PHOTOGRAPHS ILLUSTRATING THE VARIABILITY OF GLACIER DAMMED LAKES

TULSEQUAH LAKE NEARLY DRAINED BY AN OUTBURST FLOOD

TULSEQUAH LAKE (NO. 5), COAST MOUNTAINS. LOCATED JUST EAST OF THE INTERNATIONAL BOUNDARY IN CANADA, THIS LAKE GENERALLY DRAINS CATASTROPHICALLY IN LATE SUMMER. THE RESULTING FLOODS MOVE DOWN THE TAKU RIVER VALLEY WHERE A HIGHWAY CONNECTION TO JUNEAU HAS BEEN PROPROSED.

SUMMIT LAKE FILLED TO NEAR MAXIMUM LEVEL

SUMMIT LAKE (NO. 32) WHICH IS DAMMED BY AN UNNAMED GLACIER IN THE CHIGMIT MOUNTAINS. THIS PHOTOGRAPH, TAKEN IN AUGUST 1963, SHOWS THE LAKE NEAR ITS MAXIMUM LEVEL AND ICEBERGS ARE BEING DISCHARGED FROM THE GLACIER MARGIN.

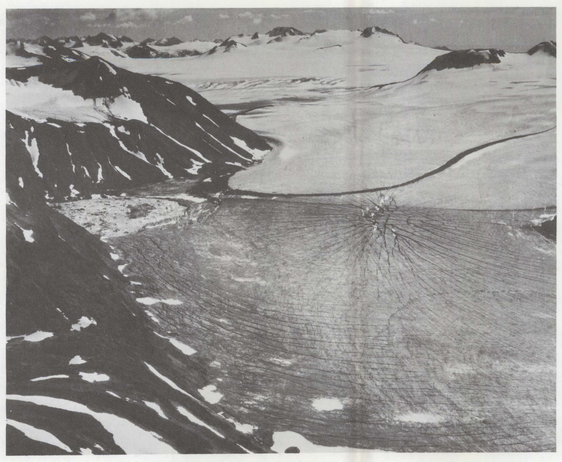
SUMMIT LAKE ALMOST COMPLETELY DRAINED

SUMMIT LAKE (NO. 32) PHOTOGRAPHED IN AUGUST 1970. THE LAKE HAS DRAINED THROUGH A SUBGLACIAL CHANNEL TO NORTH FORK BIG RIVER (RIGHT). THIS GLACIER HAS BEEN RETREATING FOR MANY YEARS; THE PRESENT ICE DAM WILL FAIL COMPLETELY IF RETREAT CONTINUES FOR A FEW MORE DECADES.

BLOCKADE LAKE IN THE PROCESS OF REFILLING

BLOCKADE LAKE (NO. 31), CHIGMIT MOUNTAINS. THIS LAKE IS IMPOUNDED BEHIND A MASSIVE ICE DAM 15.2 KILOMETERS (9.5 MILES) IN LENGTH FORMED WHERE BLOCKADE GLACIER LATERALLY ENTERS A DEEP, NARROW VALLEY AT THE FAR END OF THE LAKE. ALTHOUGH THE MAJOR FLOW OF ICE IS TO THE EASTERN TERMINUS, A PORTION OF THE ICE FLOWS TOWARD THE LAKE TERMINATING IN AN ICE CLIFF FROM WHICH LARGE ICEBERGS ARE DISCHARGED. THIS LAKE DOES NOT DUMP ANNUALLY BUT LARGE CHANGES IN SURFACE LEVEL INDICATE THAT THE ICE DAM FAILS EVERY FEW YEARS CAUSING MAJOR FLOODS ON MC ARTHUR RIVER.

SKILAK GLACIER—SHOWING LATERAL AND SUBGLACIAL LAKES



THIS ICE DAMMED LAKE (NO. 27) IS LOCATED IN AN EMBAYMENT BETWEEN SKILAK GLACIER AND AN UNNAMED GLACIER IN THE KENAI MOUNTAINS. AN EXPOSED LAKE CAN BE SEEN ON THE LEFT; THE RADIAL PATTERN OF CREVASSES IN THE CENTER OF THE GLACIER SUGGESTS THAT THIS ICE IS RAISED AND LOWERED BY ALTERNATE FILLING AND DRAINING OF A SUBGLACIAL LAKE. WATER FROM THIS LAKE CREATED A DEVASTATING FLOOD IN THE KENAI RIVER VALLEY IN JANUARY 1969.

