ENVIRONMENT CANADA

THE SQUAMISH RIVER ESTUARY
STATUS OF
ENVIRONMENTAL KNOWLEDGE TO 1974

REPORT OF THE ESTUARY WORKING GROUP

DEPARTMENT OF THE ENVIRONMENT

REGIONAL BOARD PACIFIC REGION

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Scientific Services Unit,

Atmospheric Environment Service,

Vancouver, B.C.

Special Estuary Series No.2

JANUARY 31 1975

4. HYDROLOGY AND WATER QUALITY

4 (i) HYDROLOGY

The Squamish delta receives runoff from four sources - the Squamish River, its two main tributaries (the Cheakamus and Mamquam rivers), and the Stawamus River. The Squamish system drains an area of 1404 square miles, of which 904, 371, and 129 sq. mi. are contributed by the Squamish, Cheakamus, and Mamquam rivers, respectively (Water Survey of Canada, 1973). In addition, the Stawamus drainage basin occupies a further 24 sq. mi., emptying into Howe Sound via the Mamquam Channel (Stathers, 1958). Thus, the total area draining to the Squamish delta is 1428 sq. mi.

The first streamflow stations on the Squamish system were established on the Cheakamus River and Brandywine Creek, in 1914, as a result of a proposed power development. Since then, eighteen streamflow flow stations and five water level stations, at various places, have operated periodically, and for various reasons. The location and period of record of these are listed in Appendix 4.1.

It should be noted that the present Squamish system is a relatively recent product of several evolutionary changes, many of which have altered its characteristic flow. Stathers (1958) indicated that a comparison of the earliest land surveys, done in 1889, with those of 1958 showed that the Squamish had not changed the general form of its major meanderings [although they have changed in width (Levings, 1974)] since 1889, but, due to erosion, there had been a tendency for them to move downstream. Also, early surveys showed the Mamquam River flowing directly to the sea, via the northeast corner of the delta, until 1921,

when a major flood caused it to be diverted westward to its present position of confluence with the Squamish River. Giovando (In: Department of Environment, 1972) continued this history, indicating that, in 1945, another flood resulted in a major portion of the Mamquam flow being temporarily diverted into a channel which meandered across the centre of the delta. In 1957, the Cheakamus Power Development was completed, with the building of a dam on the Cheakamus River at Daisy Lake. This dam served to divert water through a seven-mile long penstock to the Squamish River valley (Water Survey of Canada, 1973). More recently, in 1972, a three-mile long training dyke was completed on the east bank of the west channel of the Squamish River, and a 350-foot wide trench was dredged to a depth of five feet for 5400 feet up the west channel, north of the river mouth (Bell, *et al.*, 1973). Later, a culvert was installed in the dyke to permit some flow of water through the central channel. The overall result of these natural, and human, modifications of the river channels has been to substantially change the Squamish River's previous natural flow characteristics to those recorded presently.

The long-term (18 years) mean monthly flow of the Squamish, recorded at Brackendale, is 8,600 cubic feet per second (cfs) (Water Survey of Canada, 1973), with the maximum usually occurring in June (27,000 cfs) and the minimum usually in March (2,500 cfs) (Department of Environment, 1972; Waldichuk, 1972). Other records for flow, recorded at Brackendale, appear in Table 4.1. Figure 4.1 shows a typical hydrograph.

The Cheakamus River has a mean flow of 1,660 cfs, an order of magnitude less than that of the Squamish (Waldichuk, 1972). Stathers (1958) indicated that the maximum flow recorded on the Cheakamus River (29,000 cfs)

Table 4.1. Other flow records measured at Brackendale, B.C. (Water Survey of Canada, 1973).

