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GROUND-WATER RESOURCES OF SUMAS, CHILLIWHACK, AND KENT MUNICIPALITIES, BRITISH COLUMBIA

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By
E. C. Halstead

D E P A R T M E N T O F
M I N E S A N D T E C H N I C A L S U R V E Y S
C A N A D A

CONTENTS

CONTENTS (cont'd)

GROUND-WATER RESOURCES OF SUMAS, CHILLIWHACK, AND KENT MUNICIPALITIES, BRITISH COLUMBIA

Chapter I

INTRODUCTION

Sumas, Chilliwhack, and Kent Municipalities and adjoining unincorporated districts covered in this report are all in the eastern part of Fraser Lowland, British Columbia, between longitudes 121°45' and 122°15' and latitudes 49°00' and 49°15'. Although parts of the area obtain ample water from surface sources, most of it depends on ground water for industrial, municipal, domestic, and irrigation uses.

The ground-water investigation was conducted by the writer during the field seasons of 1955 and 1956; geological mapping was directed by J.E. Armstrong during the 1955 field season. The writer was assisted by J.D. Stothers and P.L. Strack in 1955 and by W.L. Groom and W. Marusy in 1956. Well owners and drillers supplied much of the data on wells and aquifer performance.

The investigation included an inventory of representative wells and springs, and the report incorporates additional data from logs of private wells and test-holes drilled since 1955. All records and logs are filed at the British Columbia office of the Geological Survey of Canada at Vancouver, and are available to anyone seeking additional ground-water data.

CLIMATE

The climate of the Fraser Lowland is highly variable and is largely controlled by the mountains to the north and east. This influence accounts for a strong increase in precipitation from south to north and from west to east throughout the lowland.

Heavy winter rainfall and a summer dry period are characteristic of the eastern part of the lowland. About two thirds of the average total precipitation occurs from October to March inclusive. Rainfall during the growing season—April to September—is inadequate in most years for the maximum development and yield of crops. The heavy sustained rains from October to March replenish the ground-water reservoirs. During this period, little water, apart from run-off, is lost by evaporation and transpiration. The soil and unconsolidated surface deposits above the water-tables are kept wet and maximum infiltration results.

Precipitation and temperature records for four stations in the area are given in Table I.

Table I

Precipitation and Temperature Records

Station	Altitude (feet)	Average Monthly Mean Temperature (°F)		Average Annual Precipitation (inches)
		High	Low	
Abbotsford Airport	198	62	33	60.30
Agassiz	52	64	34	63.19
Chilliwack	21	63	34	61.18
Cultus Lake	190	63	32	58.02

PHYSICAL FEATURES

The major physiographic feature of the region is Fraser Valley, bounded on the north by the Coast Mountains and on the south and east by the Cascade Mountains. Within its flat-bottomed floor that averages 7 miles wide, the Fraser River occupies a mile-wide channel. North of Fraser River, foothills of the Coast Range attain elevations of 4,000 feet or more. Within the Cascade Mountains, maximum relief is about 5,500 feet.

Sumas Municipality occupies part of Sumas Valley, which is included in Fraser Valley. Sumas Valley averages 4 miles in width, with a flat floor less than 50 feet above sea-level. It is bounded on the southeast by Vedder Mountain, on the north and east by Sumas Mountain, and on the west by an upland area south of Abbotsford.

Chilliwhack Municipality lies northeast of Sumas Municipality, and Vedder Canal is a common boundary. Most of Chilliwhack Municipality has a relatively flat floor, less than 50 feet above sea-level, modified by the deposition of flood-plain deposits. The flood-plain area extends to Fraser River; within it, Chilliwack and Shannon Mountains respectively rise to elevations of more than 1,200 and 300 feet above sea-level.

South of Chilliwhack Municipality, the unincorporated district of Ryder Lake occupies a rolling hilly area on Lookout Ridge. Between Lookout Ridge and International Ridge, the Chilliwack River flows in a narrow U-shaped valley.

Columbia Valley, between International Ridge and Vedder Mountain, attains an elevation of more than 600 feet above sea-level at the International Boundary; it slopes northeast to Cultus Lake at an elevation of approximately 150 feet.

North of Fraser River, the unincorporated Nicomen district extends from Hatzic Lake to Harrison Mills. The district is mountainous with a wide area of flood-plain and delta deposits that extend from the base of the mountains to Fraser River.

Kent Municipality, east of Nicomen unincorporated district, is generally mountainous, but the part in the area investigated is a broad flat plain that attains an elevation of less than 60 feet above sea-level. Within the plain, Hopyard and Cemetery Mountains rise to elevations of more than 700 feet.

WELLS AND WELL DEVELOPMENT

Failure to obtain water from a well is due either to conditions existing in the formations penetrated or to the type of well and construction methods used. The information that follows is intended to draw the attention of engineers, drillers, and prospective well owners to certain fundamental principles of ground-water recovery and well use, so that they may know the problems that exist and the corrective measures used elsewhere. Additional information may be obtained from drillers' magazines and from some of the references listed in this report.

Types

Dug, bored, driven, and drilled wells are the four main types and each has its special use according to existing conditions. The type of well is determined by (1) depth to water, (2) characteristics of the sediments from ground surface to water, (3) characteristics of the water-bearing sediments, (4) static level of the ground water, (5) amount of water required, and (6) investment of the prospective well owner.

In the area studied, ground water is obtained by installing dug wells in unconfined or perched aquifers in Sumas till. However other types of wells are more satisfactory and require a smaller-diameter hole, eliminating the danger of objects or animals falling into the well. Dug wells are commonly lined with concrete tiles or wood curbing, but those dug in till may not require lining as the compact till will stand without caving or slumping in an open hole. In most dug wells in Sumas till, water is collected from surface run-off;

these function chiefly as cisterns.

Bored wells, sunk by hand- or power-driven auger, are not found in the area, partly because driven and drilled wells are easily installed and the principal aquifers are at or near the surface.

Driven wells are common and are economical for obtaining ground water from reservoirs within the Fraser flood-plain and channel deposits, and lacustrine and stream deposits. Driven wells are constructed by driving a casing tipped with a drive-point or sand-point. They perform most efficiently where the sands are medium to coarse grained and where the water-table is near the surface.

Drilled wells are the most effective type for the recovery of ground water, and are required where large yields are needed for municipal, industrial, or irrigation use. Drilled wells are lined with a casing commonly more than 6 inches in diameter, and may be finished as open-end, screened, or gravel-packed wells. Cable-tool and rotary drilling rigs are used, commonly the former.

An open-end well allows water to enter through the open end of the casing. As such a well has no screen or other device to keep sand from entering, failures are common especially when the well is subjected to overpumping. Screened wells are fitted with a screen or strainer placed opposite the permeable water-bearing materials or aquifer. The screen provides for the exposure of a greater area of water-bearing material through which water is taken into the well. By the use of proper development equipment and procedures, the fine material around the screen is removed. This leaves a coarser sand surrounding the screen and provides the greatest possible amount of open space for water to enter the well. Where the water-bearing material is fine and uniform in size, gravel may be introduced around the screen to provide a gravel wall.

Development

Wells are developed by post-drilling treatments to establish the maximum yield of usable water. Methods commonly used to improve the yield include surging, overpumping, backwashing, and treatment with acids or other chemicals. All except the acid treatment are designed primarily to wash the fine sand, silt, or clay from the water-bearing formation immediately surrounding the well screen.

