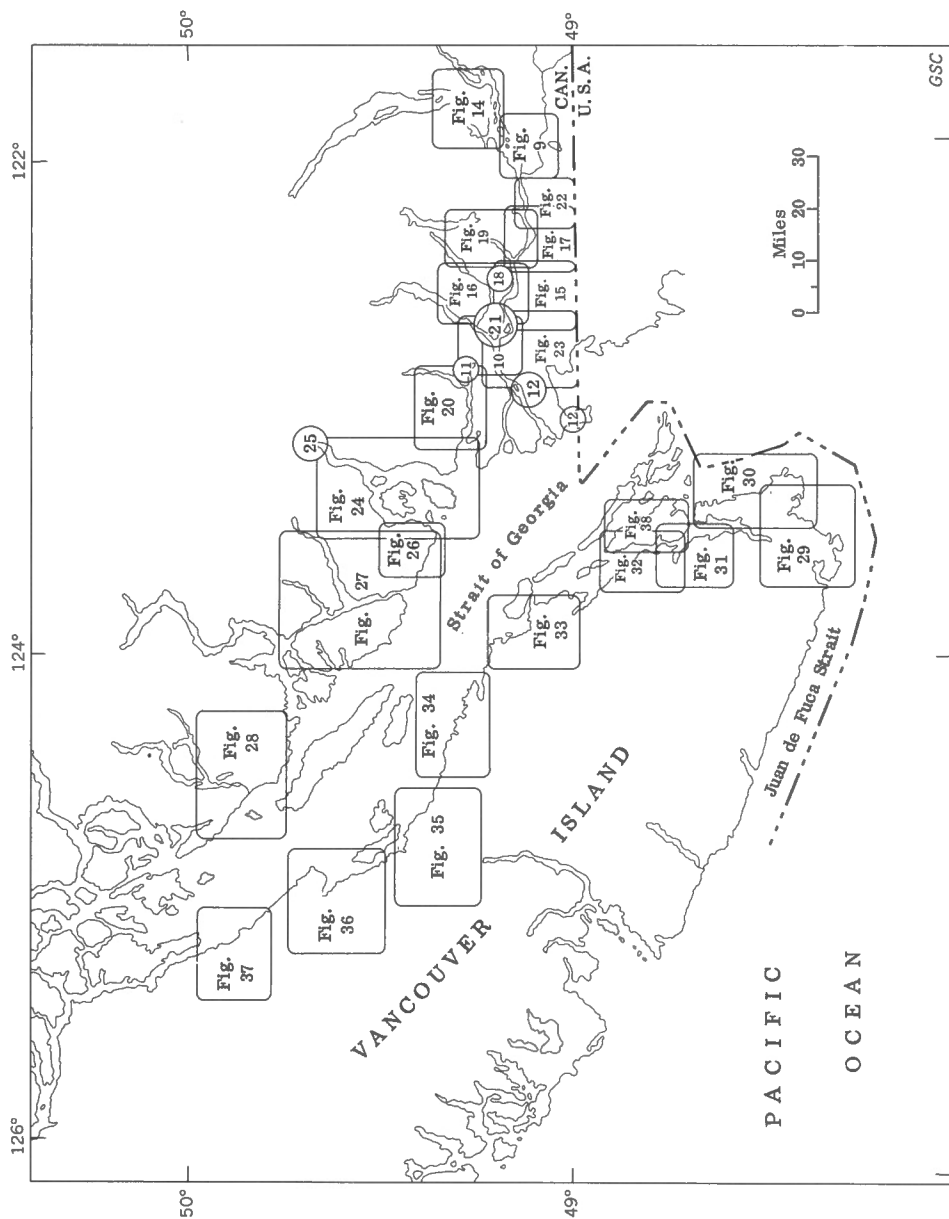


Figure 2. Index to sketch maps.

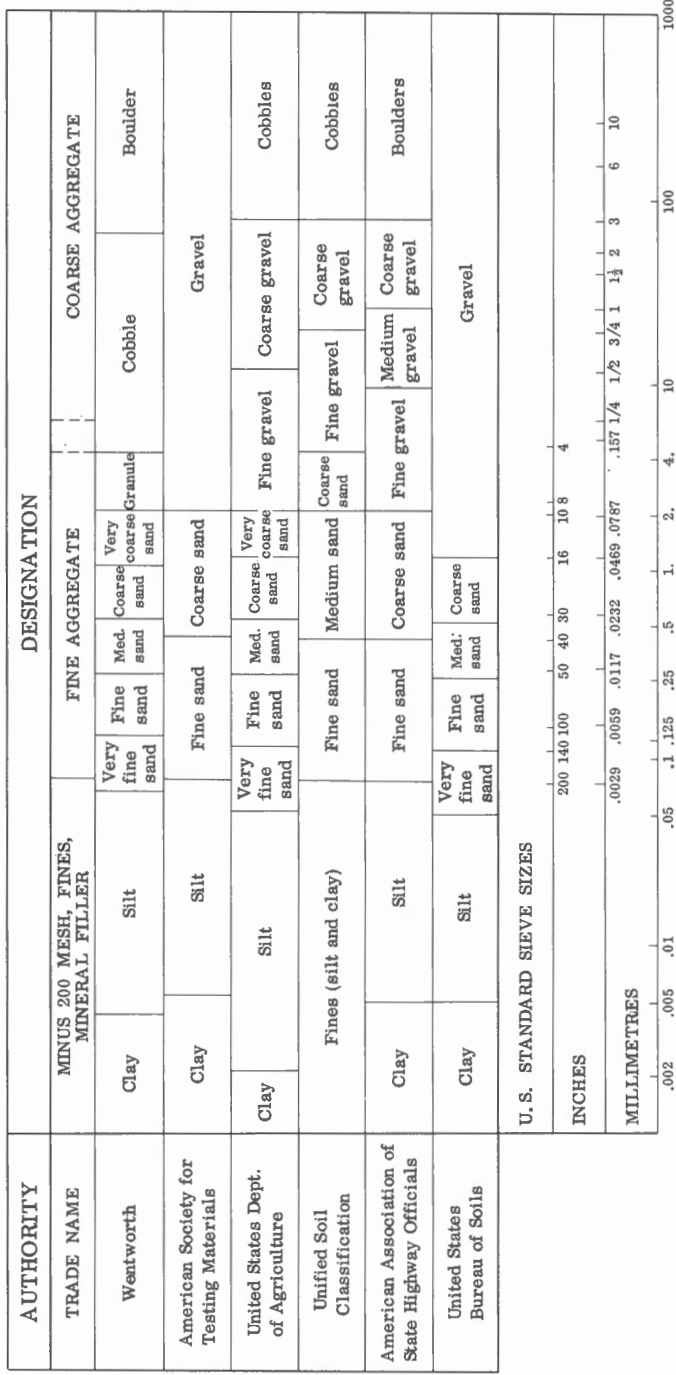


Figure 3. Classification of sediments.

GSC

The writer is indebted to many in the sand and gravel industry, particularly Mr. Thomas Routledge and Mr. Jack McArthur. Thanks are due to Mr. Angus McLean, engineer in charge of the Department of Transport laboratory on Sea Island for mechanical analyses. Dr. J.E. Armstrong, of the British Columbia office of the Geological Survey of Canada, supervised the project and helped in many ways with the preparation of the manuscript.

TERMINOLOGY, TECHNOLOGY AND GENERAL CHARACTERISTICS OF THE SAND AND GRAVEL INDUSTRY

DEFINITIONS

Sand and gravel are naturally occurring, more-or-less rounded fragments of rocks and/or minerals having certain size limits, the latter differing with the defining authority - see Figure 3. The most common way of measuring size limits is by shaking the material through a set of screens having square openings arranged in some definite size ratio.

In this report the following definitions will be used: Sand - naturally occurring rounded fragments of rocks and/or minerals which can pass through a 1/4-inch screen but are retained on a #200 mesh screen. Gravel - naturally occurring rounded fragments of rocks and/or minerals which will pass through a 4-inch screen and be retained on a 1/4-inch screen. Boulders - naturally occurring rounded fragments of rocks and/or minerals too large to pass through the meshes of a 4-inch screen. Fines - fragments of rocks and/or minerals which will pass through the meshes of a #200 mesh screen. Fines include particles of silt and/or clay size.

Deposits of sand and deposits of gravel rarely contain only sand or gravel as defined above. The natural series of sediments grades from coarse to fine, and the proportions may be infinite. Accordingly, the following definitions will be used in this report.

A sand deposit is one in which at least 50 per cent of the material is of sand size as defined above.

A gravel deposit is one in which at least 50 per cent of the material is of gravel size as defined above.

A classification by proportion of sizes is outlined below:

TABLE I

<u>Per cent content</u>	<u>Name of deposit</u>
(a) Boulder-gravel	
90-100 boulder size	boulders
50-90 " "	gravelly boulders
10-50 " "	bouldery gravel
0-10 " "	gravel
(b) Gravel-sand	
90-100 boulder size	gravel
50-90 " "	sandy gravel
10-50 " "	gravelly sand
0-10 " "	sand
(c) Sand-silt (and clay)	
90-100 sand size	sand
50-90 " "	silty sand
10-50 " "	sandy silt (and clay)
0-10 " "	silt (and clay)

Table I assumes only two size ranges in each of the three groups and is an oversimplification of natural occurrences where boulders, gravel, sand and silt may all be present. Where analyses show appreciable quantities of more than two size ranges, the name may be modified further, thus silty, sandy gravel, or a sandy, gravelly boulder deposit.

The term aggregate is generally used for the hard, inert, granular, processed material used in making concrete, black top, and base courses for roads. The most common aggregate materials are sand and gravel, but may be expanded shale, cinders, slag, crushed stone or other mineral substances such as magnetite or barite.

For some uses the material is merely graded for size; in others the material is also crushed to produce crushed aggregate. Aggregate of sand size is called fine aggregate; aggregate of gravel size is called coarse aggregate. Material taken from a gravel pit and crushed is called crushed gravel although in a sense it is also crushed aggregate. In this report the term aggregate will refer to the processed products of gravel pits.

Crushed stone is the product of rock quarries. It can be distinguished from crushed gravel by the fact that the components are all the same material, have a large number of fracture faces and are without any sign of former roundness.

SIZE CLASSIFICATION

Sand and gravel particles are classified on a size basis. The concept of size is usually considered in terms of the diameter. Because these particles are irregular in shape, the term has no great precision. In practice, size is measured in terms of the least cross-sectional area of the particles because they are tested on a screen having definite mesh openings through which the particle will pass or on which it will be retained. The size is a continuous variable and an infinite number of screens would be needed for a complete analysis. This is impractical, so the particles are grouped into size ranges by using a finite series of screens arranged with decreasing mesh openings. Standard screens are made with definite relationships between succeeding screens. Thus the Tyler and U. S. Standard ratio is $\sqrt{2}$ so that each screen opening is twice the area of the following. For closer sizing $\sqrt[4]{2}$ ratio is used.

The determination of the distribution of size ranges is called a mechanical analysis. The procedure is now standardized and the names given to size ranges are more-or-less standardized but the exact limits to the size ranges differ according to various authorities. Thus on Figure 3 material in the size range 140 to 200 mesh is called fine sand by some, and very fine sand by others. Material between 40 and 50 mesh size is called fine sand by some, medium sand by others. Material between #4 and #8 mesh is called gravel, fine gravel, coarse sand or granules, depending on the authority. A graphic representation of the results avoids this ambiguity and shows the actual distribution of sizes. The results of a mechanical analysis may, of course, be simply tabulated but generally a graphical representation is made by one of three methods.

The simplest method is the histogram or frequency pyramid. This is constructed on simple cross-sectional graph paper. Each class is shown by a rectangle, the base of which is proportional to the class limits and the height to the percentage of the total weight of material (see 'A' Fig. 4).

The histogram has several limitations the main objection being that it depicts the material as composed of discrete fractional sizes and not a continuous size change. The simple frequency curve depicts continuous size change and is derived from the histogram by drawing a smooth curve through the largest diameter in each pyramid (see 'B' Fig. 4).

For certain statistical studies a better scheme has been devised. This is the cumulative frequency curve. In this curve the percentage retained on each screen is added to the percentage retained on the preceding screens. The data is plotted on semi-log paper with the class interval plotted logarithmically (see 'C' Fig. 4). Figure 5 shows several typical curves for various materials.

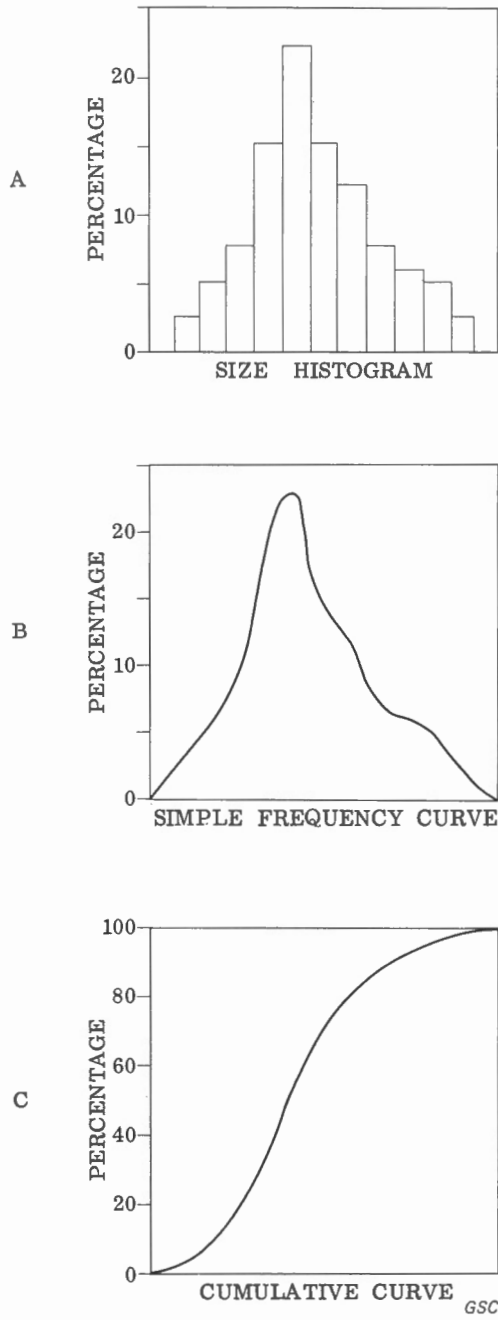


Figure 4. Graphical representation of mechanical analyses.

Material used in mechanical analyses must be representative of the whole. The reader is referred to Krumbein and Pettijohn (1938), Twenhofel and Tyler (1941), Proudley (1948), and American Society for Testing Materials (1948) for sample procedures. As a general rule samples should be large enough to include several fragments of the largest size present in the deposit. Krumbein and Pettijohn (1938) (op. cit. page 32) suggest the following weights for sizes from sand to cobbles.

<u>Material</u>		<u>Weight of sample</u>
Gravel		
Cobbles	64-128 mm	32 kg
Pebbles	4-64 mm	2-16 kg
Granules	2-4 mm	1 kg
Sand		
	2-1/16mm	125-500 gm

Sand and gravel may have appreciable quantities of clay and silt, some of which may cling to the larger particles and not be recorded in a mechanical analysis, thus giving an erroneous measure of the minus 200 mesh fraction. Washing may be all that is required to insure the passage of this material through the fine openings of a 200 mesh screen. More stubborn cases may require some dispersing agent (see Krumbein and Pettijohn, 1938).

If the total weights of the material retained on the screens do not equal the weight of the material introduced on the top screen the difference is attributed to the dust loss and the amount is usually added to the finest fraction.

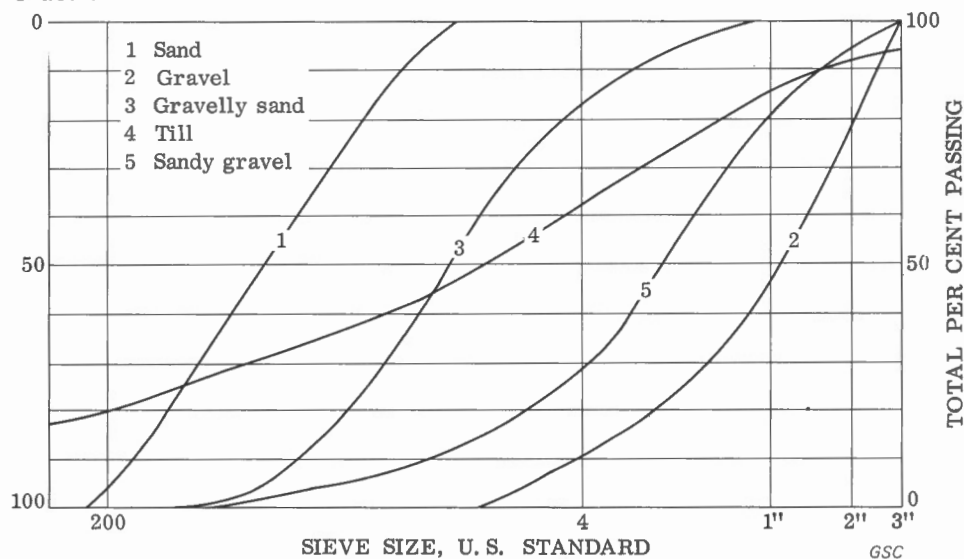


Figure 5. Typical cumulative curves.

A theoretical consideration of sieving action shows that all the particles capable of passing a given mesh opening never do but after about 10 minutes the rate at which the particles pass through has fallen off to a very low value. It is therefore important that sieving be continued long enough (see Pilgrim, 1958).

STANDARD TESTS FOR AGGREGATES

Specifications are limits placed on variations in physical (and chemical) properties of aggregates. These limits are determined by empirical tests and theoretical calculations relating to the strength and durability of products made from sand and gravel.

The most widely quoted authority for test procedures is the American Society for Testing Materials (A. S. T. M.). Engineers may write their own specifications for highway, airfield, and other types of construction but in these cases the test procedure is usually that of the A. S. T. M. Aggregates must be tested for some or all of the following:

Gradation: This is the range of sizes in a particular material. Pit run gravel may consist of boulders, cobbles, pebbles, sand, silt, and clay. The gradation is determined by shaking a weighed quantity of material through a set of screens having graduated openings. The weight retained on (or passing) each screen size is expressed as a percentage of the whole. The standard method of sieve analysis is laid down in A. S. T. M. Designation C136-46.

Soundness: Soundness is the resistance of aggregate to weathering action, notably freezing and thawing. It can be measured by actually freezing and thawing samples but this procedure is slow and expensive, requiring rather elaborate equipment.

The usual procedure is to immerse the sample in a solution of sodium or magnesium sulphate which penetrates the cracks and pores. The force of the growing crystals of the sulphate spalls off small pieces of the rock thus affecting a size reduction. The process is repeated through a number of cycles. The actual test procedure is laid down by A. S. T. M. Designation C88-46 T.

Resistance to abrasion: The common method for measuring this factor is the 'Los Angeles rattler method'. The sample is revolved in a cylindrical drum which acts like a ball mill causing impact and abrasion to the particles, thereby effecting a size reduction which is a measure of the toughness of the components. A. S. T. M. Designation C131 gives the standard method of this test.

Organic Content: This test is made by extracting the organic content of a sample with a 3 per cent solution of sodium hydroxide, and comparing the colour to reference colour solutions. The A. S. T. M. procedure is C40-48.

Specific Gravity and Absorption: The procedures for measuring these properties are somewhat different for fine aggregate than for coarse aggregate. The procedure for fine aggregate is contained in A. S. T. M. Designation C128-42; for coarse aggregate, Designation C127-42.

Specific gravity is a comparison between the weight of the material and an equal weight of water. There are several ways of defining the term; the most useful is the bulk gravity which is defined as:

$$\frac{A}{B - C}$$

Where A = weight in grams of oven dried sample

B = weight in grams of a saturated surface - dry sample in air

C = weight in grams of saturated sample in water

A second type of bulk specific gravity is defined as:

$$\frac{B}{B - C}$$

This is the saturated surface-dry basis. The apparent specific gravity is defined:

$$\frac{A}{A - C}$$

Absorption is calculated from the data by:

$$\text{Absorption (per cent): } \frac{B - A}{A} \times 100$$

Percentage of Fracture: For some purposes gravel (or rock) is crushed to make angular fragments with the aim of improving binding and bonding qualities. When gravel is passed through a crusher, only the fragments larger than the size of the discharge opening are crushed and therefore a certain percentage of round smooth stones is included in the product. Specifications may limit the amount of unfractured material to 40 per cent or less. The test is made by visual examination of each particle of a sample of the material.

Specifications may call for at least one fractured face on 60 per cent of the particles. More rigid specifications might call for two fractured faces on 80 per cent of the particles.

Fineness Modulus: This is obtained by adding the cumulative percentages retained on the 100, 50, 30, 16, 8, 4, 3/8", 3/4", 1 1/2" etc. screens and dividing by 100.

PROCESSING OF SAND AND GRAVEL

A few deposits of sand and gravel may be sufficiently clean and comprise a proper proportion of size ranges to be suitable for some purposes without any treatment. With this exception most gravel is subjected to two or more of the following operations:

- (1) extracting
- (2) scalping
- (3) crushing
- (4) screening
- (5) washing
- (6) sand classification
- (7) blending

Extracting: In most cases preparation of the site for extraction is the first step in aggregate production; river or beach deposits may be the exception. Gravel on land is generally covered with vegetation, and has at the surface a few feet of top soil containing organic matter which must be removed. In places a layer of clay or till may underlie the top soil and must also be removed. The economical removal of overburden is determined by the following factors:

- (1) thickness of overburden
- (2) thickness of sand and gravel underlying overburden
- (3) possibility of sale of the overlying material for rough fill and top soil
- (4) possibility of utilizing the material in aggregate production
- (5) ease of removal and handling

The actual removal of the overburden and gravel may be made by:

- (1) power shovel
- (2) front-end loader
- (3) cable-drawn scraper
- (4) clam-shell or dragline excavation

Power shovels are available in large sizes thus making unit cost of extraction very low. They are cumbersome pieces of equipment and are used mostly in the larger operations to load from a bank to a truck.

Front-end loaders are common items in most operations. They have the advantage of mobility and speed and consequently can serve several needs, not only feeding the plant, but removing reject boulders, stockpiling, and loading trucks.

Scraper systems are used on thick deposits when re-rigging is not too frequent and for extraction below water. In this system a bucket, which may be up to 15 cubic yards capacity, is drawn into the gravel by a cable. Operations using this system of extraction (the Sauerman system) may be either:

- (1) dragscraper
- (2) slackline cableway

The dragscraper has more flexibility and can handle larger buckets. Both systems are particularly applicable to extraction from underwater deposits but they are also used in dry pits. In the Strait of Georgia area, Sauerman systems are used by:

- (1) Construction Aggregates, Britannia Beach
- (2) Deeks-McBride-Larsen pit, Surrey
- (3) Valley Aggregates Ltd., Atchelitz Creek
- (4) J. A. Evans Gravel Ltd., Atchelitz Creek, Chilliwack

Sand and gravel are unconsolidated deposits, but in places stand in steep, compact banks because of the nature of the shape and packing of the particles. Material of this sort may be loosened by explosives, or saturation by water.

Scalping: The term is used in screening when 90 per cent of the load passes the mesh size. The first step in processing most gravels is the rejection of oversize material. Crushed aggregate may be made from large boulders and most pits in the Strait of Georgia area have little material that cannot be handled by reasonably-sized crushers.

Washed aggregate used in concrete cannot be greater than 3 to 4 inches in diameter. Material in this size range is used for drain rock but round stone or uncrushed material larger than 2 to 4 inches is scalped off, usually in two stages. Firstly on a set of grizzly rails spaced at 10 to 12 inches and secondly on the top deck of a multideck vibrating screen.

All but the operators of the smallest pits send the scalping rejects to crushers for reduction to useful size.

Crushing: In many cases, particularly for road building and asphalt paving, crushed aggregate is required. The crushing is normally done in stages using different types of crushers, depending on the size reduction required. The jaw crusher is the oldest type, and is widely used especially for the initial or primary crushing. It consists of two jaws lined with manganese steel. One jaw is fixed and the other is moved back and forth by an eccentric pitman arm. The great horizontal pressure brought to bear on any rock fragment lodged between the jaws breaks the rock material into smaller sizes. Newer types of jaw crushers make both jaws movable for greater output.

A second type of crusher is the gyratory crusher. It consists of a truncated cone on a gyrating shaft within a bowl. Both the cone and the bowl are lined with manganese steel. The action of the gyrating cone is similar to that of the jaw crusher but it does include some bending and shearing stresses on the material being crushed. (There is also some grinding in gyratory crushers which generally produces more fine material than jaw crushers.) Gyratory crushers are mostly used as secondary crushers but can be used as primary crushers when they are designed for the purpose.

Roll crushers generally consist of two counter rotating cylinders, studded with some hard alloy, which bite into the rock, compress large fragments, and also provide a hammer action against the opposite face plate or roll. Roll crushers are commonly the secondary crusher in portable crushing plants used widely in road construction.

Other types of crushers have been devised but the three mentioned above seem to be the usual types found in gravel operation.

Screening: Screening is used to separate the pit-run material into size ranges. With a single screen two size ranges are produced. Firstly those fragments which pass through the screen and secondly those that are retained on it. With two screens, three size ranges are produced. Many major producers make up to six size ranges of materials in gravel range. In common practice these are:

- (1) minus 2 1/2 plus 1 1/2"
- (2) minus 1 1/2 plus 1
- (3) minus 1 plus 3/4
- (4) minus 3/4 plus 1/2
- (5) minus 1/2 plus 3/8
- (6) minus 3/8 plus #4 or 1/4"

Except for revolving screens which usually have round holes, most screens have square openings made by weaving steel wire on thin rods at right angles. The revolving screens, called trommels, have been largely replaced by vibrating flat screens but when scrubbing action is needed to wash off clay or other coatings on pebbles, trommels are used.

Flat screens are made in a variety of sizes with openings from 1/4 inch up. Material smaller than about 1/4 inch is separated into size ranges by hydraulic methods (see sand classification). Flat screens are vibrated either mechanically or electrically to provide a forward motion to the fragments presented for sizing. Flat screens may be horizontal but more commonly are inclined at a small angle so that the downward motion of the pebbles is brought about by a simpler vibratory motion of the screen.

Washing: In many operations, washed gravel is produced in order to make a clean aggregate free from clay, organic matter, or other light weight deleterious constituents. Washing is combined with a scrubbing action on screens

and is commonly done by mounting spray nozzles over vibrating screens. The amount of water needed may vary widely. Rockwood (1948) gives as a general formula, one gallon per minute per cubic yard of material per 10 hour day but states that in difficult material as much as five times this may be required.

Another machine, the log washer or sand screen, may be used for cleaning gravel, but is more commonly used in sand preparation. The log washer was originally a wood log set with a spiral arrangement of paddles, but steel has been substituted for the wooden log. With this arrangement the material is pushed up against a descending flow of water which washes out the fine and light material.

Sand Sizing: Sand sizing is the sorting of sand into several size ranges. This is done on a laboratory scale by sieves, but in practice hydraulic methods are used in which the difference in settling velocities of particles in running water is utilized. In part this depends on specific gravity as well as size, but in the sand range most particles consist of quartz and feldspar grains which are fairly close in specific gravity and the settling velocities essentially depend on the size.

The material is introduced into a moving column of water and the smaller particles, having lower settling velocities, are carried farther along the stream to be deposited or taken off at a different point on the system. In most machines the flow of water is adjusted to carry the finer sizes out of the overflow. The discharge of the machine is taken to a second machine if another size range is sought or else discarded if no further classification is desired.

Blending: In the larger gravel operations, the raw material is separated into a number of size ranges which must later be blended in the proper proportions to meet customer specification.

The most efficient method of blending is to store the various size ranges in separate stockpiles over a reclamation tunnel, a long concrete structure which forms a passage through a series of stockpiles. Vibrating feeders under each stockpile discharge the material onto a conveyor belt. The rate of discharge to each vibrating feeder is varied over a wide range resulting in a continuous blending of materials from the various size ranges in each stockpile. Because the reclamation tunnel is built on the surface of the ground, a high proportion of material is dead storage and normally only about one third is live storage, that is, capable of moving into the vibrating feeder by gravity flow.

Handling and Storage: Most aggregate plants discharge the processed material onto conical surge piles for storage purposes and during this process the larger, rounder and heavier particles will roll or slide farther down the slope than smaller, angular and light particles. This gives rise to a

separation of sizes known as segregation. Segregation may also occur when a strong cross-wind at the discharge to sand stockpiles blows the finer sizes downwind.

Suggestions in handling and storing aggregates, are contained in various technical publications (Portland Cement Association). When conical piles are essential, as those over reclamation tunnels, close sizing in each pile is necessary to minimize segregation. Material stockpiled by truck, clamshell or loader, should be laid down (and removed) in horizontal layers of uniform thickness.

ESTIMATION OF SAND AND GRAVEL RESERVES

A gravel reserve is a deposit of gravel which can be extracted at a profit. This implies that:

- (1) The deposit is close to a centre of consumption resulting in low transportation costs.
- (2) The deposit may be obtained for reasonable royalty, rental or purchase price.
- (3) The deposit can be easily extracted, that is, it is not covered by too much overburden, such as clay.
- (4) No municipal regulations prevent exploitation.
- (5) The material is of suitable quality.

Most deposits are visually appraised by prospective producers using the rough rule-of-thumb of 5,000 cubic yards per acre per yard of depth to give an estimate of the quantity. Thus a deposit showing a 12-foot face in a pit on a 10-acre plot of what appears to be gravel-bearing land, would be expected to yield $5,000 \times 10 \times 4 = 200,000$ yards. This estimate may be out by 100 per cent if the deposit extends to 24 feet. It would not be serious if the error were in this direction but if, in fact, only 5 acres were underlain by 12 feet of gravel, the error would be in the other direction and only half the quantity would be available. The estimation of volume therefore requires some confirmation of suspected extent and thickness.

The horizontal dimensions may be established by backhoe, bulldozer or even hand-dug test pits. The vertical dimension is best established by drill-holes. Churn drills provide for recovery of the material in a suitable condition for analysis and the holes may be logged and variations in composition may be determined. Drilling is relatively expensive and the number of holes is determined by the money available. Three holes should be considered a minimum (and many more might be ideal) as the altitude of layers of till, bedrock, etc. can be determined from this information.

Unless the area under consideration is essentially flat, some elementary topographic survey is essential. The simplest method is to determine elevations by aneroid barometer along regularly spaced profile lines across the deposit. The area of each section is determined by plotting the data on squared paper and counting the squares. The area of gravel on each section is assumed to extend halfway to each adjacent section. The volume centred on each section then is the area multiplied by the separation. If the area is measured in square yards and the separation is in lineal yards the volume in cubic yards is directly determined.

In determining the area of gravel in each section, the information from the drill-holes must be included and projected if necessary to each section. Without some knowledge of subsurface conditions, the calculations would give only the maximum volume of material; and this figure may be greatly in error.

THE CONSTITUENTS OF SAND AND GRAVEL

Sand and gravel have been defined (in part) as more-or-less rounded fragments of rocks and/or minerals.

Gravel is essentially all rock fragments and the only mineral commonly found in gravel deposits in the Strait of Georgia area is quartz in amounts up to 2 per cent. Sand, on the other hand, is largely composed of mineral grains. Quartz, feldspar and mica are the main representatives with minor quantities of magnetite, pyrite, hornblende, zircon and fragments of fine-grained rocks.

A large percentage of the bedrock exposed in the Strait of Georgia area is of granitic composition hence a large part of the components of gravel is made up of this rock type. The Cascade Mountains, the eastern boundary of the Fraser Lowland, are underlain by a higher percentage of non-granitic rocks and the percentage of these types in the gravel increases. North of Squamish, contributions from the Tertiary and Recent Garibaldi volcanic rocks are a prominent component. On the eastern side of Vancouver Island Upper Cretaceous shales and sandstone together with basic volcanic rocks are conspicuous components in the Nanaimo area.

Most of the components of the Strait of Georgia gravels are hard, inert fragments, but some unsound material is present in places. A noticeable feature of many pits is the decomposed granitic stones which may amount to as much as 10 per cent of the total granitic component. In most cases these rocks are so weak that they disintegrate on washing and screening. Shales are weak rocks and in those pits where they form an appreciable percentage of the components, an inferior gravel results.

Garibaldi volcanic rocks also make inferior aggregate as the material is too absorptive for some uses.

Most of the pits in the Fraser Lowland contain some chert pebbles. This is a deleterious substance in many parts of the world as some types react with the alkali in the cement to form "pop-outs" and hence failures in the finished concrete. However, the chert found in pits in Fraser Lowland is innocuous. Chert is not the only alkali-reactive substance; volcanic rocks are also suspect, particularly those containing chalcedony, opal and acidic glasses.

Most gravel deposits in the area tend to be sandy and are classified as sandy gravel. In the Powell River area some producers have to screen gravelly sand to make aggregate. Only rarely is it necessary to add sand to a gravel deposit to obtain the required grading. Pits in fine sandy gravel are normally short of crushing material and when this material is required blending of larger sizes from other sources is the only solution.

TRANSPORTATION

The utilization of sand and gravel depends to a large extent on low cost transportation. In most cases trucks are used especially for final delivery to the consumer but four other means of transportation are available for bulk hauling. These are: (1) barge, (2) railway car, (3) conveyor belt, (4) pipeline.

Barges are used in the Strait of Georgia area both on open water and on the Fraser River. Many factors are involved in estimating barging costs but a rough estimate of the cost of transporting gravel from plants on Howe Sound to Vancouver is about 50 cents per cubic yard. These plants are about 30 miles from Vancouver so the unit cost is about 1.6 cents per cubic yard per mile. With very large barges the unit cost would be even lower.

Four railway lines enter Vancouver from various parts of the Fraser Lowland. Some pass close to gravel areas and could presumably be used to transport gravel into the Greater Vancouver area. Some figures have been supplied by the railway companies as a guide; they are not firm prices and, with large quantities, the prices would be lower.

<u>Line</u>	<u>Load point</u>	<u>Distance</u>	<u>Cost per cubic yard per mile</u>
B. C. Hydro & Power Authority Railway	Sperling	35 miles	9 cents
Great Northern Railway	Colebrook	24 miles	12 cents
Canadian National Railways	Fort Langley	30 miles	5 cents
Canadian Pacific Railway	Albion	29 miles	10 cents

Conveyor belts are an integral part of gravel plants and in a few operations they have been extended from the plant to the pit to eliminate truck transportation. In some places conveyors have been used for transportation from the plant to the consumer. A four-mile long conveyor system is being used to transport the fill for the dam on the Peace River at Portage Mountain.

Sand has been pumped from the Fraser River and Mud Bay and transported by pipeline for various projects such as straight fill, pre-loading of building sites and overpass construction. No figures on unit costs are available but it is known that very low unit costs are achieved by this method.

Fluming, a variation of the pipeline method, has been used for short-distance transportation in one or two places in the Strait of Georgia area. The method is limited in application.

Transportation costs may be quoted in terms of cubic yards or tons. Most freight rates are quoted on a ton basis; road restrictions limit the weight which can be carried and most blending is controlled by weightometers, consequently the weight basis is displacing the older volume basis of mensuration. As an approximation, a cubic yard of gravel may be considered to weigh a ton and a half or 111 pounds per cubic foot; the normal range may extend about 100 to 130 pounds per cubic foot depending on the amount of voids and the percentage of moisture.

STATISTICS AND OUTLOOK

Producers of sand and gravel are required under both the Dominion Statistics Act and the Mining Acts of the provinces to complete a form giving pertinent data on the operation for each calendar year. The statistics of the industry are compiled from these completed forms and are published annually by both authorities. The report of the Dominion Bureau of Statistics is available from the Queen's Printer, Ottawa. The Mineral Resources Division of the Department of Energy, Mines and Resources also publishes the Dominion Bureau of Statistics figures with further comments in a pamphlet making up a part of the Mineral Review Series. This is available from the Department in Ottawa. In addition, the annual reports of the Minister of Mines for British Columbia present the statistics by Mining Divisions and give further information on many specific operations. These reports are available from the Department of Mines and Petroleum Resources, Victoria, B.C.

The growth of production in three mining divisions bordering on the Strait of Georgia area is shown in Figure 6 which leaves room for projections into the future, a procedure which is highly speculative. A general increase in demand for aggregate with the increase in population is expected and will increase the depletion rate of existing sources. One result will be a rapid

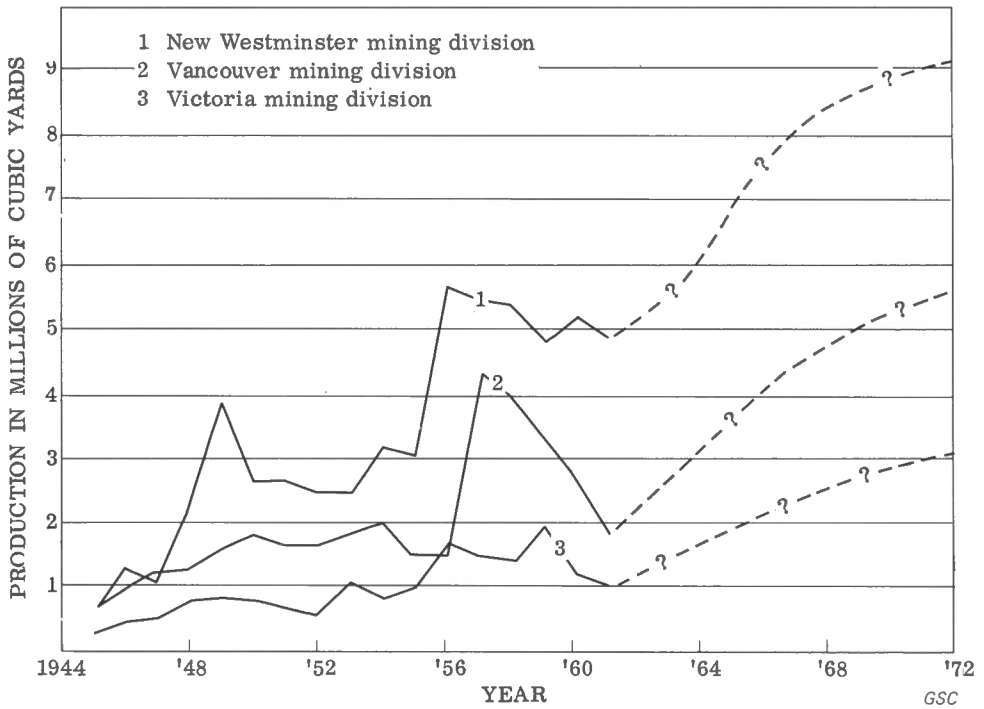


Figure 6. Sand and gravel production.

decline in production in areas close to the centres of population. Production will have to be maintained by new pits and these will become progressively farther away. Transportation cost will rise accordingly.

Whereas production in the Vancouver mining division will probably fall, production from other mining divisions, notably New Westminster, Victoria and Nanaimo, will probably increase.

Gravel deposits in Surrey, Langley, and Coquitlam municipalities are suitably located to fill most future requirements if steps are taken to set aside suitable reserves before it is too late.

At present there is no duty levied on the importation of pit-run gravel from the United States of America and some competition from these sources is likely. Many changes in the production pattern are foreseeable. The number of pits will be reduced considerably and only large-scale producers using the cheapest methods of production and transportation will survive. This probably means that the industry will be left to the few producers who have acquired very large reserves in convenient places.

Many parts of the world are short of good supplies of sand and gravel and have to manufacture aggregate from suitable rock formations. A large amount of rock, mainly limestone, is used where sand and gravel is scarce or unsuitable. Crushed limestone offers some advantages as an aggregate in that it is more uniform in both physical and chemical properties than most gravel. The production of crushed stone in Canada in 1960 made large gains over former years. In 1961, limestone for road metal amounted to over 19 million short tons, and nearly 8 million short tons for concrete aggregate. A small amount of crushed limestone from Texada Island is used in the Greater Vancouver area for walks and driveways. Limestone deposits in the Strait of Georgia area are potential sources for aggregate. Rocks other than limestone are used in some places for making aggregate. An unlimited supply is available in British Columbia especially if granitic rocks are suitable. At present, however, quarrying and crushing costs prohibit exploiting this resource.

Sand and gravel have a variety of uses, the most important are the construction of roads, and the making of concrete. For some special uses, the unit value may reach as high as \$1.95 a ton but most of the uses require so much material that only a very low unit cost makes utilization possible. A breakdown by uses, showing the unit value, percentages of total value and percentage of total weight for 1962 is shown in Table II. As stated above the most important item is sand and gravel for roads.

GEOLOGICAL PRINCIPLES

Sand and gravel are part of the sedimentary series which ranges from clay to huge boulders. The entire series is ultimately derived from the bedrock crust of the earth by mechanical disintegration or chemical weathering or a combination of both.