Record	cfs	Date
maximum daily flow	78,600	Sept. 6, 1957
minimum peak daily flow	21,400	June 9, 1923
minimum daily flow	388	Feb. 12, 1923
largest mean annual flow	10,300	1967
smallest mean annual flow	6,770	1923
maximum mean monthly flow	26,200	June, 1967
minimum mean monthly flow	859	Feb., 1923

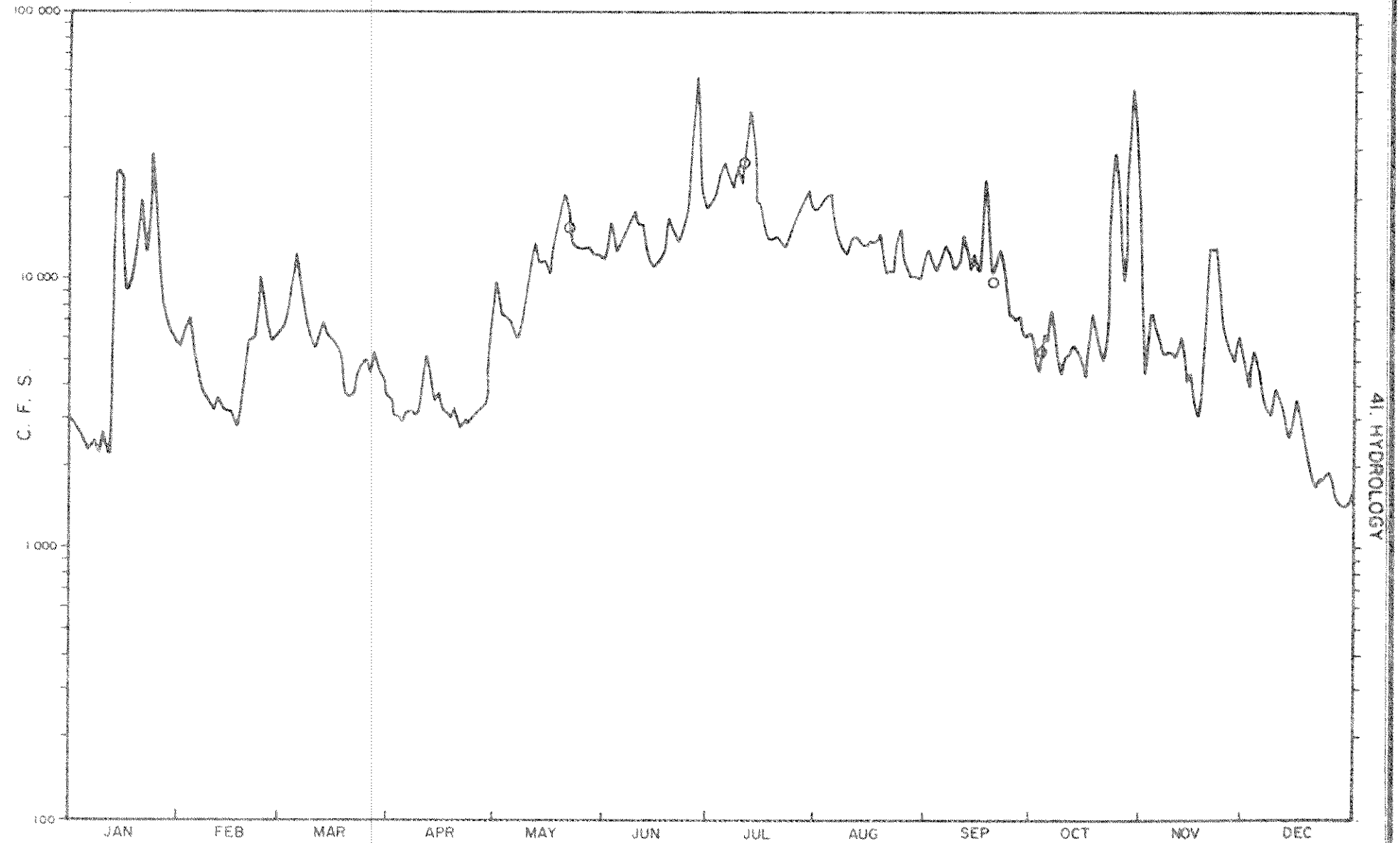

Figure 4.1. Discharge hydrograph for 1969, Squamish River near Brackendale (Stat. No. 08GA022).

occurred in October, 1921, and that this date corresponds to that when the Mamquam River diverted its course to flow into the Squamish River.

A gauge station installed 1/2 mile above Mashiter Creek on the Mamquam River, three miles north-east of Squamish, has monitored this river's flow since 1966. The average annual discharge (1937-1973) is 977 cfs, with a usual maximum in June (2,072 cfs), and a usual minimum in March (453 cfs) (Water Survey of Canada, 1973).