Surging is most commonly used where the water-bearing materials contain sand and fine gravel mixed with silt; over-pumping is satisfactory where coarse sand and gravel make up the aquifer. In the surging method, a surge plunger is operated up and down in the well casing to create an alternating inward and outward movement of water through the screen. The repeated surging action eventually moves the fine sand up and through the screen where it can be removed by bailing. The coarser particles left on the outside of the screen have a higher porosity and permeability. In the backwashing treatment, the pump is operated at its maximum capacity, then periodically stopped and the foot-check valve released. The water then rushes back into the well and agitates the sediments around the screen.

Wells are developed to increase their specific capacity or yield per foot of drawdown. During pumping, the water in the well drops from its static level to the pumping level, and this drop, measured in feet, is known as the drawdown. As the water in the well drops to the pumping level, the attitude of the water level in the aquifer around the well becomes that of an inverted cone. The size and shape of this cone—known as the cone of depression—are controlled by the rate of pumping, the permeability or water-yielding capacity of the water-bearing material, and the slope of the water-table in the vicinity of the well. For example, if the pumping rate is high and the water-bearing material is coarse, the cone of depression will affect a large area of the water-table, but the height of the inverted cone will be relatively small. Under these conditions many neighbouring wells may be affected. When pumping is stopped the dewatered area normally fills up again.

The specific capacity or yield per foot of drawdown of a well should be determined especially when large flows are demanded. Irrigation wells should be developed to maximum capacity as they will be subjected to long-term pumping. Most wells drilled for domestic or farm needs do not require extensive development as the initial yield meets the requirements.

SELECTED REFERENCES

Armstrong, J.E.

1960a: Surficial Geology, Sumas, New Westminster District, British Columbia; Geol. Surv., Canada, Map 44-1959.

1960b: Surficial Geology, Chilliwack, New Westminster District, British Columbia; Geol. Surv., Canada, Map 53-1959.

Armstrong, J.E., and Brown, W.L.

1953: Ground-water Resources of Surrey Municipality, British Columbia; Geol. Surv., Canada, Water Supply Paper 322.

Halstead, E.C.

1957: Ground-water Resources of Langley Municipality, British Columbia; Geol. Surv., Canada, Water Supply Paper 327.

1959: Ground-water Resources of Matsqui Municipality, British Columbia; Geol. Surv., Canada, Water Supply Paper 328.

Odynsky, P.

Notes on Ground-water Investigation in Agassiz-Harrison Hot Springs Valley; Water Rights Branch, B.C. Dept. Lands, unpub. rept., File 0192858.

Thomas, J.F.J.

1953: Scope, Procedure and Interpretations of Survey Studies: Industrial Water Resources of Canada; Canada, Mines Br., Water Surv. Rept. 1, Pub. No. 833.

1959: Water Quality at Some Canadian Military Establishments, 1956-57: Industrial Water Resources of Canada; Canada, Mines Br., Water Surv. Rept. 12, Pub. No. 865.

Chapter II

GENERAL GEOLOGY OF PLEISTOCENE AND RECENT DEPOSITS

The Coast and Cascade Mountains in the map-area consist of bedrock that at low elevations is covered with a mantle of drift; in places this drift is less than 25 feet thick. Elsewhere, unconsolidated deposits cover the area to a maximum thickness of at least 1,100 feet; they accumulated for the most part during Pleistocene time, but deposition has continued up to the present. The term Pleistocene refers to that epoch in the earth's geological history when large areas of the earth's surface were periodically covered by glaciers many thousands of feet thick. The epoch is estimated to have started less than a million years ago. The last glacial ice advance in the map-area was a valley glacier that originated in the Cascade Mountains about 11,000 years ago. The term Recent here refers to the present non-glacial time.

The deposits formed during the Pleistocene and Recent epochs are shown on Figure 1. They consist of clay, silt, sand, peat, varved clay and silt; stony clayey silt, silty clay and related till-like mixtures; and till and peat. The use of the terms clay, silt, and sand is based on the diameter of the constituent particles, as follows: clay, less than 0.002 mm; silt, 0.002 to 0.05 mm; and sand, 0.05 to 2 mm. The clays and silts of this area are believed to consist largely of fine particles of feldspars, quartz, and other common rock minerals, and to contain only a small proportion of clay minerals.

Glacial till is a compact unsorted mixture of sand, silt, clay, pebbles, and boulders, which was deposited directly beneath glacial ice. Mechanical analyses of the fine fraction of representative samples of Sumas till averaged 63 per cent sand, 33 per cent silt, and 4 per cent clay. The tills in the mountain valleys have a greater proportion of sand than tills of the same age in the Fraser Lowland.

Outwash refers to the sediments deposited by streams issuing from glaciers; in the map-area these sediments are mainly interbedded sand and gravel deposited in deltas, flood-plains, and meltwater channels.

STRATIGRAPHY AND DISTRIBUTION OF DEPOSITS

Figure 1 is an attempt to show graphically the complex stratigraphic relations of deposits comprising the Vashon, post-Vashon, and Salish groups.

A Cordilleran ice-sheet is known to have covered the area more than 12,000 and probably less than 25,000 years ago. The only deposits exposed in the map-area that are believed to be related to this ice-sheet form a thin mantle on bedrock in the higher mountains. Huntingdon gravels (2), the oldest known unconsolidated deposits in the map-area, appear to be stream deposits laid down following the retreat of the Cordilleran ice-sheet. These gravels and related deposits are overlain by sediments transported by the Sumas ice-sheet which apparently originated in the Cascade Mountains about 11,000 years ago and advanced into the Fraser Lowland as a valley glacier to a point a few miles west of Abbotsford.

Huntingdon gravel (2), underlying Sumas till (3), is exposed in a good section between Abbotsford and the International Boundary, along the cliff at the west end of Sumas Valley. Also in the Ryder Lake district, Huntingdon gravel (2) is exposed toward the Chilliwack River valley, underlying Sumas till (3). Huntingdon gravels are also present at the north end of Hatzic Valley and near Harrison Bay.

Sumas till (3) is present in the upland areas south of Abbotsford, on Sumas Mountain, and in the Ryder Lake district.

Abbotsford outwash (4) covers an area that extends south of Abbotsford to the International Boundary; on the lower rolling hills at the west end of Sumas Mountain, drill-holes have penetrated more than 100 feet of these deposits. North of Fraser River, Abbotsford outwash (4) extends from Deroche to Harrison Mills. It also covers the floor of Columbia Valley.

The post-glacial deposits (5-9), which comprise the Salish group, include lake, stream, flood-plain, slopewash, and swamp deposits, all occupying the low-lying areas. Lacustrine deposits (5), present at the surface throughout Sumas Valley, consist of silt, clayey silt, and silty clay deposited during a period when Sumas Valley was occupied by standing water. As the sediments were deposited the lake became progressively smaller, and beaches and spits were left in the southwest part of Sumas Valley as elongated ridges. Sumas Lake, drained in 1926, occupied part of this area.

Stream deposits (6) occupy a large part of the map-area and in places are mixed with Fraser flood-plain (7) and lacustrine (5) deposits. The stream deposits (6), up to 50 feet thick, represent material deposited by Chilliwack River as it reached the Sumas-Chilliwack Valley and emptied into Sumas Lake.

Fraser flood-plain deposits (7) occupy areas bordering the present channel of Fraser River and represent those deposits left at flood stages of the Fraser River system.

Swamp deposits (9) occupy lowland areas of poor drainage in which peat, clayey peat, and peaty clay accumulated. Slopewash deposits (8), in particular fan and stream deposits, represent recent deposition of sand and gravel at the base of mountains from streams that rise on their summits.

Within Sumas Valley the lacustrine deposits, in places as much as 200 feet thick, are underlain by similar older deposits, probably Cloverdale sediments. The thickness of Cloverdale and lacustrine deposits together is perhaps more than 1,000 feet.

