Measurements of Taku River, Alaska During Tulsequah Lake Outburst Floods

Introduction

Water stored behind, under, or within glaciers can be released rapidly and unexpectedly. These outburst floods can pose a serious threat to life and property. Post and Mayo (1971) identified glacier-dammed lakes in southeastern Alaska and in adjacent areas of Canada, and characterized the potential hazards associated with outburst floods. Tulsequah Lake in Canada (fig. 1) was identified as one of these glacier-dammed lakes with a long history of annual outburst floods.

Tulsequah Lake is at about 1,140 feet above sea level on the north side of Devils Paw Mountain. The lake is impounded by a distributary branch of Tulsequah Glacier and is about 20 miles upstream from the mouth of the Tulsequah River, a major tributary to the Taku River. The U.S. Geological Survey (USGS) has operated a streamflow-gaging station on the Taku River (station No. 15041200) since 1987.

Outburst floods from Tulsequah Lake have occurred frequently and have been documented by Marcus (1960), Miller (1963), Post and Mayo (1971), and the USGS (1988-99) (table 1). Tulsequah Lake is filled during the summer months by rainfall and by glacial melt. As Tulsequah Lake fills, the lake surface rises until the hydrostatic pressure at the base of the ice dam causes the ice to float. As this occurs, water begins flowing near the base of the glacier. This flowing water thermally erodes the dam, progressively enlarging the opening. At Tulsequah Lake, no surface drainage is evident, and all discharge appears to be through a subglacial tunnel. Data from documented outburst floods indicate that the flow of the Taku River generally doubles or triples during a 2- to 3-day period.

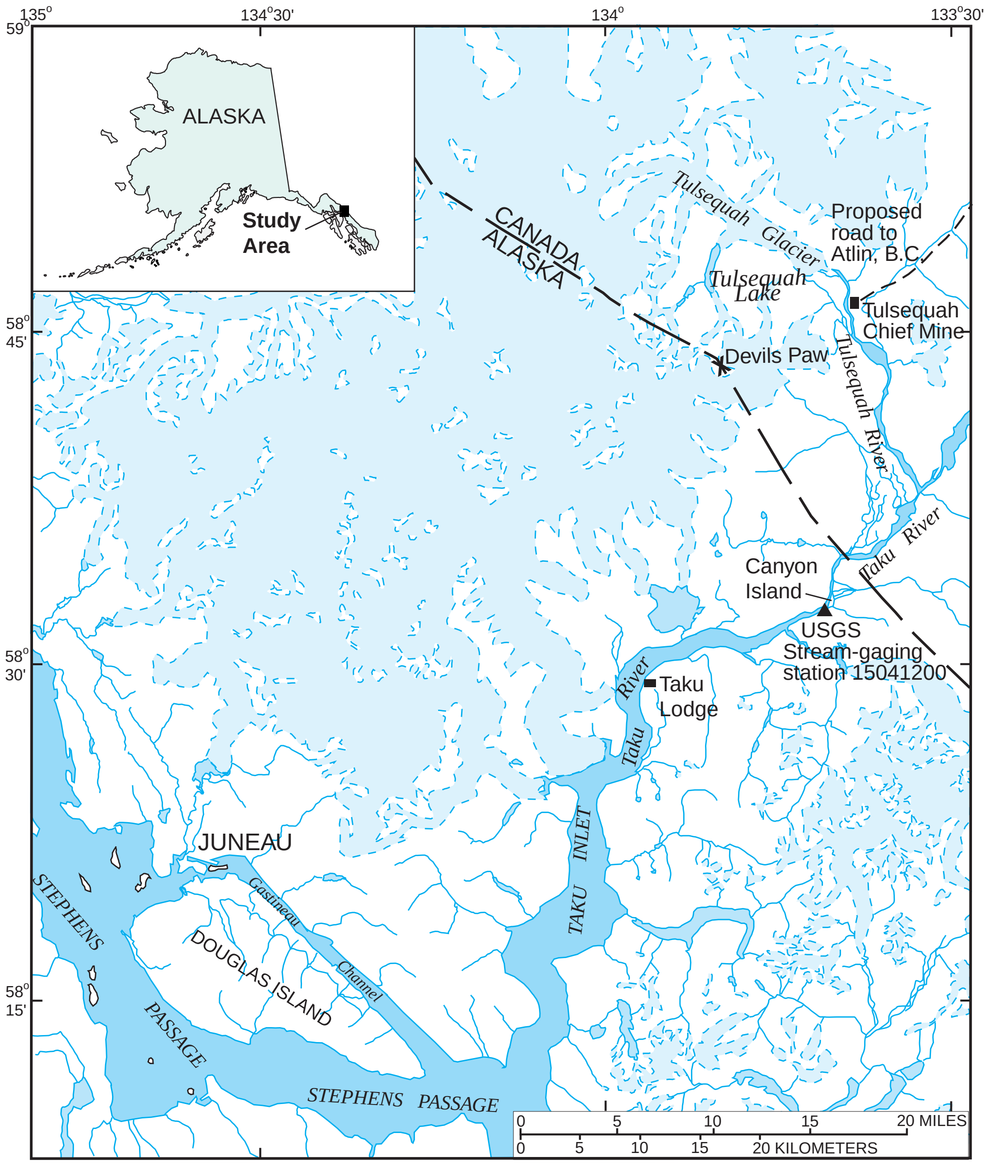

Figure 1. Location of Tulsequah Lake and Glacier and the USGS gaging station on the Taku River, southeast Alaska.