Sediments are normally laid down in layers called beds which are essentially horizontal (except in deltas). When the beds are distinct the deposit is said to be well-bedded (Fig. 7A). Bedding may be indistinct or rudimentary and the deposit is said to be poorly-bedded (Fig. 7B). Each bed may contain a narrow range of particle sizes in a well-sorted bed (Fig. 7C) or contain a wide range of sizes in a poorly-sorted bed (Fig. 7D). Beds which vary vertically from coarse to fine are called graded beds (Fig. 7E).

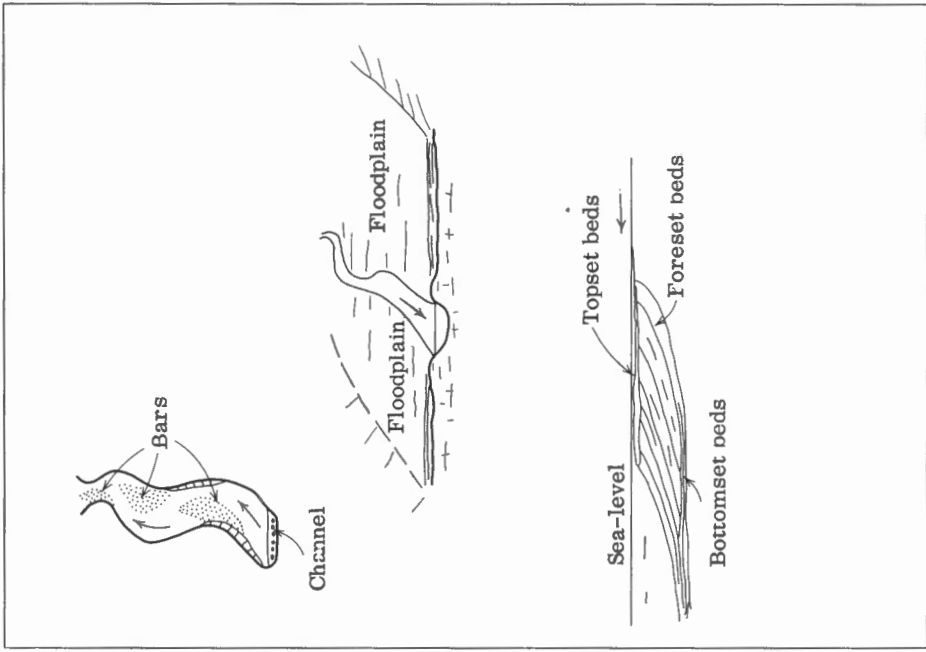
The initial action in the production of sediments is the formation of angular blocks, slabs, or grains in exposed upland areas, where, under the force of gravity, the material loosened by frost action, root wedging, thermal expansion, etc. is normally transported downhill to end in a watercourse where further transportation is effected. Watercourses themselves grow headwards and enter areas of loosened material. This provides the bed load for the stream and in the process of transportation a two-fold modification

TABLE II

Production of Sand and Gravel by Users in 1962*

<u>Sand and Gravel</u>		<u>Dollars Per Ton</u>	<u>Per Cent of Total Production</u>	<u>Per Cent of Total Value</u>
Fill	1,217,958 tons			
	611,681 dollars	0.49	6.75	5.60
Backfill for mines	52,717 tons			
	29,288 dollars		.29	
Roads	11,675,632 tons			
	5,939,722 dollars	0.51	65.40	54.9
Concrete aggregate sand	294,669 tons			
	306,217 dollars	1.04	1.67	2.8
Gravel	1,103,751 tons			
	1,155,863 dollars	1.02	6.15	10.4
Asphalt aggregate	208,215 tons			
	298,674 dollars	1.43	1.16	2.7
Railroad ballast	83,233 tons			
	32,180 dollars	0.39	.47	.3
Mortar sand	24,972 tons			
	40,893 dollars	1.68	.14	.4
Other special uses	120,140 tons			
	96,360 dollars	0.80	.67	.9
			<u>82.70</u>	
<u>Crushed Gravel</u>				
Backfill for mines			-	-
Roads	1,438,177 tons			
	1,178,611 dollars	0.82	8.20	11.3
Concrete aggregate	525,029 tons			
	543,155 dollars	1.04	2.93	4.9
Asphalt aggregate	163,095 tons			
	132,279 dollars	0.81	.91	1.2
Railroad ballast	697,735 tons			
	379,151 dollars	0.57	3.90	3.4
Other uses	84,910 tons			
	96,532 dollars	1.14	.47	.9
TOTALS	17,879,395 tons			
	10,992,346 dollars	0.61	99.11	99.7

* Latest figures available from Dominion Bureau of Statistics



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Figure 8. Sedimentary deposits.

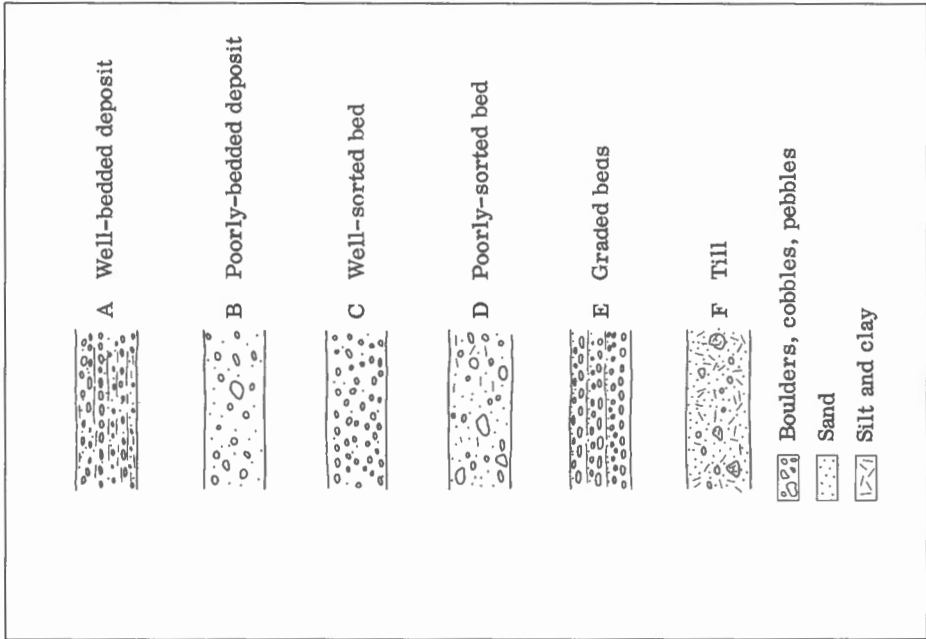


Figure 7. Sedimentary features.

results: (1) the material is sorted; that is, the finer fragments are swept farther downstream than larger ones and (2) the fragments are rounded, that is, the sharp edges and corners are blunted and hence the fragment becomes smaller. In this connection two terms should be noted: (1) roundness and (2) sphericity. Roundness refers to the sharpness of the edges and corners; sphericity is the approach to the spherical shape. Roundness is due to abrasion, and a high degree of roundness implies long travel in stream deposits; however, beach deposits are often highly rounded yet may have travelled only a short distance from the parent bedrock. Long continuous wear might produce a spherical shape but this is largely determined by the shape and homogeneity of the original fragment. The difference between roundness and sphericity is well illustrated by Pettijohn (1949) and Krumbein and Pettijohn (1938).

Sedimentary deposits are built up of material no longer being transported by natural agencies. In the case of sand and gravel, the moving agent is usually running water in streams but may be waves or tides on beaches. The wind is the transporting agent for certain sand deposits (dunes).

With decrease in velocity, the moving agents are less able to act and larger fragments cannot be transported. These are then left behind to form deposits of boulders or coarse gravel. With further decrease in velocity, smaller cobbles and pebbles remain behind to form deposits of gravel, and with still further decrease in velocity, sand drops out. The normal sequence is thus coarse to fine. All of this occurs under ideal conditions which are rare in nature. Streams do not long maintain the same velocity. There is a seasonal cycle: low water in winter, rapid runoff in spring; daily cycles, especially for mountain streams in early spring; random flash-floods from heavy rains so that at any one point in a river the current varies enough to drop one size today, and another size tomorrow. Also, initial deposition of a particle is not final as the water course may be scoured out by the next increase in velocity. Thus the deposits in river channels will be variable within fairly wide limits. The velocity of a stream is a function of the gradient of its bottom. This changes with geological conditions. A river may be rejuvenated by earth movements causing uplift which increases the gradient and results in more rapid erosion and the river may cut down through the deposits it laid down previously. In this way terraces are developed.

The velocity of a stream may be decreased in several ways. A reduction in the quantity of water in a stream will affect its velocity. The natural gradient of a stream results in a decrease in velocity in the downstream direction. Discharge into a lake or the ocean results in a rapid decrease in velocity. Under flood conditions a channel may not be able to contain all the water that descends from the source and will pour over the banks, carrying with it much sediment which rapidly drops out as the velocity falls as the water spreads over the flood plain.

The deposits formed under these various conditions are identifiable by their characteristic structures.

Channel deposits are variable both vertically and horizontally over short distances. They are typically lenticular in shape. Bedding is usually distinct.

Discharge into a body of standing water results in the deltaic structure common in many gravel pits in the Fraser Valley. In this type of deposit the foreset beds are inclined at angles up to 30 degrees to the horizontal and are well bedded and sorted. Flood plain deposits are generally sand, silt or clay. Only under unusual conditions is gravel rolled out of the river course and then only for a short distance. Channel, bar, flood plain and deltaic deposits are illustrated diagrammatically in Figure 8.

Wind blown sand is deposited in low hills (dunes). There are some good examples of this type of deposit in the Fraser Lowland and on Vancouver Island.

Wave action has produced some sand and gravel deposit along the sea coast. The reader is referred to text books on sedimentation, stratigraphy, etc. for further information on the subject. Special reference may be made to the works of Twenhofel (1950), Dunbar and Rodgers (1957), Weller (1960), Krumbein and Sloss (1956), and Pettijohn (1949).

Much sediment in the Strait of Georgia area owes its origin directly or indirectly to glacial ice that formerly covered the area. All such deposits are collectively called drift and include sand and gravel from glacial streams (glacio-fluvial) deposits; clay and silt in glacial lakes, glacio-lacustrine deposits, and till which is a heterogeneous deposit of wide range generally laid down under the advancing ice (glacial deposits proper).

For further information on such deposits the reader is referred to Flint (1957).

SURFICIAL GEOLOGY OF THE STRAIT OF GEORGIA AREA

The Pleistocene and Recent sedimentation of the Strait of Georgia area is one of alternate glacial and non-glacial deposition. During each major glacial episode a Cordilleran glacier, originating in the mountains of southwestern British Columbia, largely on the Mainland but partly on Vancouver Island, advanced southward and southwestward into the Strait of Georgia and the bordering lowlands. At its maximum the last Cordilleran ice-sheet covered the Strait of Georgia and the mountains of Vancouver Island. Earlier ice-sheets probably covered the same area.

The first recorded subdivisions of the Pleistocene and south-western British Columbia were made by Dawson (1890). He noted two tills separated by stratified sands and silts, but did not apply stratigraphic names to the deposits. The earliest published named subdivisions of the Pleistocene were presented by Willis (1898), who also recognized two glaciations, Admiralty (older) and Vashon, separated by a non-glacial interval which he named Puyallup. This sequence with minor modifications was subsequently adopted by Clapp (1913, 1914, 1917) on southern Vancouver Island and Burwash (1918) and Johnston (1923) in the Fraser Lowland.

A major program of field work on the Pleistocene and Recent deposits of the Fraser Lowland was begun by Armstrong in 1949 resulting in several preliminary papers (1956, 1957, 1960, a,b) in which he established the following sequence of events and stratigraphy for the part of the Pleistocene and Recent with which this paper is concerned. Informal names used by Armstrong in the preliminary papers are shown in quotation marks.

"Salish Group" (youngest) (post-glacial deposits still being formed in part overlap "Capilano" deposits): alluvial, deltaic, estuarine, marine, lacustrine, colluvial, and swamp deposits. Includes Fraser River delta deposits at least 700 feet thick. "Salish" deposits are believed to have been laid down after the present relative position of the land and sea first became established. "Richmond delta" and "Fraser flood plain deposits" were included in this group.

"Sumas Group" (post-"Vashon" glacial deposits related to valley ice). The glacier responsible for these deposits advanced into the sea depositing glacio-marine sediments (marine drift) up to 300 feet thick and terminated about 25 miles east of Vancouver. As the land rose the glacier was grounded, depositing till, and as the glacier wasted, recessional outwash and glacio-lacustrine deposits up to 450 feet thick were laid down. "Abbotsford outwash", "Whatcom glacio-marine deposits", "Cloverdale sediments", "Huntingdon gravel", and "Sumas till" were included in this group.

"Capilano Group" (post-"Vashon" non-glacial deposits, no longer being formed. In part older, in part contemporaneous, and in part younger than "Sumas Group"): marine off-shore, littoral, and delta deposits, alluvial and aeolian deposits formed during uplift of the land above the sea following the retreat of the "Vashon" ice-sheet. "Capilano gravel", "Bose gravel", "Sunnyside sand" were included in this division.

"Vashon Group" (deposits of last glaciation of continental ice-sheet proportions). As the ice-sheet advanced, outwash up to 200 feet thick was deposited in front of the glacier and till beneath it. During the ice advance the land was depressed at least 750 feet below present sea level and during wasting of the ice-sheet the glacier thinned, losing contact with the sea floor and became

floating ice from which debris was dropped to form marine drift "Surrey till". "Haney outwash", "Mary Hill outwash" and "Newton stony clay" were included in this group.

"Quadra Group" (intertill, probably interglacial sediments): alluvial sediments deposited during a time which had a temperate climate somewhat similar to present-day climate. The group included "Point Grey beds", "Colebrook gravel", "Nicomekl silt" and "Sapperton sediments".

"Semiamu Group" (deposits related to glaciation): till and stratified drift very poorly exposed and probably missing in much of the area as explained above. The glacier responsible for these deposits was probably of continental ice-sheet proportions. "Semiamu till" and "Semiamu sediments" were included here.

"Pre-Surrey deposits" (oldest) Older glacial, marine, and non-marine deposits included here were "Seymour till", "Lynn outwash", and "Sisters varved clay".

Since publishing the preliminary papers Armstrong (personal oral communication) has had the opportunity to obtain much additional information including a fairly large number of radiocarbon dates. He has found it necessary to revise the stratigraphic sequence outlined above and has dropped the term group (not used correctly according to present geological usage) and many of the informal names. In a paper (Armstrong et al., 1965) a new stratigraphic nomenclature for the late Pleistocene deposits in southwestern British Columbia and northwestern Washington has been proposed. The proposed terminology may be summarized as follows as it applies to the Fraser Lowland.

Geologic-Climatic unit		Absolute time, thousands of years B. P. * (approx.)	Stratigraphic units
Fraser Glaciation	Sumas Stade	9? - 11	Sumas Drift
	Everson		Whatcom glaciomarine deposits
	Interstade	11 - 13.5	Capilano Newton stony clay sediments
			Cloverdale sediments
Olympia Inter-glaciation	Vashon Stade	13.5-24.5	Surrey Drift
		24.5-36.5	
		possibly considerably older at lower limit	Quadra sediments
Pre-Olympia			Semiamu Drift also older deposits

*B. P. - Before present (time)

Armstrong (personal oral communication) states that in the preliminary papers "Semiamu Group" now Semiamu Drift was shown as younger than Quadra, but later mapping and interpretation has proven Semiamu to be older than Quadra. In further discussion in this report the following stratigraphic terminology will be used, where it differs from that in the published reports and older usage is shown in brackets, all the names are informal unless capitalized.

Salish sediments (Salish Group)	Fraser flood plain deposits
Sumas Drift (Sumas Group)	Abbotsford outwash Sumas till Huntingdon gravel
Capilano sediments (Capilano Group)	Bose gravel Whatcom glacio-marine deposits Newton stony clay Cloverdale sediments Capilano sediments (Capilano gravel)
Surrey Drift (Vashon Group)	Haney outwash Surrey till Mary Hill outwash
Quadra sediments (Quadra Group)	
Semiamu Drift (Semiamu Group)	

Pre-Surrey sediments; in much of the area Quadra and older deposits cannot be separated.

In the published preliminary papers some of the gravels and sands were mapped incorrectly. In this report they are shown correctly. Every place where there has been a change the old name will be referred to in brackets.

On Vancouver Island Fyles (1959, 1960, 1963) and Halstead (1963) have established the following stratigraphic units and in further discussion of the Vancouver Island area the writer will conform to this terminology.

Salish sediments: shoreline and fluvial deposits and associated materials related to the present sea, river, and lake levels.

Capilano sediments: marine, fluvial, and lacustrine deposits related to former (higher) sea, river, and lake levels.

Vashon Drift: glacial deposits lying unconformably on the Quadra sediments or on deposits beneath the Quadra, and constituting the uppermost drift sheet of the region.

Quadra sediments: sands; plant-bearing silts and gravels; marine stony clays and laminated clays.

Dashwood Drift: till locally intercalated with gravel, sand, and silt, and lying conformably beneath the clays of the Quadra sediments.

Mapleguard sediments: sand, silt, and clay lying beneath the Dashwood drift.

DISTRIBUTION OF SAND AND GRAVEL DEPOSITS
IN THE STRAIT OF GEORGIA AREA

GEOLOGY AND DISTRIBUTION OF SAND AND GRAVEL
IN FRASER LOWLAND

INTRODUCTION

For the purpose of this report it is convenient to divide the Strait of Georgia area into three subdivisions: the Fraser Lowland, the east coast of Vancouver Island and the Georgia Lowland. The Fraser Lowland is mainly controlled by municipal governments each of which has different by-laws for regulating the sand and gravel industry. For this reason it is convenient to treat the subdivisions by municipalities. The east coast of Vancouver Island is largely unorganized and it is more convenient to consider the sand and gravel industry there by map-areas in so far as these have been published. The Georgia Lowland is largely unorganized and unmapped and the sand and gravel industry of minor importance at present.

In the preceding section the surficial geology of the Strait of Georgia area has been summarized. The stratigraphic units in the Fraser Lowland from which sand and gravel are produced are described in more detail in this section.

Salish sediments (Salish Group)

The Salish sediments are post-Glacial deposits and in many places are still being formed. They consist, in a large part, of sediments deposited by present day rivers and streams in bars, channels, flood plains and deltas. Also included are beach and colluvial deposits, the latter consisting of talus and slopewash (fans). The Salish sediments range in size from clay to gravel and in places are sources of sand and gravel, particularly along the larger rivers such as the Fraser, Capilano, Seymour, Coquitlam, Alouette, Stave and Chilliwack.

The Fraser is the largest river in the area and deposits of silt, sand and gravel are associated with it. Silt and sand are the main sediments in the lower reaches and at the mouth, but sediments become progressively coarser upstream. Gravel is scarce down stream from New Westminster and one of the few places it is known in that part of the river is at the west end of Annacis Island where a small area of gravel on the south bank of the river is being eroded. Shipping channels in the river are repeatedly dredged by the Federal Government as far upstream as Sapperton Reach in New Westminster; some of the dredged material, mainly sand and fine gravel, is stockpiled on land where it is available for commercial purposes. The distribution of gravel in the river above Sapperton Reach is not known. The gravel becomes finer downstream from Hope and much of the channel bar and

flood plain material is silt and sand. Local gravel areas in the river may not be normal Fraser River sediments but material added from another source so the whole becomes a mixed deposit of Fraser River sediments and mountain stream gravel such as is well exemplified by the delta of Norrish Creek where it joins the Fraser River two miles east of Dewdney.

Sand and gravel deposited by Capilano River, Seymour River and Lynn Creek along their banks and at their debouchments in Burrard Inlet, constitute large reserves of sand and gravel. In the past, three or four producers obtained several hundred thousand cubic yards annually from these deposits but curtailment of dredging permits by the National Harbours Board in 1963 has effectively prevented further exploitation. Most of the dry diggings have also ceased because of zoning regulations and urban expansion.

The Chilliwack River is transporting and depositing sand and gravel in the eastern part of the Fraser Lowland. The deposits lie along the present and former courses of the river and cover about 11,520 acres. These deposits are up to 50 feet thick but assuming an average of 30 feet, 376 million cubic yards of sand and gravel are estimated to be present.

A U-shaped area of 4.29 square miles north of the city of Port Coquitlam is underlain by mountain stream gravels up to 25 feet thick and constitutes a deposit of 108 million cubic yards.

Two miles north-northeast of Haney an area of 730 acres is estimated to contain 3.65 million cubic yards per yard of depth.

The Stave River bottom below the dam at the outlet of Hayward Lake contains about 2 square miles of mountain stream deposits of sand and gravel up to 50 feet thick. Four pits have been opened. Tidal influences in the river however make barging difficult.

The upper Hatzic Valley contains about 960 acres underlain by mountain stream deposits centred on Durieu.

Small alluvial fans provide gravel for local use in many places throughout the Fraser Lowland. They are formed where small streams, often intermittent, discharge onto valley bottoms from steep hillsides. Good examples may be seen at Deroche, two miles west of Deroche, and along the front of the Skagit Range south of Rosedale. Fans and slopewash deposits in general are angular and coarse and are made up largely of the local bedrock. Good examples of this may be seen along the south slope of Sumas Mountain.

An area of about 700 acres of mountain stream gravel lies about 1 1/2 miles north of Haney and constitutes a deposit of some 35 million cubic yards.

Salish sediments are the youngest in the area and are therefore not covered by other formations. They may have a thin covering of topsoil and vegetation but there is no serious stripping problem. Most of the sand and gravel pits in Salish sediments encounter the water-table within a few feet of the surface. Also detrimental is the low elevation of many of the deposits which necessitates raising materials from the lowest elevation at which they occur to the height of the hopper at the plant. This places the deposits at an economic disadvantage compared to those which occur in high "dry-land" banks.

Capilano sediments (Capilano Group)

The Capilano sediments include gravel and sand deposits of different origins. The most important are raised deltaic, channel and flood plain deposits. These are best developed along the lower reaches of many of the streams flowing from the mountains; elsewhere they occur interbedded with the glacio-marine deposits. The gravels along the streams were originally mapped as "Capilano gravel" and the gravels interbedded with glacio-marine deposits in the eastern parts of the Fraser Lowland were mapped as Huntingdon gravel, a term now restricted to advance outwash deposits associated with Sumas Drift. Beach and intertidal gravel and sand called Bose gravel and Sunnyside sand respectively, were laid down during a period of deposition represented by the Capilano sediments.

The raised deltaic gravels are best developed near the Coast Mountains where they occur along lower reaches of streams such as Capilano, Seymour, Coquitlam and Alouette Rivers.

Many of the deposits in the Greater Vancouver area have been covered due to urban expansion but there is still some material available along Lynn Creek and Seymour River. An extensive area of Capilano gravels occurs in Coquitlam municipality along Pipeline Road. It covers about 2,560 acres, is as much as 30 feet thick, and represents a deposit of about 128 million cubic yards.

In the eastern half of the Fraser Lowland east of Fort Langley widespread sand and gravel deposits are found interbedded with Whatcom glacio-marine deposits. The largest area of these gravels is between Sperling Station and the old Trans-Canada Highway in Langley municipality. The area was originally mapped as Abbotsford outwash but it is now known to be part of the Capilano sediments. The area involved amounts to 10 square miles, part of which is sand and gravel and part is clay. The area underlain by sand and gravel is about 8 square miles. Assuming an average depth of 18 feet, a deposit of 154 million cubic yards is estimated.

Bose gravel is a marine beach-offshore bar, spit and lag veneer facies. It occurs extensively in Surrey and Langley municipalities and the Greater Vancouver area. It is generally only a few feet thick but in places

occurs in bars up to 15 feet thick which may be thick enough to be workable. Sunnyside sand is a marine intertidal facies of the Capilano Sediments. Best exposures occur in Surrey and Langley municipalities but they extend to the northwest corner of Matsqui municipality. This is not an important source of sand.

Sumas Drift (Sumas Group)

Sumas Drift includes advance outwash deposits called Huntingdon gravel and recessional outwash deposits called Abbotsford outwash. The best exposure of Huntingdon gravel occurs on the north side of the Fraser River from Hatzic to Silverdale. An area of 1.87 square miles is underlain by Huntingdon gravel up to 100 feet thick giving a deposit of some 178 million cubic yards. Good exposures occur along the north side of the Chilliwack River for 6 miles upstream from Vedder Crossing. In this area 2.7 square miles are exposed under the covering of Sumas till. Smaller exposures occur where erosion has stripped off the covering of till at the type locality at Huntingdon in Sumas municipality, south of Glen Valley, and east of Fort Langley.

Deposits of Abbotsford outwash underlie large areas in Matsqui, Langley, Surrey and Mission municipalities. In general two types of deposit are included under the term: (1) normal glacio-fluvial outwash deposits and (2) ice-contact deposits. The former are the most extensive and have the cleanest gravel. A large delta and its feeder channel straddles the Surrey-Langley municipal border about 3 miles north of the International Boundary. The deposit covers 11 square miles or 7,400 acres. Test holes indicate that the gravel and sand is up to 100 feet thick. The average depth may be assumed to be about half of this. Using the figure 48 feet the deposit amounts to some 574 million cubic yards.

An area of 10.7 square miles surrounding Abbotsford Airport is underlain by glacio-fluvial sand and gravel up to 125 feet thick. If this whole area were worked to a depth of 48 feet, production would amount to 547 million cubic yards. This does not include the whole deposit of Abbotsford outwash in the area. There are several different facies of the outwash in the southern part of Surrey, Langley, Matsqui, and Sumas municipalities which may be summarized as follows (including the two previously mentioned areas):

(1) Langley-Surrey outwash delta deposit	11.00 sq. mi.
(2) Langley-Surrey outwash delta channel	1.06
(3) Langley-Surrey ice-contact deposits	1.30
(4) Langley-Matsqui ice-contact deposits	6.64
(5) Mount Lehman ice-contact deposit	3.00
(6) Abbotsford Airport outwash deposit	10.70
(7) Aldergrove glacio-fluvial deposits	6.52
(8) Dune sand on gravel	3.63

(9) Pitted outwash deposits	2.79
(10) Abbotsford village glacio-fluvial deposits	3.12
Total	49.76 sq. mi.

Abbotsford outwash occurs extensively in Mission municipality. Most of the areas of outwash contain numerous small rock outcrops indicating a relatively shallow depth. Most deposits lie east of Hayward Lake and along Cardinalis Creek. Just west of the north end of Hatzic Lake 'windows' of till show through the outwash indicating a generally thin deposit. A long narrow belt of Abbotsford outwash lies just north of the Fraser flood plain from Deroche to Harrison Lake. This material is an ice-contact deposit which formed along the north wall of the valley and a tongue of ice in the valley bottom. The area involved amounts to 5 square miles.

Surrey Drift (Vashon Group)

Surrey Drift includes advance outwash deposits called Mary Hill outwash and recessional outwash deposits called Haney outwash.

Mary Hill outwash is exposed mainly in the city of Port Coquitlam where Ocean Cement Limited operate the largest sand and gravel plan in British Columbia. The material probably underlies 850 acres but a variable thickness of till and stony clay overlies the gravel and it cannot be shown positively that Mary Hill outwash gravels do in fact underlie all of Mary Hill.

Areas of pre-Surrey till gravel around the base of the Surrey upland in the western side of Surrey municipality were originally mapped as Colebrook gravel. These are now considered equivalent to Mary Hill outwash.

Haney outwash gravel is exposed only in a small area north of Webster's Corner in Maple Ridge municipality. Much of the deposit is within the boundaries of Haney Correctional Institution. In all, about 1,376 acres are underlain by sand and gravel up to 125 feet thick. Assuming an average depth of about half of this, a volume of 110 million cubic yards can be estimated.

Quadra sediments (Quadra Group)

Quadra sediments include deposits of sand and gravel laid down prior to the advent of the Surrey Drift. In most places they are covered by younger deposits and only where they have been exposed by erosion or human activity are they amenable to exploitation. Much of the Quadra sediments is sand; gravel occurs in the Mary Hill pit of Ocean Cement Limited above the second till from the surface.

Pre-Surrey deposits

Older deposits of sand and gravel are known from deep bore holes in many parts of Fraser Lowland. In a few places surface exposures of gravel which have been mapped as Colebrook gravel (Surrey Drift) have been demonstrated by radiocarbon dating of wood (or shells) to be older than Quadra sediments. These deposits lie immediately under the Surrey till and the disparity in age can be explained by erosion prior to the advance of the last ice-sheet. The best examples are found along the edge of the Surrey Upland near the east boundary of Delta municipality.

The detailed description of the individual deposits that follow are grouped under municipal subdivision.

DESCRIPTION OF AREAS

Burnaby municipality

Municipal regulations

Burnaby municipality adjoining Vancouver on the east is now largely urban. Potential gravel sources are scarce and the need for municipal regulations largely unnecessary. However, regulations do prevent development of the few potential sources left. No excavations are allowed except in peat bogs on the Fraser flood plain.

Geology and reserves

Bose gravel of the Capilano sediments occurs on the south slope of Burnaby Mountain and one pit has produced from this area. Another area of Bose gravel occurs north of Marine Drive near the eastern boundary of the municipality. Neither of these areas contains appreciable deposits, however.

The main gravel deposit in the municipality occurs in an area along Stride Avenue north of Marine Drive. Here, two pits, owned by the municipality and British Columbia Hydro and Power Authority have operated in the past but production has now largely ceased. Municipal authorities believe that two million cubic yards could be salvaged but it would necessitate relocating a power line and a railway. The gravel has been mapped as pre-Surrey and underlies a variable thickness of Surrey till. The original pit site must have been largely overlain by till as 30 to 40 feet of this material now overlies the gravel along the east boundary. A gravel here is about 95 per cent minus 8 inches and few boulders are much larger. The section which is about 50 feet high is sandy towards the bottom. Much of the till is stony and could be utilized for aggregate production. Gravel is exposed in a gully about a mile west of the pits. This is also pre-Surrey gravel and is

presumably continuous with the eastern exposures. However, the area surrounding this outcrop is completely developed for residential purposes and the deposit cannot be considered in the reserves. Between Gilley Avenue and the Stride Avenue pits, an area of about 300 acres is underlain by Colebrook gravel under a variable thickness of Surrey till and Bose gravel. Assuming an average depth of 30 feet this deposit contains about 15 million cubic yards. Probably only a very small percentage of this could be recovered owing to zoning regulations and other considerations.

Chilliwack municipality (Fig. 9)

Municipal regulations

Zoning regulations have set aside certain areas from which gravel may be taken. In general these include the south bank of the Fraser River and its sloughs; the Chilliwack River and its sloughs. Pits must not approach other zone boundaries closer than 100 feet or public highways within 200 feet. Gravel must not be removed from below the water-table. Abandoned pits are to be left clean and properly sloped. Rock-crushing and asphalt plants must be at least 500 feet from land not zoned for gravel operations. Gravel pits may be located only in gravel pit district as outlined in zoning by-law 1958; amendment by-law No. 11, 1959.

Geology and reserves

The oldest sand and gravel formation in the municipality is the Huntingdon gravel of the Sumas drift which is exposed along the north side of the Chilliwack River from Vedder Crossing eastwards. Most of the gravel in the municipality is post-glacial Salish stream deposits. The Fraser River and the Chilliwack River¹ are the most important sources. These are replenished annually. The only other sources are the fans and slides developed along the base of Cascade Mountains. For details of the surficial geology, the reader is referred to Armstrong's (1961) map. The Chilliwack River for, say 10 miles upstream, can be considered as part of the gravel reserves of the municipality although it is actually outside the boundary. An area of 16 square miles in the valley of the Chilliwack River is underlain by Salish mountain stream deposits and Huntingdon gravel up to 50 feet thick. Much of this deposit would lie below the water-table. An area of 14 square miles lies north of Vedder Crossing. This area holds a large deposit of mountain stream deposits from a former course of the Chilliwack River. Only a very

¹ The Chilliwack River is called the Vedder River downstream from Vedder Crossing.

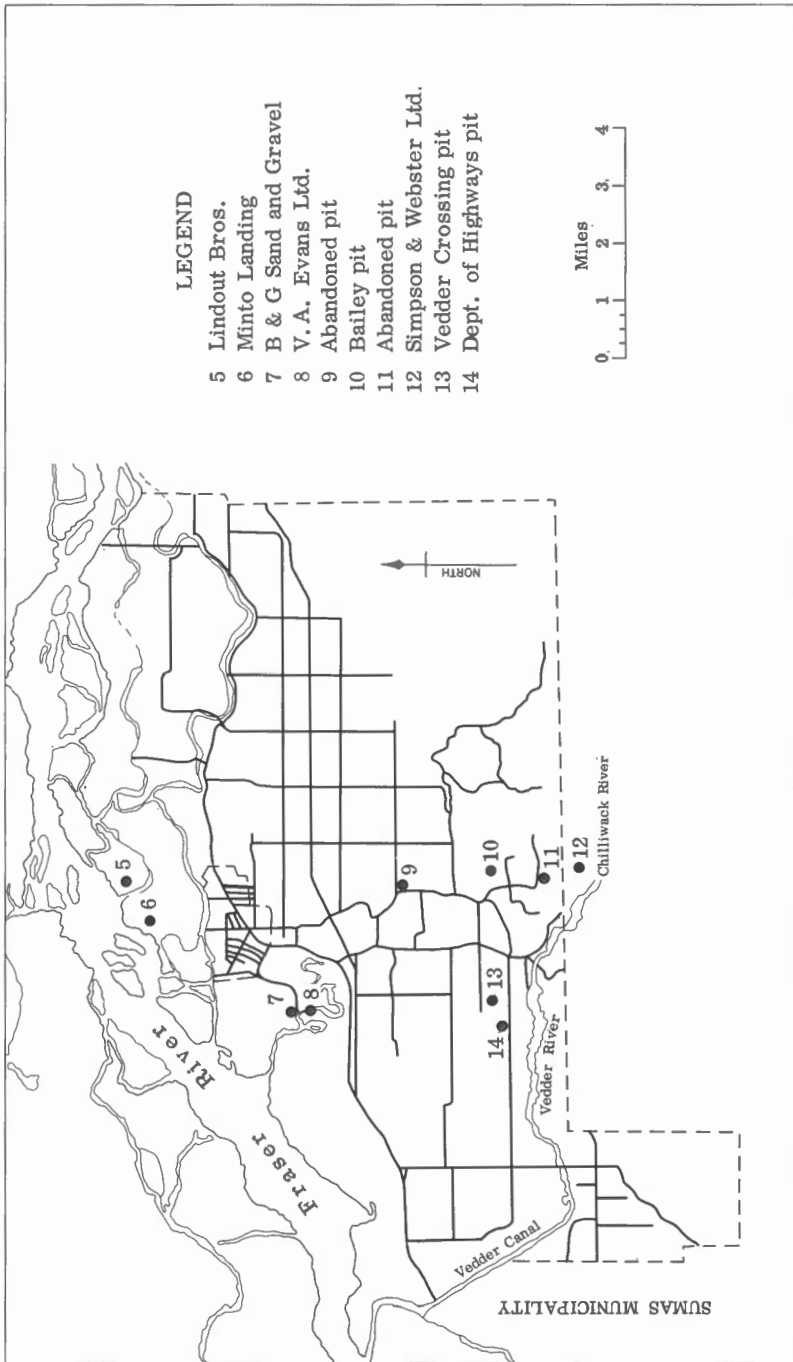


Figure 9. Chilliwack Municipality.

small percentage of this deposit is amenable to the exploitation of sand and gravel because of Indian and Military reserves, private holdings, high water-table and municipal regulations.

An area of four square miles from Vedder River to Vedder Mountain west of Vedder Crossing is underlain by Salish sand and gravel up to 50 feet thick. But here again only a small part of the deposit could be utilized because of municipal regulations and the high-water table.

Gravel is dredged out of Atchelitz Creek but the extent of this deposit is unknown. Much of the Fraser flood plain is underlain by sand and gravel although partly concealed by silt and fine sand. The bars on the Fraser River are a convenient source of sand and gravel during low water and constitute an undiminishing reserve of unknown magnitude. Two small slope-wash deposits underlying about 160 and 500 acres respectively occur along the north face of a mountain south of Rosedale. These deposits of about six and twenty million cubic yards respectively are a convenient source of aggregate for the east central part of the municipality but to date no pits have been opened in them.

Details of pits

Municipal pits

Bailey pit (10). This pit is located at the south end of Matheson Street. Only limited production is allowed owing to the proximity of adjacent residential property. The gravel which underlies 6 to 10 feet of Sumas till is classified as Huntingdon gravel. The face shows 60 to 80 feet of bedded sand and fine gravel averaging 90 per cent minus 4 inches. A pebble count on a sample gave the following composition.

Porphyry	3
Volcanic rock	13 mainly basalt
Tuff	20
Metamorphic rock	19
Chert	4
Quartz	1
Granitic rocks	6 one "rotten"
Quartzite	11
Argillite	23
	<hr/> 100%

Pit (11) at the centre of sec. 5, tp. 26. A small amount of Huntingdon gravel has been removed for municipal use but it is now overgrown and abandoned. The pit is on the northeast side of a block of about 150 acres from which the overlying till has been removed by erosion.

Fraser River bars at Minto Landing (6). Several private operators and the municipality remove gravel from bars during low water under permit from the municipality. The material varies from bar to bar and may be cobbly gravel to sand. The supply is renewed annually. In 1964 about 175,000 cubic yards were removed by the municipality and private operators.

Vedder Crossing pit (13). This pit is about a mile west of Vedder Crossing on the north side of the Vedder River. Here 20 to 30 acres are underlain by gravel which has been removed to a depth of 10 to 12 feet. Deeper excavation would penetrate the water-table. The gravel is medium to coarse in size with some boulders up to a foot in diameter. The deposit is poorly sorted, massive Salish sediments.

Private pits

B and G Sand and Gravel Ltd. (7). This company removes gravel from the channel of Atchelitz Creek about half a mile south of the Canadian National Railways bridge. The material is washed and screened for concrete aggregate. Mechanical analyses of typical gravel from the stockpile shows a deficiency in size range #30 to #4 for some specifications.

In 1963 the production amounted to 11,954 cubic yards of washed and sized aggregate. At the end of July a new company, Valley Aggregates Limited, succeeded B & G Sand and Gravel Limited. Production by the new company is reported to be 3,826 cubic yards. The deposit is classified as Salish sediments.

V. A. Evans Limited (8). This company removes gravel from Atchelitz Creek about a mile and a half south of the Canadian National Railways bridge. Production from the Salish sediments amounts to only a few hundred yards per annum.

Minto Landing (6). Several private operators reclaim sand and gravel from the bars of the Fraser River during low water. In 1964 only one operator reported production, when P. Heppner & Son reclaimed 2,328 cubic yards of run-of-pit material.

Lindout Bros. (5). Fine gravel is drag-lined from Fraser River. This material is sometimes short of sand-size. The deposit is used for ready-mix concrete for local use.

Abandoned pit (9). A few hundred cubic yards have been taken from a pit on the west side of Chilliwack River road about 1 1/2 miles south of Chilliwack. The deposit consisted of Salish stream gravels.

Simpson & Webster Ltd. pit (12). This pit is outside the municipal boundary but is included here for convenience. The deposit is classified as Huntingdon gravel of the Sumas stade. It lies on the north side of Chilliwack River road about 2 miles east of Vedder Crossing.

The deposits consist of 35 to 40 feet of silty gravel, 90 per cent minus 6 inches in diameter with the odd boulder up to 18 inches. The gravel lies in horizontal beds overlain on the east side of the pit by south-dipping foreset deltaic beds.

A pebble count gave the following rock types:

volcanic rocks	23%
metamorphic rocks	23
chert	16
granitic rocks	10
argillite	15
quartzite	11

Equipment included a Cedar Rapids 1036 portable crushing and screening plant.

Coquitlam municipality (Fig. 10)

Municipal regulations

The municipality has a soil removal by-law and zoning regulations which control removal of gravel. An area along Pipeline Road north of the Lougheed Highway has been set aside as a gravel area.

Geology and reserves

The most extensive area of sand and gravel lies along and mostly west of Coquitlam River north of the Canadian Pacific Railway. The area contains Salish, Capilano, and pre-Surrey gravels. That part of the area which lies west of Pipeline Road and north of Glen Road is zoned for gravel production and the majority of the active pits in the municipality operate there. The total volume of gravel is very large but probably only a quarter of the deposit can be considered a reserve. It is estimated that about 600 acres are underlain by sand and gravel about 30 feet thick, giving a reserve of about 30 million cubic yards.