Chapter III

GROUND-WATER GEOLOGY

GENERAL CONDITIONS

Ground water occurs beneath the land surface in a zone where all the pores in the containing rock materials are saturated. This zone may extend to the surface in places such as seep areas, marshes, lakes, and stream channels. Elsewhere the zone of ground water exists at depths of a few inches to hundreds of feet beneath the land surface, separated from the surface by a zone of aeration or a confining layer of impervious material. Some water is held in the zone of aeration—soils in particular hold significant quantities of water—but this water cannot be extracted by wells. Wells must permeate the zone of aeration or, where present, an impervious layer to reach the underlying ground-water zone.

Source

The source of all ground water is precipitation that falls as rain or snow on the immediate or adjacent areas. Annual precipitation provides an abundance of water to recharge the ground-water reservoirs. (One inch of rainfall covering one square mile is equivalent to approximately 14,520,000 imperial gallons.) The average annual precipitation at Chilliwack is 61.18 inches and at Agassiz 63.19 inches.

Some of the precipitation, after wetting the foliage and ground, runs off the surface to drains and streams. Of the precipitation that infiltrates the soil zones, part is absorbed by plant roots and part is lost in evaporation. The remainder percolates downward to the ground-water reservoirs. Such factors as temperature, amount and intensity of precipitation, slope of the land surface, and the character and texture of the surface deposits determine the amount of precipitation that will infiltrate the soil zone.

Occurrence and Movement

All water beneath the land surface occurs in voids, interstices, or pore spaces of the unconsolidated surface deposits and in fractures and fissures of bedrock. In the map-area the unconsolidated surface deposits are in places 1,000 or more feet thick, and contain the principal aquifers; some water, however, is obtained from bedrock on Sumas Mountain.

In clays and silts most of the water is held by molecular attraction and is therefore not free to supply springs or wells. Coarse material such as sand or gravel contains larger interstices and pore spaces between the grains and provides a porous or permeable medium through which ground water is free to move under the influence of water-table slopes or gravity. This water is readily available to supply springs and wells.

Ground water moves at rates measured in feet per day to feet per year, and the movement is from recharge areas to discharge areas. Recharge areas are those where the surface deposits are permeable and allow maximum infiltration of precipitation. Discharge is by artificial means such as wells, and by natural means such as springs and seeps.

Water-table

When wells are dug or drilled in unconfined permeable materials, the moisture content increases with depth until a zone of saturation is reached in which all pore spaces are saturated. The water-table is the level at which the water stands in such a well, and is roughly parallel to the top of the zone of saturation. It generally slopes with a gradient in the direction of ground-water movement. Water-tables fluctuate with changes in the amounts of recharge and discharge. In Sumas Valley a water-table is within a few inches of the surface; during some months it is at the surface. Fluctuations of the water-table in the map-area are seasonal. The greatest variation is in the Agassiz area where a rapid rebound of the water-table is observed after one or two days of precipitation.

GROUND-WATER RESERVOIRS

Ground-water reservoirs or aquifers are saturated zones or strata of permeable material, from which ground water can be obtained by pumping or natural flow. Within the unconsolidated surface deposits of the map-area there are three main types of ground-water reservoirs, all glacial; namely, perched, unconfined, and confined.

Perched ground water occurs in permeable saturated sediments separated from the main body of ground water by an impervious strata. Perched reservoirs are present in the Sumas till (3) as local lenses of sand and gravel. They yield supplies commonly sufficient for domestic or stock needs only.

Unconfined ground-water reservoirs provide nearly all the ground water used within the map-area. Unconfined ground water is present in the Abbotsford outwash deposits (4), in the Huntingdon gravels (2) in part, in the lacustrine deposits (5), in the stream deposits (6), and in the Fraser flood-plain (7) and channel deposits. All of these deposits are permeable; they cover much of the map-area, are near the surface, are recharged directly by precipitation or infiltration from surface water, have a water-table below which they are saturated, and have extensive recharge areas.

Confined ground-water reservoirs are those underlying impermeable materials. The confining layer is not necessarily impermeable, but is always less permeable than the reservoir materials. The water is under pressure and rises in the well to a point markedly higher than the top of the reservoir. One confined ground-water reservoir that supplies important amounts of water is the Huntingdon gravel (2) deposits where overlain by Whatcom glacio-marine deposits. Throughout Sumas Valley confined ground-water reservoirs are expected to exist beneath the fine sediments that fill the valley to depths of perhaps 1,000 feet. Confined water in such reservoirs would likely be under sufficient pressure to rise to the land surface and overflow. Wells that obtain water from confined reservoirs are termed artesian wells. If the pressure is such that the water rises to the surface and flows, then the well is termed a flowing artesian well. The height, then, to which the water rises in the well, is not the water-table but rather a pressure surface, called the piezometric surface.

GROUND-WATER GEOLOGY IN THE MAP-AREA

As indicated in Figure 1, a variety of geological environments existed at the time of deposition of the unconsolidated surface deposits. This gave rise to permeable outwash deposits that provide storage for large volumes of ground water, to compact till that yields little or no water, and to the post-glacial Salish group of sediments which provide complex ground-water conditions. The occurrence and development of ground water in each township or district is discussed in the following.

Township 16

Only that part of township 16 that is in Sumas Municipality is discussed here. The remainder of the township is discussed in a report on Matsqui Municipality (see Halstead, 1959).

Sections 1, 2, 11, and 12 are in Sumas Valley. They are bounded on the west by an upland area and on the north by Sumas Mountain. Sections 3, 10, and 15 are part of the Abbotsford upland which comprises approximately 25 square miles extending south and west from Abbotsford.

Reservoirs and Development

In the Abbotsford upland, outwash deposits of sand and gravel are present at the surface except where overlain by Sumas till (3). The outwash (4), in places as much as 90 feet thick, constitutes an unconfined ground-water reservoir. The water-table fluctuates seasonally, being within 15 feet of the surface after the heavy rains of the winter and as low as 25 feet below the surface following a dry summer. The water-table slopes to the south and east, and springs are common where it intersects the edge of the upland.

Huntingdon gravel (2) is also an important ground-water reservoir in the Abbotsford upland. In places Huntingdon gravel underlies Abbotsford outwash, but glacio-marine deposits commonly separate the two as a nearly impermeable barrier and provide confined ground-water conditions in the underlying reservoir. In sections 3, 10, and 15, coarse Huntingdon gravel is encountered at depths ranging from 80 to 180 feet. In section 3 some wells encountering this confined aquifer yield flowing artesian water, whereas in sections 10 and 15 confined water rises to levels ranging from 45 feet to only a few feet below the surface.

On Sumas Mountain, Abbotsford outwash (4), Sumas till (3), and mixtures of sand, gravel, and till overlie the bedrock. The outwash constitutes an unconfined aquifer, but in places it is too thin to provide storage for sufficient quantities of water to meet farm or domestic needs. Where the surficial deposits are too thin or fail to yield sufficient water, wells, especially where drilled, are continued into the underlying bedrock. The bedrock is not permeable and water movement is confined to fractures and fissures within it. Although providing some water, the bedrock on Sumas Mountain is not considered a major aquifer.

At the base of Sumas Mountain, and within the abandoned channel between Sumas Mountain and Abbotsford upland, outwash sand and gravel constitutes an important aquifer. In places the outwash may be overlain by more recent silt and alluvium.

In sections 1, 2, 11, and 12, lacustrine deposits (5) are present at the surface except where they are overlain by peat at the base of Abbotsford upland. The lacustrine deposits consist of silt, silty clay, and clayey silt up to 50 or more feet thick, and although saturated, they do not yield sufficient water to qualify as ground-water reservoirs. Fine sand underlying the lacustrine deposits yields water under pressure sufficient to cause it to rise to the surface and overflow.