The Stawamus River has only been monitored since May, 1972. The annual mean discharge is 114 cfs, with a daily maximum of 1010 cfs on January 15, 1973, and a daily minimum of 17.6 cfs on September 17, 1973 (Water Survey of Canada, 1973).

The generalized statistics above do not serve to illustrate a common hydrological phenomenon of the Squamish area - the flash floods. Drastic increases in runoff usually occur in the fall when heavy rains, combined with sudden snow-thaw, result in abnormally large river discharges. When such precipitation combines with high winds and high tides, severe flooding of the Squamish delta results. Such conditions predominated during the devastating floods of 1921, 1937, 1940 and 1949. As well as the more common fall floods, the Mamquam is known to overflow during the spring freshet, as a result of heavy runoff and abundant log jams in the channel (Stathers, 1958). The town of Squamish has been inundated with nearly five feet of water about once every sixteen years, and to a lesser degree every seven years or so (Waldichuk, 1972). These occurrences were one reason prompting the building of the retaining dyke, to accommodate a 50-year flood cycle of 75,000 cfs (Paish, 1972a,b and c).

43. Hydrology

Based on sixty-eight observations between 1955 and 1971, water temperatures for the Squamish River ranged from 34°F to 51°F (Water Survey of Canada, 1973). Levings (1974) noted that the surface temperature, at the Squamish River mouth, ranged from 4.3°C (39.7°F) in winter, to 10.8°C (51.4°F) in summer, with temperatures at the other channels being slightly higher.

Above its confluence with the Cheakamus, the Squamish River has an average gradient of 6.2 feet per mile. This is sufficiently low to allow some low-velocity areas between those of fast flow and rapids, and the river appears as a smooth, sinuous channel. The Cheakamus and Mamquam rivers, on the other hand, are much steeper. As a result, they are faster flowing and, therefore, carry greater amounts of glacial flour and sediment. Where each of these rivers meets the Squamish, there is a build up of some of this material, resulting in a kind of "step" in the main river. Below these "steps", the Squamish flows much straighter and more rapidly for a few miles. Then, as it loses velocity, it begins to meander, and sediment again drops out of suspension. During the freshet and flash floods, however, the rate of flow is very rapid throughout the rivers' course, and the water is heavily silt-laden. This material is eventually deposited on the delta by the mechanisms described for the Fraser estuary by Hoos and Packman (1974).

The delta front has been estimated to advance at a rate of about 22 feet per year (L. Bell, pers. comm.). The front is quite steep, resulting in the layers of silt being geologically, and structurally, very unstable. Water Survey of Canada (1973) lists sediment sampling stations on the Squamish. However, due to equipment problems, these

data are thought to be unreliable (I. Stewart, pers. comm.). A discussion of the types of sediments, and their build up on the delta, appears in the Geology section of this report.

4 (ii) WATER QUALITY

Very little water quality information is available for the Squamish estuary. Dissolved oxygen, pH, and alkalinity were measured at standard depths at stations throughout Howe Sound, from 1957 to 1966 (Waldichuk, *et al.*, 1968). Also, Crean and Ages (1971) analyzed the water for dissolved oxygen during their 1968 oceanographic studies (see Oceanography section).

I.T.T. Rayonier Inc., operators of the Woodfibre pulp mill, have periodically analyzed the dissolved oxygen of the receiving waters in their direct vicinity (Denison and Tollefson, 1968; and Tollefson, *et al.*, 1973). In general, in 1968, they found surface dissolved oxygen levels to be at or near saturation most of the year, with lowest records (9 parts per million, or ppm) occurring in January. Deeper water contained 6 to 7 ppm of dissolved oxygen. In 1972, the dissolved oxygen values remained high, but were somewhat lower than those of 1968, the average being about 8.5 ppm, compared to the earlier 12 ppm.

Cliff and Stockner (1973), studying Squamish estuary primary and secondary productivity, analyzed the water for dissolved oxygen, alkalinity, pH, and, for one sample series, nutrients (including nitrite, nitrate, phosphate, total phosphorus, conductivity, Ca^{++}, hardness, and turbidity). They found that nitrates and phosphates were abundant in surface waters. Turbidity, due to the freshet, was greatest from June through September, and decreased with increasing distance from the river mouth. Squamish