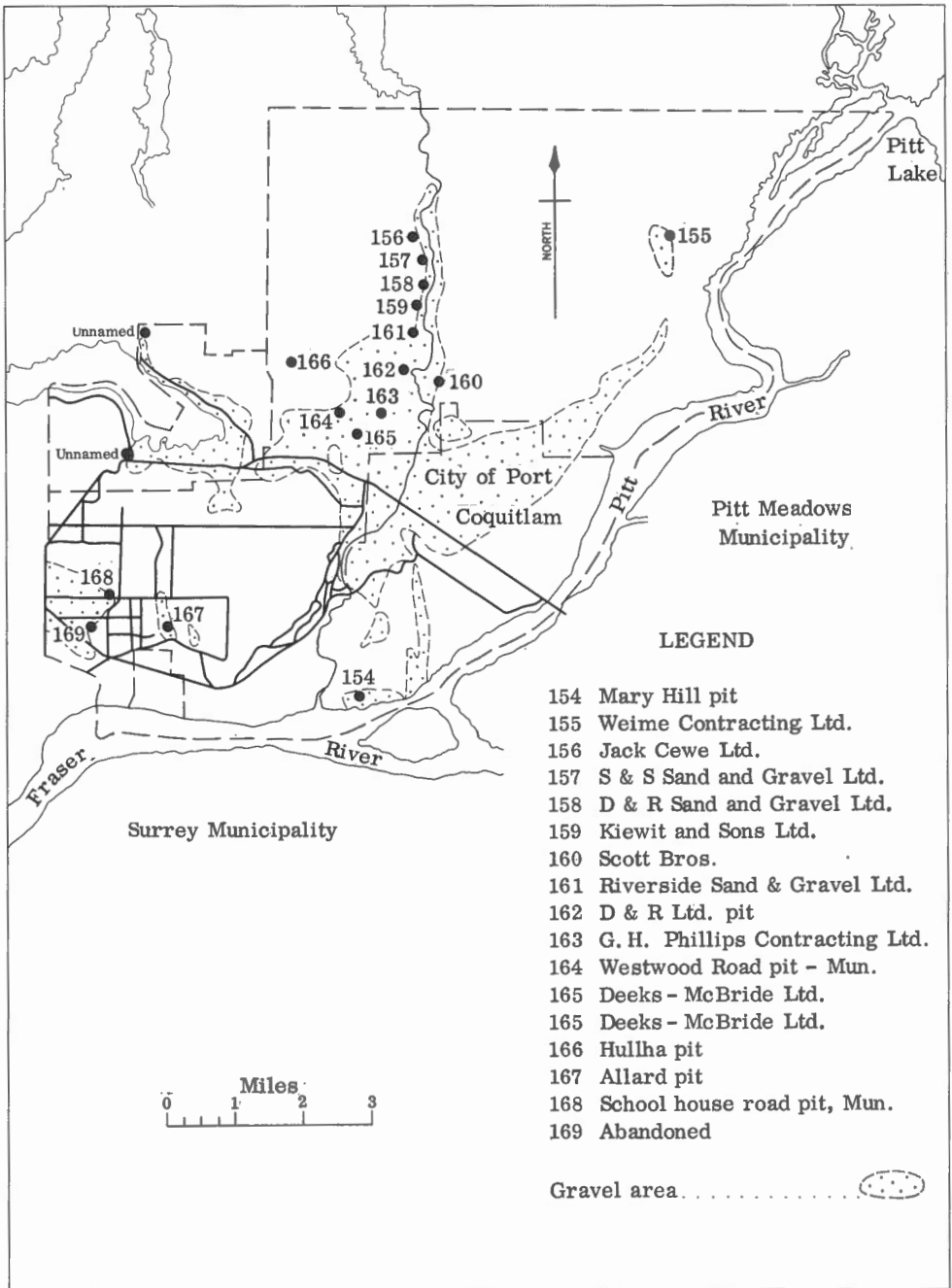


Figure 10. Coquitlam Municipality.

A small area of Capilano and pre-Surrey (Sapperton sediments) occurs along the west boundary of the municipality near North Road but, due to residential and industrial development, little room is left for the gravel industry. Two small areas of Surrey Drift (Mary Hill outwash) occur in the vicinity of Maillardville and two pits were worked here at one time but they are now closed due to impending encroachment on or by residential subdivisions.

Details of pits

Municipal pits

Westwood Road pit (164). This pit is at the end of Westwood Road about a mile west of Pipeline Road. About 15 feet of deltaic foreset beds of Capilano gravel overlain by 3 feet of flat-lying sand and gravel, which may be deltaic topset beds, are exposed in this pit. The material is mainly fine to medium grained 90 per cent minus 6 inches, with interbeds and lenses of sand. The component rock types are dominantly granitic and related intrusive rocks with minor volcanic rocks.

Schoolhouse Road pit (167). This pit was located off Schoolhouse Road but is now abandoned owing to the proximity of a school and residences. The gravel is Mary Hill outwash.

Pipeline Road reserve. An area of 40 acres west of S & S Sand and Gravel (157) holdings on Pipeline Road has been set aside for future use. No pit has yet been opened. The location is in an area mapped as Mary Hill outwash.

Private pits

Deeks-McBride Limited (165). The company operates a pit on the west side of Pipeline Road about a mile north of Lougheed Highway. The deposit is part of a large area underlain by Capilano gravel. The pit faces show 20 feet of marine delta foreset beds of sandy gravel, interbedded and capped by flat-lying foreset beds (or beach gravels) up to 10 feet thick. The gravel is mainly composed of granitic rocks of the Coast Range Intrusions. A pebble count on a representative sample gives the following: granitic rocks 87 per cent, pendant rocks 10 per cent, greenstone (altered volcanic rocks) 2 per cent and unaltered volcanic rocks 1 per cent. The material is sandy gravel, 90 per cent minus 18 inches with some boulders 2 to 3 feet in diameter. The deposit is about 50 per cent sand. The water-table shows in the pit in the wet season but is generally about 30 feet below the surface.

In 1960 a modern plant was installed to produce six size ranges of gravel, five size ranges of crushed gravel and three size ranges of sand. The plant has a capacity of 400 cubic yards a day and an annual production of

230,000 cubic yards (1963) including run-of-pit material. Crushing equipment consists of a 30 inch by 18 inch jawcrusher and a 3-foot core crusher. Three triple deck screens size the products and the minus 3/8 inch material is separated into two sand sized by a classifying tank and two dewatering screens.

The sized material is stockpiled by a radial arm stacker. This company is one of the major suppliers of ready-mix concrete in the Greater Vancouver area and a batching plant for this purpose is operated from a site adjacent to the stockpiles of sand and gravel.

G. H. Phillips Contracting Limited (163). The company produces fill and crushed gravel from a pit off Westwood Road a quarter of a mile west of Pipeline Road. The property lies along the contact between Capilano gravel to the south and outwash gravel of Surrey drift to the north and both gravels are exposed in the pit. The Capilano gravel is about 8 feet thick and laps on the underlying Surrey drift which includes stony clay and Mary Hill advance outwash. The gravel is mainly coarse bouldery material. Some boulders are as large as 4 to 6 feet long. Because of the large boulders and variable amount of clay, the pit is hard to work and unlikely to be operated for long.

D & R Sand and Gravel Limited (158). The company operates a pit on the west side of Pipeline Road about a half mile north of Westwood Road. A diesel shovel loads trucks with a pit-run material. The deposit is partly of the Surrey drift. Gravel and sand is exposed under 10 feet of laminated stony clay. Two sand layers separated by 10-15 feet of coarse unsorted gravel, 90 per cent minus 10 inches in size, underlie the clay. Five feet of sandy gravel is exposed under the lower sand bed but the total thickness of the gravel is not exposed.

Deeks-McBride Ltd. (165). This company has a gravel reserve outside the main property. A pit has been opened up on the west side of Pipeline Road a few hundred feet north of Westwood Road. This is pre-Surrey gravel. The material is 90 per cent minus 3 inches and about 60 per cent sand by visual estimate. A few very large boulders lie on the pit floor but none was seen in the face. The deposit is horizontally stratified but in places some slumping has occurred. Lenses of clay and till occur in the section.

Kiewit and Sons of Canada Limited (159). The company opened a pit on the west side of Pipeline Road about a mile north of Westwood Road. Pre-Surrey till deposits of sand, silt, sandy gravel, and clay, and coarse gravel are exposed over a vertical range of 400 feet. A stony clay layer near the middle of the section divides the deposit into a gravel section underneath and a sandy section on top.

S & S Sand and Gravel Limited (157). The company operates from two locations on the west side of Pipeline Road. The original holdings were about half a mile north of the Kiewit pit but current production is mainly from a pit

adjacent to Kiewit's, formerly operated by Pipeline Sand and Gravel Ltd. Production in both pits comes from the lower gravel formation noted in Kiewit's pit, a unit which extends north to Coquitlam Lake. The gravel is horizontally stratified, fine to medium in size, 90 per cent minus 6 inches. In the original pit two layers of very large boulders were contained in the upper 15 feet of a 90-foot face. Stones are mainly granitic rocks of the Coast Range Intrusions with minor metamorphic rocks, greenstone, quartzite and porphyry.

Jack Cewe Limited (156). This company operates a plant and several pits along the west side of Pipeline Road and is at present the northernmost producer of aggregate from the pre-Surrey till deposits in this area. The main gravel source is the same formation which extends south for two miles. The overlying sand, silt and sandy gravel presents a steep face and several large slides have developed. Some change in character of the main ground formation is noted in north exposures. The northernmost pit operated by Cewe exposes 40 feet of medium gravel, 90 per cent minus 6 inches of clean granitic cobbles and medium sand. Fine sand and fines seem to be present. There is much openwork gravel in the horizontal stratification.

Scott Bros. Gravel Co. Ltd. (160). The company operates a pit on the east side of the Coquitlam River about 2 1/2 miles north of No. 7A highway. The pit shows two ages of gravel and a veneer of Bose gravel of the Capilano sediments. The main deposit is pre-Surrey till in age and consists of fine sandy gravel with sand lenses showing crossbedding, and an overlying layer of advance outwash gravel. The gravel has been compacted by ice loading and stands in high steep faces. The company also dredged gravel from the bed of the Coquitlam River where modern stream deposits are being formed. These are clean gravel with well-rounded stones up to 2 feet in diameter, and are predominantly granitic in composition. Utilizing the material for aggregate also provides a measure of flood control.

Weims Contracting Ltd. (155). This company operates a pit in Salish (?) slopewash gravels on McIntyre Creek west of Pitt River road. The stones are coarse and angular granitic rocks laid down in layers resembling deltaic foreset beds. The deposit extends to 200 feet in vertical range although the true thickness probably does not exceed 40 feet. The material is used mainly as a source of crushed aggregate.

D & R Limited pit (162). This company opened up a pit on the west side of Pipeline Road about a mile north of the turn-off to Westwood race track. The deposit is pre-Surrey and underlies 10 feet of stony clay. The section under the clay shows five feet of gravel, followed by five feet of sand and sandy gravel, 90 per cent minus 2 inches; a 10-foot section of coarse unsorted gravel, 90 per cent minus 10 inches; the lowest bench shows 10 feet of silty sand and 5 feet of fine sandy gravel. There was no plant in operation at the time of inspection.

Riverside Sand and Gravel Ltd. (161). The pit operated by this company has been inactive for several years and it is probably abandoned. The deposit is pre-Surrey.

Hullah pit (166). Gravel along Scott Creek north of Glen Drive was extracted as part of landscaping for a housing development and used to make crushed aggregate for Port Mann Bridge approaches.

The deposit consisted of fine, sandy gravel of Salish mountain stream deposits about 10 feet thick overlying fossiliferous marine clay.

City of Port Coquitlam (Fig. 10)

Municipal regulations

The city of Port Coquitlam controls the operation of gravel pits by zoning regulations. New applications are considered by the city council and re-zoning is possible in certain cases.

Geology and reserves

The land area of the city is 6,700 acres of which about 63 per cent is underlain by sand and gravel. Much of this is pre-empted for residential or commercial use. Most of the available gravel land is owned by Ocean Cement Limited whose Mary Hill plant is the largest in the province. The company owns 325 acres which contains a reserve of 35-40 million cubic yards of sand and gravel. Further reserves might be uncovered north of Ocean Cement Ltd. but the area is rapidly becoming urbanized. In addition, the stony clay and till partly removed by erosion at the Mary Hill pit, may be considerably thicker, thus making removal uneconomical.

The Mary Hill deposit is now known to be more complex than the original exposure would indicate. As well as Mary Hill outwash, a second gravel formation lies below a till sheet under the Mary Hill outwash. Radio-carbon dating shows this to be part of the Quadra sediments. Bose gravel occurs on the flanks of Mary Hill but it is not an important source of gravel.

Mountain stream deposits of the Salish sediments form extensive deposits but they are largely removed from exploitation by urbanization. Dredging the eastern bank and bed of Coquitlam River provides a further source of gravel and this is regularly done as a flood control measure. Part of the discharge of the Coquitlam River is within the city limits and some unknown quantity of sand and gravel should be available there.

Details of pits

Municipal pits

Mary Hill pit - Ocean Cement Ltd. (154). The Mary Hill pit of Ocean Cement Limited in the city of Port Coquitlam has been used since 1928 but the complexity of the deposit was not realized until the last few years when greatly expanded production provided a deeper look into the hill.

Erosion along the south end of the hill removed the covering of Bose gravel, Newton stony clay and Surrey till exposing the underlying gravel. The gravel is probably drift from the Vashon ice-sheet of Fraser glaciation which has been given the formational name, Mary Hill outwash. The deposit is non-stratified or poorly so, and poorly sorted. It contains a wide range of sizes from small boulders down to silt, and clay. This layer is about 40 feet thick and bottoms on a second till sheet included in the Surrey Drift as a local advance of the ice-sheet during Fraser glaciation. Below this till is a section of sand and gravel consisting of an upper lenticular sand layer and a lower gravel layer. The sand contains a silty layer with organic matter which has been dated by the radiocarbon method as $26,450 \pm 520$ years old (GSC - 124), making the deposit Olympia Interglaciation in age.¹ The lower gravel is a fine bedded sandy gravel with some binding clay and silt but which is easily cleaned. The stones are well rounded but low in sphericity. They are mainly granitic in composition. Some tests by the Department of Transport on this material gave the following bulk specific gravity:

Minus #4 fraction 2.75
Plus #4 fraction 2.69

The upper gravel, Mary Hill outwash, is a poorly sorted, non-stratified, silty gravel. The stones are 90 per cent minus 6 inches in diameter. The weight of overlying ice has compacted the material and vertical faces of 40 to 50 feet are usual. Much of the till in the section is processed for aggregate and this, with the silty nature of the gravel, necessitates extensive scrubbing and washing to insure properly graded aggregates. To do this a modern plant was installed in 1960 at a cost of 1.7 million dollars.

Fourteen sizes of products are turned out in three sections of the plant: (1) gravel in six sizes - $2\frac{1}{2}'' \times 1\frac{1}{2}''$, $1\frac{1}{2}'' \times 1''$, $1'' \times \frac{3}{4}''$, $\frac{3}{4}'' \times \frac{1}{2}''$, $\frac{1}{2}'' \times \frac{3}{8}''$, $\frac{3}{8}'' \times \#4$. (2) crushed rock in five sizes - $1\frac{1}{2}'' \times \frac{3}{4}''$, $\frac{3}{4}'' \times \frac{1}{2}''$, $\frac{1}{2}'' \times \frac{3}{8}''$, $\frac{3}{8}'' \times \#4$, and minus #4. (3) sand in three sizes - concrete sand #4 x #100; fine sand #16 x #200, fill sand minus #4.

¹Published in Paper 64-40, Geological Survey of Canada, Radiocarbon Dates III; W. Dyck and J. G. Fyles

The raw material is dug from high banks and loaded into 19 cubic yard capacity for transportation to a hopper at the base of which a 42"x48" crusher breaks down the oversize to minus 6 inches. A conveyor takes this material at a rate of 650 tons per hour to a separation tower where the initial split into sand and gravel is made. Oversize goes to the crushed rock section. The minus 6 inch plus #4 fraction is stockpiled. From the stockpile it is conveyed to the gravel tower from where the sized products are discharged onto surge piles over the reclamation tunnel.

The sand fraction is separated in the sand tower. Two sand classification tanks with triple collecting and blending flumes separate the sand into three fractions which are individually rewashed, dewatered and delivered to stockpiles over a reclamation tunnel.

All the products may be blended in any proportion by automatic control. The load-out tower normally places the material on barges which can be loaded at a rate of 1,500 tons per hour.

Water for washing is pumped from the Fraser River by two 250 h.p. pumps supplying 6,650 gallons per minute.

This is the largest plant in the province and in 1964 production was reported to be 1,052,700 cubic yards.

City of Port Moody (Fig. 11)

Municipal regulations

Control of gravel operations in the city of Port Moody is exercised through a soil removal by-law.

Geology and reserves

There are two sand and gravel formations within the city limits:

- (1) Bose gravel of the Capilano sediments.
- (2) Pre-Surrey till deposits.

Bose gravel underlies a U-shaped belt around the eastern end of Burrard Inlet and a small area around the mouth of Mossom Creek. Three pits have been opened up in this formation but production is now restricted to an intermittent operation on Mossom Creek. Most of this deposit underlies established facilities and little is left as potential sources of sand and gravel.

The high parts of the city are underlain by till that overlies sand and gravel but both the thickness of the till and urbanization prevent exploitation of the deposits. An area of a few hundred acres of pre-Surrey till

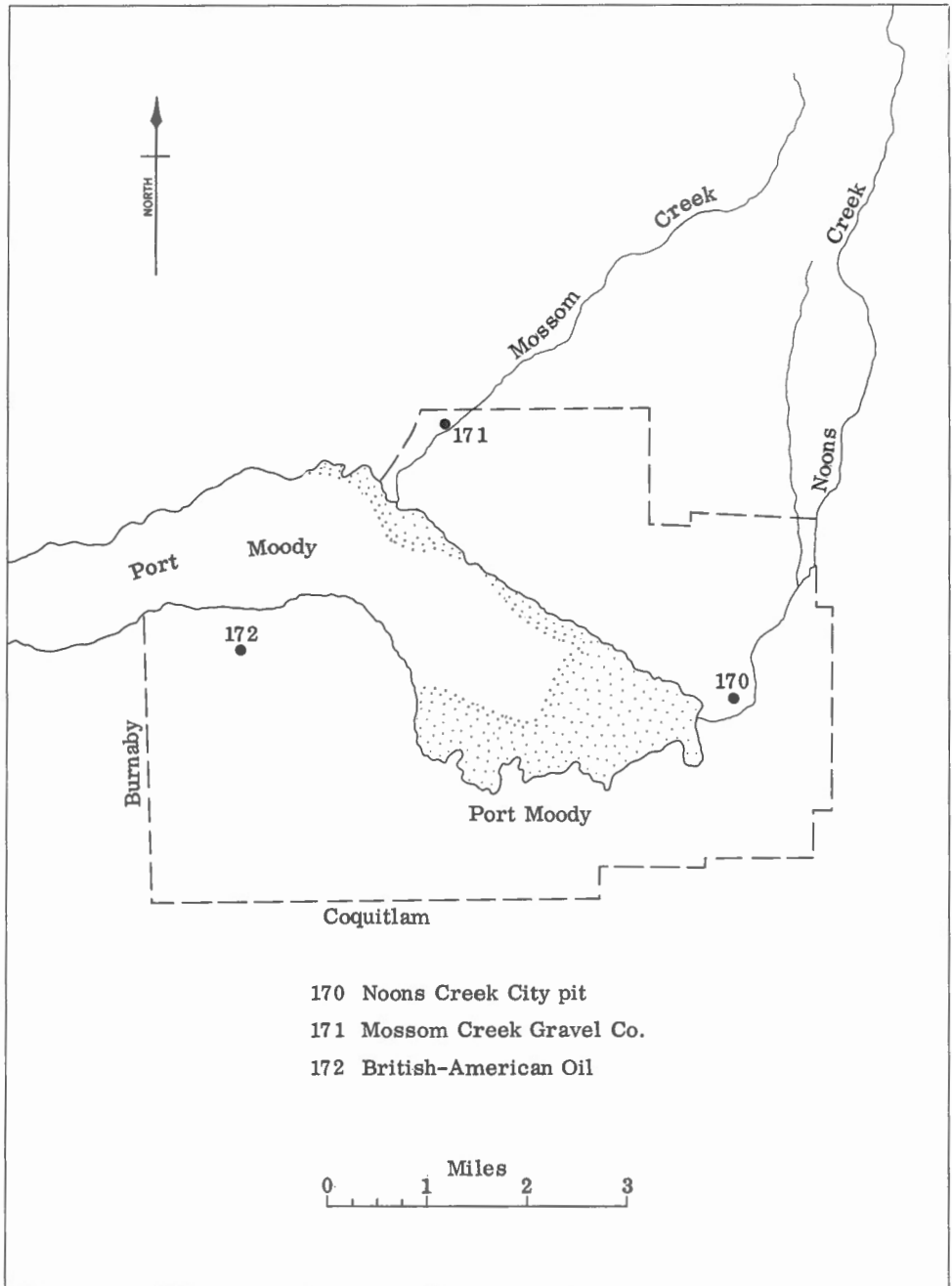


Figure 11. Port Moody.

deposits is exposed along the south side of the Barnet Highway on the west side of the city. Much of the material is sand or sandy gravel.

Details of pits

Noons Creek City pit (170). This pit is located on Noons Creek about 1/4 mile north of Ioco Road. It is now abandoned owing to increasing content of sand and large boulders. The deposit was classified as Bose gravel of the Capilano sediments.

Mossom Creek Gravel Company (171). From time to time this company operates a pit about half a mile up Mossom Creek on the north side of Burrard Inlet. Some Bose gravel shows in the face but most of the production has been from the pre-till gravel which is considered as equivalent to Mary Hill outwash.

British-American Oil Company pit (172). A pit has been opened up on the property adjacent to the Barnet Highway one-half mile east of the city limits. The original exposure showed a layer of sand overlying gravel. As the pit area was enlarged a more complete section was revealed. At the south side of the pit area 4 to 5 feet of till lies at the surface and this is underlain by about 40 feet of sand and sandy gravel with lenses of clay. A bed of clay with sand lenses separates the upper sand and gravel from a lower section of sand and gravel.

The pit was used as a source of sand by Scott Bros. Gravel Limited. It is now inactive.

Delta municipality (Fig. 12)

Municipal regulations

A soil removal by-law and zoning regulations control the sand and gravel operation. Applications for intended operations must be supported by plans and specifications.

Geology and reserves

Gravel is found in two main areas:

- (1) the upland adjacent to Point Roberts,
- (2) the upland west of the Surrey-Delta municipal boundary.

The latter is the most important deposit in the municipality. The sand and gravel is mainly pre-Surrey till in age but in places Bose gravel of the

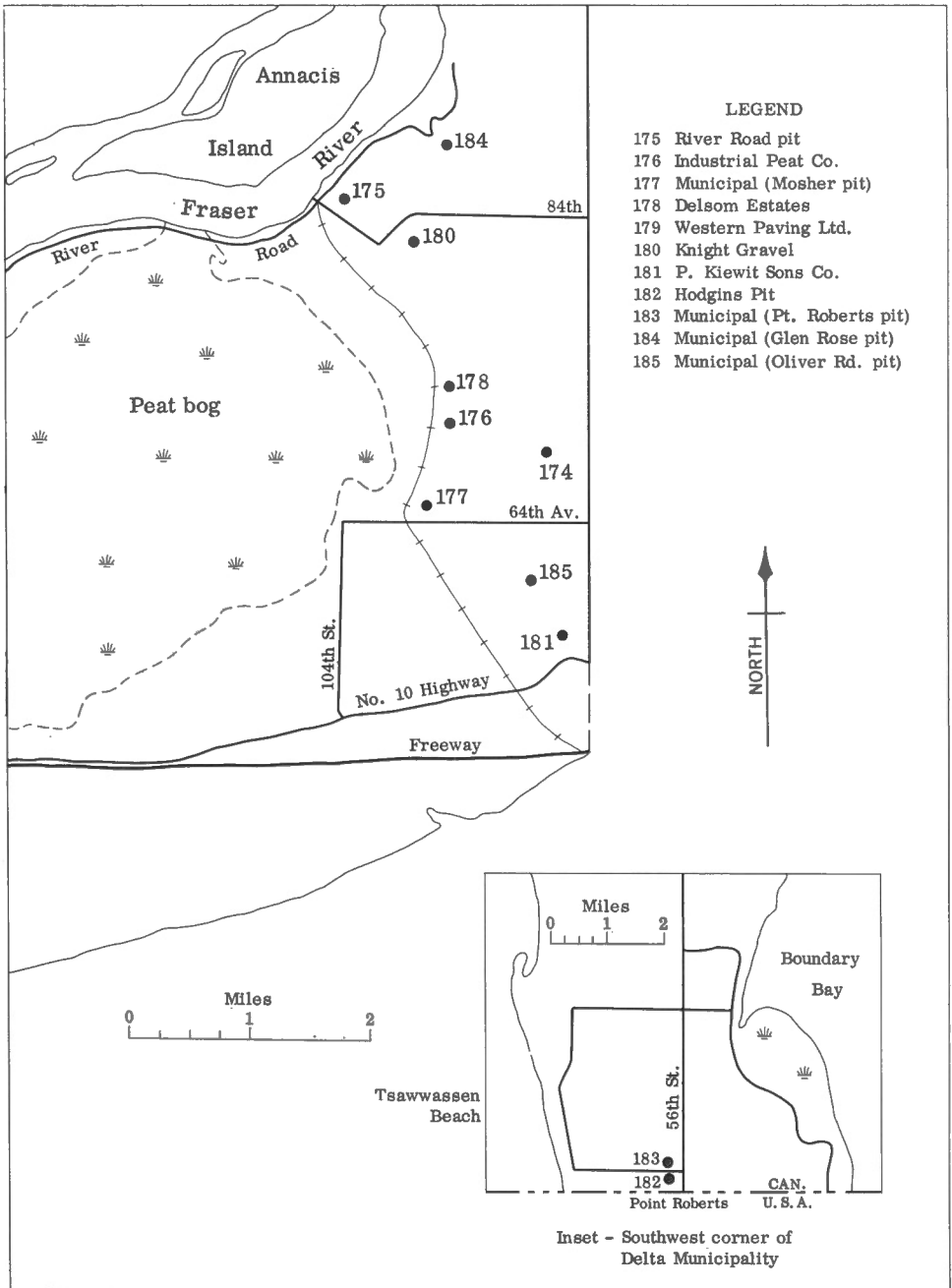


Figure 12. Delta Municipality.

Capilano sediments is present. The front of the upland overlooking the Fraser delta has in part been denuded of the overlying till, stony clay and beach gravels, revealing the pre-till gravels, and it is here that the largest volume of gravel in the municipality is to be found. However, only a small percentage can be considered as a gravel reserve. About 500 acres covered by existing pits and reservations ensure about 200 million cubic yards of sand and gravel if the acreage is not reduced in future.

Details of pits

Municipal pits

Point Roberts Road pit (183). This pit lies just north of the International Boundary west of Point Roberts Road. The gravel lies beneath a glacio-marine deposit of stony clay which is up to 15 feet thick. The gravel is probably advance outwash of the Mary Hill type. An area of 18 acres, 20 feet thick gives a reserve of about half a million cubic yards.

Oliver Road pit (185). This pit lies at the end of Oliver Road in the southwest quarter of section 12, township 4. A 20-acre parcel here includes about 4 acres underlain by pre-till sand and gravel.

Mosher pit (177). This pit lies west of Mosher Road at the base of the upland. The gravel is Bose gravel of the Capilano sediments. It is a relatively shallow deposit resting on clay and till. The pit lies in a 40-acre block but remaining reserves are small.

Glen Rose Horseshoe pit (184). This pit is a one-acre sand pit located on the south side of the river opposite Annacis Island.

Private pits

Hodgins pit (182). The pit lies west of Point Roberts Road along the International Boundary. It is now largely depleted. Gravel occurs under a layer of till and glacio-marine stony clay. The occurrence is similar to that in the municipal pit which bounds it on the north.

Western Paving Limited (179). This company operates a pit half a mile west of Scott Road at 68th Street in the northeast corner of the municipality. It is a major supplier of pit-run gravel, washed aggregate and road mulch for the immediate area. In 1964 production of 63,435 cubic yards of pit-run and washed aggregates and 46,000 tons of paving mix were reported.

The main production comes from a fifty-foot section of Quadra sediments that underlie a relatively thin cover of Surrey till. Some production of sand and gravel has also come from Capilano sediments on the east side of the property, where easterly-dipping beds in an offshore bar are up to 20 feet thick.

The Quadra gravels are horizontally bedded deposits of sandy gravel with sand lenses. A diagrammatic cross-section of the pit is shown on Figure 13.

Industrial Peat Company-Holmes pit (176). This pit lies just east of the plant of Industrial Peat Company at the west end of 72nd Avenue. It is a joint venture with Mr. L. Holmes. The pit shows a good section through a part of the upland, beginning with Bose gravel at the surface, stony clay and till overlying 30 feet of sand and gravel. A test hole at the bottom of the pit showed a further 7 feet of gravel above a marine clay containing shells. The sand and gravel can only be described as pre-till.

Knight Gravel Limited (180). This company operates out of a pit at 84th Avenue and 107th Street. Production comes from pre-Quadra beds of silty sandy gravel under a variable thickness of Surrey Drift. The material is non-stratified and includes thin clay beds. Below this gravel, 10-15 feet of crossbedded medium sand containing ash beds dips east at 50 degrees under the gravel. Wood from a clay lens under the Surrey till has an age determination of greater than 39,000 (GSC-62)¹. In 1964 production amounted to 16,196 cubic yards.

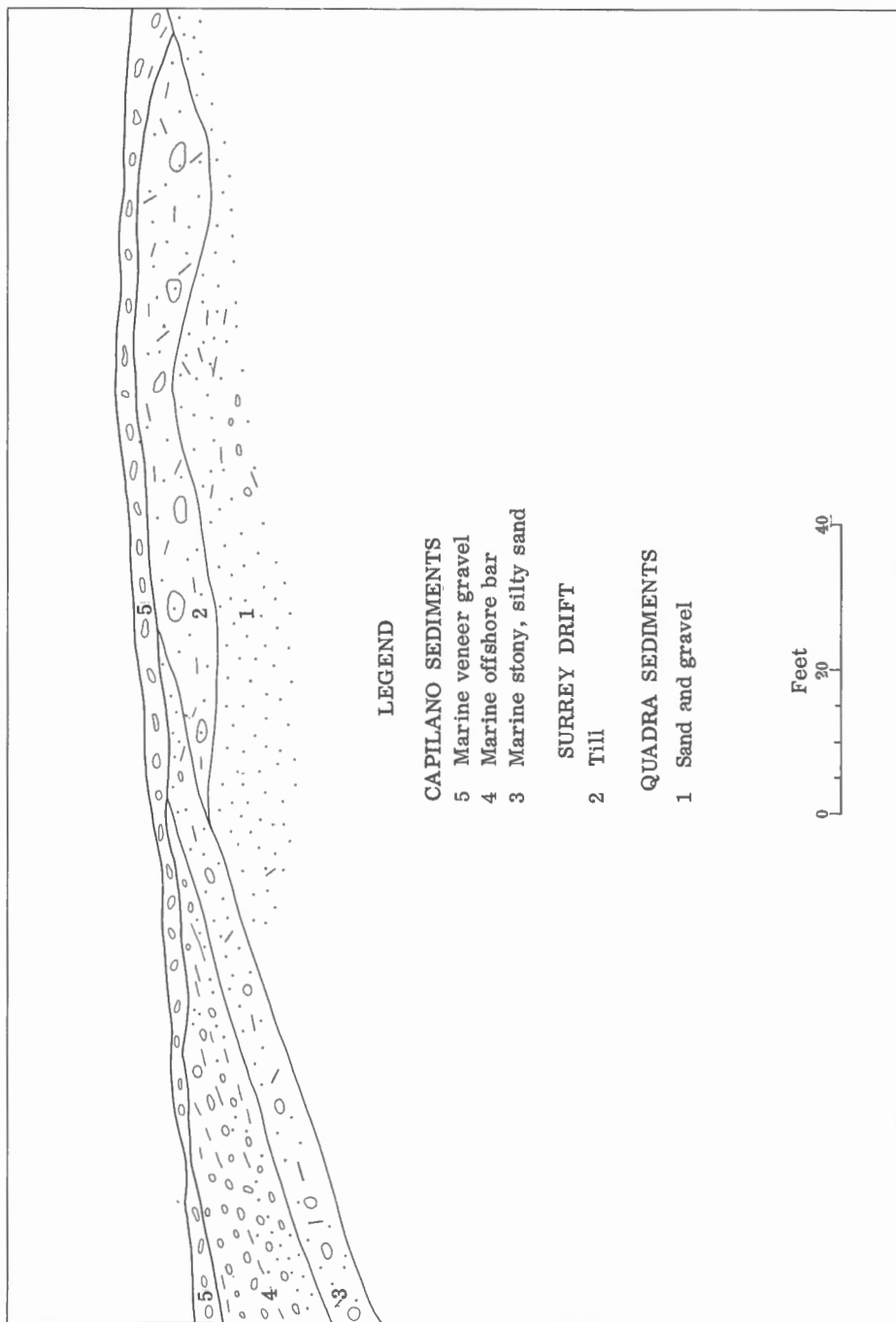
Newton Road pit - Delsom Estates (178). This pit lies north of 72nd Avenue and 110th Street. A small amount of gravel has been excavated to a depth of about 10 feet where blue stony clay was encountered. The gravel is probably an offshore bar of the Capilano sediments and may include some Bose beach veneer gravels as well.

River Road pit - Delsom Estates Ltd. (175). This is a sand pit on the south side of River Road opposite the east end of Annacis Island.

Peter Kiewit Sons Company of Canada Ltd. (181). This company holds ground west of No. 10 Highway at the base of Scott Road hill. The property is now mainly a storage and repair depot for construction machinery but was at one time used as a source of gravel. From time to time small quantities are removed.

The gravel is pre-Surrey and is exposed under a capping of till and clay along the front of the upland to the north. The deposit was at one time correlated with Colebrook Gravel but it has been shown to be much older as wood from stratigraphically higher silty sand gave a radiocarbon date of greater than 37,000 years B.P. (GSC - 60)¹.

¹ Published in Paper 63-21, Geological Survey of Canada, Radiocarbon Dates I and II; W. Dyck and J.G. Fyles.



Kent municipality (Fig. 14)

Municipal regulations

There are no municipal regulations in effect to control the sand and gravel operations.

Geology and reserves

This municipality lies north of the Fraser River between Harrison Mills and Ruby Creek near the east end of the Fraser Lowland. The southern boundary is actually near the centre line of the Fraser River, giving the municipality some jurisdiction over many of the islands and bars.

The largest source of sand and gravel is the Fraser River. Islands, bars, and channel deposits in the river, and deposits beneath a thin veneer of flood plain silt and sand along the banks provide extensive deposits of clean washed sand and fine gravel. During low water extraction would be simple but in the flood state it would be more difficult. The best procedure would be to stockpile a sufficient quantity during periods of low water.

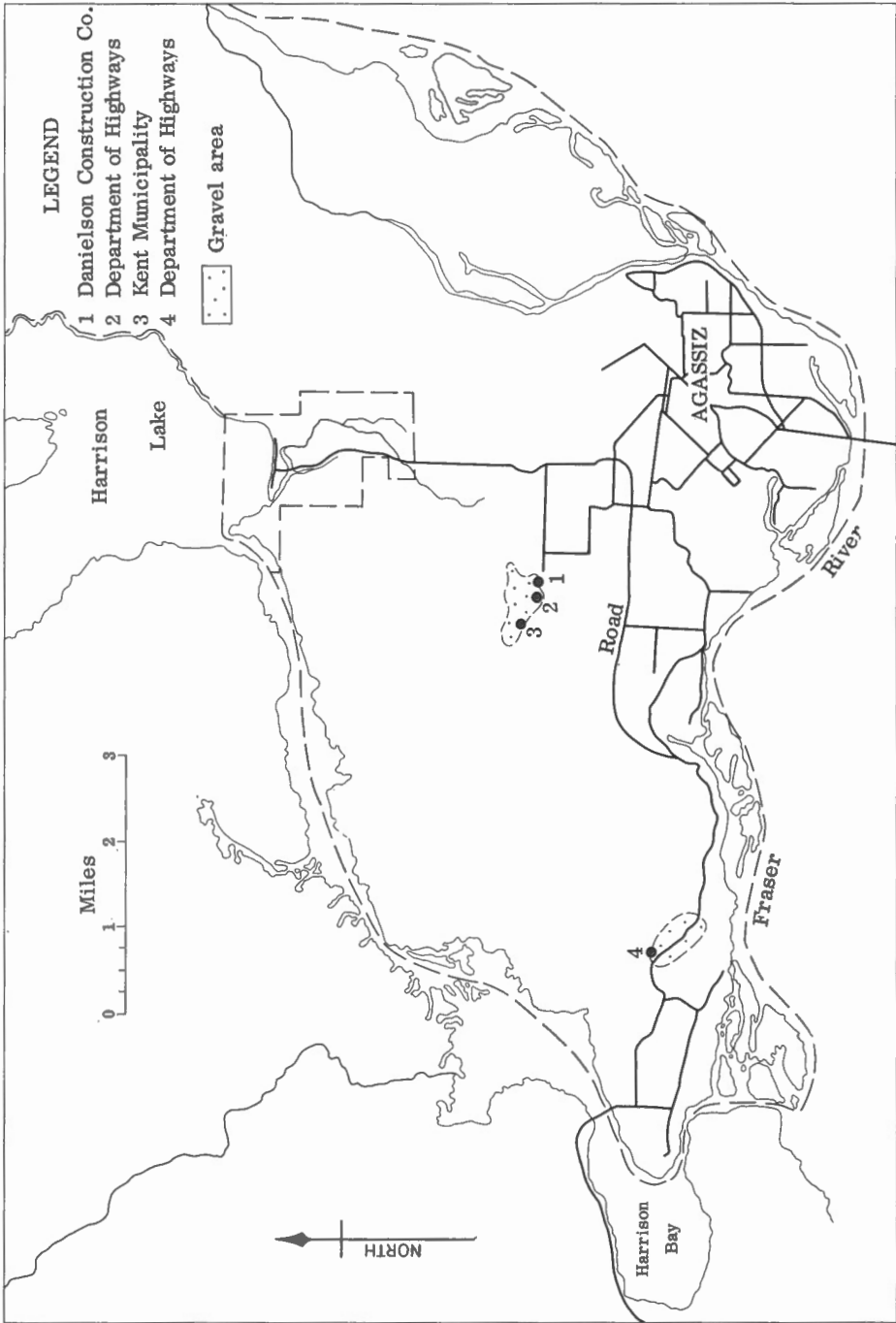
The only other source of much significance is the kame terrace deposit on the south side of Mount Agassiz. Essentially all the production of sand and gravel for municipal uses comes from this deposit; three pits have been opened:

Kent municipality (3)
Department of Highways (2)
Danielson Construction Company (1)

The deposit was formed along the contact of the Sumas valley glacier and the valley wall. It consists of dirty sand and gravel containing patches of till. The dimensions of the deposit are: length, 3,500 feet; width, 1,500 feet; thickness, 40 feet; total content, about 7.7 million cubic yards. Not all of the deposit is available for gravel as a cemetery takes up a part of the area. The material is mainly used for road building and maintenance. It is inferior for concrete because of the high content of silt and clay.

A small area of Abbotsford outwash lies astride No. 7 Highway about 2 miles east of the bridge over Harrison River. Some gravel for road work was extracted from a pit here but the deposit is small and is not an important occurrence.

Danielson Construction have a lease on a gravel bar on the east side of sec. 20, tp. 3, range 28 W.6.



GSC

Figure 14. Kent Municipality.

Langley municipality (Fig. 15)

Municipal regulations

Control of gravel operations is obtained through a soil removal by-law and agreements with the municipality. In general, gravel pits must preserve a natural barrier of trees or shrubs in a 50-foot strip adjacent to the boundaries of the property with a further 100-foot strip from which no top soil or gravel shall be removed. In addition no drainage of the water-table is permitted.

Geology and reserves

A large part of the gravel deposits in Langley municipality is classified as Abbotsford outwash. Most of the remainder is Capilano gravel. Both units are part of the Sumas Drift. Minor amounts of gravel of pre-Surrey Drift are exposed in places in the northwest quarter of the municipality. Bose gravel and Sunnyside sand of the Capilano sediments mantle the surface here and there in the northern half of the municipality.

Abbotsford outwash occurs in the southern part of the municipality in three distinct physiographic units: (1) a delta along the western border, with its (2) feeder channel leading from (3) an area of outwash plain and ice-contact deposits in the southeast corner of the municipality. Most areas of gravel north of the Trans-Canada (old) Highway shown on map 16-1957 by Armstrong (1957) as Abbotsford outwash are now known to be part of the Sumas Drift and are referable to Huntingdon gravel.

The deltaic area along the Langley-Surrey municipal border embraces about 4,500 acres underlain by gravel known to be up to 100 feet thick. The average depth is probably less than half this amount. The gravel is a source of groundwater, however, and only in a few places would it be permissible to extract gravel below the water-table. To the depth of 9 feet, which is about the most that could be extracted above the water-table, the deposit contains about 67 million cubic yards. Existing pits in this deposit cover about 600 acres which assures a reserve of about 30 million cubic yards if extracted to a depth of 30 feet.