DESOLATION VALLEY—FORMATION AND EVOLUTION OF TWO LAKES

TWO LARGE ICE DAMMED LAKES ARE IN THE PROCESS OF FORMATION IN DESOLATION VALLEY, FAIRWEATHER RANGE. IN THE FOREGROUND IS DEBRIS COVERED ICE WITH SEVERAL LARGE, LONGITUDINAL AND CONCENTRIC CREVASSES WHICH ARE ATTRIBUTED TO RAISING AND LOWERING OF THE ICE DUE TO FLOATING. WATER IS VISIBLE ALONG THE MARGINS AND IN THE LARGER CREVASSES. BETWEEN DESOLATION AND LITUYA GLACIERS (UPPER CENTER) THE ICE HAS RECENTLY BROKEN UP AND A LARGE LAKE (NO. 9) IS NOW CLEARLY VISIBLE. THE LAKE PARTIALLY DRAINS SUBGLACIALLY AT INTERVALS TO LITUYA BAY (MIDDLE DISTANCE). THE RECENT FORMATION OF THESE LAKES IS DUE TO THINNING OF THE GLACIERS OCCUPYING THE VALLEY.

BERG LAKE—A RECENTLY DEVELOPED HAZARDOUS SITUATION

BERG LAKE (NO. 14), NEAR KATALLA. RETREAT OF AN ARM OF BERING GLACIER, WHICH IN 1905 FILLED MOST OF THIS LARGE EMBAYMENT, HAS JOINED FIVE SEPARATE LAKES THAT OCCUPIED INDIVIDUAL BAYS OF THE PRESENT LAKE. LOWERING OF THE ICE DAM IF CONTINUED WILL ALMOST CERTAINLY LEAD TO THE RELEASE OF IMMENSE FLOODS IN THE NEAR FUTURE. THE BERING RIVER FLOOD PLAIN AND AREA SURROUNDING BERING LAKE ARE ENDANGERED BY THIS INCREASINGLY CRITICAL SITUATION.

RUSSELL FIORD—SITE OF A LARGE POTENTIAL LAKE

DISENCHANTMENT BAY AND RUSSELL FIORD (NO. 13), NEAR YAKUTAT. THE MASSIVE HUBBARD GLACIER, DRAINING AN AREA OF APPROXIMATELY 4,000 SQUARE KILOMETERS (1,550 SQUARE MILES) DISCHARGES INNUMERABLE ICEBERGS INTO THE BAY FROM AN ICE CLIFF NEARLY 100 METERS (300 FEET) HIGH AND 10 KILOMETERS (6 MILES) LONG. THE GLACIER HAS BEEN SLOWLY ADVANCING SINCE IT WAS MAPPED IN 1895. IF THE ADVANCE CONTINUES AT THE SAME RATE, IN A FEW DECADES THE GLACIER WILL CLOSE OFF RUSSELL FIORD (FOREGROUND) TURNING THIS ARM OF THE SEA INTO A LAKE 230 SQUARE KILOMETERS (90 SQUARE MILES) IN AREA.

PHOTOGRAPHS ILLUSTRATING HOW TEMPORARY LAKES ARE CAUSED BY PERIODICALLY SURGING GLACIERS

TIKKE GLACIER AT BEGINNING OF SURGE

TIKKE GLACIER, LOCATED IN CANADA NORTH OF GLACIER BAY, IS SUBJECT TO PERIODIC SURGES IN WHICH THE ICE SUDDENLY ADVANCES SEVERAL KILOMETERS AT APPROXIMATELY 20-YEAR INTERVALS. THIS VIEW OF THE GLACIER WAS TAKEN IN AUGUST 1965 WHEN A SURGE WAS MOVING RAPIDLY DOWN THE GLACIER. LATERAL VALLEYS TO THE RIGHT OF THE GLACIER DO NOT CONTAIN LAKES; FARTHER UP GLACIER ON THE LEFT SIDE THE FAST-MOVING ICE RECENTLY HAS DAMMED THE LATERAL STREAMS.