Recharge and Discharge

The Abbotsford outwash sand and gravel deposits are permeable and allow downward percolation of most of the rainfall. These deposits are present at the surface over a large part of Abbotsford upland and Sumas Mountain. They provide not only the recharge areas but also, where thick, reservoirs for the storage of ground water.

Ground water discharges naturally at the surface as springs along the edge of Abbotsford upland and at the base of Sumas Mountain in section 15. Some of the springs are the overflow from the water-table but others represent the seepage of water at the contact where saturated gravel and sand overlie impervious glacio-marine deposits.

Ground water in the unconfined aquifers discharges through downward percolation to recharge the underlying confined aquifers.

Recovery

In township 16, significant volumes of ground water for municipal and industrial use are recovered from the Abbotsford outwash and Huntingdon gravel.

In SE 1/4 sec. 15, an earth dam, constructed at the Fraser Valley milk producers' plant, creates a surface reservoir that collects and stores ground water discharged by springs along the edge of Abbotsford upland. This plant probably consumes about 10,000 gallons of water an hour.

At the Pacific Co-op (well 21, Table II), a well penetrated 24 feet of slumped Sumas till and Whatcom glaciomarine deposits overlying 24 feet of Huntingdon gravel. The confined water in the Huntingdon gravel was under sufficient pressure to rise to the surface and overflow at a rate of 10 gallons a minute. The development procedures carried out included the installation of 15 feet of well screen and surging operations. This well will yield 18,000 gallons an hour.

Well 26 (Table II), drilled for the municipal supply at Abbotsford, is at the base of Sumas Mountain on the edge of an abandoned meltwater channel. The well penetrates 61 feet of Abbotsford outwash gravel. A well screen was installed and development procedures carried out. When pumped at a rate of 230 gallons a minute, the drawdown in this well was 34 feet—that is, the water level in the well lowered during pumping from a static level of 5 feet to a pumping level of 39 feet.

Water is recovered for domestic and farm use by means of dug, driven, or drilled wells. Unconfined water is recovered for domestic use in the upland area from wells dug 15 to 35 feet deep, or deeper wells drilled into the Huntingdon gravels. Wells drilled into bedrock on Sumas Mountain recover water from fractures in the bed-rock, and yields of 5 to 10 gallons a minute are reported. In Sumas Valley, poor-quality water, commonly with a high iron content, is available within the lacustrine deposits, and confined water is recovered by driving sand-points into the underlying fine sands.

Well Logs

	Material	Thickness (feet)	Depth (feet)	Formation
Well 22 (Table II), Test-hole, SW 1/4 Sec. 15	'hardpan'	36	36	Sumas till
	coarse gravel, water	1	37	
	blue clay	18	55	Whatcom glacio-marine deposits
	coarse gravel, water	4	59	Huntingdon gravel
	hard-packed gravel	21	80	
	coarse sand, water	8	88	
	sand, some gravel, sandy clay	27	115	
	silty clay	25	140	Newton glacio-marine deposits
	blue clay	90	230	
Well 8 (Table II), Test-hole, NE 1/4 Sec. 3	silt, clay	70	70	lacustrine and older deposits
	sand, some gravel, water	14	84	

Township 19

Most of township 19 is in Sumas Valley. It is bounded on the northeast by Sumas Mountain and on the southeast by Vedder Mountain. Sumas River and its tributaries, Lonzo and Saar Creeks, as well as man-made channels, drain the valley area.

The communities of Kilgard and Straiton are located on Sumas Mountain in the northwest corner of the township. The southeast corner lies on Vedder Mountain. Surface run-off from Vedder Mountain is collected to supply the 3,500-gallon daily consumption of the Arnold Creek waterworks system in sections 2, 3, 4, 10, and 11, and the 1,000 gallons needed daily by the Kidd Creek Water system in sections 12 and 13.

Reservoirs and Development

Sumas Valley is underlain by unconsolidated deposits that are probably more than 1,000 feet thick. Lacustrine deposits (5), up to 50 feet thick, are present at the surface. They consist of silt, clayey silt, and silty clay, and in places, sand beaches of the former Sumas Lake. Older deposits of silt and clay underlie the lacustrine deposits.

The lacustrine deposits, including the sand beaches, constitute an unconfined aquifer. Local lenses of silt or silty clay in effect function as confining layers; but as a whole the ground water within the lacustrine deposits is considered as free, unconfined water and the water-table is at or within a few feet of the land surface. To provide satisfactory working conditions during the laying of a pipeline across the valley, this high water-table was lowered sufficiently by the installation of temporary wells that were pumped at 50,000 or more gallons an hour.

The unconsolidated surface deposits overlying the bedrock on Sumas Mountain are commonly less than 25 feet thick. They consist of mixtures of sand, gravel and Sumas till. In places, gravel underlying these mixtures constitutes a local aquifer that will yield 3 to 5 gallons a minute. No test-holes have been drilled into the bedrock for ground water, but aquifers yielding ample water have been encountered in bedrock test-holes drilled for the Clayburn Co. Ltd. on Sumas Mountain.

Recovery

Ground water is recovered from the lacustrine and beach deposits by shallow dug or driven wells. The water is commonly of poor quality with a high iron content. Large volumes of ground water are available for irrigation, and three irrigation wells—Nos. 3, 6, and 8 (Table III)—will each supply about 200 gallons a minute.

At Sumas pump station, well 13, (Table III), an aquifer at a depth of 35 to 39 feet was developed by means of screen installation, gravel-packing, and surging. The well was test pumped at 50 gallons a minute. The water has a high iron content.

On Sumas Mountain, wells are dug into the unconsolidated surface deposits. Where permeable sand and gravel are encountered they supply sufficient water to meet domestic needs. Elsewhere, wells dug into the till-like mixtures function as cisterns collecting surface run-off; during the summer months they are dry.

Well Logs

	Material	Thickness (feet)	Depth (feet)	Formation
Well 13 (Table III), Test-hole, Sumas Pump Station	silty clay	19	19	lacustrine deposits
	fine sand	7	26	
	fine sand, silt, clay	9	35	
	fine sand	4	39	
	blue clay	61	100	Cloverdale sediments
Well 11 (Table III), Test-hole, Sumas Air-strip	sand	3	3	lacustrine deposits
	sand and gravel	6	9	
	silt, clayey silt, clay, minor sand, wood	74	83	
	clayey silt, silty clay, clay and minor sand	238	321	Cloverdale sediments

Township 20

Most of township 20 south of Fraser River consists of the northern part of Sumas Mountain; only section 1 and part of sections 2, 12, and 13 are in Sumas Valley. North of Fraser River, the township includes a flood-plain area extending east from Hatzic Lake to Norrish Creek and the west part of Nicomen Island.

Surface water collected by a dam on the northeast end of Sumas Mountain is the source of the Barrowtown water supply. Twenty-two farms in sections 12 and 13 use 40,000 gallons daily from this source.

Reservoirs and Development

Sumas Valley is underlain by lacustrine (5) and older deposits consisting of silt, silty clay, clay and fine sand. Although these deposits do not contain a good aquifer some water has been recovered from lenses of sand within them. A test-hole drilled in section 12 penetrated 610 feet of interbedded silt, clay, and fine sand, but did not encounter sufficient water.

On most of Sumas Mountain, unconsolidated surface deposits are thin or lacking. However, locally, mixtures of till, sand, and gravel are thick enough that wells are dug into them, and limited aquifers of gravel have been found below the till-like mixtures. A well drilled in section 6 encountered gravel below till that yields 3 gallons a minute. Ground water is probably available from the bed-rock, and the same bedrock aquifer conditions exist as in township 19.

Areas of slopewash (8) along the base of Sumas Mountain consist of sand and gravel and are worth prospecting as sources of ground water.