The feeder channel to the delta contains a relatively small amount of gravel. The municipality holds some small reserves here but estimates on the potential reserves have not been made.

The outwash and ice-contact deposits in the southeast corner of the municipality underlie about 2,000 acres. Potential reserves are very large. A conservative estimate indicates at least 60 million cubic yards are

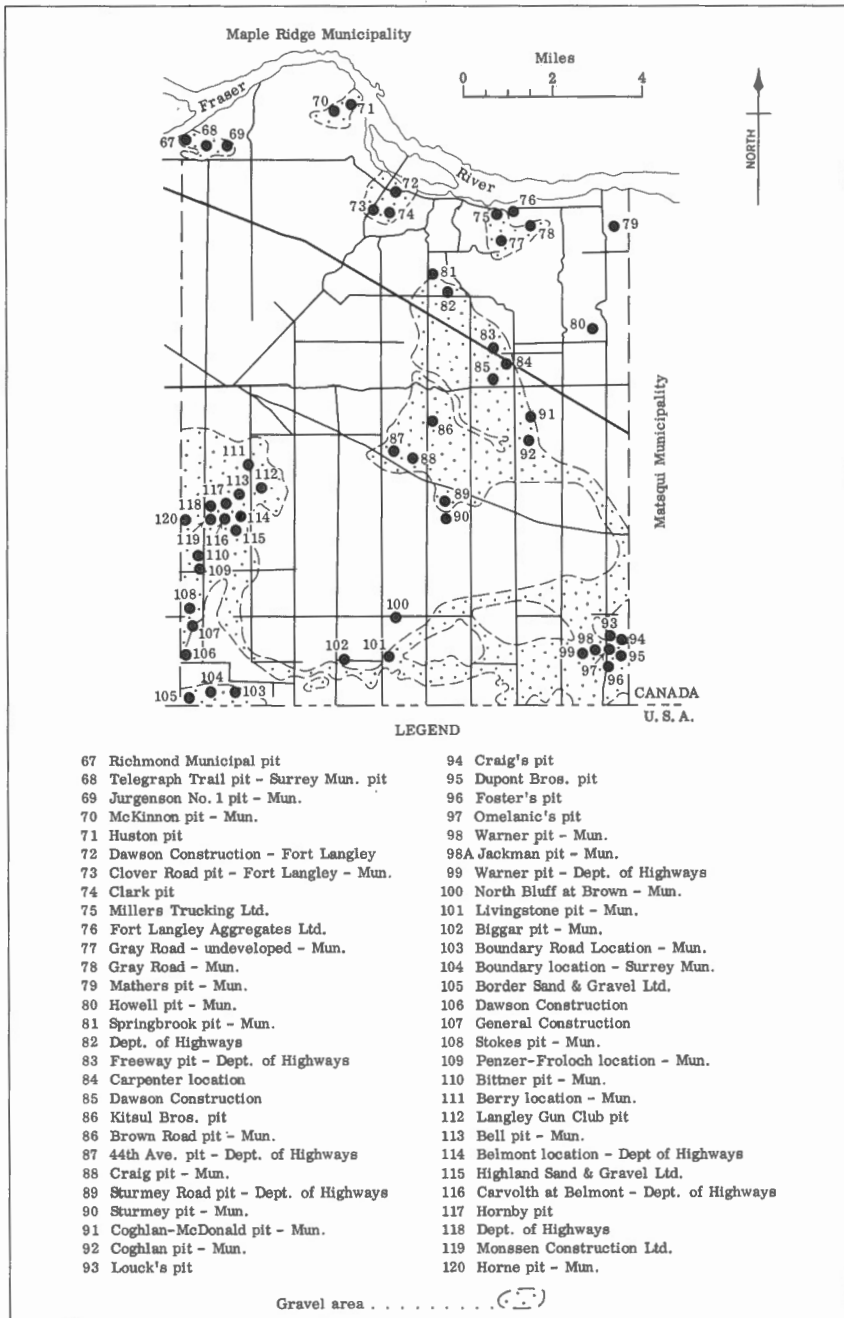


Figure 15. Langley Municipality

available. About 300 acres around the intersection of Jackman and Warner Roads assures a reserve of some 15 million cubic yards of glacio-fluvial and ice-contact deposits.

A further reserve of sand and gravel of Abbotsford outwash occurs along the International Boundary in the southwest corner of the municipality. About 380 acres are underlain by ice-contact deposits containing about 19 million cubic yards. Most of this area is held by municipal governments and one private company.

Capilano gravels are now considered more abundant in Langley municipality than was recognized during preliminary mapping (Armstrong, 1957). The large area north of the old Trans-Canada Highway along Brown and Otter Roads together with the gravel areas along the Fraser River must now be considered as Capilano sediments of the Everson Interstade.

The Brown-Otter Roads deposit extends over 6,400 acres but not all is sand and gravel. About 200 acres can be considered as reserves because of the existence of pits. This gives a reserve of about 10 million cubic yards. The deposit is many times this volume and the reserves could conceivably be expanded many times. In some parts of the area, notably north of Sperling station along Brown Road, at the intersection of Brown and Roberts Roads, 100 feet of gravel are known from test holes. In such areas large reserves can be held in small acreages.

Fort Langley is built on a remnant of Capilano gravel but little of the deposit can be considered as a reserve as private residences and a National Historic Site take up most of the area.

Low-lying deposits northwest of Walnut Grove, and east of Glen Valley afford convenient deposits for use in the northern part of the municipality. The water-table is high necessitating either shallow extraction under dry conditions, or dredging methods for deeper extraction; these deposits are close to the Fraser River from where sand-fill could be obtained to reclaim the land after the gravel has been extracted.

Details of pits

Municipal pits

Jurgenson No. 1 pit (69). This pit is south of Mitchell Road just east of 201st Street in the northwest corner of the municipality. The pit is largely exhausted above the water-table. The face averages about 10 feet and shows fine to medium gravel with a few sand lenses in foreset beds. Beach gravels mantle the surface. The gravel is tinted brown by iron-oxide. This deposit is now classified as a member of the Capilano sediments.

Glover Road pit - Fort Langley (73). This pit is on the east side of Glover Road on the south side of Fort Langley village. It is largely exhausted above the water-table, but there may be as much as 40 feet of gravel below the water-table. The gravel is classified as Capilano. It is a clean sandy gravel with horizontal bedding.

Howell pit (80). This pit is on the west side of Jackman Road, half a mile south of Howell Avenue. The pit is now abandoned. A small area of Capilano gravel was exposed in a hole in the overlying beds but presumably too much clay was present for continued exploitation.

Craig pit (88). The pit is on a 3-acre plot north of the old Trans-Canada Highway at 235th Street. The pit, in Abbotsford outwash, is no longer productive.

Sturmey pit (90). This pit is at the end of Sturmey Road about a half mile south of Otter School. The material is Abbotsford outwash, fine to medium silty gravel in poorly sorted beds. It is largely exhausted over a 10-acre plot.

Coghlan pit (92). The pit lies along Coghlan Road, north of Salmon River. It embraces only one-half acre of Capilano gravel.

Stokes pit (108). On the north side of Stokes Road about a quarter mile west of Carvolth Road a small pit in Abbotsford outwash shows a low face of sandy gravel and sand lenses.

Mathers pit - Glen Valley (79). This pit is on two acres south of Mathers (84th Ave.) at 276th Street. The material is fine to medium Capilano gravel.

Coghlan-McDonald pit (91). A small area of Capilano gravel has been used locally for road work.

Brown Road pit (86). This pit is located on the east side of Brown Road (240th Street) half a mile north of McDonald (48th Ave.). The material is clean sandy Capilano gravel in well sorted beds.

Gray Road pit (78). The pit is located on 41 acres of Capilano gravel north of Gray Road (84th Ave.) at 260th Street. The material is Capilano gravel. The pit faces are 10-12 feet high and show fine silty gravel, 85 per cent. minus 4 inches in diameter. Some thin open-work beds dip to the west at a small angle.

Springbrook pit (81). The Springbrook pit is on the east side of Brown Road (240th St.) at 76th Avenue. Up to 12 feet of fine sandy gravel is exposed in a narrow sinuous strip bordered by stony clay. The gravel is part of the Capilano sediments.

Biggar pit (102). This pit is on the east side of Biggar (224th St.) at 4th Avenue. The material is Abbotsford outwash channel deposits. The material is a clean sandy gravel.

Livingstone pit (101). This pit lies east of Livingstone Road (232nd St.) at 6th Avenue. It lies in the channel feeding the Abbotsford outwash delta on the Surrey-Langley municipal border.

Jackman pit (98A). Several pits are located near the intersection of Jackman Road (272nd St.) and Warner Road (8th Ave.). The gravel is Abbotsford outwash mainly the normal outwash but includes some ice-contact deposits which are inferior due to presence of clay and till lenses. Normal outwash is clean sandy gravel, but ice-contact phases have some very large boulders and a high percentage of silt.

Gray Road pit - undeveloped reserve (77). The municipality holds an undeveloped parcel of land at the corner of Gray Road and McIver Street. The deposit is part of an area of Capilano sediments consisting of sand and gravel.

Bell pit (113). The pit is located at the corner of Bell (36th Street) and King (206th Street). The material is Abbotsford outwash. Ten-to 15-foot faces show fine sandy gravel with occasional boulders. About half the gravel obtainable above the water-table has been extracted.

Horne pit (120). The Horne pit is located east of Carvolth Road at 34th Avenue. A high water-table exists and only low faces are possible without drag-line operations. The material is Abbotsford outwash, generally with a high gravel to sand ratio. The gravel is 90 per cent minus 6 inches in horizontal beds.

Warner pit (98). The municipality holds about 92 acres of gravel land in the vicinity of the intersection of Jackman Road (272nd Street) and Warner Road (8th Avenue). The pit has low faces owing to the high water-table. The material is medium-sized (80 per cent minus 4 inches) silty gravel. It is only rudely stratified and poorly sorted. The deposit is classified as Abbotsford outwash of the ice-contact facies. There seems to be a higher percentage of unsorted granitic stones in this pit than in most Abbotsford outwash deposits. Reserves here are of the order of 1.3 million cubic yards above the water-table.

McKinnon pit (70). This pit is on District Lot 414 about 2 miles northwest of Fort Langley. The deposit is Capilano gravel and consists of fine sandy gravel and interbedded sand in deltaic foreset beds dipping south. The highest face shows 12 feet of sand and gravel.

Kells pit (110). The pit is along the Surrey-Langley border, south of McInnes Road (32nd Avenue). The deposit is Abbotsford outwash similar to others in this same delta.

44th Ave. location (87). The area is located on the north side of 44th Avenue, half a mile east of Livingstone Road (232nd Street). It includes 12.29 acres of Capilano gravel. It is a sandy gravel about 10 feet thick underlain by clay.

Bittner location (110). This plot of 20 acres is located west of Carvolth Road (200th Street) at 26th Avenue. It is part of the Abbotsford outwash delta.

Penzer-Froeloch location (adjacent to Bittner) (109). The location comprises 26.44 acres of Abbotsford outwash being held for future use.

Berry location (111). This is a 9-acre parcel on the west side of Berry Road (208th Street) at 42nd Avenue. The site is used for a garbage dump. It is part of the Abbotsford outwash delta.

Boundary Road location (103). This is a parcel of 114 acres off Berry Road (208th Street) at the International Boundary. It is part of an ice-contact deposit of Abbotsford outwash.

Carpenter location (84). A 5-acre parcel south of Carpenter (60th Avenue) a quarter of a mile west of Coghlan is underlain by sandy gravel of the Capilano sediments.

North Bluff pit (100). A pit at the corner of North Bluff (16th Avenue) and Brown Road (240th Street) has been opened in a channel deposit of Abbotsford outwash. The deposit was used for local fill and is only an acre or two in extent. The material is typical fine sandy gravel of Abbotsford outwash.

Surrey municipal pits in Langley

Telegraph Trail pit (68). This pit is located south of the Canadian National Railways at 198th Street. It is Capilano gravel. Low faces above the water-table show fine- to medium-bedded sandy gravel and sand lenses.

Boundary location (104). No pit has opened up in this location which lies along the International Boundary adjacent to the Langley municipal gravel reserve at 208th Street. The deposit is ice-contact Abbotsford outwash.

Richmond municipal pits in Langley. Richmond municipality owns a pit (67) adjacent to Fraser River in the northwest corner of the municipality. Low faces of Capilano gravel show fine to medium gravel 90 per cent minus 4 inches.

Department of Highways pits

Sturmey Road pit (89). This pit adjoins the municipal pit of the same name in a similar material.

Warner pit (99). The pit is located north of Warner Road, near Jackman Road in an area of Abbotsford outwash.

Pit (116). This pit is located south of Bell (36th Avenue) between Carvolth Road (200th Street) and Belmont (204th Street). It exposes 8 to 12 feet of Abbotsford outwash, showing fine to medium, horizontally stratified gravel with sand lenses. Some iron-oxide cements the pebbles along the north face.

Belmont location (114). The area lies along the west side of Belmont Road (204th Street) between 32nd and 34th Avenues. It is part of the Abbotsford outwash delta held for future use.

Freeway pit (83). A pit was opened up in Capilano gravel to supply aggregate for construction of the Freeway. The material is typically sandy gravel with sand lenses.

44th Avenue pit (87). This pit is located north of 44th Avenue at 236th Street. It is possibly Abbotsford outwash. It is the highest in a succession of gravel layers which are exposed to the north of the Trans-Canada Highway and of which the lower gravels are now known to be Capilano sediments. The upper gravel cannot be classified by stratigraphic means.

Department of Highways - Carvolth Road pit (118). The Department of Highways maintains a pit at the corner of Carvolth Road (200th Street) and Bell (36th Avenue) Road. The deposit is part of the delta of Abbotsford outwash which lies along the Langley-Surrey municipal boundary.

Department of Highways - Springbrook pit (82). The Department of Highways owns a pit on Springbrook (72nd Avenue) half a mile east of Livingstone (232nd Street) Road. The deposit is part of the Capilano sediments and consists of fine sandy gravel.

Private pits

Dupont Brothers pit (95). Duponts have a pit just north of Warner Road (8th Avenue) west of the Langley-Matsqui municipal boundary. The deposit is Abbotsford outwash in part ice-contact facies. A 15-foot face in the pit shows horizontally stratified sand and gravel and sand lenses.

Foster's pit (96). This pit now owned by Anderson Construction Co. is located south of Warner (8th Avenue) between Jackman Road (272nd Street) and 276th Street shows 25 feet of clean sandy gravel with sand lenses

showing crossbedding. Stony clay underlies the deposit and can be seen along the eastern boundary. The deposit is Abbotsford outwash.

Louck's pit (93). Louck's pit lies east of Jackman Road (272nd Street) about 1/8 mile north of Warner (8th Avenue). It is a small excavation in Abbotsford outwash.

Craig's pit (94). This pit lies on the north side of Louck's pit and is similar material, but seems to have a higher gravel to sand ratio.

Omelianiec's pit (97). This pit is located on the northeast corner of the intersection of Warner and Jackman Roads adjacent to Louck's pit and is in Abbotsford outwash. The material is used by Aldergrove Cement Tile. Production in 1964 was 950 cubic yards.

Highland Sand and Gravel Ltd. (115). A subsidiary of Ocean Cement Limited. This company operates a pit and plant south of McInnes (32nd Avenue) between 204th and 206th Streets.

The deposit is Abbotsford outwash, known to be up to 100 feet thick. A high water-table necessitates excavation under water excavation. The deposit is a fine to medium gravel with horizontal stratification.

Extraction is done largely by a drag scraper working below the water-table. A washing, screening and crushing plant turns out a full range of products for concrete, asphalt and road material. Production in 1964 amounted to 60,000 cubic yards of run-of-pit and washed concrete aggregate.

Border Sand and Gravel Limited (105). This company operates a pit and plant north of the International Boundary between 196th and 200th Streets in the southwest corner of the municipality.

The deposit is an ice-contact facies of Abbotsford outwash. It is roughly stratified and contains lenses of clay and till. Collapse structures are well developed. The material contains a high percentage of minus 200 mesh silt and clay and must be thoroughly washed for concrete aggregate. The material is well suited for the production of road metals as it has a high percentage in the gravel size, giving good crushing characteristics, and sufficient fine silt and clay for good binding.

Production in 1964 was reported as 16,711 cubic yards of run-of-pit and washed aggregate.

Mossen Construction Ltd. (119). The company operates out of a pit on the east side of Carbolth Road at 35th Avenue. It is Abbotsford outwash similar to the adjoining Department of Highways' pit.

Langley Gun Club pit (112). The Langley Gun Club has a pit on their property at the corner of Bradshaw Road (40th Avenue) and Berry Road (208th Street) which they lease to various operators. In 1964 B & B Trucking produced 159,322 cubic yards of run-of-pit, sized aggregate and asphalt mix.

The deposit is Abbotsford outwash and is here a medium gravel, 90 per cent minus 6 inches in diameter. The gravel is horizontally bedded and contains sand lenses.

Fort Langley Aggregates Ltd. (76). A pit near Glen Valley road at 252nd Street is operated by this company to produce run-of-pit gravel and sized aggregates. In 1964, 40,000 cubic yards was produced.

The deposit is in the Capilano sediments. The pit shows 8-9 feet of fine gravel and interbedded sand. A test hole in the pit floor showed a further 25 feet of sand and gravel.

Kitsul Brothers pit (86). The pit is located north of Dogwood Road (49th Avenue) a quarter mile east of Brown Road (240th Street). The deposit is Capilano gravel and shows about 15 feet of clean, fine to medium gravel with sand lenses. A test hole in the floor of the pit shows 10 to 12 feet of sand. In summer the water-table is well below the pit floor. Concrete aggregate is made from the pit-run material but presumably no rigid specifications are required.

Miller's Trucking Limited (75). This company has used a shallow pit at the corner of McIvor Road (88th Avenue) for fill material. The pit is in Capilano gravel. The face shows 4-foot gravel over 5 feet of silty sand over 8 to 9 feet of fine gravel. The gravel layers are about 40 per cent sand. The upper gravel and the silty sand dip gently north and appear to be unconformable with the lower gravel. A high water-table shows in the pit which is near the level of the Fraser River.

Huston pit (71). Huston pit is located 2 miles northwest of Fort Langley in remainder D, Lot 415 G2.

The deposit is part of the Capilano gravel formation in which the McKinnon Road municipal pit occurs. It is a fine sandy gravel with interbedded sand.

Clark pit (74). Mr. H.G. Clark has a pit located on the south side of Fort Langley along the edge of the Capilano gravel which underlies both the village and the National Historic site. Expansion of the pit is limited owing to residential requirements. The gravel extends below the water-table which is largely governed by the level of the Fraser River. The deposit is a fine to medium gravel with about 50 per cent sand size. H.G. Clark washes and screens the material for ready-mix concrete. In 1964, 4,480 cubic yards of washed and sized aggregate and ready-mix concrete was produced.

Dawson Construction Company (72). A gravel pit was operated in this location in 1964 and produced 70,000 cubic yards for Freeway construction. The water-table is high and only shallow (6 foot) faces were allowed. The deposit is part of the Capilano sediments and consists of 25 feet of sandy gravel and sand lenses in horizontal beds.

Dawson Construction Company (85). This pit was also used during Freeway construction from a deposit of Capilano gravel adjacent to the highway.

Dawson Construction Company (106). Gravel for construction of the new Highway 99 was obtained from an area of Abbotsford outwash north of Campbell River road near the Surrey-Langley border.

General Construction Company (107) working on the new Highway 99 obtained gravel from Abbotsford outwash along the Surrey-Langley border. The material is typical of the area, fine to medium gravel 90 per cent minus 6 inches with sand lenses in horizontal beds.

Hornby pit (117). A small pit on the east side of Carvolth Road near the corner of Bell and Gopsil Streets has been used intermittently. The material is typical of the Abbotsford outwash delta which supports 7 other pits in the area.

Maple Ridge municipality (Fig. 16)

Municipal regulations

There are few restrictions governing gravel operations within the municipality other than zoning by-laws and business licences.

Geology and reserves

The main productive gravel deposits in Maple Ridge municipality are those lying along Alouette River and under the capping of till and stony clay on the west side of Grant Hill, but extensive deposits occur elsewhere.

Mountain stream deposits (Salish sediments) occur along the course of Alouette River and in smaller patches along Kanaka Creek. An ear of about 700 acres between the two forks of Alouette River, 2 miles north of Haney is underlain by sand and sandy gravel. Along Kanaka Creek at Webster's Corners an area of 130 acres is underlain by channel gravels up to 50 feet thick and contains about 11.7 million cubic yards.

A sinuous band of Bose gravel covers an area of 1,600 acres south of Whonock Lake. This gravel reaches a thickness of 15 feet in places but is generally only a few feet thick.

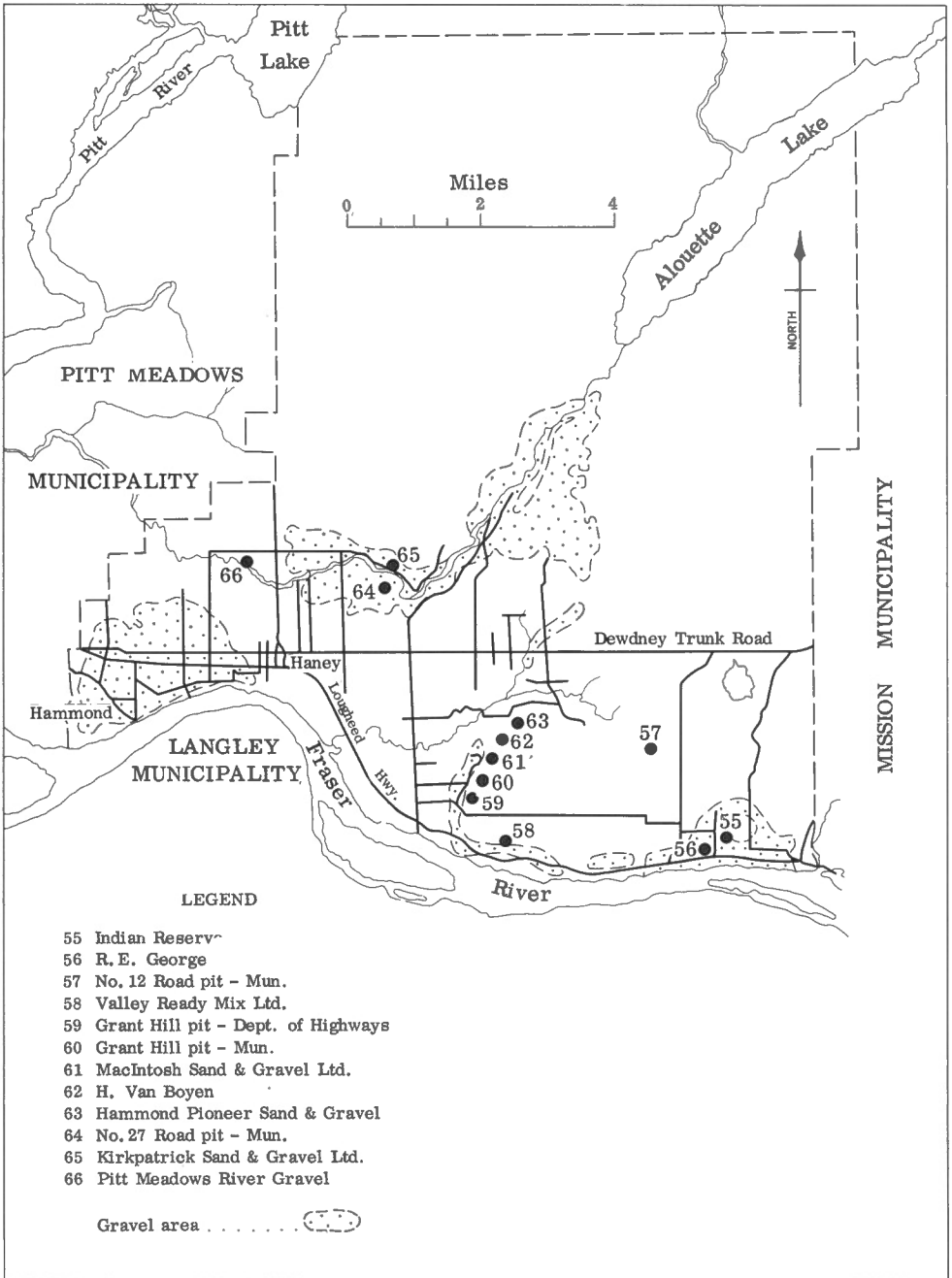


Figure 16. Maple Ridge Municipality.

Capilano gravel occurs along the upper parts of the Alouette River. About 1,200 acres of land are estimated to contain 60 million cubic yards of sand and gravel. A sandy phase of Capilano sediments underlies 3.7 square miles north of Port Hammond. It has little gravel potential.

Haney recessional outwash of the Surrey Drift occurs north of Webster's Corners where it underlies about 1,200 acres. The deposit is up to 100 feet thick and is mostly a clean well-sorted sandy gravel.

Mary Hill outwash is the main source of gravel. A thick deposit of this material underlies Grant Hill and on the west side of the hill five operators have opened up pits. A minimum of 200 acres is underlain by sand and gravel up to 100 feet thick giving a potential reserve of about 30 million cubic yards.

Details of pits

Municipal pits

Grant Hill pit (60). This pit is on the southwest side of Grant Hill just off No. 6 Road. The gravel forms in high banks (80-90 feet) under a cover of till and clay. It is classified as Mary Hill outwash and occurs in westerly dipping deltaic beds of fine to medium gravel. In 1964, 12,000 tons of asphalt mix was prepared from this material.

No. 12 Road pit (57). The pit is a quarter mile south of No. 12 Road and half a mile west of 30th Avenue. It is in Mary Hill outwash (?) where the latter is exposed in a "window" in the overlying clay. The gravel is 12 to 15 feet thick on the upper bench and a further 6 to 8 feet shows in the lower bench.

No. 27 Road pit (64). This pit is south of No. 27 Road a quarter mile east of 14th Avenue. The deposit underlies stony clay and is classified as Capilano gravel. The deposit consists of (1) lower deltaic beds of medium-sized gravel (a few boulders over 15 inches in diameter are present) and sand lenses. There are many open-work beds. (2) An upper horizontally bedded layer of sandy gravel with remnants of clay at the surface. The highest working face is about 15 feet. The material is noticeably high in granitic rocks.

Alouette River is dredged as a flood control measure and thereby provides an annually renewed reserve of gravel. Pitt River municipality (66) as well as Maple Ridge municipality uses this source for aggregate.

Provincial government pits

Grant Hill pit (59). Six pits are worked along the west front of Grant Hill (see Fig. 18). The municipal government operates the largest pit for road construction material. All are in the Mary Hill outwash of the Surrey Drift. There is large reserve because of the great thickness of the gravel which is at least 80 feet thick. The limitation to extraction will largely be determined by the amount of till which will have to be removed as the pits are worked back into the hillside.

At the Municipal pit over 70 feet of gravel is exposed under 5 to 10 feet of Surrey till. The gravel-to-sand ratio appears higher than is generally found in most deposits of Mary Hill outwash. The deposit is disposed in foreset deltaic beds dipping to the west.

Excavation is by dragscraper from a high face loosened by explosives. Production varies with municipal requirements. Base course and paving mixes are the main products.

Grant Hill Operators. Four private companies, as well as the municipal and provincial governments, operate pits along the west front of Grant Hill. All are geologically similar. See Grant Hill under municipal pits.

The four companies with 1964 production figures are given below:

Hammond Pioneer Sand and Gravel (63)	no production reported
Valley Ready Mix Limited - lease to (63)	24,000 cu. yards
H. Van Boyen (62)	685 cu. yards
MacIntosh Sand & Gravel Ltd. (61)	20,000 cu. yards

Private pits

R. E. George (56) operates a pit on lease from Indian Reserve Whonock No. 1 about a mile east of Whonock on the north side of the highway. Pit-run material is dug from low faces with front-end loader and transported in a 5-yard truck. The deposit is classified as Capilano gravel and consists of an upper 10-foot layer of clean gravel, 90 per cent minus 4 inches with numerous openwork beds, overlying about 8 feet of silty, compact gravel or till. In 1964, 1,672 cubic yards of run-of-pit material was produced.

Kirkpatrick Sand and Gravel Limited (65). This company operates a pit and a small washing and crushing plant at the end of No. 27 Road adjacent to Alouette River.

The pit face shows a 25-foot section of deltaic beds of fine to medium gravel with sand lenses underlying a thin layer of horizontally bedded gravel and capped with a thin bed of clay. The stones are mainly

granitic and few are over 15 inches in diameter. Tests made by the Department of Transport on a plus #4 mesh fraction gave a bulk specific gravity of 2.72 and an absorption of 1.2 per cent.

The deposit is classified as Capilano gravel. Production in 1964 was reported as 10,640 cubic yards.

Indian Reserve pit (55). An unused pit on Langley Indian Reserve No. 5 about 5 miles east of Haney shows about 10 feet of Mary Hill outwash under clay and till of Vashon Drift.

Valley Ready Mix Limited (58). This company operates a gravel pit on the north side of the Lougheed Highway about 4 miles east of Haney. The deposit consists of fine sandy gravel and sand in beds and short lenses. There are a few clay lenses visible in the pit. The material is classified as Mary Hill outwash and is overlain by clay and till. Up to 20 feet of sand and gravel is exposed.

Matsqui municipality (Fig. 17)

Municipal regulations

Control of gravel operations is exercised through a soil removal by-law and zoning regulations.

Geology and reserves

Deposits of sand and gravel underlie about 134,000 acres in the southern part of the municipality. This amounts to a volume of 670 million cubic yards to a depth of 30 feet. Of this volume only about 25 million cubic yards is contained in existing pits and reserves.

Practically all the gravel in the municipality is Abbotsford outwash. Most of this outwash comprises recessional deposits laid down in front of the retreating Sumas ice-tongue. Some sand and gravel occurs in ice-contact deposits. South of the village of Abbotsford dune sand up to 25 feet thick and covering an area of 3.6 square miles overlies the outwash. Much of the outwash is flat, low-lying agricultural land with a high water-table so that deep extraction of sand and gravel would spoil much valuable land. The ice-contact deposits generally exhibit irregular topography and rise above the general level. Extraction of sand and gravel from the hummocks could increase the residual value of such deposits if they were worked with this end in view.

Although most of the sand and gravel deposits are Abbotsford outwash of the Sumas valley glacier, a substantial amount of Capilano gravel, forming two layers, is exposed in the northwest corner of the municipality.

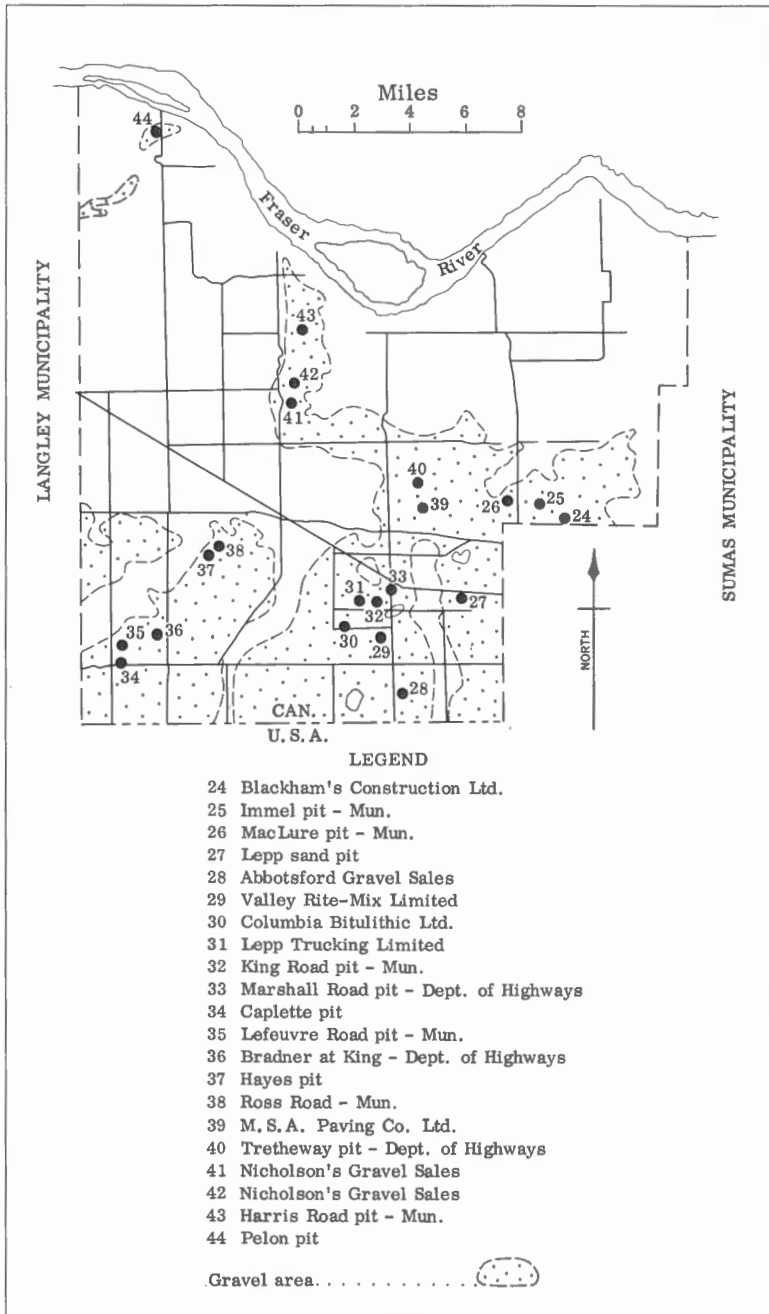


Figure 17. Matsqui Municipality.

The deposits are interbedded with stony clay although this is not apparent for the lower layers where the contact relationships are obscured by a mantle of slope wash sand and silt. The lower layer has a surface exposure of about 1,000 acres. A pit on the north end shows a thickness of about 20 feet of sand and gravel. Using this figure, a minimum of 3 million cubic yards is estimated for the whole deposit.

The upper layer is exposed in a narrow band along the steep part of the front of the upland. No pits have been opened up in this unit and the exact thickness is unknown. The surface expression continues westward into Langley municipality where it is exposed in the valley of Northern Creek.

Details of pits

Municipal pits

Ross Road pit (38). The pit lies west of Ross Road (296th Street) at 20th Avenue. The deposit is Abbotsford outwash. It has excess sand which must be rejected when road mulch is made from the material.

Harris Road pit (43). Harris pit lies north of Harris Road (46th Avenue) at Olund (308th Street). The deposit is Abbotsford outwash ice-contact material. The pit is largely worked out and is being used as a municipal garbage dump.

Lefebvre Road pit (35). This pit lies on a 20-acre parcel on the east side of Lefebvre Road at 10th Avenue. The deposit is Abbotsford outwash. Most of the faces are 25 feet high and underlying stony clay is reached in some parts of the pit.

King Road pit (32). A pit at the corner of King (16th Avenue) Road and Foy (316th Street) is now abandoned and used for garbage disposal. It is in Abbotsford outwash.

Immel pit (25). Immel pit is located at the end of Immel Road (344th Street) a mile east of Abbotsford village. It is in Abbotsford outwash standing as a high ridge.

Maclure pit (26). This pit lies on the north side of Turner Road half a mile north of Abbotsford. It is now abandoned. It shows about 15 feet of Abbotsford outwash resting on stony clay. It consists of fine- to medium-bedded gravel with sand lenses. The material is silty.

Department of Highways pits

Bradner (288th Street) at King (16th Avenue) (36). Bradner pit is located on an 80-acre tract of Abbotsford outwash. The face of the pit is 20 feet high

and discloses horizontally bedded sand and gravel with sand lenses. Some of the gravel is in coarse openwork beds.

Trethewey pit (40). This pit is located at the end of Trethewey Road north of Clearbrook. It contains a clean sandy gravel, 90 per cent minus 3 inches in diameter. The deposit is Abbotsford outwash and this type was deposited around the blocks leaving a pitted surface when the ice melted.

Marshall Road pit (33). The Department of Highways have a pit south of the Clearbrook interchange on Highway 401. The deposit is part of the Abbotsford outwash. The pit is now abandoned.

Private pits

Abbotsford Gravel Sales Limited (28). The company operates a plant in a pit half a mile north of the International Boundary on the east side of Clearbrook Road (320th Street). The pit shows about 50 feet of medium-sized gravel above the water-table. The sand fraction is said to be particularly suitable for plaster aggregate.

The company produces ready-mix concrete as well as a variety of sand and gravel products. In 1964 production amounted to 34,700 cubic yards.

Valley-Rite-Mix Limited (29). The company operates a pit and plant off Walmsley Road (12th Avenue) east of Abbotsford Airport. The deposit is medium-sized sand and gravel (95 per cent minus 6 inches) with interbedded sand lenses. The material is about 60 per cent in the gravel size range. Water from a sump in the lowest part of the pit is used to wash the aggregate for concrete ready-mix. The deposit is Abbotsford outwash. In 1964, 28,501 cubic yards was produced.

Lepp Trucking Limited (31). The pit is at the corner of King (16th Avenue) and Foy Road (314th Street). A face 10 to 12 feet high shows fine to medium gravel with sand lenses. The deposit is Abbotsford outwash. In 1964, 8,000 cubic yards of pit-run gravel was produced.

Hayes pit (37). Hayes pit is half a mile west of Ross Road at 17th Avenue. The property is owned by Grant Materials and Equipment Limited. The deposit is mainly Abbotsford outwash ice-contact material and has some lenses of till; coarse, unsorted, slumped sections; large boulders; and sand beds. The deposit has supplied aggregate for highway and road construction. Production in 1964 amounted to 4,000 cubic yards of run-of-pit gravel and sized aggregates.

Caplette pit (34). The pit is at the corner of Lefebvre Road (280th Street) and Huntingdon Road (8th Avenue). A small pit in Abbotsford outwash shows

10 feet of gravel with a high gravel to sand ratio. In 1964, 3,981 cubic yards of pit-run material was produced.

M. S. A. Paving Co. Ltd. - Clearbrook pit (39). Clearbrook pit is on Trethewey Road about half a mile north of the old Trans-Canada Highway. The face shows 20 feet of medium to coarse gravel with sand lenses. The deposit is Abbotsford outwash.

Blackham's Construction Limited (24). This company operates a pit at the south end of Immel Road along the Sumas-Matsqui municipal border about a mile east of Abbotsford.

The property lies along the northwest side of a southwest trending ridge. Two pits in the ridge expose an 80-to 100-foot section. The lower pit is about 75 feet deep and shows a medium gravel 95 per cent minus 10 inches with interbedded sand lenses. The upper pit exposes a 70-foot section of fine to medium gravel with sandy silt, and clay beds. The material makes a good road mulch but the lower pit is used when cleaner material is required.

There is a small remnant of Sumas till on the top of the ridge so the gravel is pre-Sumas and presumably Huntingdon outwash. No groundwater is available at reasonable depth and wash water when required must be obtained from the Matsqui municipal system. Production of 58,707 cubic yards of run-of-pit and sized aggregate was reported for 1964.

Nicholson's Gravel Sales (41). This company operates a pit off Olund Road (305th Street) at 48th Avenue. It is an ice-contact phase of Abbotsford outwash. A face up to 50 feet high shows slumped beds dipping east at 30 degrees. The material is 90 per cent minus 4 inches with minor sand beds. A second pit (42) a quarter of a mile north is similar.

Pelon pit (44). This pit, west of Bradner Road (288th Street at 83rd Street), was opened up to provide fill along the Fraser River embankment. The section shows about 4 feet of bedded clay on top of 20 feet of silty, coarse gravel. The deposit is classified as Capilano gravel.

Columbia Bitulithic Limited (30). A pit on the east boundary of Abbotsford Airport in 1963 produced asphalt cement for the airport runway extension. The deposit is Abbotsford outwash. The material is medium gravel, 80 per cent minus 6 inches and contains a few sand lenses. Extraction has been mainly above the water-table, giving faces up to 15 feet high. A sandy compact gravel which may be a remnant of Sumas till was noted on the north side of the pit.

Mission municipality (Fig. 19)

Municipal regulations

Mission municipality is aware of the need to conserve gravel reserves for its own use and no municipal land is available for commercial gravel development. There is, however, a large amount of privately held land containing gravel which could be acquired by negotiation.

Geology and reserves

The main sand and gravel formation in the municipality is Abbotsford outwash deposits which lies on an irregular basement of bedrock of Sumas till. The largest single tract of this material lies north of Steelhead down Cardinalis Creek. The volume of the deposit is unknown but must be very large as that part north of Steelhead underlies at least 1,500 acres, giving a reserve of about 45 million cubic yards to a depth of 20 feet.

Huntingdon gravel underlies much of the Sumas till and is locally exposed. A large area occurs in a strip more or less bordering Fraser River from Hatzic to Silverdale Creek. However, most of this is pre-empted for purposes which preclude development as gravel supplies.