Table 1. Dates of Tulsequah Lake outbursts

Year	Date of outburst	Year	Date of outburst	Year	Date of outburst
1998	July 31–August 3	1987	August 25–28	1948	July 23–27
1997	July 25–28	1958	July 7–10	1947	August 5–9
1996	September 17–20	1957	August 13–16	1946	August 4–8
1995	July 24–27	1956	August 29–September 1	1945	August 8–11
1994	July 28–August 1	1955	September 4–7	1944	August 15–19
1993	July 26–29	1954	September 11–14	1943	July
1992	August 18–21	1953	July 6–10	1942	July
1991	August 30–September 2	1952	August 6–9	1932	August 15–20
1990	July 18–21	1951	July 26–29	1926	January
1989	August 14–18	1950	July 27–30	1910	Summer
1988	July 31–August 2	1949	August 7–10		

1997 Tulsequah Lake Outburst Flood

An outburst flood from Tulsequah Lake was documented on the Taku River during July 25–28, 1997. USGS personnel from Juneau measured the discharge, stage, and temperature of the water surface at the gaging station on the Taku River. For the first time since the gaging station was established in 1987, measurements were made at the actual time of an outburst flood. Four measurements were made while flood stage and discharge were increasing, one measurement was made during the peak discharge, and three measurements were made while stage and discharge were decreasing (fig. 2). The prebreakout discharge was about 35,000 cubic feet per second on July 24, and the peak discharge was about 70,000 cubic feet per second.

An Acoustical Doppler Current Profiler (ADCP) was used to measure the discharge during the 1997 outburst flood. The ADCP is an improved method of making high-quality discharge measurements (Morlock, 1996). Discharge measurements made with the ADCP take less time, are safer, and have smaller errors than those made by conventional methods. The decreased time required for measuring the discharge is important for making high-quality measurements during a rapidly changing stage. Furthermore, the position-tracking capability of the ADCP permits the measurements to be made without need for a cable across the flood path and allows the boat to be maneuvered to avoid debris carried by the river during the flood.

The ADCP also recorded temperatures of the water surface during the eight discharge measurements. Water temperature of the Taku River decreased as Tulsequah Lake drained (table 2) and then increased slightly—but not uniformly across the river —during the peak of the outburst flood. Temperature continued to increase and become more uniform as the water discharge decreased. This temperature distribution probably indicates that the Taku River waters were not well mixed and that cooler outburst waters were concentrated on the north side of the river. The length of river that is incompletely mixed appears to extend as far as the gaging station, 8.5 miles downstream from the confluence of the Tulsequah and Taku Rivers. A similar temperature distribution was observed in the 1998 flood, during which the peak discharge was 69,000 cubic feet per second.

Table 2. Water temperature of the Taku River, July 25-28, 1997

Date July 1997	Time	Water temperature (degrees Celsius)	
		South bank	North bank
25	9:29 p.m.	8	8
26	11:02 a.m.	5.5	4.5
	8:03 p.m.	7	4.5
27	6:57 a.m.	6	2.5
	2:36 p.m.	8.5	4.5
	7:11 p.m.	9.5	6
	10:27 p.m.	8	7.5
28	1:37 p.m.	8.5	8.5

Flood Hazards

The annual glacier outburst of Tulsequah Lake is a potentially dangerous and destructive flood that may affect inhabitants of the Taku and Tulsequah River Valleys. As this area becomes developed, the frequency and magnitude of outburst floods are of great concern.

The Tulsequah Chief Mine (fig. 1) is approximately 18.5 miles upstream from the Alaska–Canada border in the Tulsequah River Valley. Recently, the Canadian government has approved permits to reactivate the mine and build a 100-mile-long road to access the mine from Atlin, British Columbia. Outburst floods could damage the mine and road. About 40 cabins have been built along both banks of the river near the USGS stream-gaging station. In addition, increased tourism routinely brings visitors to the Taku River and Taku Lodge by boat and floatplane during the summer months. The floodwaters and debris released during the outburst floods can threaten the safety of tourists and have negative consequences on the fishing industry in Taku Inlet. Deposits of debris and sediments associated with the outburst may dramatically change the river channel during and after the Tulsequah Lake outburst floods. These channel changes create potentially hazardous conditions for an unknowing boat operator or floatplane pilot.

Understanding how rivers can rise unexpectedly and rapidly during an outburst flood improves the ability to identify possible downstream hazards and increases awareness. Understanding how discharge and water temperature vary during an outburst flood allows a better comprehension of the physical processes that released the water, which improves definition of downstream hazards and water quality.

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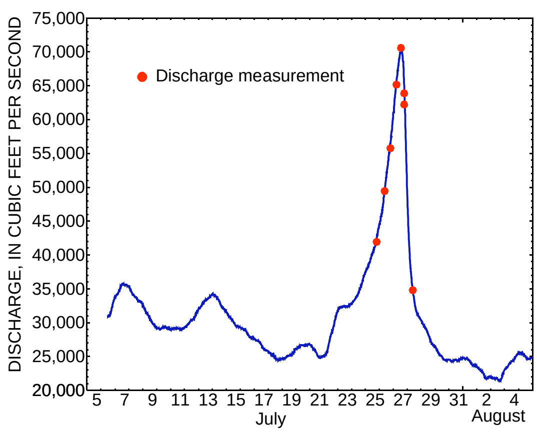

Figure 2. Discharge in the Taku River from July 5 to August 5, 1997. Tulsequah Lake outburst flood was on July 25-27.

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