North of Fraser River, Fraser flood-plain deposits (7) are more than 100 feet thick. They consist of sand and minor silt up to 10 feet thick, resting on gravel and in places mixed with stream deposits of sand and gravel. The Fraser flood-plain deposits constitute an unconfined aquifer from which sufficient supplies of good-quality water are obtained from shallow dug or driven wells.

In SW1/4 sec. 32, a test-hole penetrated 150 feet of Fraser flood-plain and older deposits. Water under artesian pressure was encountered at 130 feet in an aquifer of fine sand, but development procedures failed to produce sand-free water.

Well Logs

	Material	Thickness (feet)	Depth (feet)	Formation
Well 3 (Table IV),	brown clay, boulders	12	12	Sumas till
SE 1/4	gravel and boulders	6	18	Sumas till
Sec. 6	gravel, water	4	22	outwash (?)

(cont'd)

	Material	Thickness (feet)	Depth (feet)	Formation
Well 4 (Table IV), Test-hole, SW 1/4 Sec. 12	silt and fine sand	135	135	lacustrine and Cloverdale sediments
	silt, silty sand and fine sand	77	212	
	silty, silty clay, clay	16	228	
	silt, and fine sand	182	410	
	silty clay, clayey silt and clay	200	610	
Well 8 (Table IV), Test-hole, SW 1/4 Sec. 32	clayey silt and silty clay	28	28	Fraser flood-plain and older deposits
	sand, silty sand and minor silt	40	68	
	sand, gravel, minor clay and silt	12	80	
	fine sand	11	91	
	sand, silty clay and minor gravel	7	98	
	silty clay, clayey silt, sand	27	125	
	sand	5	130	
	silty clay with wood	2	132	
	fine sand	9	141	
	fine sand and clayey silt	9	150	

Township 22

A large part of this township is occupied by Vedder Mountain which is separated from the Cascade Mountains to the south and east by Columbia Valley and Cultus Lake. The northwest corner of the township, sections 30, 31, 32, and part of 33, lie in Sumas Valley.

Run-off from Vedder Mountain is controlled on creeks that rise in sections 33 and 28, and is distributed through a gravity system to supply a daily consumption of 450,000 gallons in the Yarrow district. The Cultus Lake resort area is supplied by water, collected in a 100,000-gallon storage tank, from three creeks on the southeast end of Vedder Mountain.

Reservoirs and Development

In the Yarrow district, stream deposits (6) resting on lacustrine deposits (5) form a shallow aquifer from which ground water may be recovered by installing dug or driven wells. However, the water supply is limited and little or no ground water is developed. Instead, surface water distributed by the Yarrow waterworks system is used. To meet the increasing demands on the waterworks system, especially during the fruit-processing season, a test-hole was drilled in search of ground water. It penetrated 400 feet of lacustrine and older deposits, but yielded insufficient water to warrant development. A well drilled for a food-processing plant in NE 1/4 sec. 29 supplies 2,400 gallons of water an hour for 24-hour periods throughout the processing season.

In Columbia Valley the unconsolidated surface deposits consist of outwash gravel, sand, and lenses of till. Springs are common along the side of the valley and issue at the contact of the surface deposits and bedrock. Wells are shallow, commonly less than 25 feet deep, and yield supplies sufficient for stock and domestic use.

On the terrace at an elevation of approximately 725 feet in section 10, a dry hole penetrated 75 feet of shale overlain by a thin mantle of gravel. Although this test-hole failed to yield water, it is expected that supplies sufficient for domestic and stock needs may be developed from drilled wells that encounter fractures and fissures in the shale.

Stream deposits (6) at the south end of Cultus Lake are permeable and constitute an unconfined aquifer. Wells drilled to depths up to 50 feet yield about 25 gallons a minute; it is expected that developed wells could yield larger volumes.

Well Logs

	Material	Thickness (feet)	Depth (feet)	Formation
Well 8 (Table V), Well, NE 1/4 Sec. 29	gravel and clay	23	23	stream deposits
	gravel, some water	2	25	
	clay	9	34	lacustrine deposits
	gravel, sand, water	1	35	
	clay, minor gravel	30	65	
	gravel, water	4	69	

(cont'd)

	Material	Thickness (feet)	Depth (feet)	Formation
	silty clay	11	11	stream deposits
	clay, sand, wood	3	14	
	gravel, water	3	17	
	fine sand, silt, wood	3	20	
	fine sand, silt, clay, wood	9	29	
Well 9 (Table V), Test-hole, NW 1/4 Sec. 33	clay	20	49	lacustrine and older Cloverdale sediments
	fine sand, water	2	51	
	clay	23	74	
	fine sand, little water	1	75	
	sandy clay	10	85	
	silty clay	46	131	
	sandy clay	2	133	
	fine sand, clay	9	142	
	clay	21	163	
	sandy clay, little water	15	178	
	clay	222	400	

Township 23

Township 23 occupies part of the flood-plain area that extends northeast from Sumas Valley. Vedder River crosses sections 1 to 5 and flows into Vedder Canal which joins Sumas River in township 20. Chilliwack Mountain rises to elevations of more than 1,200 feet in section 27, but elsewhere the surface is generally flat. Fraser River crosses the northeast corner of the township.

Reservoirs and Development

Surficial flood-plain, channel, stream, and lake deposits consist of silt, silty clay, sand, and gravel. The stream deposits (6) constitute an unconfined aquifer into which wells are dug or drilled to depths of 50 feet or less. The lacustrine deposits (5) and Fraser flood-plain deposits (7) yield sufficient water, which is recovered by driven wells up to 100 feet deep.

At York Farms, in section 11, ground water is developed to meet the daily demand of about 400,000 gallons. A well 53 feet deep penetrates gravel, and is fitted with a screen in the bottom 10 feet.

At the Chilliwack army camp water is taken from Vedder River, and a drilled well supplies the Bridging area in section 4.

Well Logs

	Material	Thickness (feet)	Depth (feet)	Formation
	gravel	12	12	stream deposits
	blue clay	4	16	
Well 10 (Table VI), Test-hole, NE 1/4 Sec. 10	gravel, sand some clay	39	55	
	blue clay	3	58	lacustrine and older Cloverdale sediments
	sand, gravel	4	62	
	hard blue clay, silt	26	88	
	fine sand, silt, clay	42	130	
	coarse sand	12	142	
	fine sand, clay	17	159	
	clay, little sand	42	201	
Well 11 (Table VI), Well, NE 1/4 Sec. 11	gravel, sand, some silty layers	24	24	
	gravel, sand, clay	6	30	
	coarse gravel, sand	4	34	lacustrine deposits
	clay	1/2	34 1/2	
	gravel and sand	7 1/2	42	
	coarse gravel	11	53	

Township 24

Most of this township is occupied by mountains that rise to elevations of more than 4,000 feet. A belt of Fraser flood-plain and channel deposits (7), approximately a mile wide, extends from the base of the mountains to Fraser River. Recessional outwash and ice-contact gravel and sand (4) are found overlying the bedrock on the lower slope and at the base of the mountains.

Fraser flood-plain and channel deposits (7) yield sufficient water for domestic and farm needs. Wells are dug or sand-points driven to depths of less than 25 feet. In section 4 on Nicomen Island a test-hole drilled to a depth of 50 feet was abandoned, and a sand-point was installed at a depth of 35 feet where an adequate supply of water was obtained.

The outwash and ice-contact gravel and sand (4) provide, in places, suitable aquifers, but these deposits are commonly thin and are most effective as recharge areas for the flood-plain and channel deposits. Surface water is collected from streams on the mountains, and at Deroche, water is supplied by a gravity system installed on Deroche Creek.