Mountain stream deposits occur mainly below Hayward Lake and along Stave River. About 1,000 acres of flood plain are underlain by gravel between Fraser River and Hayward Lake but the depth of the deposit is unknown. Presumably it is fairly shallow as it rests on stony clay eroded by the river and well exposed around the edge of the flood plain and on an island in its centre.

Details of pits

Municipal pits

Stave Falls pit (50). This pit is on a 160-acre block about half a mile east of the dam at the south end of Stave Lake. A large pit has been opened up in Abbotsford outwash. The gravel is fine to medium sized 90 per cent minus 6 inches with sand lenses. Most of the gravel is contained in north-dipping deltaic beds. Over this gravel a layer of flat-lying topset beds adds 3 to 10 feet to the depth making a total of at least 20 feet. Varve-like bedded clay with thin gravel and sand layers was noted on the southwest side of the pit. Part of the gravel is till-like but could be processed for aggregate. The size of the pit indicates that about 300,000 cubic yards have been removed.

Stave Lake Road pit (47). A small borrow pit in Abbotsford outwash lies along the west side of Stave Lake Road immediately south of Kirkpatrick Road.

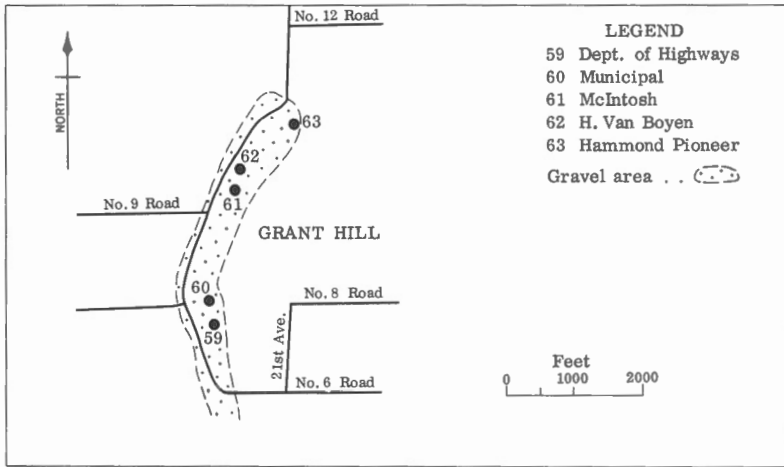


Figure 18. Grant Hill gravel area, Maple Ridge Municipality.

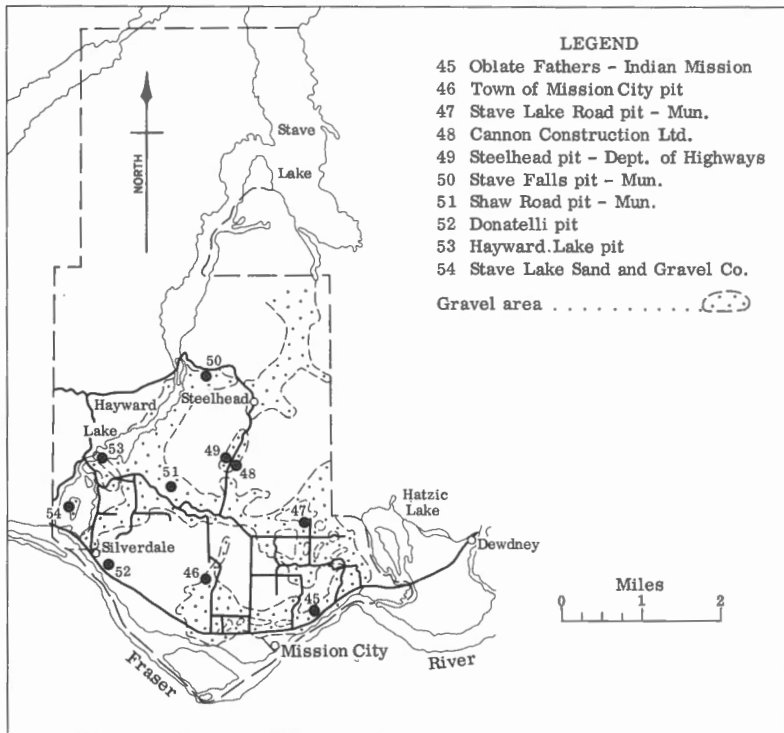


Figure 19. Mission Municipality.

Shaw Road pit (51). An area of .52 acres south of Carswell Road and east of Shaw Road contain a municipal pit in ice-contact Abbotsford outwash. The deposit is poorly sorted silty gravel, 90 per cent minus 10 inches in diameter. It is estimated to contain 1.5 million cubic yards.

Department of Highways pits

Steelhead pit (49). Steelhead pit is 1.8 miles south of Steelhead on the west side of the Dewdney Trunk Road. The deposit is an ice-contact phase of Abbotsford outwash. The gravel is poorly sorted; some very large 6-to 8-foot boulders have been removed from the pit. Silty sand and clay in short lenses exhibit slump structure.

Private pits

Donatelli pit (52). This pit lies adjacent to the west side of Hayward Road just north of the Lougheed Highway. The gravel is classified as a post-glacial mountain stream deposit of the Capilano sediments. It is a fine to medium sized gravel deficient in minus 200 mesh size for some purposes such as road mulch where fines are needed to insure good packing characteristics.

Stave Lake Sand and Gravel Company (54). This company owns a gravel deposit at the northwest end of an island in the middle of the flood plain of the Stave River below Ruskin dam. The island is connected by causeway to the Lougheed Highway. In 1960 Routledge Gravel Company washed and screened 9,500 cubic yards for the Port Mann bridge project. The deposit is close to Fraser River tidewater, but the shallowness of the water on the flood plain makes barging difficult. The gravel is fine to medium in size, clean and sandy. Boulders up to 2 feet in diameter are uncommon. The deposit is deltaic; foreset beds dip west. Underlying stony clay is exposed at the north and east side of the island. The deposit is a post-glacial mountain stream deposit.

Cannon Construction Ltd. (48). Cannon Construction Ltd. operates a pit on the east side of the Dewdney Trunk Road about 2 miles south of Steelhead. The gravel is fine and sandy with interbedded horizontal sand layers. Coarser beach gravels cap the deposit which shows a working face of about 70 feet.

Oblate Fathers Roman Catholic Indian Mission (45). Two pits on the Mission property are used intermittently on a small scale. The upper pit contains sandy gravel with 20 per cent silt. Bedrock is exposed in the pit floor. The deposit is classified as Huntingdon gravel of the Sumas Drift. The lower pit, which is about 500 feet south of the upper pit is essentially a sand pit.

Town of Mission City (46). The corporation of the town of Mission City extracts gravel from a 40-acre tract at the corner of Wren and Beals Roads. The deposit consists of 8 to 10 feet of coarse beach gravel (Bose) overlying glacio-marine clay.

North Vancouver municipality (Fig. 20)

Municipal regulations

Control of gravel operations is mainly exercised through a soil removal by-law and zoning regulations.

Geology and reserves

The main gravel areas in this municipality include (1) Capilano River area; (2) Lynn Creek-Seymour River area, and the foreshore of Burrard Inlet.

The Capilano River area is now largely residential and no gravel production is possible. The Lynn Creek-Seymour River area (Fig. 21) is the last reserve of sand and gravel now that foreshore dredging has been stopped by virtue of National Harbours Board's policy to conserve the gravels for use in building up the waterfront.

The Lynn Creek-Seymour River area is underlain by about 4,000 acres of Capilano and Salish sediments, most of which is sand and gravel. About 20 per cent is still available as a gravel reserve.

Details of pits

Municipal pits

Capilano Dam pit (195). A sand pit about one half mile southeast of the Capilano Dam is operated intermittently by the municipality. A 20-foot face shows crossbedded sand with minor gravelly lenses.

Fell Avenue pit (194). A small pit at 19th Street and Fell Avenue is abandoned.

Lillooet Street pit (192). This is the main source of gravel for municipal uses and is between Lynn Creek and Lillooet Street in an area of Capilano gravel. The pit faces show a 4- to 6-foot flat-lying beach gravel over fore-set deltaic beds of silty gravel with rusty layers and sand lenses. The deltaic beds are up to 40 feet thick.

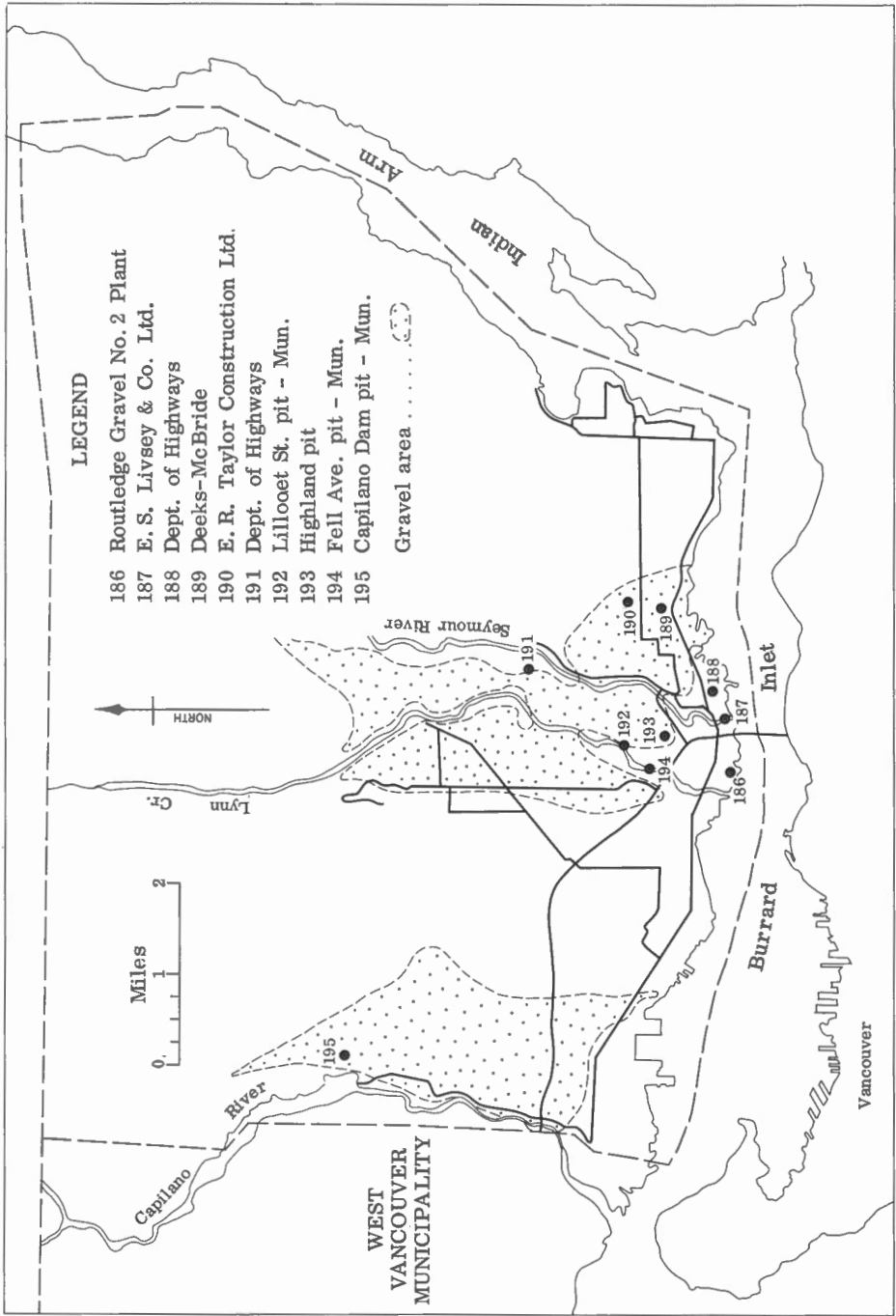


Figure 20. North Vancouver Municipality.

Provincial pits

The Department of Highways has no pits in the area but has investigated gravel deposits in the Lynn-Seymour area (188) and (191). The Lynn Creek test area and the municipal gravel bars are examples of mountain stream deposits of the Salish sediments. The Seymour test area is in Capilano gravel. All gravels show a deficiency in fines (minus 200 mesh) and have, in fact, little material smaller than 100 mesh. The gravel is essentially all minus 3 inches.

Private pits

E. R. Taylor Construction Ltd. (190). This company owns a sand pit at the end of River Street off Riverside Drive. Minor gravel lenses occur within the sand which is here about 100 feet thick. The sand is presumably part of the Quadra sediments. A few very large boulders are scattered around the pit. These probably come from the overlying till. Some gravel lies above the till but the true thickness and extent are unknown. The whole section is capped by a layer of stony clay with a surface veneer of Bose beach gravel. Production is now intermittent and minor.

Deeks-McBride - North Vancouver plant (189). At one time a deposit of Capilano gravel east of Seymour River on the Dollarton Highways was processed in this plant. When this source became depleted the plant was fed from dredged foreshore deposits. Now that this source is no longer available for lease, raw material for the plant must be brought in from other deposits. The plant was a major supplier for aggregates for the area. In 1959 297,000 cubic yards of sand and gravel was processed.

Routledge Gravel, No. 2 plant (186). Gravel at the mouth of Lynn Creek was once extracted by dragline dredge to supply No. 2 plant but this source is no longer available for lease and the plant is closed.

E. S. Livsey and Co. Ltd. (187). This company produced sand and gravel products from material dredged from the foreshore of Burrard Inlet near Seymour River and like the others is also now closed.

Highland pit (193). Highland Sand and Gravel Limited operated a pit off East Keith Road west of Seymour River. In 1960 production was suspended although the pit was not depleted. The deposit was mainly in Capilano terrace gravels. The material was washed, sized and crushed for a variety of products including cement tile and blacktop. At one time the plant production was as high as 180,000 cubic yards per annum.

Pitt Meadows municipality (Fig. 21)

Municipal regulations

Although there is very little gravel in this municipality and thus no necessity to regulate the industry, there is a soil removal by-law which could be invoked should the occasion arise.

Geology and reserves

Pitt Meadows municipality is largely underlain by Salish sediments consisting of silt and clay, minor sand and peat. An area of Capilano sediments, mainly sand, around the village of Pitt Meadows has supplied sand and minor sandy gravel from two pits. A small portion of a deposit of sand of mountain stream origin extends westward from Maple Ridge municipality about 3 miles north of Port Hammond.

The paucity of gravel within the municipality is indicated by the fact that about 20,000 cubic yards of gravel a year for municipal purposes is obtained from the Alouette River in Maple Ridge municipality.

Details of pits

Haney Brick and Tile pit (152). This pit is in a deposit of sand and very sandy gravel a mile and a half southeast of Pitt Meadows village. It is essentially a sand pit used in connection with the manufacture of clay products. A 20- to 25-foot face is worked intermittently. The deposit is classified as part of the Capilano sediments.

Lasser pit (153). This pit, on the west side of Bronson Road, half a mile south of the Haney Brick and Tile pit, is also essentially a sand pit with about 8 per cent fine gravel and is also classified as part of Capilano sediments.

The municipal pit (151) across Bronson Road from Lasser's pit is now exhausted and used for a municipal dump. It was similar to the other pits in the vicinity in composition and gradation.

Richmond municipality

Municipal regulations

Richmond municipality includes most of the islands in the delta of Fraser River. These consist mainly of sand, silt and clay. No gravel occurs on the surface but small amounts of sandy gravel are reported from the south arm of the Fraser River near Steveston and in the main channel near Annacis Island.

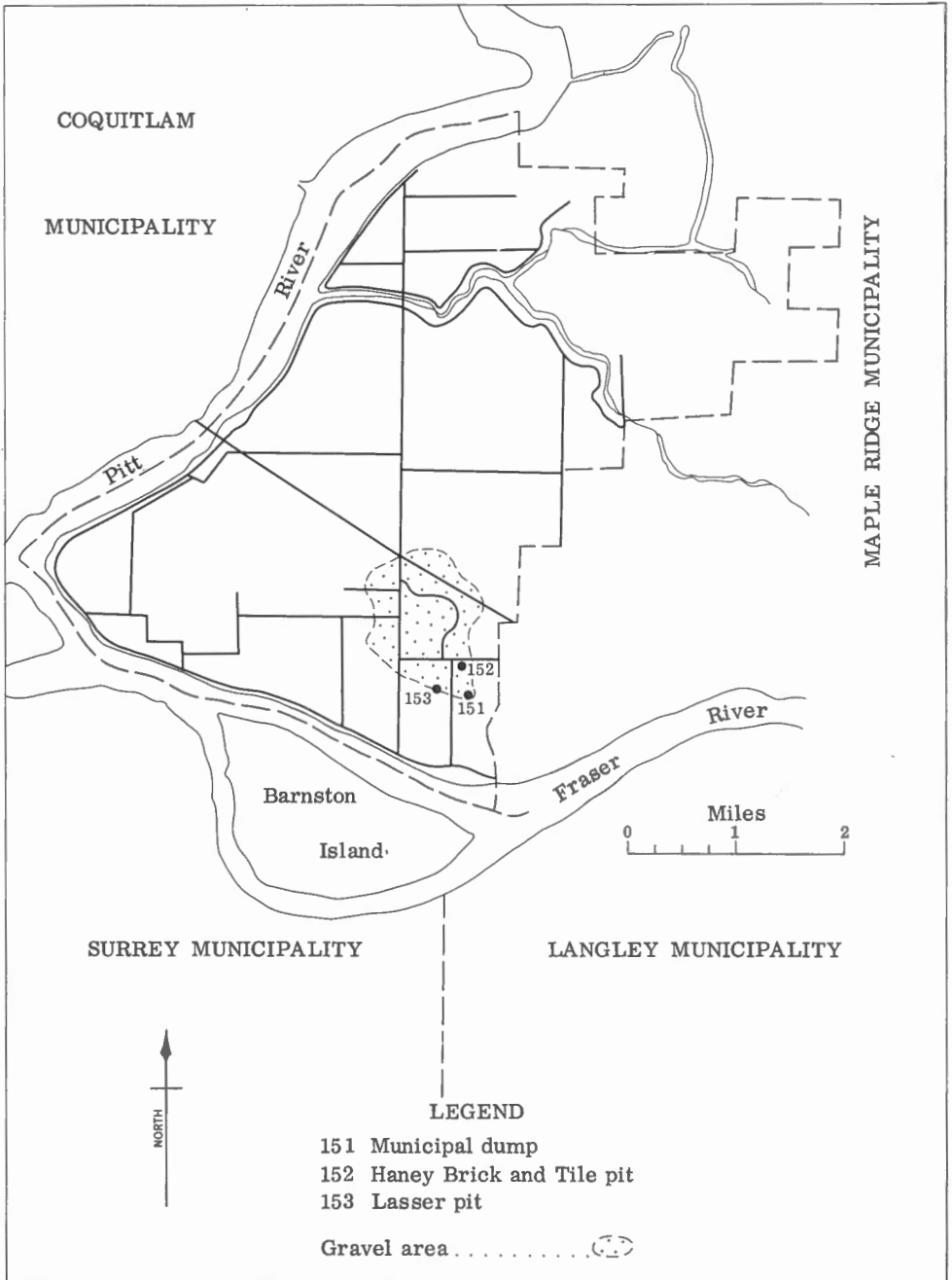


Figure 21. Pitt Meadows Municipality.

Sand is dredged from the Fraser River by the Federal Government in order to maintain shipping channels. This sand is usually stockpiled on land and is available for commercial purposes.

A mechanical analysis of sand from the channel at Steveston showed it to be essentially minus 30 mesh plus 100 mesh and therefore a fine to medium sand by most classifications.

Sand and gravel producers

Basic Materials Company. This company produces sand from the Fraser River off Twigg Island. The product is used for plaster aggregate and fill.

Routledge Gravel Limited. This company maintains a storage yard on the south side of the north arm of the Fraser River at Bridgeport. Gravel is brought in for resale and dredged sand is also stockpiled here.

Sumas municipality (Fig. 22)

Municipal regulations

Few regulations are applied to the sand and gravel industry. There is a soil removal by-law which may be invoked to control operations.

Geology and reserves

Most sand and gravel deposits are in the western parts of the municipality near Abbotsford. The thickest deposits underlie Sumas till. South of Abbotsford this underlying gravel is exposed by erosion along the upland front facing the Sumas Valley. Up to 100 feet of sand and gravel is thinly capped by till and dune sand. Under these conditions as much as 150,000 cubic yards per acre can be recovered. This is the Huntingdon gravel of the Sumas Stade. East of Abbotsford village similar conditions prevail and a large amount of sand and gravel is available. In places Huntingdon gravel is overlain by Abbotsford outwash. Much of this outwash is sand but some is gravel and in a few localities both Abbotsford outwash and Huntingdon gravel is present, separated by a thin layer of Sumas till.

A few slope wash deposits occur along the south flank of Sumas Mountain and constitute a small reserve of angular material suitable for road building.

The eastern part of the municipality is best supplied with sand and gravel from the Vedder River deposits in Chilliwack municipality.

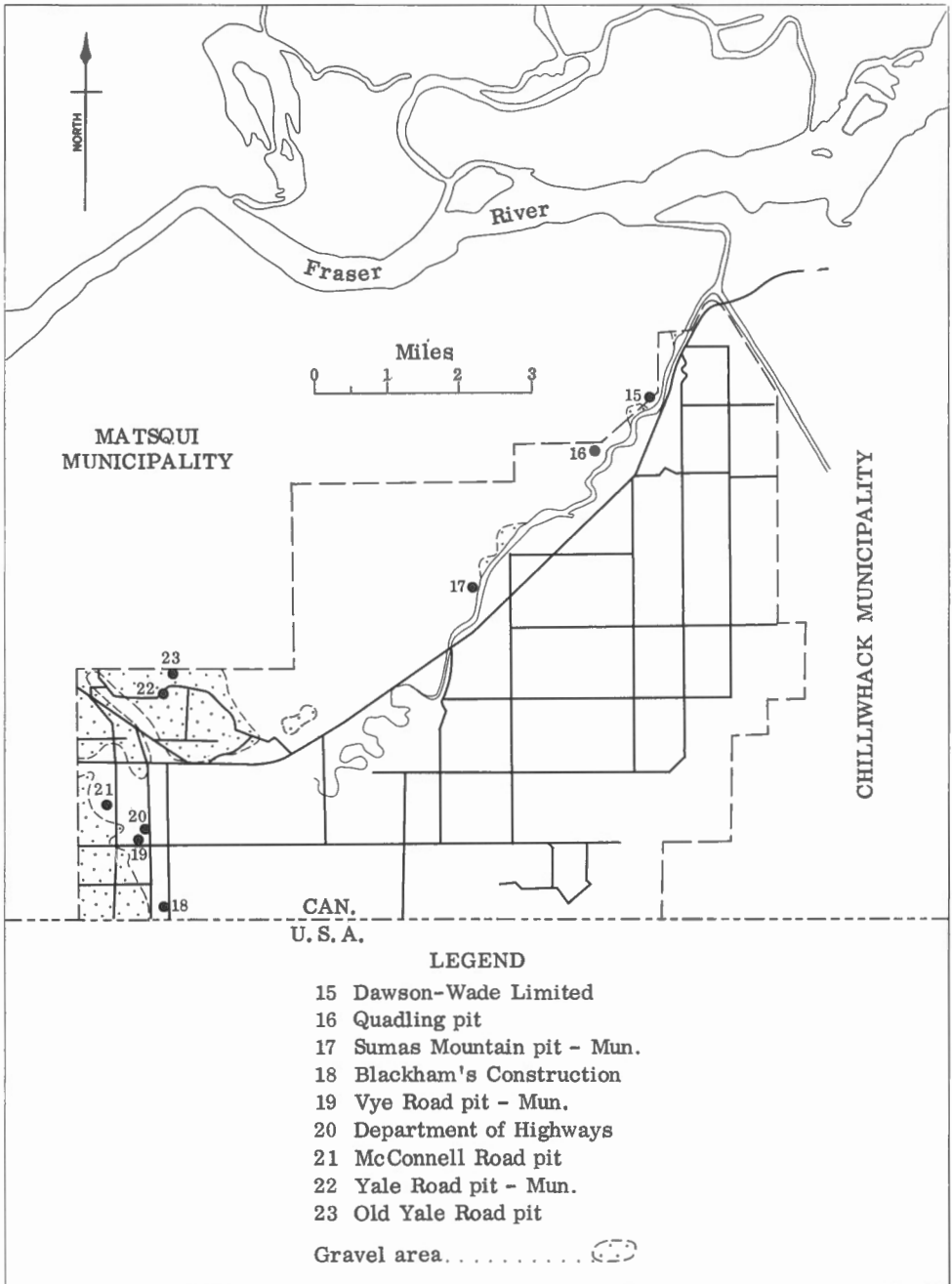


Figure 22. Sumas Municipality.

Details of pits

Municipal pits

Vye Road pit (19). This pit is located on the side of Vye Road a quarter mile west of Riverside Road. The section includes about 80 feet of medium-sized Huntingdon gravel with sand lenses capped by about 10 feet of Sumas till which in turn is overlain by about 5 feet of dune sand of Abbotsford outwash. Production varies from year to year with changes in municipal needs. In 1964, 11,039 tons of asphalt paving material was produced from the pit.

Yale Road pit (22). Yale Road pit lies on the north side of Yale Road at 344 Street. The deposit is medium-sized gravel with sand lenses with many open work beds. The gravel is overlain by as much as 15 feet of Sumas till. The deposit is classified as Huntingdon gravel.

An undeveloped reserve of slope wash angular gravel is held on the south slope of Sumas Mountain a mile and a half east of Kilgard.

Sumas Mountain pit (17). The municipality maintains a pit at the base of Sumas Mountain north of Fireclay Road. The deposit is a gravel fan of Salish sediments of angular fragments of quartz diorite.

Provincial pits

Department of Highways pits (20). A small amount of gravel land is held by the Department of Highways between the municipal Vye Road pit and the right-of-way of the Great Northern Railway. It is Huntingdon gravel of the Sumas Stade. The deposit is largely depleted.

Old Yale Road pit (23). This pit lies north of the municipal pit in the north-west corner of the municipality. The deposit is Huntingdon gravel and here is capped with a thin layer of Sumas till. It is a sandy gravel with sand lenses. Some clay balls are present in the gravel beds.

Private pits

Blackham's Construction pit (18). A pit formerly operated adjacent to the village of Huntingdon is now depleted and abandoned. The gravel underlies Sumas till and dune sand and is similar to the municipal Vye Road pit deposit. The section exposed at the faces shows about 15 feet of sand at the surface overlying about 10 feet of till and this in turn overlies 75 feet of gravel.

McConnell Road pit (21). An abandoned pit on the west side of McKenzie Road just north of McConnell Road shows Huntingdon gravel under 10 feet of Sumas till.

Quadling pit (16). This pit is located at the base of the south slope of Sumas Mountain east of Taggart Peak. It is a slope wash deposit still being formed. The material is mainly angular fragments of granite and volcanic rocks which form the bedrock core of the mountain. The material is 95 per cent minus 3 inches in diameter, and 63 per cent plus #4 U.S. Standard sieve size. In 1964, 7,349 cubic yards of fill material was removed.

Dawson Wade Limited - Sumas Mountain pit (15). Slope wash gravel and talus from Sumas Mountain was used by Dawson-Wade Limited during construction of Highway 401. The deposit consists of a large fan of angular blocks and fragments of granitic and volcanic rocks which form Sumas Mountain.

Surrey municipality (Fig. 23)

Municipal regulations

Control of gravel operations is affected by soil removal and zoning by-law. Before a pit is opened, a soil removal permit must be obtained. Application for a permit must be accompanied by plans of existing and final grading. To insure that the property is left in a neat condition a bond of \$1,000 per acre with a \$5,000 minimum must be posted. No pits are allowed in residential zones and processing is permitted only in manufacturing zones. Gravel may be extracted but not processed in suburban zones.

Geology and reserves

The principal sand and gravel formations in Surrey municipality are (1) Abbotsford outwash and (2) pre-Surrey till formation, in part Mary Hill outwash equivalent and in part older formations. Abbotsford outwash occurs over a semicircular area with the flat side along the Surrey-Langley municipal boundary from about 8th Avenue north to 48th Avenue. This is the western edge of a large delta formed by the discharge of a meltwater channel into an arm of the sea during the recession of the Sumas ice. The area of the delta in Surrey municipality is about 2,750 acres. Thus assuming a depth of 9 feet, the general level of the water-table, a volume of over 40 million yards may be present. In selected places much deeper extraction is possible as the thicknesses of a hundred feet of sand and gravel are known from test holes in some places in the delta. However, this area to a large extent is already occupied by residences, road allowances, and other alienated acreage and the precise reserves are impossible to calculate. At present about 220 acres are held as gravel land and constitute a minimum reserve of 6 million cubic yards using an average depth of 18 feet.

An upland area along the International Boundary in the southwest corner of Langley continues into Surrey municipality where it underlies an area of about 450 acres. This upland is composed of ice-contact deposits of Abbotsford outwash. The material is a mixture of silty gravel, clean gravel,

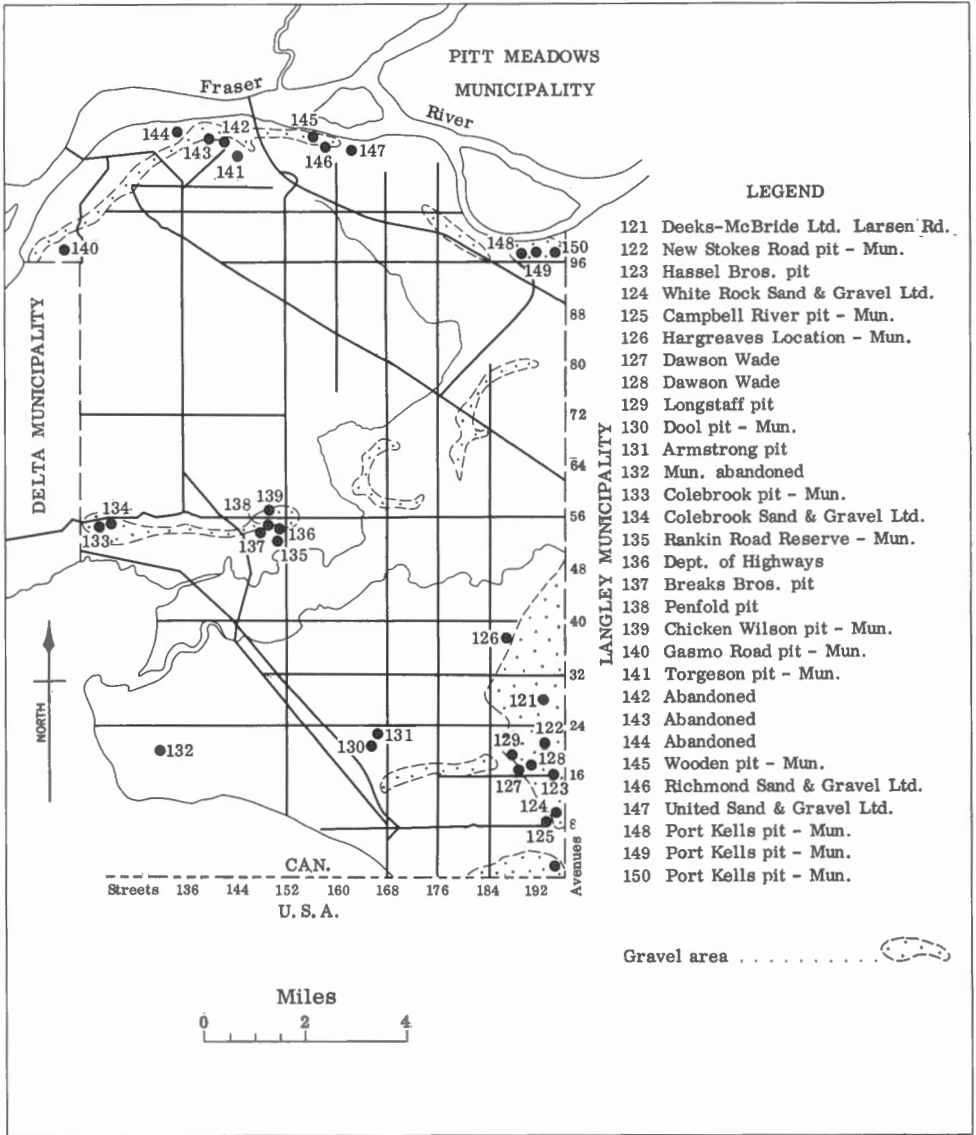


Figure 23. Surrey Municipality.

lenses of till and clay. Test holes indicate 30 to 40 feet of gravel along the Boundary. Using an average depth of 30 feet, a potential reserve of 22 million cubic yards is indicated.

Gravel is exposed more-or-less continuously along the base of the Surrey upland in the northwest part of the municipality where the coverage of till and a stony clay has been removed by erosion. The sand and gravel deposits are known to be of different ages; in part they are advance outwash of Mary Hill gravel and in part they are older gravels of interglacial age. The different ages have been demonstrated by radiocarbon age determinations from organic matter found in certain beds within the gravel formation.

Although natural exposures occur mainly along the base of the upland, the covering of till and clay on the top of the upland is in places thin enough to be economically removed. This adds an unknown volume to the potential reserves of sand and gravel. About 7,800 acres of sand and gravel are exposed and perhaps another 1,000 acres could be added from thinly-covered areas. Of this amount, about 600 acres are held as sand and gravel reserves by the municipality and private companies. An estimated 30 million cubic yards is contained in this area.

Thin deposits of Bose gravel of the Capilano sediments have developed on till and stony clay. These are extensive but rarely thick enough to be considered as gravel reserves. In a few places, however, Bose gravel does exist in beds up to 25 feet thick. Two areas are known in the southwest corner of the municipality; one, a mile northeast of Crescent Beach contains a depleted pit; the other, a mile east of Crescent Beach has not been worked.

Details of pits

Municipal pits

Gasmo Road pit (140). This pit lies north of Townline Road west of Scott Road. It shows 6 to 8 feet of Bose gravel. The reserves are small due to the limited extent and thickness.

Municipal pit (132). Abandoned. Bose gravel, a few feet thick was once extracted from a pit.

Torgeson pit (141). The Torgeson pit is north of 111A Avenue off Bon Accord Street. It is a pre-Surrey till deposit showing about 20 feet of silty gravel under 4 to 5 feet of till. A sand layer, 15 feet in thickness, is exposed on the west side of the pit but the base of the sand is not exposed so the total depth is unknown.

The gravel here contains more fines (minus 200 mesh) than acceptable for most applications except base courses in road construction. The reserve contains about 160,000 cubic yards.

Wooden pit (145). This pit is located north of 1112th Avenue between Clow and Pike Streets. It is considered part of the Surrey Drift (Mary Hill outwash) but may be an older gravel. The deposit is exposed along the front of the Surrey Upland where the overlying till has been removed or thinned by erosion. Reserves in 1960 were estimated at 245,000 cubic yards.

Port Kells pits (148) (149) (150). Three small areas around Port Kells are held as gravel reserves. They are in Capilano gravel with a high water-table. The municipal engineer considers they are possible sources of emergency material only.

Chicken Wilson pit (139). Pre-Surrey till gravel has been excavated on the north side of No. 10 Highway a quarter of a mile west of Johnston (152nd) Street. This is the Chicken Wilson pit which is largely depleted. Till and stony clay remnants were removed and to some extent used in developing the pit. It is now a garbage disposal area.

Rankin Road reserve (135). The Rankin Road reserve is located south of Chicken Wilson pit on the opposite side of No. 10 Highway. It adjoins the provincial government pit. The deposit is probably part of the Surrey Drift but could be part of an older deposit. Reserves in this pit are estimated at 185,000 cubic yards.

Colebrook pit (133). This pit lies south of McLellan Road near the Delta-Surrey municipal boundary. The deposit underlies the eroded remnants of Surrey till. The till is sometimes processed and mixed with the gravel for the production of road mulch. The usable fraction of the till is included with the municipal estimate of reserves which, in 1960, amounted to over a million cubic yards.

Dool pit (130). This pit lies between Stokes Road and Sunnyside Avenue west of Coast Meridian Street. This pit is largely depleted. It consists of Bose gravel overlying stony clay.

New Stokes Road pit (122). This pit is north of Stokes Road near the eastern municipal boundary. Faces 10 to 12 feet high have been opened up in Abbotsford outwash. The material is good quality gravel but lacks fines for some specifications. The deposit is well bedded and sorted. At the south-east side of the pit deltaic beds containing clay balls can be seen. Ground-water from the pit drains into Campbell River. The pit is on an 80-acre parcel with reserves calculated to be about 4 million cubic yards.

Campbell River pit (125). This pit lies south of Campbell River Road about one quarter mile east of Latimer Road. In this pit Bose gravel overlying stony clay and till which in turn overlies a pre-Surrey till gravel is exposed in a small pit at the base of an upland area extending eastward. The deposit is essentially exhausted.

Hargreaves location (126). A 20-acre parcel held for gravel is maintained on the north side of Hargreaves near the Surrey-Langley municipal boundary. It is undeveloped but is known to contain Abbotsford outwash, sand and gravel. A high water-table exists so that reserves in excess of 150,000 cubic yards can only be postulated if dragline excavation methods can be used.

Provincial pits

The Department of Highways pit (136). The provincial government has a pit across No. 10 Highway from the municipal Chicken Wilson pit. This is an area in which pre-Surrey till gravels are exposed by erosion of the overlying till and stony clay. The pit is largely depleted and used mainly for a storage yard. The face shows up to 30 feet of deltaic beds of coarse gravel and 15 feet of horizontal beds of fine gravel and sand.

Private pits

Colebrook Sand and Gravel Limited (134). This company operates a pit north of Colebrook Road one quarter mile east of Scott Road. It is adjacent to the municipal pit and is almost entirely in the lower sand deposit which underlies the gravel in the municipal pit. The sand is considered part of the Quadra sediments. Some gravel lenses are interbedded with the sand which is up to 30 feet thick.

Breaks Bros. pit (137). This pit is located north of Colebrook Road half a mile east of the King George Highway. It is a pre-Surrey till gravel exposed along the south slope of Panorama Ridge where the overlying till has been removed by marine erosion. Deltaic beds dipping easterly show in a 20-foot face.

Penfold pit (138). This pit lies adjacent to the Breaks Bros. pit and was opened up at the same time in order to obtain material for construction of the Deas Island Freeway (499). The Penfold pit shows 5 to 10 feet of brown sandy gravel overlying 5 feet of sand. The gravel is medium to coarse in size and estimated to be 90 per cent minus 4 inches in diameter.

Armstrong pit (131). This pit is adjacent to the municipal pit west of Coast Meridian Road between Stokes and Sunnyside Avenues. It is a thin deposit of Bose gravel on Surrey till.

Longstaff pit (129). This pit, which is in Abbotsford outwash, lies south of Stokes Road half a mile east of Halls Prairie Road. The material is clean sandy gravel in flat-lying beds. The water-table shows in the pit about 10 feet from the surface.

White Rock Sand and Gravel Limited (124). The company operates a pit north of Campbell River Road near the Langley-Surrey municipal boundary. The deposit is Abbotsford outwash which here is a fine to medium silty gravel with sand lenses.

Deeks-McBride Limited - Larsen Road pit (121). The pit is south of Larsen Road near the Langley-Surrey municipal boundary. Fine gravel with little or no oversize is extracted from below the water-table by dragline scraper. The material is used mainly in ready-mix concrete. The deposit is reported to be more sandy at depth. It is part of the Abbotsford outwash delta which extends over a large area along the Langley-Surrey municipal boundary in the southeast corner of the municipality. In 1964 total production of washed and sized aggregate, ready-mix concrete and run-of-pit gravel was 75,140 cubic yards.

Richmond Sand and Gravel Limited (146). This company operates a pit and plant off 112th Avenue at the end of Pike (160th) Street. The material is fine to medium bedded gravel with sand lenses. It is overlain by stony clay, 10 to 15 feet thick. The deposit is worked on a 40-foot face. Washed and sized aggregate and pit run-material is produced. The deposit is probably pre-Surrey till in age and may be the equivalent of Mary Hill gravel. In 1964, 10,000 cubic yards of run-of-pit and sized aggregate was produced.

United Sand and Gravel Limited (147). The company operates a pit northeast of the corner of Pike Road and 112th Avenue. The gravel is similar to that on the Richmond Sand and Gravel pit but here the overlying stony clay has been largely removed by erosion. The deposit which is about 35 feet thick is underlain by 90 feet of sand. In 1964, run-of-pit and sized aggregate production amounted to 40,909 cubic yards.

Hassel Bros. pit (123). Hassel Brothers operated from a pit on the north side of North Bluff (16th Avenue) near the Langley-Surrey municipal boundary for construction of the new King George Highway. The deposit is Abbotsford outwash and consists of fine sandy gravel and sand lenses. The water-table is about 12 feet from the surface.

Dawson-Wade Limited pits (127) (128). These adjoining pits on the north side of North Bluff (16th Avenue) at 199th Street were used during construction of the new King George Highway. The deposit is Abbotsford outwash and consists of fine sandy gravel and sand lenses.