TIKKE GLACIER AFTER SURGE

TIKKE GLACIER IN AUGUST 1966 AFTER THE CULMINATION OF THE SURGE SHOWN IN PROGRESS IN THE VIIEW TO THE LEFT. THE ADVANCING ICE HAS NOW FORMED DAMS BLOCKING BOTH SIDE VALLEYS ON THE RIGHT SIDE OF THE GLACIER. SINCE COMPLETING ITS RAPID MOVEMENT, THE GLACIER HAS RELAPSED INTO NEAR STAGNATION. THE GLACIER DAMMED LAKES PROBABLY WILL FILL AND DUMP ANNUALLY UNTIL MELTING REMOVES THE ICE DAMS. TIKKE GLACIER IS ONLY ONE OF NEARLY 200 SURGING GLACIERS IN ALASKA AND ADJACENT CANADA WHICH CAN BE EXPECTED TO FORM HAZARDOUS LAKES PERIODICALLY.

PHOTOGRAPHS ILLUSTRATING THE EFFECTS OF AN OUTBURST FLOOD DUE TO VOLCANIC ACTIVITY

REDOUBT VOLCANO BEFORE 1966 ERUPTION

REDOUBT VOLCANO, CHIGMIT MOUNTAINS. PHOTOGRAPH AUGUST 1963 SHOWING CONDITIONS BEFORE THE ERUPTIONS BEGAN IN JANUARY 1966. THE LARGE, UNNAMED GLACIER SHOWN HERE DESCENDS FROM THE SUMMIT CRATER. ALTHOUGH THE GLACIER IS LITTERED BY MUCH DEBRIS ON ITS LOWER REACHES, THE SPECTACULAR ICE CASCADES ON THE MOUNTAIN SLOPES ARE ALMOST DEBRIS FREE, INDICATING RECENT DECADES OF LITTLE VOLCANIC ACTIVITY.

GLACIER ON REDOUBT VOLCANO AFTER ERUPTION

REDOUBT VOLCANO IN AUGUST 1966 SHOWING CHANGES IN THE GLACIER RESULTING FROM THE ERUPTIONS. STEAM CLOUDS FROM THE ACTIVE CRATER STILL OBSCURED THE SUMMIT OF THE MOUNTAIN. THE ICE CASCADES FLOWING FROM THE SUMMIT CRATER HAVE BEEN COMPLETELY DESTROYED AND A LARGE STREAM OF YELLOWISH, DEBRIS-LADEN WATER WAS RUSHING DOWN THE GORGE IN ITS PLACE. AERIAL OBSERVATIONS IN 1967 INDICATED LOWERING OF THE GLACIER SURFACE LEVEL IN THE CRATER WHICH SUGGESTS THAT ICE MELT DUE TO VOLCANIC HEAT WAS THE PRINCIPAL SOURCE OF THE FLOOD WATER. THE LOWER GLACIER IS ALMOST COMPLETELY BURIED BY DEBRIS DEPOSITED BY THE FLOOD WATERS.