Township 25

With the exception of Chilliwack River valley, this township is mountainous. Recessional outwash and stream deposits of gravel and sand occupy the valley and provide storage for the ground water obtained by digging shallow wells or driving sand-points.

Township 26

Ryder Lake district, which lies in the southeast part of this township, is hilly, with elevations that rise to more than 2,700 feet above sea-level. The rest of the township lies within a flood-plain area that has a relatively flat floor, not more than 25 feet above sea-level.

Reservoirs and Development

Within the Fraser flood-plain area silty clay, clayey silt, and silt up to 30 feet thick rest on sand and gravel, and in places, stream deposits of gravel and sand up to 50 feet thick are present at the surface. These surficial deposits together constitute a widespread ground-water reservoir with a near-surface water-table. Ground water available in this unconfined reservoir should provide an ample supply for present and future irrigation needs. Water for domestic and farm needs throughout the lowland area is provided by the Elk Creek waterworks.

In sections 7 and 18 stream deposits of sand and gravel up to 50 feet thick are present at the surface. These deposits provide an excellent ground-water reservoir, and wells drilled or dug to depths of less than 50 feet provide sufficient supplies for domestic and farm needs.

In the Ryder Lake district, glacial drift consisting of sandy Sumas till and, in places, stratified drift, overlie the bedrock.

Some water percolates through the till and is stored where stratified drift has accumulated, but most of the rainfall is lost to direct run-off. Therefore, wells commonly do not yield sufficient supplies and during the summer months are dry.

The bedrock consists of shales and argillites that may yield some ground water from joint and fracture zones. No wells or test-holes have been drilled into the bedrock.

Well Logs

	Material	Thickness (feet)	Depth (feet)	Formation
	peaty loam	22	22	swamp deposits
Well 5 (Table VII), Test-hole, NW 1/4 Sec. 9	blue clay	5	27	Fraser flood-plain and older deposits
	silt and fine sand	1	28	
	coarse sand, rusty water	10	38	
	clay	17	55	
	clay, silt, fine sand	66	121	
	coarse sand, water bailed dry in 20 minutes	2	123	
Well 2 (Table VII), Well, NW 1/4 Sec. 5	sandy till, boulders	23	23	Sumas till and till-like mixtures overlying bedrock
	gravel	1	24	
	clay	6	30	
	sand, gravel, little water	2	32	
	sandy till	19	51	
	boulders	2	53	
	dry gravel	10	63	

Townships 27 and 30

Townships 27 and 30 within the map-area are not entire townships owing to the land subdivision into the New Westminster and Yale land districts. The area included in these townships lies south of Fraser River and east of Chilliwack and is divided into island segments by sloughs and drainage ditches.

Fraser flood-plain deposits (7) at the surface rest on gravel and constitute an unconfined ground-water reservoir. An irrigation well on lot 459, Fairfield Island, penetrated 30 feet of permeable sand and gravel and yields 25 gallons a minute.

Although much of the area is supplied by Elk Creek waterworks, large volumes of ground water for irrigation can probably be developed from the permeable surface deposits.

Township 3, Range 28, W6

Included in this township, within the Yale land division, is an area south of Fraser River and Cheam Lake in the northeast corner of the map-area. Flood-plain and channel deposits (7), as well as surface-exposed fan and slide gravel (8) up to 50 feet thick, constitute the principal aquifers. Wells are commonly drilled to depths of not more than 80 feet. At Mount Cheam motor court, a well that penetrated 57 feet of gravel yields sufficient water to supply 12 cabins and 8 trailers.

Kent District Municipality

The northeast corner of the map-area, north of Fraser River, is in Kent District Municipality. This area is generally flat, and dissected with sloughs and drainage ditches. Fraser flood-plain deposits (7) are present at the surface except where bedrock outcrops on Woodside, Hopyard, and Cemetery Mountains.

The flood-plain deposits consist of silty sand, sandy silt, sand, and some gravel, and constitute the principal aquifer. Unconfined ground-water conditions with a near-surface water-table exist over much of the area, but in places ground water is confined locally below flood-plain silts and clays. Dug or driven wells, 8 to 30 feet deep, obtain sufficient supplies to meet the demand, and large volumes of ground water are available. Fluctuations of the water-tables in this area indicate recharge not only from precipitation but also by infiltration from Harrison Lake and Fraser River.

QUALITY OF WATER

Water samples were collected during the field season and forwarded to the laboratories of the Industrial Waters Section, of the Mines Branch, Ottawa. Table VIII is an analytical report on these samples.

A chemical analysis determines the usefulness of the water. For industrial use, water is required to meet certain standards. Hardness is one property that affects all users because hard water is soap-consuming, and when hard water is heated a scale is deposited in the container. Calcium and magnesium, which cause water hardness, are present as both calcium and magnesium carbonates and calcium and magnesium sulphates in the samples analyzed. Table VIII shows total hardness, expressed as parts per million, ranging from 43.1 to 134.6. Water with a total hardness of less than 60 parts per million is soft; from 61 to 120 parts per million is medium to hard; and more than 121 parts per million is hard. The ground water in the map-area is generally medium to soft, but there are some exceptions. Where hard water is found, its total hardness is not excessive and does not limit the use of the water.

Ground water with a high iron content is objectionable. It stains kettles, pails, and porcelain fixtures, and pipelines or conduits conducting such water may become clogged with iron precipitates. Most of the ground water obtained from the lacustrine deposits within Sumas Valley has a high iron content.

The suitability of ground water for irrigation is determined not only by the crop to be irrigated but also by the type and drainage conditions of the soil. Plants will not tolerate salty water, and water with a high sodium content will reduce the permeability of the soil. Ground water in the map-area falls within safe limits for irrigation use. Some might be rejected because of its high iron content and the probable damage it would cause to the distribution system.

A representative sample of surface water was analyzed and the results are included in Table VIII. Surface water differs from ground water mainly in physical properties such as colour and turbidity. It may be yellow to brown owing to leaching of decaying vegetation, and at some seasons of the year it may be turbid as a result of suspended clay, silt, or finely divided organic matter. High colour is detrimental in some process waters, and, for practically all uses, turbidity causes trouble.

The fairly constant chemical quality and constant temperature of ground water are factors that favour its development where it is available in sufficient volume.

USE AND DEVELOPMENT

Permeable sand and gravel at or within a few feet of the surface provide extensive recharge areas and storage reservoirs for large volumes of good-quality ground water within the map-area. Fraser flood-plain deposits, Abbotsford outwash, stream, and, in places, lacustrine deposits are the principal unconfined ground-water aquifers. The Huntingdon gravel is by far the most important confined ground-water reservoir, but in places, confined gravel is found underlying till in the mountain areas. Bedrock supplies a limited amount of ground water in areas where the surficial deposits are thin. or lacking, but elsewhere its importance as a source of ground water has not been considered in this report.

Domestic and Municipal Use

By far the greatest use of ground water is for domestic supplies. Wells are dug, driven or drilled and each is required to yield perhaps as much as 500 gallons daily.

Surface water has met much of the demand in the map-area. The Elk Creek waterworks system utilizes surface water from creeks that rise in the Cascade Mountains and this water is distributed throughout Chilliwack city and the greater part of Chilliwhack Municipality. The daily consumption is about 3,700,000 gallons. Creeks that rise on Vedder Mountain supply the Yarrow waterworks system with 450,000 gallons daily, the Kidd Creek system with 4,000 gallons daily, and the Arnold waterworks with 3,500 gallons daily. The Barrowtown waterworks obtains surface water from a creek on the northeast end of Sumas Mountain and the daily consumption averages 40,000 gallons. At Deroche, north of Fraser River, water is supplied to the immediate area from Deroche Creek.