Port Mann pits (142, 143 and 144). These gravel pits in Port Mann have been abandoned owing to encroachment of urban development. The deposits are pre-Surrey till in age. The pits will be back-sloped and used for residential subdivisions.

West Vancouver municipality

Municipal regulations

Most of the potential sources in West Vancouver municipality lies within residential areas and is therefore affected by zoning regulations.

Geology and reserves

The most extensive sand and gravel deposits in the municipality are the raised marine deltas and channel deposits of the Capilano sediments of the Everson Interstade west of Capilano Creek. However, little or none of this material may be classed as gravel reserves as a result of urbanization which has pre-empted the land for residential and commercial purposes.

Salish sediments formed by the discharge of the Capilano River have built and are still building deposits on the foreshore of Burrard Inlet. These deposits are controlled by the Federal Government through the National Harbours Board. Current policy is to conserve the deposits for building up the harbour front at some future date. Accordingly no leases are renewed on expiration so that all operations have ceased.

West Vancouver now has little gravel production; those pits shown are worked out, zoned out or otherwise closed down.

Foreshore Salish deposits included Capilano crushing (198), Routledge Gravel (197). Two municipal pits (199) and (200) are now defunct. The pit on the British Properties (196) is on the edge of a large gravel terrace now completely developed for residential purposes.

Small amounts of Capilano gravels are found along the Upper Levels Highway and north of Horseshoe Bay, along the Squamish Highway. These are mostly small deltaic deposits of a few hundred thousand cubic yards or less.

GEOLOGY AND DISTRIBUTION OF SAND AND GRAVEL
IN THE GEORGIA LOWLANDS
(exclusive of the Fraser Lowland)

INTRODUCTION

The Georgia Lowland as used by Holland (1964) is the coastal mainland from Sayward south and includes the Fraser Lowland. In this report only that part of the Georgia Lowland between Lund and Sechelt is considered. For convenience the deposits in Howe Sound and from Squamish north to Mamquam River are included although they are not properly part of the Georgia Lowland.

No maps of the surficial geology have been published for this area and consequently little is known of the geology and distribution of sand and gravel deposits. The writer spent only a short time examining the known pits but observed enough surface features to anticipate a general conformity to the glacial history as worked out for the rest of the Strait of Georgia area.

Salish sediments are being transported and deposited by the Squamish and Mamquam Rivers; modern deltas and channel deposits are associated with smaller rivers and some creeks. Beach deposits varying from sand to cobbly gravel occur in many places along the coastline.

Capilano sediments form large and important deposits along both sides of Howe Sound, and Bose-type lag veneers and bars overlie till in many places.

Outwash sand and gravel considered equivalent to Mary Hill outwash of the Surrey Drift is exposed on the Sechelt Peninsula and is known from drill records in the Powell River area.

Deposits equivalent to the Quadra sediments are probably represented by the thick sand sections at Powell River. The presence of two till sheets in the Gower Point area is suggestive of two glaciations although the possibility of a minor retreat and readvance of the ice-sheet of one glaciation must be considered. McConnell (1914) in describing the glacial deposits on Texada Island notes two "boulder clays" (till) separated by about 200 feet of sand and silt which are referred to as an interglacial period. The upper "boulder clay" is overlain by a few feet of sand and gravel. The assumption must be that the upper gravels are Bose gravel of the Capilano sediments; the upper till is equivalent to Surrey till; the sand and silt is part of the Quadra sediments and the lower till may be Semiamu Drift.

Local consumption of sand and gravel in this area is small but production is large. In 1964 over 1.2 million cubic yards was produced;

consumption is estimated at about 109,000 cubic yards. The excess was essentially all used in the Greater Vancouver area.

It seems likely that Howe Sound deposits will continue to supply a large part of the requirements for sand and gravel in the Greater Vancouver area for some time to come. Much of the potential gravel supply is on land belonging to Anaconda Company around Britannia Beach. Actual reserves here cannot be stated with any accuracy but must be in the order of 10 to 15 million cubic yards. A similar quantity may be estimated for the area around Port Mellon.

A potentially large reserve of sandy gravel extends from the mouth of Chapman Creek to Porpoise Bay. About 2,000 acres may be underlain by gravel to a depth of 20 feet or more. This deposit forms as a topographic ridge. Several small pits have been opened but nowhere has the deposit been tested for depth and quality. The deposit rests on till and is considered equivalent to the Capilano sediments in the Fraser Lowland. A large area behind Gower Point, possibly as much as 1,000 acres, is underlain by surficial deposits up to 200 feet thick. In part these are sand and gravel and constitute a reserve of several million cubic yards. In part also these sand and gravel deposits are equivalent to Mary Hill outwash and are covered by till and in part are drift from an earlier glaciation.

DESCRIPTION OF AREAS

Howe Sound area (Fig. 24)

Details of pits

Hillside Sand and Gravel Ltd. (211). The company, a subsidiary of Ocean Cement operated a pit and plant on the west side of Howe Sound near Dakota Creek. The plant was shut down in 1964 after many years operating at a capacity of 300 to 400 thousand cubic yards per annum.

The deposit is an example of a Capilano raised marine delta. The top of the deposit is over 300 feet above sea-level. The gravel is fine to medium in the foreset deltaic beds which dip east towards Howe Sound. Some large boulders and coarse gravel occur in a beach gravel mantling the deposit.

Witherby Beach Road pit (212). A borrow pit for road construction was opened a third of a mile south of Witherby Beach road about 3 miles north of Langdale on the east side of Howe Sound.

The pit is now largely overgrown but a 12 to 15-foot face shows easterly-dipping foreset beds of medium gravel and sand lenses. Beach gravels mantle the deposit. Till underlies gravel in the vicinity but does not

show in the pit. Only a few thousand cubic yards have been removed. The deposit is classified as part of the Capilano sediments.

Unnamed pit (213). A small borrow pit 3.8 miles north of Langdale shows a few feet of coarse gravel on top of marine clay. The deposit was used for fill during road construction.

Port Mellon Indian Reserve pit (210). This pit is south of the village of Port Mellon on the west side of the road to Langdale and was worked to a depth of about 18 feet over a few acres for aggregate in construction work by Canadian Forest Products Limited in Port Mellon. The deposit is Capilano raised delta with Bose gravel veneer on top.

Canadian Forest Products pit (209). This pit lies north of Rainy River, between Port Mellon and Longview. The deposit consists of a 2-foot-thick rusty beach gravel over a layer of large boulders under which at least 15 feet of fine to medium gravel shows in the pit face. The deposit has only been worked in a small area of an acre or two.

Construction Aggregates Limited (202). A large sand and gravel operation on the east side of Howe Sound at Britannia Beach is conducted by this company. In 1964, 899,904 cubic yards of various products were produced by the plant from a deposit of Capilano raised marine delta. The deposit is largely fore-set deltaic beds of fine to medium gravel. The deposit is very clean and for some purposes fines must be added. A thin remnant of till or glacio-marine clay was seen on the upper bench which is about 150 feet above the pit floor. Several million cubic yards have been removed from the pit and the bedrock floor has been reached on the north side.

The pit is worked by caving with a dragscraper into a hopper with six inch spaced grizzly rains. The material crosses the Squamish Highway and Pacific Great Eastern Railway on a 30-inch conveyor belt to the plant located along the shore of Howe Sound from where the products are loaded on barges for transportation to Vancouver.

McMillan pit (214). McMillan's pit lies west of the road to Port Mellon at the Langdale ferry turnoff. The face shows 20 feet of deltaic Capilano (?) sediments of sandy gravel and sand in foreset beds, with a thin layer of coarse beach gravel. A test hole dug to 15 feet below the pit floor reached the water-table.

Routledge Gravel Limited - Furry Creek pit (201). Routledge Gravel Limited work a pit south of Furry Creek on the east side of Howe Sound. The property is leased from the Anaconda Company. Pit-run and crushed gravel is conveyed across Highway 99 to a washing and screening plant on the sea shore. The processed material is shipped by barge to Vancouver. In 1964, 279,736 cubic yards was produced.

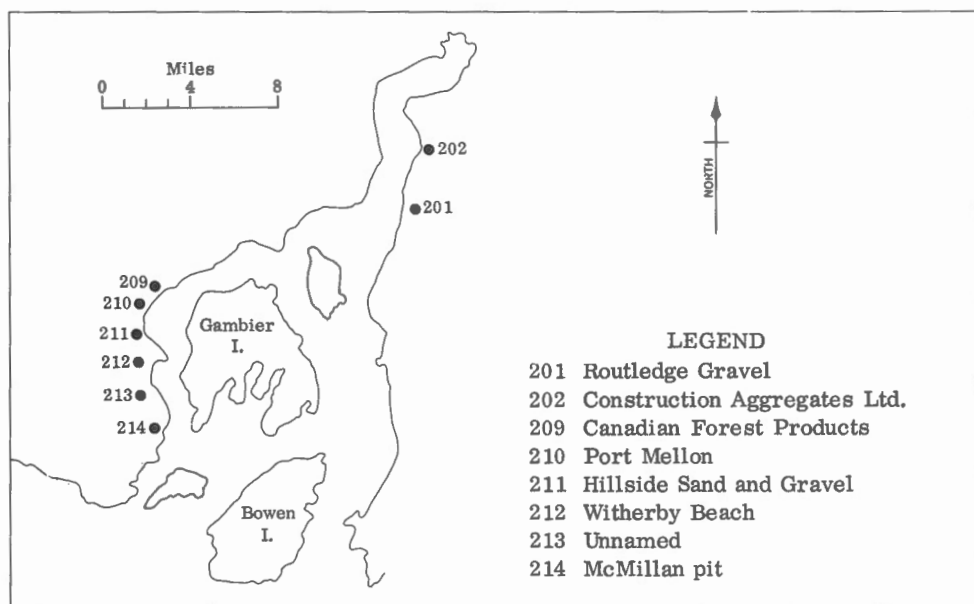


Figure 24. Howe Sound area.

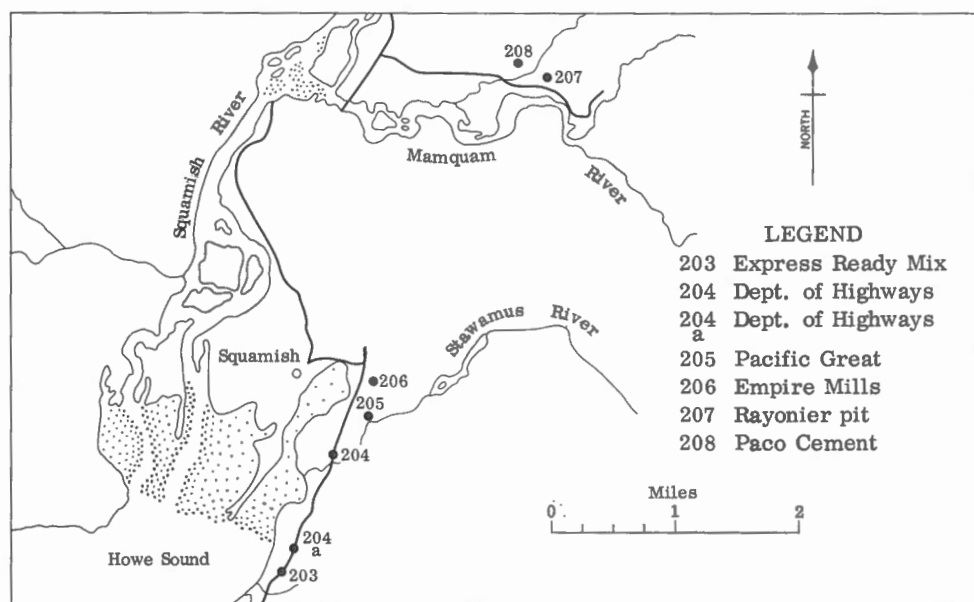


Figure 25. Squamish area.

The deposit was revealed by highway construction which exposed the base of a 150-foot-high terrace. A preliminary survey and some test holes indicated a deposit of several million cubic yards and justified the installation of a plant and wharf facilities.

The deposit is disposed in two terraces; a main lower terrace and a smaller, remnant terrace. The lower terrace rests on irregular bedrock and/or marine clay. The main terrace is cut in foreset deltaic beds of fine to medium gravel. Most of the stones are granitic in composition but some are of volcanic origin. The terrace is about 150 feet thick. It is capped with a thin (10-foot) layer of till mantled by a thin veneer of beach gravel.

The upper terrace lies on the till of the lower terrace and extends to the bedrock wall along the east side of the property.

Squamish area (Figure 25)

Geology and reserves

Sand and gravel deposits in the Squamish area are mainly Salish sediments associated with Mamquam and Squamish Rivers but there are some Capilano raised marine delta.

The Salish deposits occupy low-lying valley floors and underlie potential industrial sites. In addition the rivers are salmon streams over which the federal Department of Fisheries exercises considerable control. The potential reserve of these deposits is likely to be only a small percentage of the total volume.

The main area of Capilano deposits is east of the village of Squamish and is now largely residential. Much of the Capilano deposits rest on very irregular bedrock thus estimates of volume without determining the configuration of the bedrock surface are apt to be exaggerated. The reserves should be more than enough for local needs.

The deposits generally have a high percentage of volcanic rocks from the Garibaldi eruptions. These rocks are highly absorptive and it is known that some deposits have been rejected for making asphalt aggregate by the Department of Highways. Concrete aggregate from this material is used for local construction and is apparently satisfactory; it is not known whether it would meet more rigid specifications for heavy industrial structures.

Details of pits

Empire Mills pit (206). A small pit on the south side of the village opposite the Department of Forestry building on Highway 99 is intermittently worked

for pit-run gravel. The deposit consists of coarse open-work gravel and fine lenses of sand and gravel in westerly-dipping deltaic beds exposed to a height of 12 to 15 feet. A random sample of pebbles and cobbles showed the constituents to be: granitic rocks, 16 per cent; Garibaldi volcanic rocks, 77 per cent; metamorphic rocks, 7 per cent. It is not an active pit.

Pacific Great Eastern pit (205). This pit is north of the Stawamus River just off Highway 99 but it is not active and expansion would necessitate relocation of a power pylon. The gravel lies in westerly-dipping deltaic beds of sand and gravel overlain by slopewash gravel. The working face is up to 30 feet high.

Highways pit (204). Half a mile south of the above pit, the Department of Highways removed gravel from a small pit for highway construction. About 20,000 cubic yards of deltaic gravel was removed. Working faces are 12 to 15 feet.

Highways pit (204a). A small pit about 3/4 mile north of Shannon Creek was used for highway construction. The pit is part of the delta of Capilano gravel formed along the base of Stawamus Chief Mountain.

Express Ready Mix Concrete Limited (203). This company operates a ready mix and aggregate plant in a pit half a mile north of Shannon Falls. The size of the pit suggests that about 15,000 cubic yards have been removed. A fan about 25 feet high shows medium gravel with sandy lenses in foreset deltaic beds dipping southwesterly at about 15 degrees. A few boulders up to 2 feet in diameter lie on the pit floor. No production is on record from this pit.

PaCo Cement Products Limited (208). This company holds gravel leases north of Mamquam River at Mashiter Creek. The deposit consists of post-glacial sand and gravel; a lower deltaic layer with northwesterly dipping beds of fine sandy gravel and sand lenses, and an upper coarse gravel in poorly sorted horizontal beds. The deposit is exposed in a 30-foot face. Most of the constituents of the gravel are stones of Garibaldi volcanic rocks. Production in 1964 was reported as 11,760 cubic yards of pit-run gravel.

Rayonier pit (207)

Gibsons area (Fig. 26)

Geology and reserves

Sand and gravel deposits in this area appear to fit the general scheme of Armstrong's classification for the Fraser Lowland and the Salish and Capilano sediments and Vashon and Semiamu Drift appear to be represented. Most natural exposures and the few gravel pits do not show very much of the subsurface conditions.

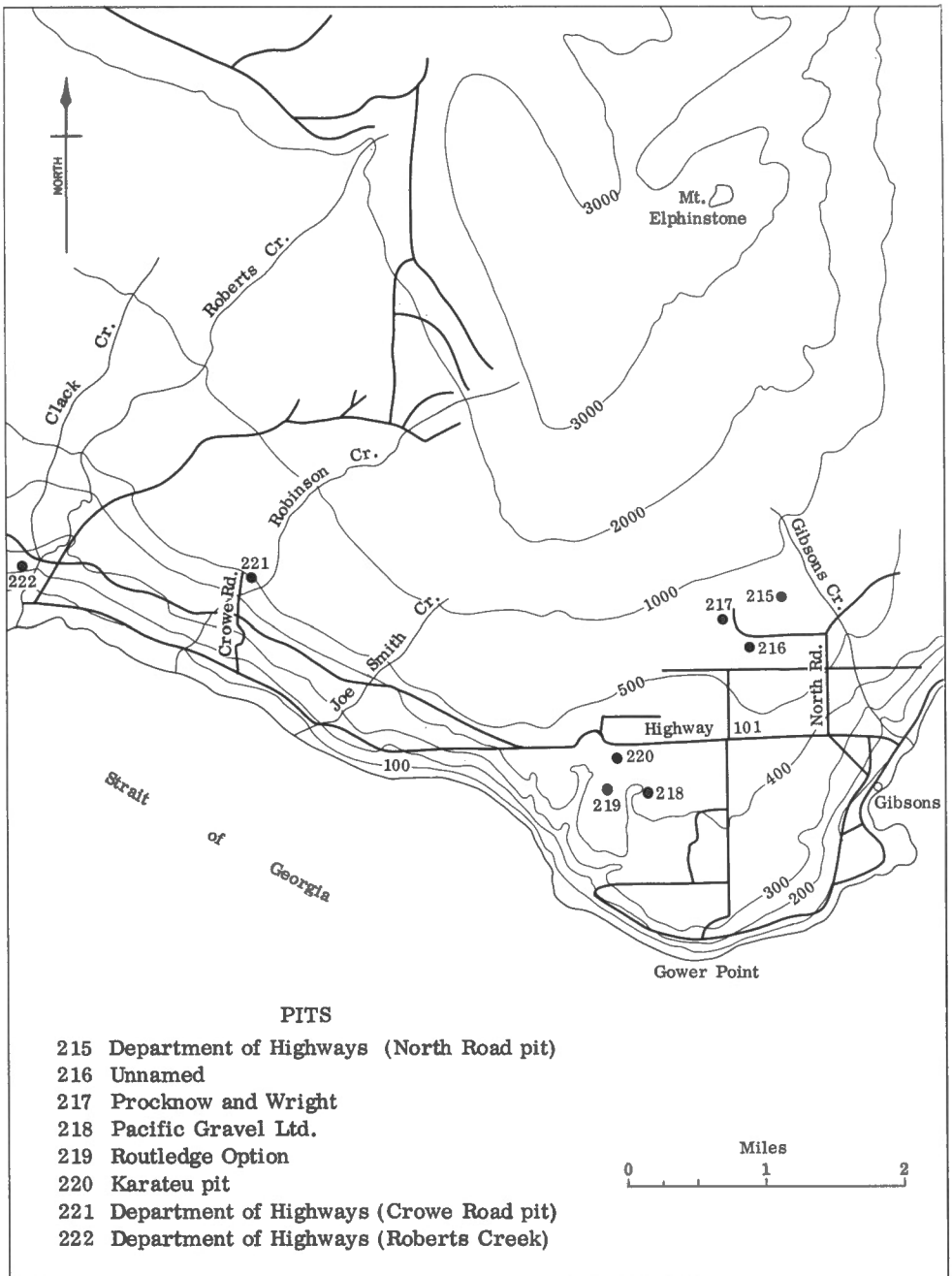


Figure 26. Gibsons area, Sechart Peninsula

Details of pits

Pacific Gravel Limited (218). Prior to 1963 Pacific Gravel Limited opened a pit on Lot 908 on the east side of Chester Creek. A crushing and screening plant was installed and a few hundred cubic yards of gravel was processed. Apparently the operation was not profitable and it was shut down. A good section of the surficial deposits was revealed by the artificial exposures in the pit along the road leading to Chester Creek.

Three layers of gravel are present separated by till or stony clay. Only the upper gravel was worked. This included 2 to 3 feet of beach gravel, 0 to 5 feet of till and 18 feet of sand, sandy gravel, and a gravel with sand lenses.

Crowe Road pit (221). The Department of Highways operated a pit for highway construction from a deposit on Crowe Road, 0.6 mile north of Highway 101. Working faces in the pit show about 3 feet of beach gravel above 25 feet of deltaic beds of sand and gravel. The deposit is considered a Capilano raised marine delta. The material is mainly a fine sandy gravel with less than 5 per cent minus 200 mesh in size.

Karateu pit (220). This pit, on Lot 907, south of Highway 101 west of Gibsons was opened up along a gully exposing 25 feet of sand and gravel under three to four feet of till. Production has been intermittent and small and only a few hundred cubic yards have been extracted.

Proknow and Wright pit (217). This company operates a pit and plant on Lot 1657, 1 1/2 miles northwest of Gibsons. A concrete batching plant was added in 1963. All production is for local requirements and in 1964, 8,000 cubic yards was extracted and used in various gravel products.

The deposit consists of sandy deltaic beds which are classified as Capilano sediments. Sandy beach deposits overlie the foreset beds. The material is a sandy gravel.

North Road pit (215). The Department of Highways owns this pit, located on Lot 1657, 1 1/2 miles northwest of Gibsons. The deposit is ice-contact sandy gravel with lenses of till. Some very large boulders occur in the deposit. Material recovered in test drilling by the Department was 100 per cent minus 3 inches in diameter, 55 per cent sand size and 5 per cent silt or clay.

Roberts Creek pit (222). This is another highway pit which was developed on a curve in Highway 101 at Roberts Creek. The gravel appears to lie under till and stony clay. Bedrock is exposed at the culverts which contain the creek. About 3 feet of coarse gravel overlying 8 feet of sand can be seen on the south side of the highway. The sand and gravel is considered equivalent to Mary Hill outwash of the Surrey Drift.

Sechelt area (Fig. 27)

Gravel pits from Ruby Lake to Roberts Creek along or near Highway 101 are included in this section. Most were used for highway construction, some supply sand and gravel for concrete and fill in construction around Sechelt.

Details of pits

Ruby Lake pit (234). The Department of Highways owns a pit about 2 miles south of Ruby Lake on the east side of Highway 101. It is an ice-contact deposit, typically poorly sorted, with lenses of till and large boulders. Most of the constituents are angular. Material recovered from the test holes by the Department contained less than 8 per cent silt and clay; averaged about 35 per cent sand. One test hole yielded material 85 per cent minus 3 inches in diameter; three others contained no material greater than three inches in diameter.

Silver Sands pit (232). A sand pit used by the Department of Highways lies along Silver Sands road about 1 1/2 miles east of Highway 101 at Bargain Bay. The material is a well sorted and bedded angular sand with a few pebbly layers. The deposit occurs at an elevation of 500 feet above sea-level and is considered a Capilano raised marine terrace.

Mason Road pit (231). The Department of Highways operated a pit 2 miles up Mason Road which runs north off Highway 101 about 2 miles west of Sechelt. The pit was used for highway construction but is now overgrown and abandoned. A working face up to 25 feet high shows fine sandy gravel in horizontal beds. The material averages about 5 per cent sand and clay, 50 per cent sand, and is 100 per cent minus 2 1/2 inches in diameter. The deposit is probably equivalent to Capilano gravel of the Fraser Lowland.

Stockwell pit (229). Mr. H. Stockwell operates a pit on the hillside on the east side of Porpoise Bay. The material is a fine sandy gravel in deltaic foreset beds. It is considered to be a raised marine delta of Capilano sediments. Sample tested for Mr. Stockwell by a commercial firm showed that the material was 100 per cent minus 2 inches in diameter, and contained less than 1.9 minus 100 mesh in the fine aggregate (minus #4 mesh). Strength for concrete was more than adequate.

Naylor's pit (230). The pit is located on Lot 6715 about 4 1/2 miles north of Sechelt village. The deposit has been used to gravel the road to Naylor's lodge. The material is a coarse gravel presumably a raised marine delta of Capilano sediments. Production amounted to only a few hundred cubic yards for road construction.

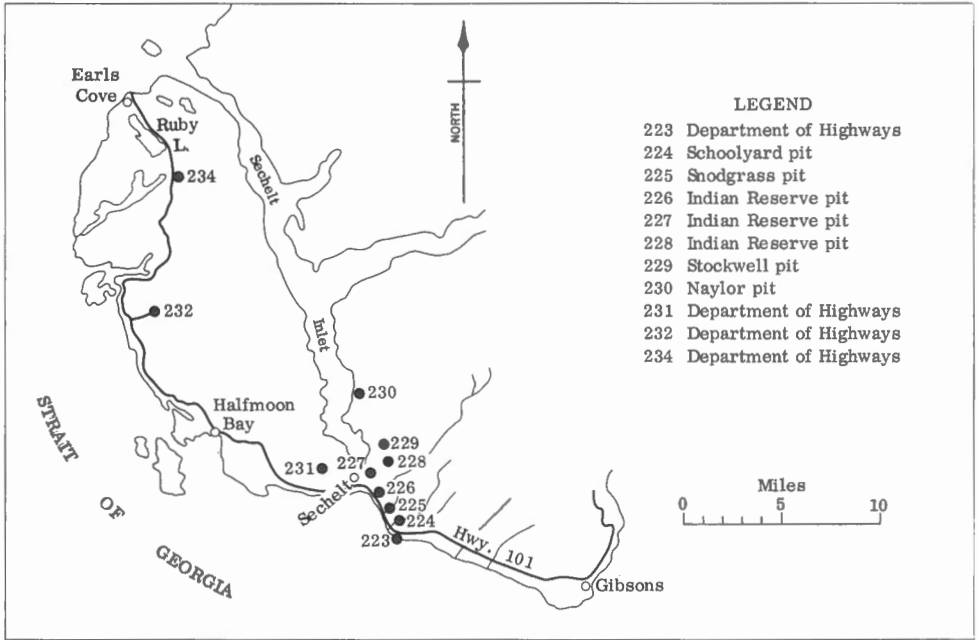


Figure 27. Sechelt area.

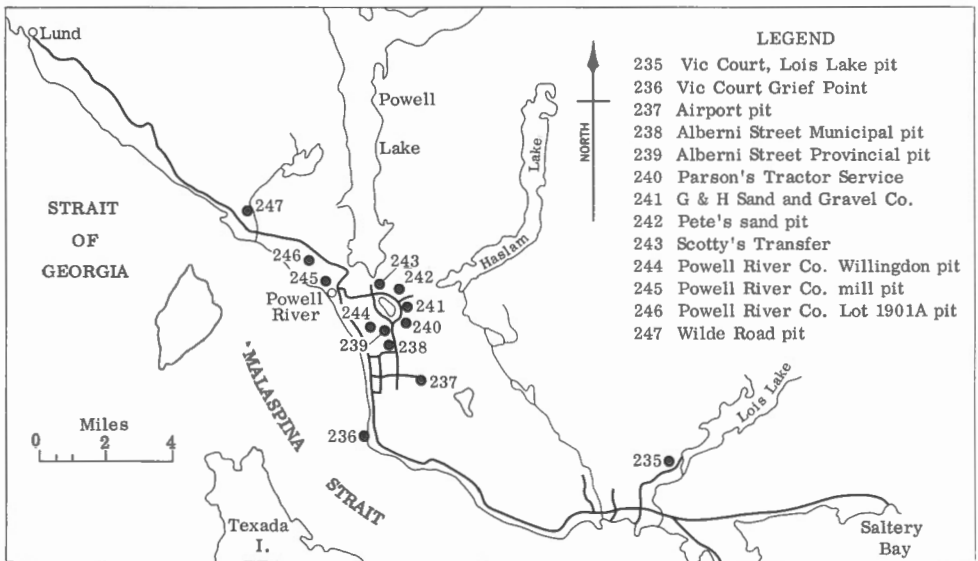


Figure 28. Powell River area.

Porpoise Bay Road pits (227) (228). Two pits on Indian Reserve No. 2 along the east side of Porpoise Bay Road have yielded a few hundred cubic yards of sandy gravel.

Selma Park pit (226). This pit is also on Indian Reserve No. 2 on the east side of Highway 101 about half a mile north of Selma Park. It is a sandy gravel, 90 per cent minus 2 inches in diameter, disposed in foreset deltaic beds. The working face is about 20 feet high. Only a few thousand cubic yards have been extracted.

Snodgrass pit (225). Much of the asphalt concrete for Highway 101 from Sechelt to Gibsons was made from aggregate produced in this pit which is located half a mile south of Selma Park. The deposit is a fine sandy gravel with interbedded sand lenses in foreset deltaic beds dipping west. It is classified as a raised delta of the Capilano sediments. The material is 90 per cent minus 3 inches in diameter. About 60,000 cubic yards have been removed, mainly for highway construction.

Schoolyard pit (224). A small pit in raised beach gravel was opened up for fill in the school area about 2 miles south of Selma Park and east of Highway 101.

Chapman Creek pit (223). A pit on the north side of Highway 101 at Chapman Creek has supplied gravel for highway construction. The pit face shows a few feet of beach gravels overlying horizontally bedded sand and gravel which in turn overlie deltaic foreset beds. The pit covers an area of about an acre, has 10-to 12-foot high faces and has produced about 15,000 cubic yards. The deposit is considered as part of the Capilano sediments.

Powell River area (Fig. 28)

Geology and reserves

For purposes of this report the Powell River area includes the Corporation of the District of Powell River and the coastal lands from Lund to Saltery Bay.

No information on the surficial geology of the area has been published except for brief notes by Le Roy (1908) and Bancroft (1913). The writer has not mapped the area but in visiting all the known pits it is evident that the surficial geology here is analogous to the stratigraphy outlined for the Strait of Georgia as a whole.

Salish sediments are represented by beach and stream deposits; Capilano sediments by raised marine deltas and veneer gravels (Bose equivalent). Deposits related to the Vashon Stade of the Surrey Drift include till,

stony clay and outwash gravel. A thick deposit of sand northeast of Cranberry Lake may be equivalent to Quadra sediments.

Drill holes for water wells penetrated as much as 91 feet of till in the terrace extending from Wildwood to Westview. In places up to 20 feet of sand and gravel lie on the till and in most holes sand and gravel underlies the till. Forty-six feet of sand and gravel was found in one hole. The pre-till gravels may be potential sources of aggregate in those places where erosion has removed the till. The front of the terrace extending north from Powell River would seem to be a logical place to look for pre-till deposits.

Details of pits

Municipal pits

Alberni Street pit (239). The municipality operates a pit between Ontario and Fernwood Avenues north of Alberni Street in Westview. The pit face shows 8 to 10 feet of sandy gravel. The base is not exposed. Lateral expansion is not possible because of adjoining private property. The deposit is considered equivalent to Capilano gravel and probably rests on till within a few feet of the pit floor.

Provincial pits

Alberni Street pit (238). The Department of Highways pit adjacent to the municipal pit above is largely exhausted. Both pits are geologically similar.

Airport pit (237). A shallow gravel deposit resting on till was worked on the south side of the east end of the municipal airport runway. The deposit is Bose gravel.

Wilde Road pit (247). A pit at the end of Wilde Road about 1.2 miles east of Highway 101 and 2 miles north of Wildwood was evidently used for highway work but is now abandoned. Sandy gravel in deltaic foreset beds rests on bedrock. The material is classified as part of the Capilano sediments. The deposit appears to be largely worked out.

Private pits

Powell River Company (Willingdon) pit (244). Gravel for highway use was taken from a pit along Highway 101 between Powell River and Westview. Extraction served the dual purpose of removing a sharp curve in the highway and providing aggregate for asphalt cement production. The deposit lies on Lot 450 owned by McMillan, Bloedel and Powell River Company.

The deposit consists of at least 15 feet of sand and gravel below a thin layer of till and stony clay. The sand and gravel beds show evidence of extensive disturbance. Coarse unsorted gravel layers contain well bedded sand layers disposed in contorted folds; these are interpreted as being due to ice push on frozen beds of sand within outwash gravels. The deposits are considered advance outwash of the glacier which deposited the overlying till and probably equivalent to Surrey Drift of the Fraser Lowlands.

When crushed to minus 3/4 inch the product conformed to specifications with only occasional departures which were easily corrected by blending finer or coarser material available within the pit. Less than 2 per cent of the pit-run material was rejected as oversize, i. e. plus 8 inches in diameter.

Lot 1901A pit (246). This pit is about 600 feet south of Highway 101 at Wildwood Heights. A 20-foot face of fine sandy gravel in foreset deltaic beds is exposed in the pit. A thin mantle of beach gravels overlies the deposit. Till or stony clay is assumed to lie at or near the pit floor thus the deposit is classified as a raised marine delta of the Capilano sediments. The pit area amounts to 3 or 4 acres. In 1961 it was inactive.

Powell River Company (Mill pit) (245). An exposure of sand and gravel about 100 feet high lies north of No. 9 plant of the McMillan, Bloedel & Powell River Company along the south side of Powell River. The deposit was used to provide concrete aggregate in the construction of No. 9 plant. Marine fossils are abundant in sandy layers. A thin layer of stony clay lies in the middle of the section. The deposit is probably equivalent to Capilano sediments and Whatcom glacio-marine deposits of the Everson Interstade.

Scotty's Transfer pit (243). A small pit in sandy gravel with clay lenses on Lot 5304, on the northwest side of Cranberry Lake was formerly operated by Scotty's Transfer. The pit is now overgrown by alders and abandoned. Production amounted to only a few hundred cubic yards. The deposit is classified as part of the Capilano sediments.

Pete's Sand pit (242). Mr. P. Hassichuk produces sand from a pit off Allen Road on the northeast side of Cranberry Lake. Production which in 1964 amounted to 6,290 cubic yards is mainly for plaster sand. The pit has been in use for over 20 years. The deposit, which is at least 80 feet thick, contains some gravelly lenses but it is essentially a sand pit. The deposit is tentatively considered part of the Quadra sediments.

Parsons Tractor Services Ltd. (240). Parsons Tractor Services operates a pit on Lot 5445 off Yukon Street near the south end of Cranberry Lake. The site is used as a rock quarry as well as a gravel pit. Bedrock is exposed at the back of the pit. Sandy gravel overlies bedrock and is partly covered by a thin layer of till. It is assumed that this till is equivalent to the Surrey till and hence the gravel may be equivalent to Mary Hill outwash. In 1964, 79,263 cubic yards of combined pit-run and sized aggregate was produced.

G & H Sand and Gravel Company pit (241). This company produces sand and gravel products from a pit off Haslam Lake road. The deposit is about 80 per cent sand and consists of deltaic foreset beds overlying blue stony clay. No production was reported for 1964 but in 1963, 5,000 cubic yards of washed aggregate and ready-mix concrete was produced. The deposit is classified as part of Capilano sediments.

Victor Court pit (236). Mr. Court has two foreset leases for Salish gravel at Grief Point, two miles south of Westview. The gravel is coarse and lacks fines, an exception to the general rule around Powell River. However, production must be kept small because of the danger of marine erosion of valuable land. Mr. Court also produces sand and gravel products from a deposit of Capilano gravel near Scanton Dam at the outlet of Lois Lake (235).

GEOLOGY AND DISTRIBUTION OF SAND AND GRAVEL DEPOSITS ON VANCOUVER ISLAND

INTRODUCTION

In this report only the east side of Vancouver Island south of Campbell River will be considered. Maps of the surficial geology are available for this area (see Fig. 1) and form the basis for this report.

Most of the area has been mapped since the mapping of the Fraser Lowland, hence some correlative formations on Vancouver Island bear names originally proposed in Fraser Lowland.

Salish and Capilano sediments and Vashon Drift provide the bulk of the commercial sand and gravel. Older deposits are largely covered by younger deposits and hence are unavailable for exploitation.

Salish sediments comprise gravel, sand, silt and clay with gravel sizes probably less than 20 per cent of the volume; Capilano sediments include gravel, sand, silt and clay with perhaps 50 per cent in the gravel size. Outwash of Vashon Drift is also about 50 per cent gravel size.

The older reports (prior to 1950) ignored or relegated to inferior positions some of the formations now given prominence in Pleistocene stratigraphy. Thus Clapp (1913) recognized some of the deposits now called Capilano, but failed to map them; others he apparently included with recessional outwash of Vashon Drift. In spite of this his maps of the surficial deposits of Victoria and Saanich areas are still useful although they will shortly be superseded by maps prepared by Halstead in a continuing program by the Geological Survey of Canada.

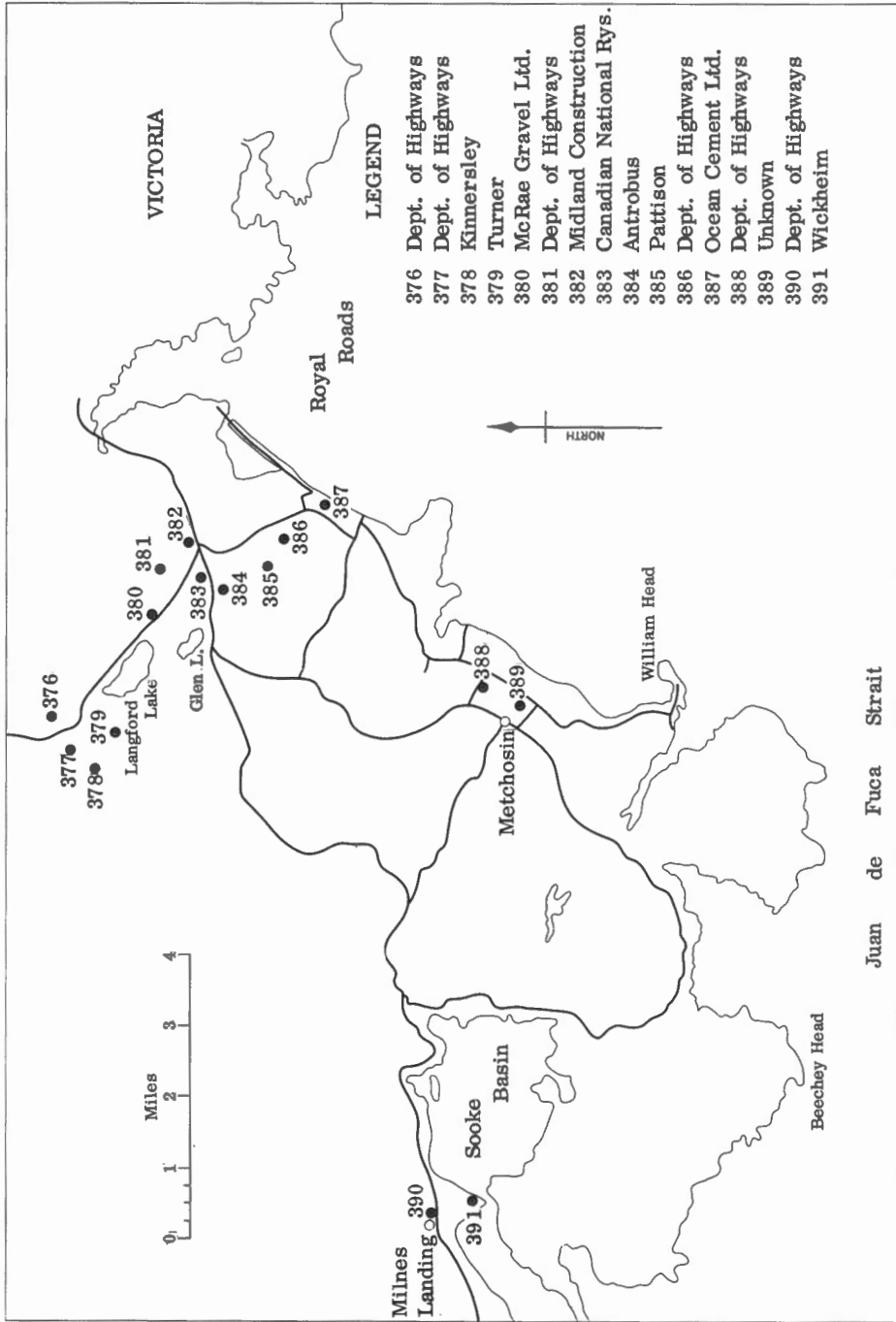
There are only a few municipalities in this section of Vancouver Island and hence it is not expedient to treat the deposits by municipalities as was done for the Fraser Lowland. It is considered more appropriate to subdivide the area into map-areas for which the surficial geology has been published.

DISCUSSION OF AREAS

Greater Victoria area (Fig. 29)

Geology and reserves

The main gravel supplies for the Greater Victoria area come from Saanich Peninsula (which will be treated separately) and the Colwood area west of Royal Roads.



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Figure 29. Greater Victoria area.

The Colwood deposit underlies about 6 square miles between Royal Roads and Langford Lake. Much of the area is characterized by pitted outwash. There are some patches of collapse structures signifying an ice-contact environment, and abundant deltaic foreset beds especially at the east end of the deposit where a former river discharged into the ocean at Royal Roads. In part the deposit is recessional outwash of Vashon Drift, in part it is Capilano sediments.

The area is estimated to contain 345 million cubic yards of sand and gravel, of which about 10 per cent can be considered a potential reserve.