PHOTOGRAPHS ILLUSTRATING DAMAGE CAUSED BY OUTBURST FLOODS

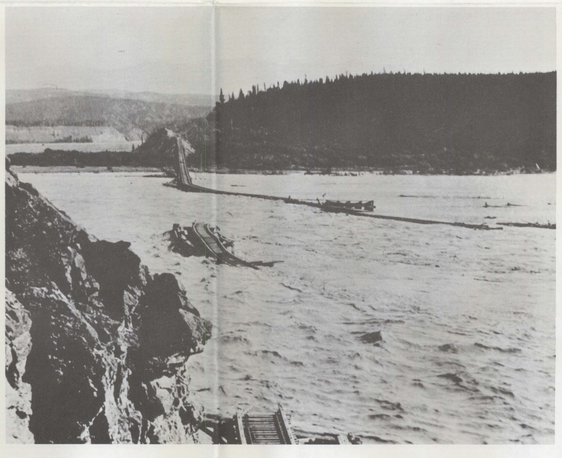
SHEEP CREEK

BRIDGE AT SHEEP CREEK, EAST OF VALDEZ, ON THE RICHARDSON HIGHWAY. DENSE LOW WILLOW AND ALDER GROWING ON THE FLOOD PLAIN INDICATE SEVERAL YEARS WITHOUT FLOOD ACTIVITY, BUT ABSENCE OF LARGE TREES SUGGESTS THAT DAMAGING FLOODS HAD OCCURRED EARLIER. BRIDGE FORMS A CONSTRUCTION IN THE FLOOD PLAIN. ALASKA DEPARTMENT OF HIGHWAYS PHOTOGRAPH, DATE UNKNOWN.

SHEEP CREEK

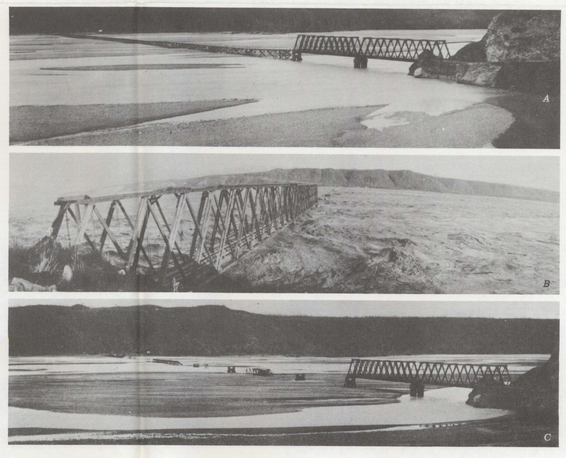
SAME BRIDGE AT SHEEIP CREEK PARTIALLY BURIED BY DEBRIS RESULTING FROM A GLACIER OUTBURST FLOOD FROM A TINY GLACIER DAMMED LAKE (NO 23). SEDIMENT BURIED MUCH OF THE WILLOW AND ALDER BRUSH, BUT AS THE FLOOD DID NOT CARRY AWAY THE COTTONWOOD TREES AT THE EDGE OF THE FLOOD PLAIN THIS FLOOD COULD NOT HAVE BEEN OF MUCH GREATER VOLUME THAN PREVIOUS FLOODS. APPROXIMATELY 7.5 METERS (25 FEET) DEPTH OF DEBRIS WAS DEPOSITED AT THE BRIDGE SITE. LARGE-SCALE EROSION UPSTREAM MUST HAVE TAKEN PLACE TO PROVIDE THE FILL MATERIAL. ALASKA DEPARTMENT OF HIGHWAYS PHOTOGRAPH, SEPTEMBER 1945.

COPPER RIVER



COPPER RIVER AND NORTHWESTERN RAILWAY BRIDGE NEAR CHITIINA BEING SWEPT AWAY BY A MAJOR FLOOD WHICH OCCURRED IN AUGUST 1932. GENERALLY CLEAR, BALMY WEATHER PREVAILED AT THE TIME SO THE FLOOD IS JUDGED TO HAVE BEEN DUE TO A GLACIER DAMMED LAKE OUTBURST, PROBABLY ORIGINATING FROM LAKES DAMMED BY TAZLINA GLACIER. ALASKA DEPARTMENT OF HIGHWAYS PHOTOGRAPH, AUGUST 1932.

NIZINA RIVER



PHOTOGRAPHS OF BRIDGE ACROSS NIZINA RIVER NEAR MCCARTHY, ALASKA, SHOWING EFFECTS OF OUTBURST FLOOD OF JUNE 1934 ORIGINATING AT LOWER SKOLAI LAKE (NO. 17). ALASKA DEPARTMENT OF HIGHWAYS PHOTOGRAPHS *A* IN 1933 BEFORE FLOOD, *B* BEING DEMOLISHED BY OUTBURST FLOOD. PHOTOGRAPH BY BEN JACKSON *C*: IN 1934 AFTER FLOOD.

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—1971—W71213

GLACIER DAMMED LAKES AND OUTBURST FLOODS IN ALASKA

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1971