Ground water supplies the village of Abbotsford and part of Sumas Municipality south of Abbotsford. A daily volume of 300,000 gallons is pumped from outwash gravel at the base of Sumas Mountain and within the channel between Sumas Mountain and Abbotsford upland.

Irrigation Use

The constant temperature and low sodium content make ground water a dependable source of irrigation water. The fact that wells can be located near the centres of areas to be irrigated allows for convenience and economy of pumping. Fraser flood-plain and lacustrine deposits are widespread and provide abundant supplies for irrigation use.

In general irrigation requirements may be determined on the basis of 15 gallons a minute for each acre to be irrigated. At this rate approximately 2 1/2 inches of water per acre will be applied over a 6-day period, pumping for 12 hours each day. The installation of a sprinkling system may be decided by the capacity of the well, assuming each sprinkler will deliver approximately 8 gallons a minute. Well 6 in township 19 supplies 14 sprinklers, thus delivering 112 gallons per minute.

Driven wells may be used to obtain irrigation water. Although a driven well commonly provides not more than 25 gallons a minute, a battery of such wells installed with a common header-unit will, in most cases, provide the required volume of water.

Industrial Use

Ground water for industrial use has been developed from Abbotsford outwash and Huntingdon gravel in section 16. During the food-processing season a well at the Pacific Co-Op will supply about 200,000 gallons daily. At the Fraser Valley milk producers' plant, perhaps 100,000 gallons of ground water are consumed daily. At Yarrow, a food-processing plant consumes 60,000 gallons of ground water daily during the summer season. At Canada Packers' plant in section 11, township 23, ground-water requirements exceed 400,000 gallons daily in some seasons.

CONCLUSIONS

Ground water is available, and its development should solve water problems that may arise in the map-area in the next several years. Permeable surficial deposits with large areal extent provide valuable recharge areas and storage reservoirs. Bedrock is a source of water for domestic supplies in mountainous areas where surface deposits are thin or lacking.

For municipal, industrial and irrigation use, drilled wells, fitted with screens and completed by methods that assure full development of the aquifer, will provide safe yields. The permeable flood-plain deposits are a potential source of large volumes of water that may be obtained where these deposits border the Fraser River. Radial type or tubular wells installed in the flood-plain deposits will provide for induced infiltration of water from Fraser River, and the volume available should be sufficient to meet all present and future water demands in the map-area.

APPENDIX

Table II

Records of Representative Wells and Test-holes, Township 16, E.C.M.

Well No.	Location		Description of Well					Principal Aquifers			Remarks
	1/4	Sec.	Type	Casing Diam. (inches)	Depth (feet)	Collar Elev'n (feet)	Static Level (feet)	Depth to Top (feet)	Character of Material	Formation (see legend, Map 40-1960)	
1	SE	1	Driven		33	29		18	sand	5a	Penetrated clay to 18 feet, fine sand to 33 feet
2	NW	1	Driven	1 1/2	65	43			sand	5a	High in iron
3	NW	1	Driven	1 1/4	73	29	-70		sand	5	Soft, high in iron
4	NE	2	Driven	1 1/2	70	28	-60		sand		
5	SW	2	Driven	1 1/2	70	34	0		sand		Overflows at surface
6	NW	2	Driven	1 1/2	71	29	+2		sand		Flowing; 90 gals. per hr.
7	NE	3	Dug	48	97	193			gravel	2	Sumas till for 10 feet, Huntingdon gravel to 97 feet
8	NE	3	Test-hole	6	84	40	0	70	gravel	2(?)	Flowing; pumped at 16 gals. per min.
9	SE	3	Driven		27	99		8	gravel	2	Penetrated 8 feet of Sumas till and 19 feet of Huntingdon gravel; yield 300 gals. per hr.
10	NW	3	Drilled	4	124	123	-49	120	gravel	2	Sumas till to 62 feet, 58 feet of sand and gravel
11	NW	3	Dug	30	81	183	-76	33	gravel	2	Sumas till to 33 feet, Huntingdon gravel 33-81 feet

12	SW	10	Dug	36	82	189	-74	18	gravel	2	Sumas till to 18 feet, gravel 18-82 feet
13	NW	10	Dug	30	32	184	-28	10	gravel	2	Sumas till to 10 feet, gravel 10-32 feet
14	SW	11	Driven	1 1/4	80	22	+1		sand		Flowing well
15	SW	13	Drilled	4	65	40	-18	10	bedrock		Water from fractures in bedrock
16	NE	14	Drilled	5	110	225	-20		bedrock	1	
17	SE	14	Drilled	6	85	52	-15		bedrock	1	Yield 120 gals. per hr.
18	SW	14	Drilled	6	24	63	-16	17	gravel	4	Yield 240 gals. per hr.
19	SW	14	Drilled	6	95	187		90	bedrock	1	Supplies 8 homes
20	NE	15	Drilled	4	120	80	-60	100	sand	2	Yield 600 gals. per hr.
21	NE	15	Drilled	12	48	60	0	24	gravel	2	Flowing at 10 gals. per min., pumped at 300 gals. per min.
22	SW	15	Test-hole	10	230	176	-35	80	gravel		See log; yield 45 gals. per min.
23	SW	15	Dug	30	40	164	-34	36	gravel	2	Dune sand to 8 feet, Sumas till 8-36 feet, gravel 36-40 feet
24	NW	15	Test-hole	8	237	173	-70	180	gravel	2	Yield 30 gals. per min.
25	SE	22	Drilled	4	90	253	-86				
26	SW	22	Drilled	10	61	92(?)	-5	0	gravel	4	Yield 230 gals. per min.
27	SE	23	Dug	36	12	188	-6		gravel	4	

Table III

Records of Representative Wells and Test-holes, Township 19, E.C.M.

Well No.	Location		Description of Well					Principal Aquifers			Remarks
	1/4	Sec.	Type	Casing Diam. (inches)	Depth (feet)	Collar Elev'n (feet)	Static Level (feet)	Depth to Top (feet)	Character of Material	Formation (see legend, Map 40-1960)	
1	SW	4	Driven	1 1/4	10	28			sand	5	See analysis (Table VIII)
2	NE	5	Driven		20	20	-13	13	sand	5	Rusty water
3	NE	5	Drilled	6	43	18	-16	15	gravel	5	Yield 200 gals. per min. Two drilled irrigation wells on farm
4	NE	6	Driven		14	21	-10	5	sand	5	Silt and clay to 5 feet, sand 5-14 feet
5	NW	7	Dug		20	20	-2		sand	5	Rusty gravel to 5 feet, gravel 10-18 feet, sand 18-20 feet
6	NW	8	Drilled		31	20	-5	18	sand, gravel	5	Irrigation well
7	SW	9	Driven		30	23	-20		sand	5	Rusty water
8	SW	14	Drilled	10	15	20		1 1/2	sand	5	Test pumped at 229 gals. per min.
9	SW	16	Driven	1 1/4	14	17	-10	8	sand	5	Silty clay to 8 feet, sand 8-14 feet
10	NW	21	Driven	1	12	37			sand	5	Sufficient for 120 head of stock
11	NE	22	Test-hole		361	15					See log
12	NW	25	Drilled	2	100	13	-4				
13	NE	27	Drilled	10	39	15	-19	28	sand	5	See log; yield 51 gals. per min.
14	NE	29	Dug	36	21	607					Not sufficient in summer
15	SE	31	Dug		21	584	-6	8	sand		Gravel 8 to 15 feet
16	NW	33	Dug	36	50	905	-35		sand		

Table IV

Record of Representative Wells and Test-holes, Township 20, E.C.M.