Details of pits

Department of Highways (Goldstream Park pit) (376). This pit is located in Goldstream provincial park on the east side of No. 1 Highway near the beginning of Malahat Drive. The pit is in an ice-contact deposit of poorly sorted gravel showing collapse structure, large boulders and lenses of till. Beds of sand and silt with fine gravel lenses occur in the lower part of the pit and are considered glacio-lacustrine deposits. Except for occasional boulders, the material is 90 per cent minus 10 inches in diameter. Most stones are either granitic or volcanic.

Department of Highways (Wishart pit) (386). Wishart pit is half a mile south of Colwood. Bedrock occurs under 6 to 8 feet of gravel at the south end of the pit. There are two types of gravel (1) a poorly sorted ice-contact gravel overlying (2) a fine, sandy gravel with sand lenses in well bedded deltaic structure.

Turner's pit (379). This pit, owned by Mr. Turner is a quarter mile northwest of the north end of Langford Lake and comprises sand and gravel of ice-contact origin that has suffered less slumping and more sorting than the Goldstream pit. The deposit is worked intermittently from faces up to 25 feet high. The pit covers about 5 acres from which about 150,000 cubic yards have been removed. The stones are mainly granitic and volcanic rocks with minor sandstone, gneiss and porphyry.

Kinnersley pit (378). Kinnersley pit is about half a mile west of Turner's pit and adjacent to the Canadian Pacific Railway line. About 20 feet of gravel and sandy gravel show in two working places. The deposit has been worked for about 90,000 cubic yards. The upper pit has a 10-foot face of fine bedded sand and gravel; the lower pit has a 15-to 20-foot face in sand and fine sandy gravel.

Pit (377). A pit of unknown ownership lies 0.4 mile northwest of Turner's pit. It may be a provincial government pit for highway construction. A 25-foot section shows an upper thinly-bedded sand and gravel layer separated from lower massive sand and gravel by a 2-foot bed of sand.

McRae Gravel Limited (380). This company operates a gravel pit east of Langford Lake just north of the Canadian Pacific Railway. The deposit has been worked along a low ridge for about 2,000 feet. Working faces up to 25 feet high reveal a medium-sized gravel, 90 per cent minus 6 inches, with a few sand lenses. A lower deltaic formation shows at the west end of the pit under horizontal surface beds. At the east end of the deposit only the upper beds have been exposed. Current production consists of pit-run material only.

Midland Construction Ltd. (382). This company operates intermittently a pit half a mile south of the village of Langford. Pit faces up to 25 feet high show horizontally bedded rusty gravel and lenses of sand overlying foreset beds, the bottom of which is not exposed. Presumably deeper extraction would reveal the water-table within a few feet of the pit floor.

Pattison pit (385). This pit is just west of Galway Road, half a mile north of Acland Road, in the Colwood district. The deposit is at least 30 feet thick and consists of fine, sandy gravel, and sand lenses. It is well bedded and dips southeast at a low angle. Beach gravels at the surface are noticeably coarser. A volume of about 30,000 cubic yards has been removed from the pit.

Metchosin pit (388). A pit of about one acre lies half a mile east of Metchosin village. Presumably the material was used for highway construction. The deposit consists of sandy gravel, with some large boulders and slabs of till and is an ice-contact type of deposit, physically resembling a kame.

Antrobus pit (384). Antrobus pit is located about half a mile east of Glen Lake. About 10 feet of bedded sand and gravel lies on a cemented gravel base at ground level. A further 10 feet of gravel is reported below the floor of the pit. The deposit is recessional outwash of Vashon Drift. Production has amounted to only a few hundred cubic yards.

Canadian National Railways pit (383). The railway operates a ballast pit on the south side of their right-of-way half a mile east of Glen Lake. The deposit consists of 10 feet of deltaic beds 90 per cent minus 2 inches in diameter overlain by 5 feet of beach gravels 90 per cent minus 6 inches in diameter. The deposit is classified as part of the Capilano sediments.

Ocean Cement Limited - Royal Bay pit (387). This company operates the largest plant on Vancouver Island at a location overlooking Royal Roads (Bay) west of Victoria. The pit has been a major source of sand and gravel products for the Victoria area for more than fifty years. Production of washed and sized aggregate was 310,150 cubic yards in 1964.

The deposit is part of the Colwood delta of recessional outwash of Vashon Drift. Rock fragments are mainly granitic and volcanic rocks in

about equal proportions with slate and sandstone as minor constituents up to 20 per cent by volume. The deposit is about 50 per cent sand size. The gravel fraction is 90 per cent minus 6 inches in diameter with a few boulders as large as 18 inches in diameter.

Most of the material is disposed in easterly dipping foreset deltaic beds up to 200 feet thick. A few feet of horizontally bedded sand and gravel layers on top of the foreset beds is considered to be beach gravel equivalent to Capilano sediments of the Fraser Lowland.

Conveyor belts are used in place of trucks to transport the raw material from the working face to the plant. The high (100-foot) banks are slumped by scraper on a slack-line cable way and loaded onto a conveyor belt by a 1 1/2 cubic yard shovel. The plant, about a mile away by conveyor belt, produces six sizes of gravel and two sizes of sand. Reclamation tunnels under the stockpiles permit blending of sizes to meet any specification.

Most of the output is transported by scow to the Victoria area.

Department of Highways (390). The Department of Highways maintains a pit on the south side of the highway at Milnes Landing. The deposit consists of fine, sandy gravel, 80 per cent minus 1/4 inch in diameter with a few feet of coarser beach gravel on top. The deposit is a raised marine delta of Capilano sediments.

Wickheim Sand and Gravel (391). This company is the main producer of sand and gravel for the Sooke area. The deposit is part of a raised marine delta of Capilano sediments. The property is adjacent to Department of Highways pit (390).

Saanich Peninsula (Fig. 30)

Geology and reserves

Commercial sand and gravel deposits on Saanich Peninsula are mainly subglacial deposits exposed by erosion. In part they are considered advance outwash of the Vashon ice-sheet; in part they may be equivalent to Quadra sediments of the previous interglacial interval.

The most productive area runs in a narrow belt from Cordova Bay to Mount Newton. About 1,200 acres of sand and gravel is exposed at the surface. The deposit is up to 100 feet thick. Assuming an average thickness of 40 feet, a volume of 80 million cubic yards is a conservative estimate of the amount of sand and gravel contained in this belt. Most of the peninsula is subdivided into small lots and most of the potential gravel land is occupied for other purposes. The actual gravel reserve would likely be only a tenth of the whole deposit.

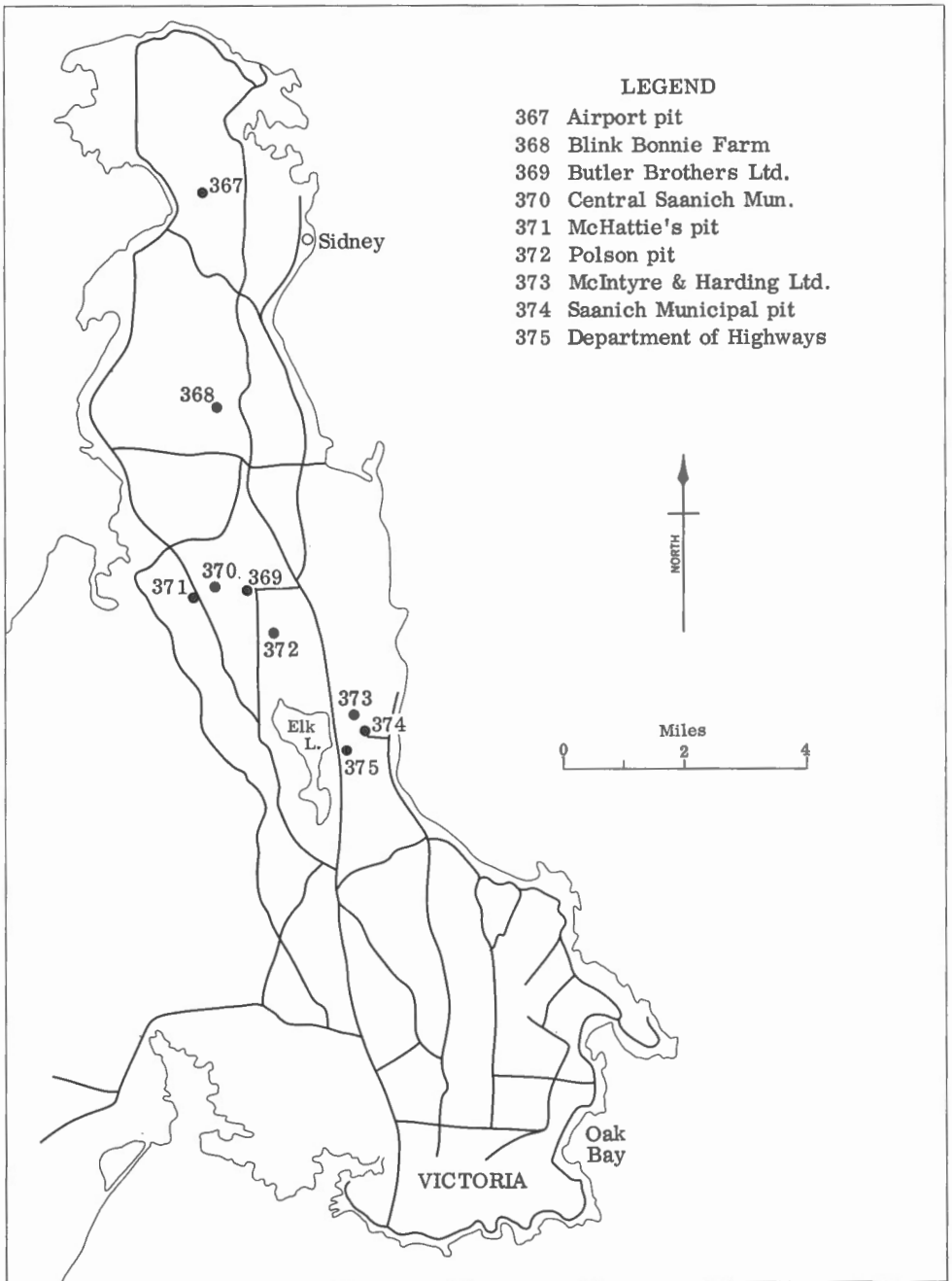


Figure 30. Saanich Peninsula.

Details of pits

McIntyre and Harding's pit (373). This company owns a pit on the north side of Cordova Bay Road half a mile east of Elk Lake. The pit shows up to 70 feet of gravel capped by five feet of till. The gravel is mostly fine and sandy, about 90 per cent minus 2 inches in diameter, and disposed in flat-lying beds with much open-work gravel and crossbedding. Sand beds and lenses up to 12 inches thick are numerous and a sand bed 15 feet thick underlies the pit at the north end.

A mechanical analysis across 8 feet at the north end of the pit gave the following:

minus 100 mesh	2 %
minus #4 mesh	48%
minus 2 inches	100%

Saanich Municipal pit (374). This pit is across the road from McIntyre and Harding's pit to which it is very similar except that a layer of sand occurs between the till and the gravel. The uphill face is about 80 feet high but the deposit thins downhill to the east to about 10 feet. The base of the gravel is not exposed.

Butler Brothers Limited (369). This company operates a pit near the corner of Keating Cross Road and Oldfield Road. The pit is worked on two benches, the upper one about 30 feet high and a lower one about 60 feet high. A thin layer of till, stony clay and beach gravel up to 10 feet thick overlies the main gravel beds and 35 feet of sand underlies the pit floor.

The gravel is composed of volcanic and metamorphosed volcanic rocks, 70 per cent, granitic intrusive rocks, 15 per cent, slate, 10 per cent, minor sedimentary rocks, 5 per cent. The gravel is considered advance outwash of the Vashon ice-sheet. It is 90 per cent minus 6 inches in diameter and laid down in horizontal beds with sand lenses. Immediately below the till, the outwash is silty, unsorted material but this grades into better sorted and bedded layers, 12 to 15 feet below the till.

The plant turns out a range of sand and gravel products and ready-mix concrete.

Central Saanich Municipal pit (370). This municipal pit is located south of Keating Cross Road about half a mile west of Butler's pit. The pit is in a subfill deposit laid down against a bedrock hill. The till at the back of the pit is about 20 feet thick and overlies about 40 feet of sandy gravel.

McHattie's pit (371). McHattie's pit lies 500 feet southwest of the municipal pit (370) to which it is geologically similar. The gravel underlies 70 feet of till and rests on bedrock. Production is intermittent.

Polson pit (372). George Polson owns a pit on the north side of Bear Hill where sub till gravel is exposed. The section shows advance outwash immediately under the till and fluvial gravels below the outwash. Production has been intermittent.

Blink Bonnie Farm pit (368). This pit lies at the end of an esker which terminates near the southeast side of Mount Newton. It is a glacio-fluvial deposit of the Vashon Drift. Part of the deposit is essentially sand.

Airport pit (367). A pit north of the Patricia Bay Airport has been opened for local use and a few thousand cubic yards have been removed. The pit is in marine gravels of the Capilano sediments.

Department of Highways reserve (375). The Department of Highways has a 40-acre reserve of sub till gravel adjacent to the Saanich municipal pit (374).

Shawnigan area (Fig. 31)

Geology and reserves

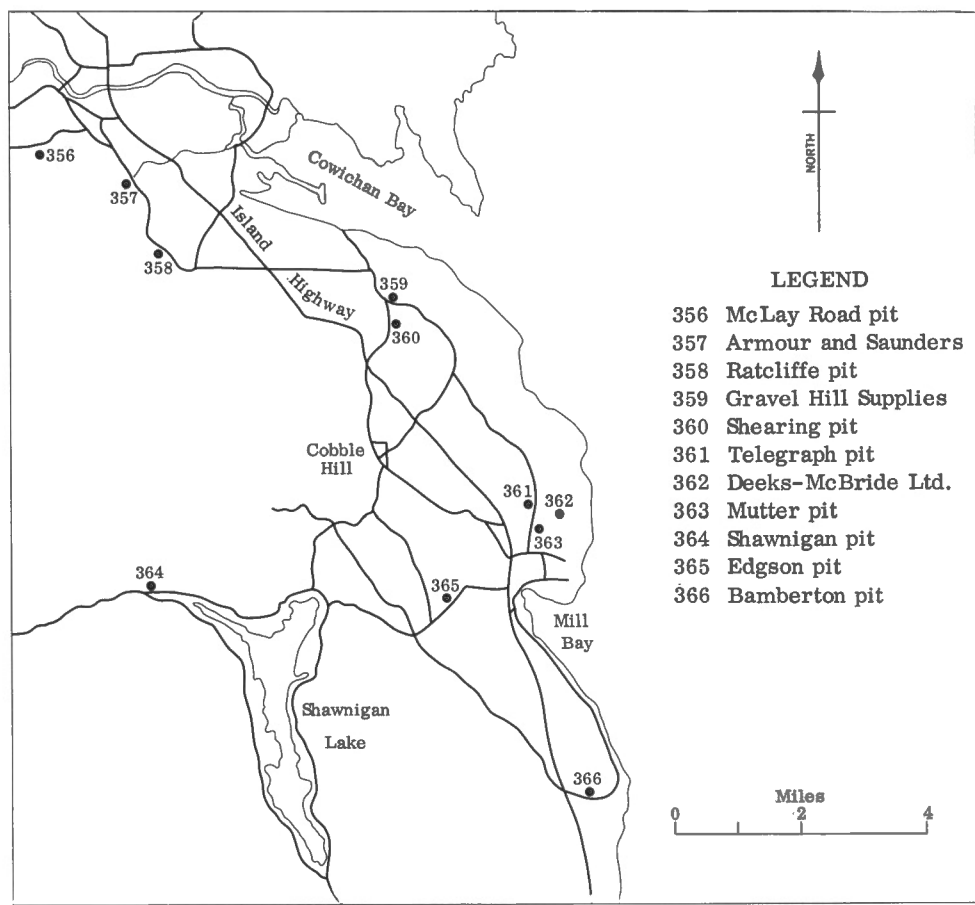
The surficial geology of Shawnigan area has been studied by Halstead (1965) and his report forms the basis for the discussion of sand and gravel deposits under the heading above.

The thickest surficial deposits in the area are found in the north-east quarter of the map-area, from McPhail Point to Cowichan Bay, in a coastal strip about 3 miles wide. Over most of the remainder of the area bedrock is either exposed at the surface or thinly-mantled by ground moraine of Vashon Drift.

Fifteen pits are plotted on Halstead's map. Their distribution in geological formations is as follows:

Salish sediments	2
Capilano sediments	
fluvial deposits	1
marine deposits	2
Vashon Drift	
recessional outwash	5
advance outwash	5

No single exposure of sand and gravel covers more than about 600 acres and many are as small as 20 acres. Bedrock outcrops are numerous and in some places extensive, indicating that the surficial deposits are generally thin. In most places the sand and gravel deposits are only a few



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Figure 31. Shawnigan Lake area.

tens of feet thick but the bedrock topography is very irregular and this has resulted in the accumulation of unconsolidated deposits 300 or more feet thick in a few places.

About 2,000 acres of sand and gravel is exposed at the surface. In places the deposits may be up to 80 feet thick thus the aggregate volume is in the order of 300 million cubic feet.

The possibility of a commercial development on a large scale (300,000 to 400,000 cubic yards per annum) was considered by one of the major sand and gravel companies for the deposits in the vicinity of Hatch Point but apparently the available reserves were not sufficient for the size of the operation considered. In the Hatch Point area about 600 acres of advance outwash is exposed and another 600 acres is covered by till which may overlie sand and gravel.

Details of pits

Shawnigan Lake pit (364). The Department of Highways uses a pit about a quarter mile west of the end of West Arm on Shawnigan Lake. The deposit consists of a lens of gravel in ground moraine of the Vashon Drift. Working faces about 10 feet high show poorly sorted silty gravel with a discontinuous bed of till up to 3 feet thick in the middle of the face. Production amounted to a few thousand cubic yards.

Bamberton pit (366). This pit is just north of Mill Bay Road half a mile west of McPhail Point. The working face shows 25 to 30 feet of fine to medium gravel 90 per cent minus 6 inches in diameter. The deposit is poorly sorted and rudely bedded sand and gravel with minor sand lenses. The main constituent is granodiorite with minor sandstone and basic volcanics. A thin remnant of till overlies the deposit which is classified as advance outwash of the Vashon Drift.

Ratcliffe pit (358). Ratcliffe pit lies at the end of Tiewall Road about 3/4 mile northwest of Cowichan Station. Sand and gravel is exposed in a 10-foot face. The deposit consists of fine to medium sized gravel, in some place in distinct beds, but elsewhere massive. It shows slump structures characteristic of ice-contact deposits. A bed of clayey silt about 2 feet thick overlies the gravel.

Shearing pit (360). Shearing pit is on the east side of Cowichan Bay Road just south of the boundary between Cowichan and Shawnigan land districts. The faces show about 25 feet of deltaic beds of fine gravel and sand lenses with 1 foot to 2 feet of beach gravel (or topset beds) at the surface. The complete thickness is not exposed. The deposit is classified as recessional outwash of the Vashon Drift.

Telegraph pit (361). This pit is about a mile north of Mill Bay on the east side of Telegraph Road near the junction with Pemberton Road. The deposit consists of about 40 feet of well-bedded, fine gravel with sand lenses. A remnant of overlying till can be seen on the west side of the pit. The stones are well-rounded, 90 per cent minus 6 inches in diameter. About half the stones are granitic rocks, the remainder being a variety of sedimentary and volcanic types. The deposit is classified as advance outwash of the Vashon Drift.

Gravel Hill Supplies Ltd. (359). This company operates a gravel pit and ready-mix plant on the east side of Cowichan Bay Road on the north side of the Cowichan-Shawnigan land district boundary. The pit shows a 35-foot section of ice-contact and deltaic beds of fine to medium gravel. The gravel is said to be 70 feet thick from information obtained in drilling a well for wash water for the plant. This deposit is classified as recessional outwash of the Vashon Drift.

Mutter's pit (363). George Mutter owns a pit a mile north of Mill Bay, on the east side of Telegraph Road near Pemberton Road but these holdings have been greatly reduced by sale of gravel land to Deeks-McBride (see below).

Deeks-McBride Ltd. (362). This company has a gravel pit on a tract of land extending from Mutter's pit to tidewater. Not all the land held has gravel at the surface. The deposit was used to supply crushed aggregate for a runway extension at Patricia Bay Airport. A conveyor belt was installed at the plant for loading scows at tidewater, but was removed on completion of the contract.

The deposit consists of 80 feet of fine to medium gravel, 90 per cent minus 6 inches in diameter in horizontal beds with crossbedded sand lenses. Glacio-marine deposits and till overlie the deposit east of the pit area.

Edgson pit (365). This pit is about a mile west of Mill Bay on the north side of Shawnigan-Mill Bay road. The deposit consists of fine sandy gravel with beds of silty sand. The beds dip north at variable angles, some as steep as 70 degrees, which implies slumping of frozen beds in an ice-contact environment. Halstead classified the deposit as a marine spit in the Capilano sediments.

McLay Road pit (356). This pit lies along McLay Road 2 miles southwest of Duncan. The deposit consists of fine to medium gravel and sand lenses in northeast dipping deltaic beds with a foot or two of topset beds. The section shows about 35 feet of sand and gravel, 90 per cent minus 4 inches in diameter and less than 10 per cent minus 200 mesh. The pit on the west side of McLay Road is known as the McLay Road pit; that on the east side of the road, as the Glenora pit. The Department of Highways has a reserve of about 100 acres.

McLay Road No. 2 pit (356). This pit lies less than a quarter mile west of McLay Road pit on a branch off McLay Road. A 15-foot-high face shows northwesterly dipping beds of fine gravel with sand lenses overlain by horizontal topset beds, about 2 feet thick. It is a borrow pit from which a few hundred cubic yards have been taken. Although included here it is not known with certainty that it belongs to the Department of Highways.

Armour and Saunders - Koksilah pit (357). The main source of supply for the company is obtained from a pit east of the junction of Doupe and Koksilah roads. The gravel is 90 per cent minus 6 inches in diameter and is well bedded and sorted but shows some slump structures. Open-work gravels are common. A thin remnant of silty clay, 2 or 3 feet thick, overlies the gravel at the north end. Pebbles are well rounded and include granitic and volcanic rocks with minor chert, sandstone and shale.

Duncan area (Fig. 32)

Geology and reserves

The Duncan area has been mapped by Halstead (1966) and his map forms the basis for the discussion on sand and gravel which follows.

The most important sand and gravel deposits occur south of Chemainus and around Duncan. The largest quantities of sand and gravel are available from recessional outwash deposits of Vashon Drift and fluvial deposits of Capilano sediments. Salish deposits of sand and gravel are of minor importance.

Twenty-six pits are indicated on Halstead's map, distributed as follows:

Salish	2
Capilano	
fluvial	8
- marine	1
Vashon Drift	
advance outwash	15

The largest area of Capilano gravel is about a mile southwest of Chemainus. It covers some 250 acres and is estimated to contain about 4 million cubic yards of sandy gravel. The largest single area of Vashon recessional outwash is that lying along the edge of the map-area south of Duncan. There about 1,200 acres of recessional outwash exposed at the surface is estimated to contain 60 million cubic yards of sand and gravel. Some isolated patches of gravel are as small as three or four acres and may contain only a few thousand cubic yards.

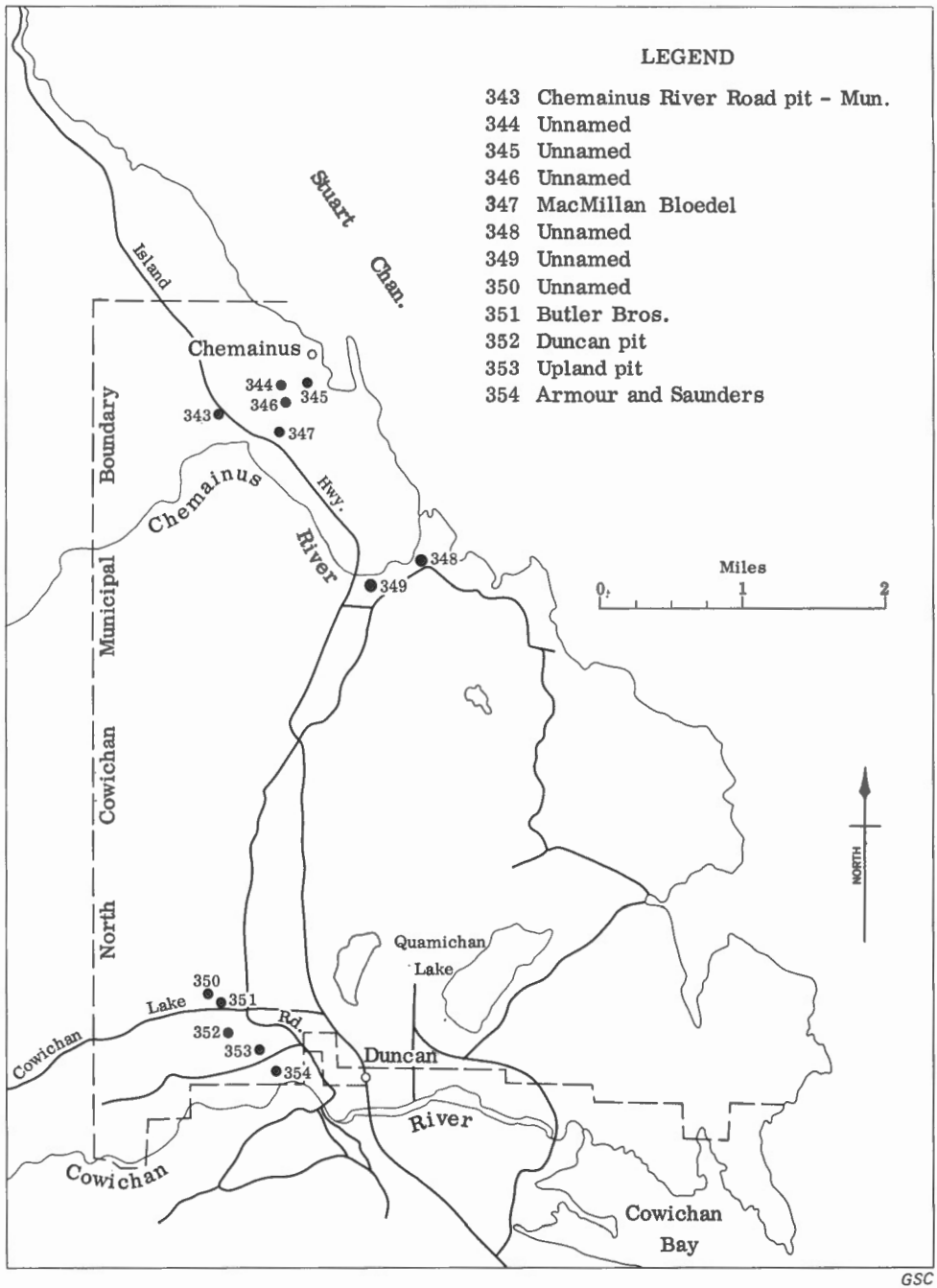


Figure 32. Duncan area.

None of the deposits are ideally located for use outside the immediate area. Much of this map-area is within the jurisdiction of the municipality of North Cowichan which controls gravel operations through a soil removal by-law and zoning regulations in built-up areas.

Details of pits

Chemainus River road pit (343). The municipality owns a pit on the west side of the Island Highway south of Chemainus River road. The pit extends over about 5 acres and appears to be worked out to a depth of 8 to 10 feet. The deposit consists of fine sandy gravel in deltaic beds dipping east. Topset beds or beach gravels a foot or two thick mantle the deposit.

Pit (344). This pit adjoins the above municipal pit and is also deltaic deposits of Capilano gravel. It was worked during highway construction but is no longer active.

Pit (345). A borrow pit from which a few hundred cubic yards have been removed lies on the north side of Henry Road, east of Fuller Lake. The deposit is in recessional outwash of Vashon Drift.

Pit (346). This pit lies north of Chemainus River road about a quarter of a mile east of the Island Highway. It consists of sandy gravel and interbedded sand lenses with an 8-foot working face and lies in glacio-fluvial deposits of Vashon Drift.

MacMillan Bloedel Ltd. pit (347). A pit on the south side of MacMillan Bloedel's logging road north of Fuller Lake has been used to build the road. The deposit shows 25 feet of sandy gravel and interbedded sand lenses dipping northeast. A foot or two of beach gravel or topset beds overlies the foreset beds. Halstead has mapped the deposit as recessional outwash of Vashon Drift.

Pit (348). Gravel is occasionally extracted from the bed of the Chemainus River downstream from the Highway Bridge about 3 miles northwest of Crofton. The deposit consists of cobbly gravel and sand.

Pit (349). A small pit of unknown ownership was opened up in Salish sediments between Chemainus River and Sicker Road about 500 feet upstream from the bridge on Island Highway. The deposit is part of a large area underlain by gravel, sand, silt and clay.

Pit (350). This pit is at the corner of Auchenachie and Evans Roads about 2 miles northwest of Duncan. A 30-foot face exposes fine gravel with sand lenses in northeast dipping deltaic beds. The deposit is part of an ice-contact delta of Vashon Drift. The pit has supplied about 50,000 cubic yards of sand and gravel.

Butler Bros. (Duncan) Ltd. (351). This company operates a sand and gravel pit on the north side of Highway 18 at Marsh Road, a mile west of Duncan. The deposit is recessional outwash of the Vashon Drift, and consists of sand and gravel at least 50 feet thick. The material is well bedded, fine to medium gravel, sandy at the south end but with an upper layer of coarse gravel.

The company produces sand and gravel products, ready-mix concrete and asphalt mix. In 1965 total production amounted to 30,000 cubic yards.

Duncan pit (352). This municipal pit lies south of Highway 18 about a mile west of Duncan. The deposit consists of 60 feet of sand and gravel in an ice-contact deposit. Patches of till and slumped gravel occur in the deposit especially at the south end. A scraper system is used to feed a portable crushing plant.

The deposit is part of a large ice-contact delta of Vashon recessional outwash.

Upland pit (353). The Upland pit, near Upland Road north of Gibbins Road shows both well-bedded and sorted sand and gravel and unsorted, slumped ice-contact recessional gravel of Vashon Drift. Some till-like material and clay overlie the deposit at the north end. Only about 20 feet of the deposit shows in the highest face. The pit belongs to the Department of Highways.

Armour and Saunders - Gibbins Road pit (354). This company owns two pits in the Duncan area. The Gibbins Road pit about 1/2 mile west of Duncan on the south side of Gibbins Road is now largely worked out and used as a plant site and storage yard.

The deposit is part of an ice-contact delta of the Vashon Drift and consists of about 50 feet of fine gravel in easterly dipping beds. Pebbles include mainly basic volcanics and sandstone, granite and minor chert.

Production in 1965 amounted to 25,000 cubic yards of washed aggregate and asphalt paving mix.

Nanaimo area (Fig. 33)

The surficial geology of Nanaimo map-area has been studied by Halstead (1963) and his report forms the basis for the description of sand and gravel deposits in this area.

The main sand and gravel deposits occur along the Nanaimo River where areas of Salish and Capilano sediments and Vashon recessional outwash successively underlie this tract of land from the mouth of the river to a point about 10 miles upstream.

Salish sediments at and near the mouth of the river underlie about 2,100 acres. Much of the material is sand and silt, but gravel does occur as well and supports one commercial operation.

Terraced fluvial deposits of Capilano gravel underlie about 1,800 acres along both sides of the Island Highway north of Cassidy. This deposit is estimated to contain at least 60 million cubic yards of sand and gravel. Nine pits have been opened up in this formation.

Recessional outwash of the Vashon ice-sheet underlie about 2,800 acres adjacent to the area of Capilano gravel. The deposit is estimated to contain 100 million cubic yards of sand and gravel. Six pits have been opened up in this formation.

Minor areas of sand and gravel occur northwest of Nanaimo where patches of marine deposits in the form of spits and bars of a few acres have provided sand and gravel for local purposes. An area of about 400 acres south of Brannen Lake is underlain by Vashon recessional outwash. The deposit may contain up to 10 million cubic yards of sand and gravel. Two pits have been opened up in this formation.

Details of pits

Ocean Cement Limited, Cassidy No. 4 Plant (332). Ocean Cement operate a ready-mix concrete plant from a pit on the east side of Highway No. 1 at Cassidy.

The deposit is part of the Capilano sediments and consists of terraced fluvial deposits, gravel and raised deltas. A surface layer of coarse gravel is considered a lag veneer left by the winnowing of finer particles by wave action as the land rose from the sea. The underlying beds are deltaic foreset beds of fine to medium gravel. About 80 per cent of the stones are volcanic in composition; the remainder is mainly sedimentary rocks of local origin, and granitic rocks.

The plant supplies washed and sized aggregate, pit-run material. In 1964 production amounted to 32,650 cubic yards.

Hub City Paving Limited (323). This company operates an asphalt paving plant on the west side of Highway No. 1 just south of the Nanaimo River Bridge at Cassidy. The gravel deposit at the plant is largely worked out. The company acquired gravel land on the north side of Nanaimo River road about a mile and a half west of the plant.

The deposit is in Capilano sediments with only the top beach gravel exposed (in 1963). The pit, then 8 to 10 feet deep, consisted of

coarse (80 per cent minus 10 inches) bouldery gravel with finer gravel and sand lenses. An area of about 2 acres was in use at the time.

Department of Highways - Cassidy pit (329). The Department of Highways used material along the highway during construction. The pit extends over 6 to 7 acres west of Cassidy airport. The deposit is Capilano gravel, with horizontal beach gravels overlying finer foreset deltaic beds. About 6 acres of gravel land contained the workings.

A bed of clay about 3 feet thick and a lens of stony clay up to 3 feet thick occurs in the middle of the face on the west side of the road. The upper gravel consists of 6 feet of fine to medium gravel in open-work beds. The thickness of the lower gravel is not revealed. It consists of medium to coarse gravel with about 30 per cent sand sizes.

General Construction Limited (328). This company owns a deposit of gravel between Nanaimo River and Nanaimo River road about half a mile west of No. 1 Highway. It is part of the Capilano terrace and delta which underlies much of the Cassidy area.

Canadian Pacific Railway pit (322). A ballast pit is maintained by the Canadian Pacific Railway along the right-of-way a quarter of a mile north of Nanaimo River road from a point a mile west of the junction with the Island Highway. It lies on the south side of the railway and extends along a length of 1,200 feet. The face is 30 feet high and shows typical deltaic foreset beds of fine to medium gravel, overlain by a few feet of beach gravels. The deposit is part of the Capilano sediments.

City of Nanaimo (323 A). The city of Nanaimo operates a pit on the north side of the Nanaimo River road about 1.3 miles west of the junction with the Island Highway. The face shows 4 to 5 feet of beach gravel overlying 10 to 15 feet of deltaic foreset beds.

Gregson pit (325 A). Mr. Gregson owns a pit on the north side of Spruston Road about 2.9 miles west of the Island Highway. The pit is about .6 acre in area.

The deposit consists of fine sandy gravel with sand lenses. Slump structures of ice-contact origin show at the south end of the pit. A layer 3 to 5 feet thick overlies 10 feet of deltaic foreset beds. The material is 90 per cent minus 6 inches in diameter with less than 2 per cent minus 100 mesh. The stones are mainly granitic, volcanic and dyke rocks (porphyry) with minor sandstone. The deposit is in recessional outwash of the Vashon ice-sheet.

A small screening plant consisting of a single deck divider shaker screen fed via conveyor belt from a hopper with 3-inch grizzly rails to reject the oversize. Production amounted to only a few thousand cubic yards.

Chadwick pit (326A). Chadwick pit lies across Spruston Road south of Gregson's pit to which it is similar but only deltaic beds are present. No machinery was seen in the pit and only a few thousand cubic yards had been produced.

Canadian Forest Products pit (326). This pit is adjacent to the Comox Logging Railway about 0.2 mile north of Spruston Road. The material is a terraced delta deposit of Capilano sediments.

Ocean Cement Limited (327). Material for the No. 4 plant at Cassidy has been taken from this pit north of Spruston Road about a mile and a half west of Cassidy. The deposit consists of 30 feet of deltaic foreset beds overlain by a layer 3 to 5 feet thick of bouldery beach gravels. It is part of the Capilano sediments.

The foreset beds are fine to medium gravel, 90 per cent minus 6 inches in diameter but there are boulders up to 2 feet in the horizontal beds. A mechanical analysis of a sample from which the plus 3-inch material was rejected, shows less than 5 per cent minus 100 mesh size. The exposed gravel face is about 200 feet long. The deposit is on or near a power line right-of-way, and one pylon stands near the south end of the pit.

Department of Highways pit (330). The Department has a pit on the north side of Spruston Road about three-quarters of a mile west of the Island Highway. The pit has 10-foot faces in deltaic Capilano gravel with one or two feet of horizontal beach gravels on top. The deposit extends over 3 to 4 acres.

Unnamed pit (331). This pit lies across the road, to the south of the Highways' pit (230). About 20 feet of gravel is exposed consisting of 15 feet of deltaic beds under 5 feet of beach gravels. The deposit is classified as part of the Capilano sediments.

Department of Highways pit (333). The Department used a pit west of the Island Highway opposite the south end of Cassidy airfield. The pit covers about 6 acres. The faces are generally low. At the middle of the west side of the pit, 6 feet of horizontally-bedded gravel, 90 per cent minus 6 inches, is exposed at the face. Clay and stony clay underlie the gravel. At the south end of the pit, the horizontal gravel beds are 4 to 6 feet thick and are underlain by at least 20 feet of coarse sand and sandy gravel. The pit is now abandoned. The deposit consists of Capilano fluvial gravel overlying Vashon recessional outwash.

Unnamed pit (334). This pit, on the east side of the Island Highway half a mile south of the Cassidy airfield, was probably a highway construction pit and is now abandoned. The main gravel bed up to 30 feet thick underlies a layer of marine clay and bedded silt. In places as much as 10 feet of Capilano gravel overlies the clay.

Unnamed pit (334A). An abandoned pit now used as a garbage dump lies half a mile west of the above pit. The deposit consisted of beach or fluvial gravels overlying deltaic beds of Vashon recessional outwash.

Department of Highways pit (314). The Department of Highways has a pit on the east side of the Island Highway at Hammond Bay road. Ten feet of fine gravel in deltaic foreset beds overlie till. The deposit is a raised marine bar of Capilano sediments.

Department of Highways (318). The Department operates a pit on the west side of McGirr Road near Invermere Road. The pit shows up to 20 feet of fine sandy gravel and sand lenses. The material is about 70 per cent sand size. This deposit is part of the Capilano sediments.

Department of Highways - Blackjack pit (317). This pit is about a mile south of Brannen Lake on the east side of Weigles Road in an area of pitted terraces in Vashon recessional outwash.

City of Nanaimo pit (319). The city maintains a pit on the east side of the Island Highway near the junction with Wellington Road. The deposit is a marine spit of the Capilano sediments and covers 8 to 10 acres.

Island Ready-Mix Limited (321). The company dredges gravel from the delta of Nanaimo River at the east of Maki Road. The material is 85 per cent minus 2 inches in diameter. This minus 2-inch fraction is graded approximately as follows:

minus 1/4 inch	33%
minus 1 inch plus 1/4 inch	33%
minus 2 inches plus 1 inch	33%

Department of Highways (335). The Department of Highways has a pit in an area of terraced Capilano sediments adjacent to No. 1 Highway at the north end of Ladysmith Harbour. The deposit consists of sandy gravel and interbedded sand lenses.

Unnamed pit (320). A small abandoned pit in marine veneer gravels lies north of Jingle Pot Road north of Westwood Lake. It consists of silty gravel and sand.

Abandoned pits (324) (325). Two small pits lie adjacent but on opposite sides of Nanaimo River Road about 2 miles west of No. 1 Highway. The deposit is part of glacio-fluvial outwash of Vashon Drift.

Island Excavating Limited (315). This company operates a pit in marine bar gravel along the Island Highway at Hammond Bay Road. The deposit consists of sandy gravel and sand and is at least 20 feet thick.

Abandoned pit (316). A pit, now abandoned, was opened up in the marine bar which contains pit 315. It is similar silty sand and gravel.

Department of Highways (317). The Department of Highways operates a pit a mile southwest of Brannen Lake in an area of pitted outwash of Vashon Drift. It consists of fine-to medium-sized gravel and interbedded sand.

Ross' pit (319A). Ross' pit is located west of the Island Highway half a mile south of Diver Lake. The deposit is a north trending kame ridge, consisting of fine sandy gravel with a few boulders.

Horne Lake and Parksville map-areas (Figs. 34 and 35)

Geology and reserves

The occurrences of sand and gravel in these areas are well described by Fyles (1963). The two maps which accompany his report show the locations of most of the pits as well as the extent of the gravel-bearing areas.

Unconsolidated deposits in gravel occur along a coastal strip from Nanoose to Fanny Bay and in Alberni Valley; the intervening mountains and hills have only a very thin veneer of soil and glacial drift above an elevation of about 1,000 feet. At the northwest end of Alberni Valley, bedrock exposures occur at much lower elevation.