Well No.	Location		Description of Well					Principal Aquifers			Remarks
	1/4	Sec.	Type	Casing Diam. (inches)	Depth (feet)	Collar Elev'n (feet)	Static Level (feet)	Depth to Top (feet)	Character of Material	Formation (see legend, Map 40-1960)	
1	NE	1	Driven	2	68	14	0	68	sand	5	Overflows at surface
2	SW	1	Driven	4	120	13			sand	5	Supply inadequate
3	SW	6	Drilled	6	22	540	-4	18	gravel	4	Yields 3 gals. per min.; see log
4	SW	12	Test-hole	2	610				fine sand	5	See log; some water at 93, 160 and 190 feet
5	SW	19	Driven	1 1/2	18	18	-12		sand	7	
6	SE	29	Driven	1 1/2	25	20	-15		sand	7	
7	NE	30	Driven	2	20	21	-2		sand	7	Yields 1,200 gals. per hr.
8	SW	32	Test-hole		150	16		130	fine sand	7	See log

Table V

Record of Representative Wells and Test-holes, Township 22, E.C.M.

Well No.	Location		Description of Well					Principal Aquifers			Remarks
	1/4	Sec.	Type	Casing Diam. (inches)	Depth (feet)	Collar Elev'n (feet)	Static Level (feet)	Depth to Top (feet)	Character of Material	Formation (see legend, Map 40-1960)	
1	SE	6	Drilled	4	43	575	-38		gravel	4	
2	NW	9	Driven	2	30	570		18	gravel	4	Well dug 18 feet, sand-point driven to 30 feet
3	SE	10	Dug	-	75	725					Dry hole, in bedrock
4	SW	14	Dug	36	30	155	-20		gravel	6	Supplies 120 gals. per day
5	SE	15	Drilled	6	41	195	-23	33	gravel	6	Yields 8 gals. per min.
6	SW	15	Drilled	8	49	190	-24	41	gravel	6	Yields 25 gals. per min.
7	SE	15	Spring	-	8	183			shale		Supplies 70 families
8	NE	29	Drilled	-	69	100	-9	65	gravel	6	Yields 45 gals. per min.; see log. Fitted with well screen
9	NW	33	Test-hole	12	400					5	See log; no supply

Table VI

Records of Representative Wells and Test-holes, Township 23, E.C.M.

Well No.	Location		Description of Well					Principal Aquifers			Remarks
	1/4	Sec.	Type	Casing Diam. (inches)	Depth (feet)	Collar Elev'n (feet)	Static Level (feet)	Depth to Top (feet)	Character of Material	Formation (see legend, Map 40-1960)	
1	SE	1	Drilled		68	100	-58	62	gravel	6	Screen installed
2	NE	2	Drilled	4	38				gravel	6	Yield 700 gals. per hr.
3	NE	3	Driven	1 1/4	42	40	-3	0	gravel	6	
4	SE	3	Driven		30	42		20	gravel	5	Silty clay to 20 feet, gravel 20-30 feet
5	SW	4	Driven	1 1/4	60	24	-54		sand	5	
6	NW	4	Driven	1 1/4	72	24	-15	70	sand	5	Fine sand to 55 feet, blue clay 55-70 feet, sand 70-72 feet; rusty water at 40 feet
7	NE	8	Driven		58	18			sand	5	See analysis (Table VIII)
8	SE	9	Driven	1 1/2	84	17	-10		sand	5	
9	NW	9	Driven	1 1/4	57	19	-15		sand	5	
10	NE	10	Test-hole	4	201						See Log
11	NE	11	Drilled	10	53		-2		gravel	6	See log; screened 43-53 feet
12	SE	11	Drilled	6	41				gravel	6	
13	NE	12	Drilled	6	33		-20	24	gravel	6	
14	NW	14	Drilled	4	145			143	gravel	5	See analysis (Table VIII)
15	NE	15	Driven		30	22	-9		sand	5	
16	SW	16	Driven	1 1/4	34	27	-30	12	sand	5	Clay and silt to 8 feet, gravel 8-12 feet, sand 12-34 feet
17	NW	17	Driven	1 1/2	30	24	-14	22	sand	7	Clay and silt to 12 feet, fine sand, 12 to 22 feet, coarse sand 22-30 feet
18	SW	18	Driven	1 1/4	80	22	-10		sand	5	
19	SW	21	Driven		85	27			sand	5	See analysis (Table VIII)
20	SE	31	Dug		24	26			sand	7	

Table VII

Records of Representative Wells and Test-holes, Township 26, E. C. M.

Well No.	Location		Description of Well					Principal Aquifers			Remarks
	1/4	Sec.	Type	Casing Diam. (inches)	Depth (feet)	Collar Elev'n (feet)	Static Level (feet)	Depth to Top (feet)	Character of Material	Formation (see legend, Map 40-1960)	
1	NE	1	Dug		28	1300		20	sand	3	Seasonal fluctuations
2	NW	5	Drilled		63	502		7	sand	3	See log
3	NW	6	Drilled	6	54		-42	48	gravel	6	
4	NW	9	Drilled	6	127		-101	118	sand	7	Yield 3 gals. per min.
5	NW	9	Drilled		123	78	-14			7	Bailed dry in 20 minutes, rusty water at 27 feet
6	SW	10	Dug		30	720			sandy till	3	Seasonal fluctuations
7	NW	11	Dug		18	741	-8		sandy till	3	Seasonal fluctuations
8	SE	15	Dug		14	647			gravel	3	Sandy till to 12 feet, gravel 12-14 feet

Table VIII

Water Analyses, Sumas and Chilliwhack Municipalities

Location	Owner	Source	Hardness as Ca CO_3			Ca	Mg	Na	K	HCO_3	SO_4	Cl	NO_3	Sum of Constituents
			Total	CO_3	Non-CO_3									
NW 1, tp. 16	I.D. Towes	Well	86.8	86.8	0.0	24.4	6.3	6.5	2.4	120.0	2.8	1.6	3.6	147.8
SW 14, tp. 16	Munro Road Water system	Well	43.1	43.1	0.0	13.9	2.3	8.5	0.5	62.8	3.8	3.8	0.6	73.0
NE 15, tp. 16	Imperial Oil Co. Ltd.	Well	108.0	108.0	0.0	28.9	8.8	8.2	2.0	147.0	6.3	1.0	2.4	158.3
SW 4, tp. 19	J. Reimer	Well	106.0	106.0	0.0	13.0	17.9	6.4	1.5	141.0	2.5	1.6	4.0	164.8
SW 7, tp. 19	I.E. Nells	Well	80.1	80.1	0.0	10.2	13.3	6.5	1.7	109.0	4.9	2.6	1.6	145.5
NE 8, tp. 23	J. J. Enns	Well	78.8	78.8	0.0	25.5	3.7	3.5	1.9	106.0	2.5	0.5	0.0	114.9
NE 12, tp. 23	G. Miller	Well	47.9	43.0	4.9	16.9	1.4	2.8	0.7	52.4	8.5	0.5	1.6	63.4
NW 14, tp. 23	C.E. Finney	Well	127.2	93.6	33.6	46.2	2.9	4.0	0.5	114.0	39.3	0.8	6.0	163.9
SW 21, tp. 23	G. Toop	Well	89.7	89.7	0.0	30.2	3.5	3.9	1.0	114.0	7.1	0.3	3.2	113.1
SW 7, tp. 26	Hipwell drug store	Well	45.6	43.8	1.8	15.8	1.5	2.3	0.6	53.4	6.5	0.3	1.6	62.6
tp. 19	Arnold water-works	Creek	81.9	79.0	2.9	26.9	3.6	3.5	0.4	96.3	10.3	1.1	2.4	107.5
Chilliwack	Chilliwack laundry	Well	134.6	130.0	4.6	35.5	11.2	16.2	1.3	158.5	29.3	8.2	1.6	205.3