Fyles classified gravel under seven headings as follows:

- (1) subfill gravel
- (2) glacio-fluvial and delta terrace gravels
- (3) river terrace gravels
- (4) marine veneer gravels
- (5) modern delta and channel gravel
- (6) alluvial fan gravel
- (7) landslide and talus deposits

Subfill gravels are only of use where the till is thin enough to be economically removed or has been removed by erosion. Most of the occurrences of natural exposures of subfill sand and gravel are found along the cut-banks of streams in the vicinity of Mud Bay, notably Wilfred, Waterloo, and Chief Creeks.

Many of the pre-till deposits are referable to the Quadra non-glacial deposits. The upper part of this sequence is dominantly sandy but locally gravel may be thick and extensive enough to be an important source of supply.

In some places along the coast marine erosion has removed most of the overlying till so that potential sand and gravel deposits may be more abundant than is obvious from a cursory inspection. Potential areas on Fyles' maps are shown by appropriate symbols, e.g. $\frac{17c}{5}$ which denotes marine veneer complex less than 5 feet thick overlying Quadra sand and gravel. Such areas may readily be tested by back hoe.

Glacio-fluvial and delta terrace deposits are the most abundant gravel formations and are well suited for commercial exploitation. They may be up to 50 feet thick and commonly are overlain with only a thin soil zone and vegetation.

Two of the largest areas of glacio-fluvial deposits are those: (1) around Spider Lake and (2) around Little Qualicum Falls Park. The Spider Lake deposit underlies about 3.8 square miles and is estimated to contain at least 170 million cubic yards. The Little Qualicum Falls Park deposit underlies about 5.8 square miles and is estimated to contain 200 million cubic yards.

Delta terrace deposits are distributed in patches along the coastal strip about 6 miles wide and vary from a few to 2,000 acres containing up to 100 million cubic yards. One of the largest areas of delta terrace deposits lies along Englishman River from the coast to a point 6 miles upstream.

River terrace deposits are of most importance in the Alberni area where those along the Somass River are up to 50 feet thick. Elsewhere river terraces are usually thin and bouldery.

Marine veneer gravels are widespread below an elevation of about 500 feet. In most places these deposits are less than 10 feet thick and are of most use for small local projects. Modern delta and channel deposits are associated with most of the larger streams. The channel deposits are generally less than 10 feet thick and do not constitute a large reserve. The deltas formed at the mouths of these streams, however, may be 50 feet or more thick and extend over several hundred acres making deposits in the order of 40 million cubic yards. Much of this would have to be recovered by drag-line methods. Some of these deltas may be worth investigating as a source of supply for the Vancouver area which is within 70 miles. With large scows this may be feasible.

Alluvial fan deposits in some places are the only convenient source of aggregate. The material is often angular and mixed in size from cobbles to clay. The base of the southwest slope of the Beaufort range north of Alberni is built up by coalescing alluvial fans. The deposit covers an area of about $2 \frac{1}{2}$ square miles and is estimated to contain at least 100 million cubic yards of fan gravel.

Landslide and talus deposits may locally be useful for road metal and may be the only convenient source of supply. Generally, however, these deposits are inferior to fluvial gravels due to the presence of large angular blocks, mixed soil, wood and weathered rock. The main area of talus and landslide deposits is along the base of the Beaufort Range northwest of Alberni.

Details of pits

Dolan's Limited (297). This company, the main supplier of ready-mix concrete in Alberni Valley, operates a pit and plant on the west side of Falls Road about 2 miles northwest of Alberni. The deposit consists of 50 feet or more of sandy gravel and sand lenses overlain by up to 10 feet of clay. A lens of sand and a lens of stony clay overlies the gravel at the west end of the pit. The overlying clay and glacio-marine deposit is part of the Capilano sediments; the gravel deposit is recessional outwash of the Vashon Drift. The material is part of an ice-contact deposit laid down between till and bed-rock valley wall and a tongue of ice which lay in the Somass River valley. Somass River has terraced the deposit in post-glacial time.

The gravel is mostly medium to fine but a few large boulders occur. The main components are volcanic rocks, 70 per cent, and granodiorite, 30 per cent.

The company operates a simple washing and screening plant to give the required aggregate for ready-mix concrete.

Island Ready-Mix Ltd. (298). This company maintains a pit adjacent to and south of Dolan's in the same geological setting. Production has been limited and intermittent.

Ocean Cement Ltd. (299). A pit belonging to Ocean Cement and maintained for occasional production, adjoins Island Ready-Mix Ltd. on their south boundary and contains similar material.

Alberni City pit (299A). The city of Alberni operates a pit to the south of, and adjoining Ocean Cement Limited. It is similar to the others in this locality.

Milligan Road pit (300). The ownership of this pit was not determined. It lies at the east end of Milligan Road, 2 miles northeast of Alberni. The deposit was worked within the confines of an acre and consists of fine to medium gravel and interbedded sand exposed in faces 12 to 15 feet high. The gravel is deltaic in origin and consists of 3 or 4 feet of topset (or beach gravels) overlying about 10 feet of westerly dipping foreset beds. Components are mainly volcanic rocks with 20 per cent granitic rocks.

Donovan & Haggard Ltd. (296). This company operates a pit east of the junction of Sproat and Somass Rivers. The deposit is mainly ice-contact gravel with marine clay on top. The material is sandy gravel and interbedded sand. Lenses of clay occur within the gravel. The deposit is partly recessional outwash of Vashon Drift, partly marine deposits of Capilano sediments. Most of the production is pit-run material; no plant was set up in the pit at the time of visit.

MacMillan and Bloedel Limited (289). This pit at the road-crossing at the east end of Great Central Lake was used for road construction and is now abandoned. It was worked to a depth of 10 to 12 feet over an area of 3 to 4 acres. The deposit consisted of glacio-fluvial gravels of Vashon Drift. The main components are volcanic and granitic rocks in about equal proportions with about 5 per cent sandstone, chert, quartzite.

Department of Highways pit (294). The Department of Highways has a pit on the west side of the road along the west side of Somass River about 2 1/2 miles northwest of Alberni. The deposit consists of fine, sandy gravel and sand in slumped ice-contact beds overlain by marine clay a few feet thick. The deposit has been worked to a depth of 30 feet over an area of 140,000 square feet. A few large (5 feet x 8 feet x 6 feet) erratics were seen on the pit floor.

Department of Highways pit (301). This pit lies on the south side of Highway 4 about a mile east of the outlet of Cameron Lake. The deposit consists of kame gravel of glacio-fluvial origin. The deposit consists of fine, sandy gravel in beds dipping north in an upper layer, and south in a lower layer. The two layers are separated by an unconformity marked by a train of boulders 2 or 3 feet in diameter. Production was limited to a few hundred cubic yards.

Department of Highways pit (302). This pit is south of Highway 4 about 2 miles east of the outlet of Cameron Lake. It was used during highway construction and is now inactive. The deposit consists of glacio-fluvial gravel in knob-and-kettle topography formed by the melting of blocks of ice from the downwasting of the last ice-sheet. The pit extended over 4 or 5 acres. Most of the component rocks were of volcanic origin.

Department of Highways (275). The Department of Highways has a pit on the west side of Highway 19 about a mile past Mud Bay. The deposit consists of north-dipping foreset beds of sandy gravel and sand lenses exposed in a 20-foot face. The sand fraction is noticeably angular and contains weak sandstone and shale particles. Many of the pebbles are iron coated.

Olympic Forest Products Ltd. (304). This pit, used for logging road construction, is located in glacio-fluvial deposits of Vashon Drift around Spider Lake.

Department of Highways (303). Kame delta deposits north of Little Qualicum Falls Park are used by the Department of Highways for road construction.

Unknown pits (280 to 284). Five pits of unknown ownership occur in terraced fluvial deposits of Capilano gravel along Rosewall and Chief Creeks near Highway 19. The gravels are composed of volcanic and granitic rocks (90 per cent) with minor sedimentary and metamorphic rocks.

Miscellaneous pits (276, 277, 278, 289). Terraced fluvial deposits of Capilano sediments provide convenient sources of gravel for highway and logging roads along the coast and inland for a few miles. Individual descriptions will not be made. The deposits are medium gravels in deltaic beds. Most of the pits are small and generally only a few feet deep.

Miscellaneous pits in Alberni Valley (285, 286, 287, 288, 290, 291, 292, 293, 295). No detailed descriptions of each pit will be made. Most are small, borrow pits for local use and many are abandoned or idle. Most of the constituents are volcanic and granitic rocks, well rounded and sound. In most pits sand makes up about 50 per cent of the deposit. Both glacio-fluvial and fluvial deposits are represented. Most of the pits along Somass Valley are Capilano sediments; around Great Central Lake most of the deposits are glacio-fluvial in origin.

Pits in Parksville area (Fig. 34)

Unknown (305). Sand from a spit of Salish sediments at the mouth of Little Qualicum River is intermittently extracted for sanding roads.

MacMillan Bloedel Ltd. (309) (310). These pits are used for logging road construction. The pits are in eskers of sandy gravel and are part of the Vashon Drift. The pits are located along private logging roads about 2 1/2 miles south of Craig.

Department of Highways (313). A small pit in Capilano delta terrace along Englishman River. Most of the constituents are volcanic rocks (70 per cent) with 25 per cent granodiorite, minor chert, quartzite, shale, gneiss and sandstone. Most of the gravel is fine to medium sized.

Department of Highways pit (306). A pit extending over 5 or 6 acres and up to 30 feet deep occurs on the north side of Highway 4, 2 1/2 miles southwest of Parksville. The deposit is part of the Quadra sediments which are usually sandy, but here a gravelly phase is exposed by marine erosion of the younger formations which, in most places, cover them. The gravel contains lenses of silt and sand.

MacMillan & Bloedel Limited pit (312). This company has several pits along logging roads which lead southerly from the camp on the south of Highway 19

about 3 miles west of Nanoose Bay. The pit considered here is about a mile southwest of the camp and lies in a 300-acre terrace of fluvial gravels of the Capilano sediments. The pit extends over about an acre with 10-to 17-foot high faces. The material is poorly bedded and well compacted. Rock components are mainly granodiorite and andesite with minor sandstone.

MacMillan & Bloedel Ltd. pit (311). A second pit lies about 1 1/2 miles south of the above pit on the southeast side of the main haulage road. Low faces, 6 to 8 feet high, reveal poorly bedded unsorted, bouldery gravel with sand beds. Some granite boulders, 2 feet in diameter, were seen. The material is about 60 per cent gravel size, and consists of granitic and volcanic rocks with 10 to 15 per cent very friable sandstone. The sand beds mark the stratification which is horizontal. The pit extends over 4 to 5 acres. It is a glacio-fluvial deposit of the Vashon Drift.

Department of Highways pits (307) (308). Two small borrow pits in Capilano terraced fluvial deposits lie on the west side of the road leading to Englishman River Falls park and lie one quarter and one mile respectively north of the park. The material is sandy gravel.

Courtenay area (Fig. 36)

Geology and reserves

The surficial geology of the Courtenay area has been studied by Fyles (1960) whose report is the basis for the discussion under this heading.

The most important gravel units in this area are:

- (1) glacio-fluvial deposits of Vashon Drift
- (2) terraced fluvial deposits of Capilano sediments

Vashon glacio-fluvial deposits between Cumberland and Bevan underlie about 3,600 acres. The average depth of this deposit is not known but some pits show as much as 90 feet of sand and gravel. Assuming an average depth of 30 feet, the deposit is estimated to contain 180 million cubic yards of sand and gravel. Northwest of Bevan swarms of eskers provide widespread sources of sand and gravel over an area of about 10 square miles. Eskers and other small areas of glacio-fluvial gravel occur in many other places throughout the map-area and are shown on Geological Survey of Canada map 1111A.

Terraced fluvial deposits of the Capilano sediments are distributed in three main areas:

- (1) along Tsable River (1.75 sq. miles)
- (2) along Trent River (3.0 sq. miles)
- (3) along Brown-Puntledge Rivers (3.8 sq. miles)

The estimated volume of sand and gravel in each area is:

- (1) Tsable River - 33 million cubic yards
- (2) Trent River - 57 million cubic yards
- (3) Brown-Puntledge Rivers - 72 million cubic yards

Many square miles along the coastal strip up to the 500-foot contour are underlain by marine deposits, largely silt, clay, and sand but which locally may have sand and gravel in usable quantities. The best marine deposits are those disposed in spits and bars. There are two such deposits in the Comox area and both contain pits. Some marine gravels are thin cobbly veneer, only a few feet thick. These are exploited wherever required and several have been opened up in the vicinity of Comox Airfield for runway construction. Reserves of marine gravels cannot be estimated with any degree of accuracy.

Salish sediments contain some gravel in river and stream channels but these are dominantly sand, silt, clay and peat. Dune sands on the coast east of Comox underlie an area of about 500 acres and probably contain 15 million cubic yards of sand.

Quadra sediments are of minor importance for two reasons:

- (1) they are usually buried under younger formations, and
- (2) they are dominantly sandy

However, Quadra sediments which contain gravel are exploited in one locality south of Comox Airfield.

Details of pits

Deeks-McBride Limited (266). The company has a large reserve of gravel and an inactive pit on the west side of the Cumberland Road about 3 miles south of Courtenay.

Pit faces are up to 110 feet high. The top 3 or 4 feet is beach gravel (or topset deltaic beds). The main gravel unit consists of westerly dipping foreset beds of fine gravel, 90 per cent minus 3 inches. The deposit stands in steep faces with the development of prominent hoodoos. The material is short in the minus 50 mesh fraction and this deficiency must be augmented by the addition of suitable sand and silt for some concrete specifications.

Island Ready-Mix Limited (267). The Courtenay plant of this company operates from a pit on the west side of Cumberland Road adjacent to Deeks-McBride pit above. Both pits are similar, being pitted terrace deposits of glacio-fluvial outwash of the Vashon ice-sheet. Dune sand from Cape Lazo is added to the material for production of concrete.

Department of Highways pit (268). This pit is located adjacent to Island Ready-Mix in the same knob-and-kettle outwash. A test hole below the pit floor is reported to show 60 feet of gravel.

Davis pit (270). This pit is located near the east end of Comox Lake about half a mile north of Cumberland Road. The deposit consists of at least 75 feet of clean, sandy deltaic gravel and sand lenses. The foreset beds dip south. The material is classified as glacio-fluvial deposits of the Vashon Drift.

The material is 90 per cent minus 6 inches in size and about 70 per cent minus #4 mesh. It is a very sandy gravel. The upper 5 to 10 feet of beach or topset gravel is less sandy. The pit covers about 6 acres.

Comox Logging Co. (?) pit (271A). A pit with 6- to 7-foot faces and covering about half an acre lies on the Browns River road about 2 miles north of Bevan. The pit shows 3 to 4 feet of beach gravel on top of 4 to 5 feet of deltaic beds dipping north. The material is a fine sandy gravel of the Capilano sediments and was used for local logging roads.

Comox Logging Company pit (272). A small pit, about an acre in extent, lies along the logging company's road half a mile south of Bevan. The deposit is part of a large pitted terrace of glacio-fluvial gravels of Vashon Drift. Working faces are up to 10 feet high and reveal a 3- to 4-foot layer of beach gravel over north-dipping deltaic gravels and interbedded sand lenses.

Comox Logging Co. pit (273). This pit is on the south side of Bevan Road about a quarter mile southwest of Bevan and lies along the former route of a logging railway. The deposit is similar to the preceding pit.

Pit (271). A small pit extending over an acre or two lies on the south side of Puntledge River about a mile northwest of Puntledge village. The pit was evidently used in the manufacture of the concrete supports for a pipeline supplying water to Courtenay. The deposit is part of the Capilano sediments and consists of gravelly veneer on top of glacio-marine stony clay.

Sumas Dredge and Supply Ltd. pit (265). This company operated a pit about a mile and a half south of Comox Airfield. The pit showed 10 to 12 feet of deltaic foreset beds of sand and sandy gravel capped by 1 to 5 feet of beach gravel. The pit extends over 6 or 7 acres.

The deposit consists of sandy gravel of the Quadra sediments mantled by a foot or two of marine gravels of the Capilano sediments.

Vanwest Logging Company pit (268A). A pit covering about an acre lies on the north side of the Vanwest logging road about 2 miles southwest of Royston.

About 3 feet of the deposit has been removed revealing brown oxidized sandy gravel over 3 feet of coarse sand. The top gravel is 90 per cent minus 3 inches in diameter. Most of the pebbles are volcanic rocks, sandstone and shale. The deposit is part of the Capilano sediments.

Cumberland pit (270A). A pit of unknown ownership lies on the south side of the village of Cumberland. A 25-foot face has been opened up in a deposit of ice-contact gravel of Vashon Drift. A heterogeneous mixture of fine gravel, crossbedded sand lenses and massive, unsorted gravel are all exposed in the face, under a surface layer of cobbly fluvial gravel of the Capilano sediments.

Comox Logging Co., Browns River Road pit (258A). This company used a pit on the north side of Browns River about 6 miles west of Courtenay for building logging roads. The deposit is part of the Capilano sediments and consists of 3 to 5 feet of fluvial channel gravel on top of 15 to 20 feet of fine gravel with coarse sand lenses in north-dipping foreset beds. One bed contains boulders up to 15 inches in diameter; the remainder of the beds contains material 90 per cent minus 3 inches in diameter.

Department of Highways - Tsable River pit (274). This pit is on the west side of Highway 19, north of Tsable River. The pit is worked by faces up to 20 feet high. The deposit is part of the Capilano sediments and consists of deltaic beds of sandy gravel overlain by beach gravels up to 3 feet thick. There are some silty beds in the deposit and one piece of coal found suggests that the organic content may be detrimental for some purposes. The stones are mostly sandstone, shale and volcanic rocks. Granitic rocks are of minor importance. The fine fraction is noticeably angular.

Comox Airfield pits (260 to 263). Several pits have been used to supply aggregate for airfield construction. These pits are all in marine veneer gravels commonly less than 5 feet thick. They are part of the Capilano sediments and have been developed on marine and glacio-marine deposits of clay, silt and stony clay. These deposits have been used because of their convenient location and suitability but because of their thinness reserves generally amount to less than 10,000 cubic yards per acre.

Department of Highways - Hardy Road pit (259). The Department of Highways opened up a pit in marine veneer gravels at the end of Hardy Road about 2 miles north of Courtenay. The deposit is a marine spit of the Capilano sediments, about 75 feet thick extending over 8 to 10 acres. The pit, however, has only used the top 3 or 4 feet, at the south end of the deposit where it is thinnest.

Cape Lazo sand pit (264). A deposit of dune sand of Salish sediments lies along the coast road from Barmoral Beach to Cape Lazo. It covers an area

of about 400 acres. Three pits have been opened in the deposit; the largest (264A) reveals 12 to 15 feet of fine sand mainly in the range plus 100 mesh - minus 30 mesh.

Crown Zellerback Canada Ltd. (257) (258). These pits are located along the company's private logging road about 2 miles south of Wolf Lake. Pit 257 is in an area of Capilano sediments and consists of interbedded sandy gravel and sand exposed for a thickness of about 15 feet. Pit 258 is in glacio-fluvial gravels of Vashon Drift.

Abandoned pit (269). A pit now abandoned was opened in pitted outwash of Vashon Drift on the north side of Cumberland Road about half a mile north of the village. The deposit consists of 10 to 15 feet of sand and gravel above the pit floor.

Oyster River map-area (Fig. 37)

Geology and reserves

The surficial geology of Oyster River map-area has been studied by Fyles (1959) and his work forms the basis for the following discussion on sand and gravel.

Surficial deposits in the Oyster River map-area are largely confined to a coastal strip 9 or 10 miles wide below the 1,000-foot contour. A thin, discontinuous veneer of ground moraine and soil mantles the bedrock on the higher ground.

Quadra sediments are exposed on the south side of Quadra Island, and are found under a few feet of marine gravels near Williams Beach. They are not exploited anywhere in the map-area.

Glacio-fluvial deposits related to the Vashon ice-sheet occur in the northern half of the area and vary in extent from a few acres to 700 acres. They are mainly terrace deposits but include esker ridges grouped in swarms around the centre of the map-area. The largest terrace deposit underlies 700 acres east of Quinsam River near the north end of the map-area. No pits have been opened in this locality but elsewhere deposits of glacio-fluvial gravels are worked intermittently in five pits.

The most extensive and continuous deposit of sand and gravel is the terraced fluvial gravels along Oyster River. Gravel from an area of 800 acres on the north side of Oyster River, west of Highway 19, has been used for highway construction. The full depth of the deposit has not been reached in any pit; the highest working face is 20 feet in a pit on the east side of the deposit. Using this as the average depth, the deposit would contain about 16 million cubic yards.

An area of 180 acres along Highway 19 south of Oyster River is also underlain by Capilano gravels. No pits have been opened up in this deposit.

Flanking Oyster River upstream from a point about 3 miles from the mouth, an area of about 6 square miles is underlain by fluvial deposits of Capilano gravel in the form of delta terraces and channel fillings. Only two pits have been opened in this deposit, in one of which a face 60 feet high exposed north-dipping deltaic beds of fine to medium gravel. The deposit is estimated to contain at least 200 million cubic yards of sand and gravel.

Marine gravels are the most extensive deposits in the map-area; they extend along the coast below an elevation of about 500 feet, and occur as a discontinuous mantle of stony, cobbly, sandy gravel, generally less than 5 feet thick but locally, in bars and spits, may attain thicknesses of 25 to 30 feet. Eight pits have been opened in these gravels, mainly as a source of road metal.

Details of pits

Department of Highways pit (248). This pit lies west of Highway 19 about a mile north of Oyster River.

The deposit consists of north-dipping deltaic beds of fine sandy gravel, openwork gravel, and sand lenses in alternating beds, overlain by horizontal beach gravels and sand lenses. The face is about 15 feet high and this is probably only half the thickness of the deposit.

A second pit (249) a quarter mile west is similar but has 20-to 25-foot faces.

Iron River Logging Co. pit (250). This pit lies on the north side of the company's private logging road, about 7 miles west of Oyster Bay. The deposit consists of deltaic gravels in north-dipping foreset beds with a foot or two of beach gravel at the surface. The material is a fine to medium gravel with a few boulders as large as 2 feet in diameter. Many of the stones are coated with iron oxide. Similar material is found in pit 251, half a mile to the west.

Private logging road pits (242) (253). Two pits in terraced fluvial deposits of Capilano sediments have been opened for logging road construction about 2 miles north of Wolf Lake.

Department of Highways pits (254, 255, 256). These pits lie in marine spits and bars. They are generally thin, up to 10 feet, and rest on till. The material is silty gravel and packs well for base courses on road construction.

GEOLOGY AND DISTRIBUTION OF SAND AND GRAVEL DEPOSITS
ON STRAIT OF GEORGIA ISLANDS.

INTRODUCTION

A large number of islands lie in the Strait of Georgia but only a few were visited by the author.

Most of the islands are known to be rocky with a thin veneer of marine clay or glacio-marine stony clay as the main surficial material. Locally marine bars and spits may be gravelly. On a few of the islands Quadra sediments, consisting of 200-foot thicknesses of sand underlie a thin mantle of till. On Texada Island McConnell (1914) noted two boulder clay (till?) deposits separated by up to 200 feet of sand and silt, with minor sand and gravel overlying the upper till at elevations of up to 500 feet above sea-level. It appears that the glacial history of the islands is similar to that of the rest of the Strait of Georgia area but probably they were subjected to more intense marine erosion. No gravel pits of commercial importance are known on any of the islands. The surficial geology of some of the islands is shown on some of the maps given in the list of references.

DESCRIPTION OF AREAS

Saltspring Island (Fig. 38)

Surficial deposits on Saltspring Island are largely confined to the main valleys and are nowhere more than a few tens of feet thick. Most of the deposits are part of the Capilano sediments, and consist mainly of delta terraces and gravelly marine veneer. On the northern part of the Island Cretaceous shale and sandstone are quarried for road construction material.

Details of pits

Department of Highways - Walter Hook pit (337). A pit half an acre in extent, half a mile south of Walter Hook was used for road building. The deposit was worked to a depth of 8 to 10 feet. The material is sandy gravel and sand lenses in north-dipping deltaic beds of Capilano sediments. Most of the constituents are shale and sandstone with minor granitic and volcanic rocks.

Department of Highways - Ganges pit (339). A sand pit 8 feet thick with a few pebbly and cobbly beds lies on the east side of the Ganges Harbour road a mile south of Ganges. The deposit is part of a delta terrace of Capilano sediments.

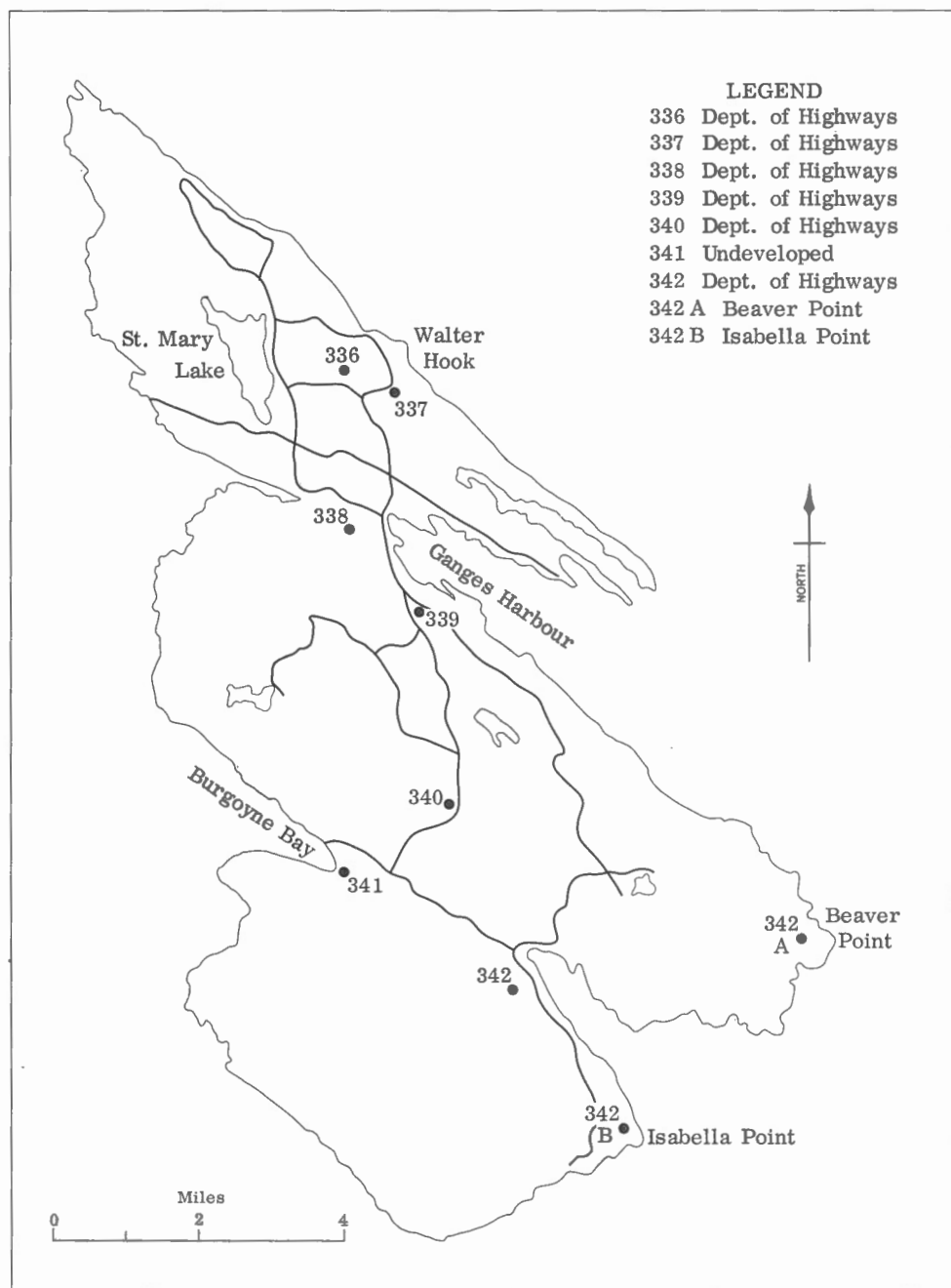


Figure 38. Saltspring Island area.

Department of Highways - Ford Lake pit (340). This pit lies adjacent to the Ganges-Fulford Harbour road about 1 mile north of the turnoff to Burgoyne Bay. The pit has a 25-foot face showing a lower 15-foot thickness of south-dipping deltaic beds of sand and sandy gravel, and a 10-foot upper section of poorly sorted, rudely stratified gravel, consisting mainly of shale and sandstone with minor granitic and volcanic rocks.

Department of Highways - Fulford Harbour pit (342). The Department of Highways maintains a pit on the west side of Fulford Harbour about half a mile south of Fulford Creek. The deposit is a fine sandy gravel with interbedded coarse sand in northerly-dipping foreset beds. A foot or two of beach gravel on top is noticeably coarser than the foreset beds which are 90 per cent minus 3/4 inch in diameter. The pit extends over 3 or 4 acres and is part of a delta terrace of Capilano sediments. Most of the stones are shale and sandstone.

Beaver Point pit (342A). A small borrow pit on Beaver Point in marine veneer gravels has supplied a few cubic yards for some small local projects.

Isabella Point pit (342B). A delta terrace of about 3 or 4 acres at Isabella Point has supplied a few cubic yards of fine gravel for local purposes. The terrace may be as much as 20 feet thick. The deposit may contain up to 50,000 cubic yards.

Department of Highways - Rainbow Road pit (338). This pit lies south of Rainbow Road about a mile west of Ganges.

The deposit consists of fine gravel and coarse sand, 90 per cent minus 1 1/2 inches in diameter, in north-dipping deltaic beds overlain by beach gravels a foot or two thick. The deposit was worked from shallow faces, up to 6 feet high. The pit extends over about half an acre.

Most of the components are shale and sandstone with minor granitic and volcanic rocks.

Two other gravel localities are shown on Figure 37. These are (341) and (336). At locality 336 an area of less than one acre has been scraped to a depth of 2 to 3 feet for road metal and at locality (341) gravel is exposed under a few feet of till.

James Island

James Island is the property of Canadian Industries Limited and is the site of their explosives plant. Access is restricted because of regulations governing explosives plants. The south end of the island exhibits a

thick section of Quadra sediments overlain by stony clay and topped with beach gravel. The Quadra sediments are largely sand with minor beds of pebbly gravel. The section is about 100 feet high.

Sidney Island

Sidney Island is a private estate. It lies east of James Island and is similar geologically in that thick Quadra sand deposits underlie most of the island. A thin layer of marine clay overlies the sand which is best exposed along the sea cliffs.

Gabriola, Galiano, Saturna, Mayne Islands

Islands in the Nanaimo Group include Gabriola, Galiano, Saturna, Mayne and nearby islets and are largely devoid of surficial deposits. A thin veneer of marine deposits is the main unconsolidated material. Bedrock is sandstone and shale of Cretaceous age.

Texada Island

Texada Island is largely denuded of Pleistocene deposits. Three small areas around Crescent Bay, Gillies Bay and Lower Gillies Bay are the main localities. There is an older till comprising Quadra sediments; younger till stony marine clay, and beach deposits of gravel and sand. Thick and extensive sand and gravel deposits appear to be absent. Crushed limestone from the many quarries provides a convenient and superior product for local aggregate requirements.

Denman Island

Most of Denman Island has little surficial cover or at most a thin veneer of marine clay. There are however, thick deposits towards the north end of the island where high cliffs expose 200-foot sections of Quadra sediments overlain by 20 to 30 feet of till and marine clays. The Quadra sediments are mainly sand.

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PLATES



Plate IA - Minto Landing, Fraser River. Gravel bars exposed at low water-level. (GSC 133696)



Plate IB - Quadling pit, Sumas municipality. Fan gravel. (GSC 133674)

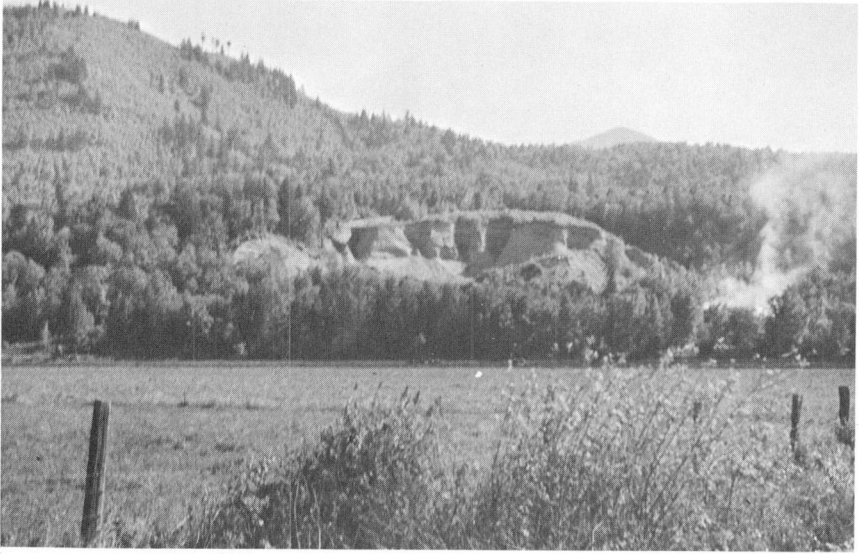


Plate IC - Bailey pit, Chilliwack municipality. Huntingdon gravel under Sumas till. (GSC 133698)

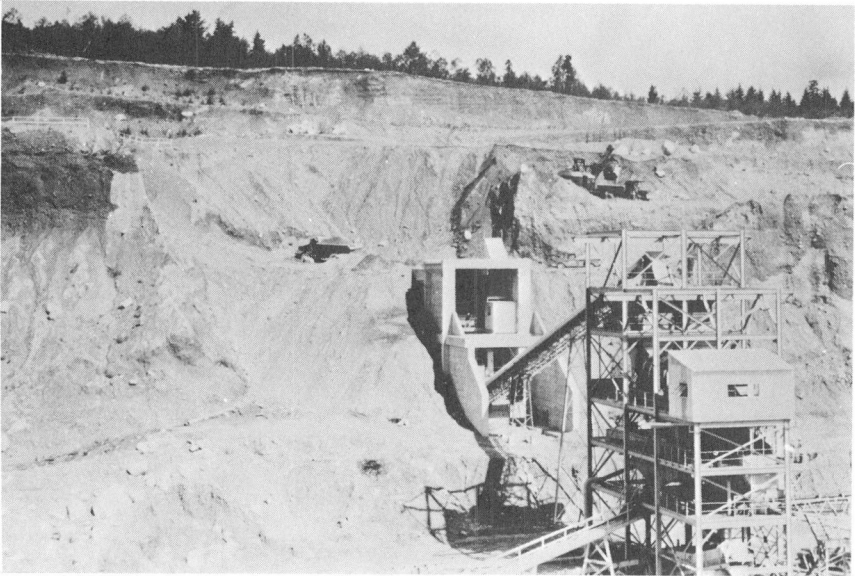


Plate ID - Mary Hill pit, Ocean Cement Ltd. City of Port Coquitlam. View from gravel tower looking north. (GSC 133667)



Plate IIA - Deeks-McBride Ltd. Pipeline road pit, Coquitlam municipality.
Deltaic deposits of Capilano gravel. (GSC 125005)



Plate IIB - Border Sand and Gravel Ltd. Langley municipality. Ice-contact
deposit, Mary Hill outwash. (GSC 133688).



Plate IIC - Department of Highways. Bradner at King - Matsqui municipality. Well-bedded Abbotsford outwash. (GSC 133693)



Plate IID - Deeks-McBride Ltd. Larsen pit. High water-table in Abbotsford outwash. (GSC 133677)

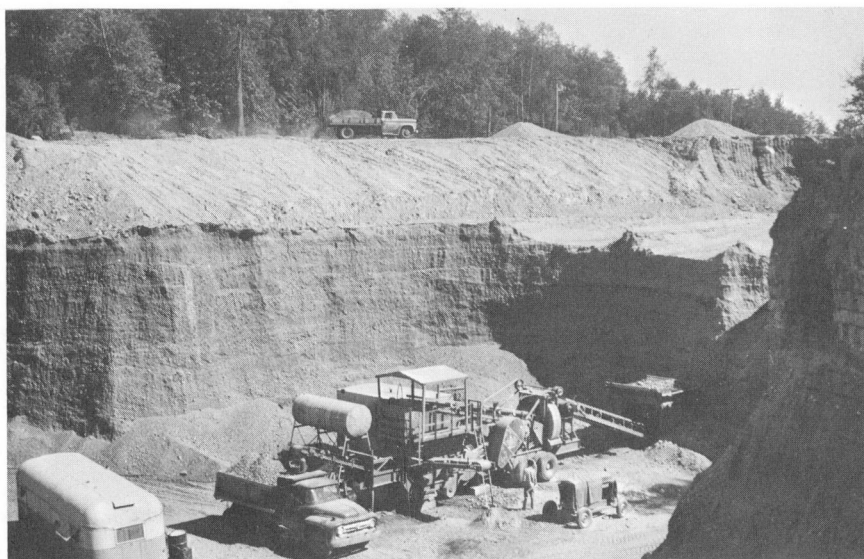


Plate IIIA - Richmond Sand and Gravel. Surrey municipality. Pre-Surrey till gravels under marine stony clay. (GSC 133659)

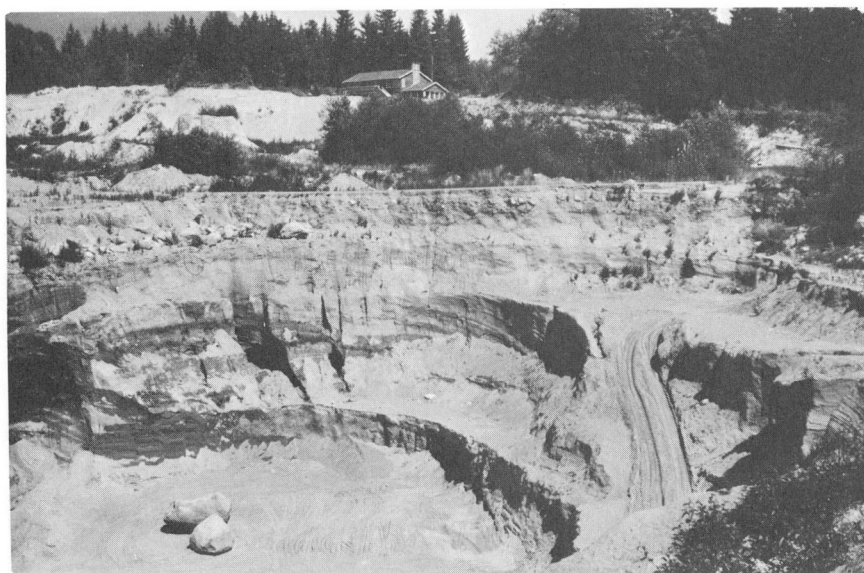


Plate IIIB - Taylor Construction Ltd. North Vancouver pit. Quadra sand under till and stony clay. (GSC 133683)

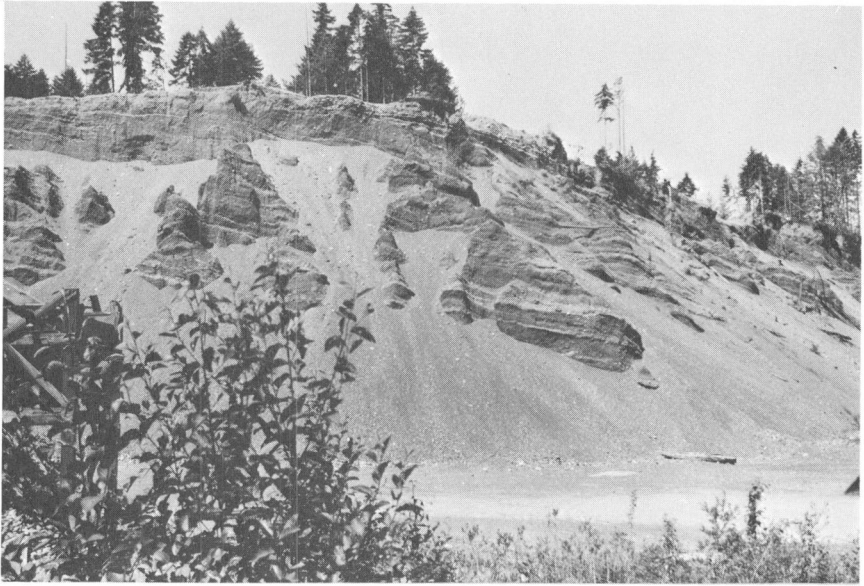


Plate IIIC - Deeks-McBride Ltd. Cumberland Road pit. Vancouver Island
Vashon glacio-fluvial deposit. (GSC 125000)



Plate IIID - Armour and Saunders Koksilah pit. Duncan, Vancouver Island.
(GSC 124999)