HISTORICAL FLOOD REVIEW: FORT SIMPSON, FORT NORMAN FORT GOOD HOPE, FORT McPHERSON, AKLAVIK, FORT LIARD, NAHANNI BUTTE

L.A. Kriwoken

Northern Hydrology Section
Surface Water Division
National Hydrology Research Institute
Environment Canada
Ottawa, Ontario
K1A 0E7

for the
Northwest Territories Technical Committee
Flood Damage Reduction Program
Yellowknife, N.W.T.

March 1983

RECORD FLOODING AT AKLAVIK, N.W.T. 5JUNE, 1982 (2 DAYS AFTER PEAK STAGE)

HISTORICAL FLOOD REVIEW: Fort Simpson, Fort Norman, Fort Good Hope, Fort McPherson, Aklavik, Fort Liard, Nahanni Butte

The forementioned report documents historical flooding in seven communities in the Mackenzie River Basin. In accordance with the National Flood Damage Reduction Program guidelines, implementation of the study is in progress, with responsibility shared by the Departments of Environment and Indian Affairs and Northern Development and the Government of the Northwest Territories.

Further inquiries can be directed to:

Flood Damage Reduction Program
N.W.T. Technical Committee

Water Resources Division
Dept. of Indian Affairs
and Northern Development
P.O. Box 1500
Yellowknife, N.W.T.
X1A 2R3

Attn: J.N. Jasper
Tele: 920-8249

(or)

Inland Waters Directorate
Environment Canada
P.O. Box 2970
Yellowknife, N.W.T.
X1A 2R2

Attn: R.A. Hale
Tele: 920-8501

(or)

Town Planning and Lands Div.
Dept. of Local Government
Government of the N.W.T.
Yellowknife, N.W.T.
X1A 2L9

Attn: W. Barraclough
Tele: 873-7570

EXECUTIVE SUMMARY

The Historical Flood Review was initiated in the spring of 1982 as one component of the Canada-Northwest Territories Flood Damage Reduction Program. Seven communities were studied with the objective of determining, in each, the level and extent of past flood events.

Information on past flood events was obtained from personal communications, archival research and field investigations carried out from May through September, 1982. Long-term residents of each community were interviewed and journals kept by the Hudson's Bay Company, Roman Catholic Church and Royal Canadian Mounted Police were reviewed. To supplement resident recollections and historical data, investigations of physical evidence of past flood and ice shove events were made. From the information compiled, extreme historical floodlines were established for each community and plotted on 1:2000 scale maps.

Past flood events experienced in the Mackenzie valley communities have invariably been caused by ice jams during spring break-up. Flooding has been the most severe in Fort Simpson and Aklavik. In the spring of 1963, three-quarters of Fort Simpson island was inundated as a result of ice jamming downstream of the settlement. During the 1982 spring break-up in the Mackenzie Delta, three separate ice jamming events downstream of Point Separation caused record flooding in the Delta community of Aklavik.

In Fort McPherson only the low-lying, peripheral areas have been threatened by flooding. On one occasion in the spring of 1957, Peel River floodwaters encroached the northern base of the hill which the majority of the settlement occupies.

Flood incidences have been rare in Fort Good Hope. High backwater levels overtopping the banks of Jackfish Creek have, on three occasions (1911, 1961 and 1976), threatened only those residents occupying the low-lying gully northeast of the Hudson's Bay Company store.

In 1964 and 1972 spring ice-jamming at the confluence of the Great Bear and Mackenzie Rivers shoved ice, up to 10 metres high, onto the lower terrace of the Fort Norman settlement. Resultant record floodwaters reached the lower settled areas in 1964.

Past extreme flood levels in Fort Liard and Nahanni Butte have, for the most part, been caused by storm events in the open water season. In June of 1977, heavy precipitation and subsequent rapid snowmelt in the mountains resulted in the worst flooding ever experienced in both communities.

ACKNOWLEDGEMENTS

The author wishes to thank the Water Planning and Management Branch, Western and Northern Region who, through the Canada-Northwest Territories Flood Damage Reduction Program, provided the financial support to conduct this study. The generous support of the following individuals and organizations is also gratefully appreciated: J.C. Anderson and M.A. Koetsier for assistance in the field (N.H.R.I., Hull); A.C.D. Terroux (N.H.R.I., Hull) for provision of water level data and aerial photograhy of the 1982 Aklavik Flood; National Airphoto Reproduction Centre (Ottawa) for furnishing the frontispiece to this report; F.E. Parkinson (Lasalle Hydraulic Laboratory Ltd., Lasalle, Quebec) for assistance in the field and provision of data; P. Wood (Water Survey of Canada, Fort Simpson) for information and advice; P. Shaw (D.P.W., Fort Simpson), B. Gauthier (D.I.A.N.D., Fort Simpson), N. Guilbeault (Nahanni National Park, Parks Canada, Fort Simpson), and E. Schroff (D.I.A.N.D., Fort Liard) for provision of accomodation and logistic arrangements; Department of Public Works (Inuvik) for provision of N.W.T. Transient House accomodation; Royal Canadian Mounted Police, Fort Simpson Detachment, for access to RCMP diaries; the Roman Catholic Missions in Fort Simpson, Fort Norman, Fort Good Hope, Aklavik, and Fort Liard for information and access to church records; S.A. Smith (Keeper, Hudson's Bay Company Archives, Winnipeg) for research guidance; J.N. Jasper, R.A. Hale and W. Barraclough (N.W.T. Flood Damage Reduction Program Technical Committee) for critically reviewing the preliminary draft of this report; and finally, S.C. Bigras, D.K. MacKay and especially T.D. Prowse (N.H.R.I., Hull) for their comments and encouragement throughout the written stages of this report. Special mention is due the settlement and band councils for their assistance and cooperation and all community residents whose historical recollections were invaluable to this study.

CONTENTS

List of Tables

List of Figures

List of Photographs

I. INTRODUCTION

The Canada-Northwest Territories Flood Damage Reduction Program, initiated in 1979, provides for the identification and mapping of the flood risk areas in selected communities in the Northwest Territories. The primary aim of the program is to discourage further development in areas vulnerable to flooding by designating flood risk zones in the communities.

Upon request of the Water Planning and Management Branch, Western and Northern Region, the Northern Hydrology Section of the National Hydrology Research Institute undertook investigations on floodline delineation in seven communities in the Mackenzie River basin. Specifically, the floodlines were to be established on the basis of extreme historical flood events. The communities included in the Historical Flood Review were: Fort Simpson, Fort Norman, Fort Good Hope, Fort McPherson, Aklavik, Fort Liard and Nahanni Butte (Figure 1).

The historical floodlines were based on data acquired from field investigations and archival research carried out from May through September, 1982. Sources of information were compiled and analyzed to produce, as accurately as possible, a complete chronology of past flooding in each community. All available information on the date, cause, timing and areal extent was described for each flood event and extreme floodlines were plotted on 1:2000 scale topographic maps. Where evidence was available, ice shove limits of each event were indicated.

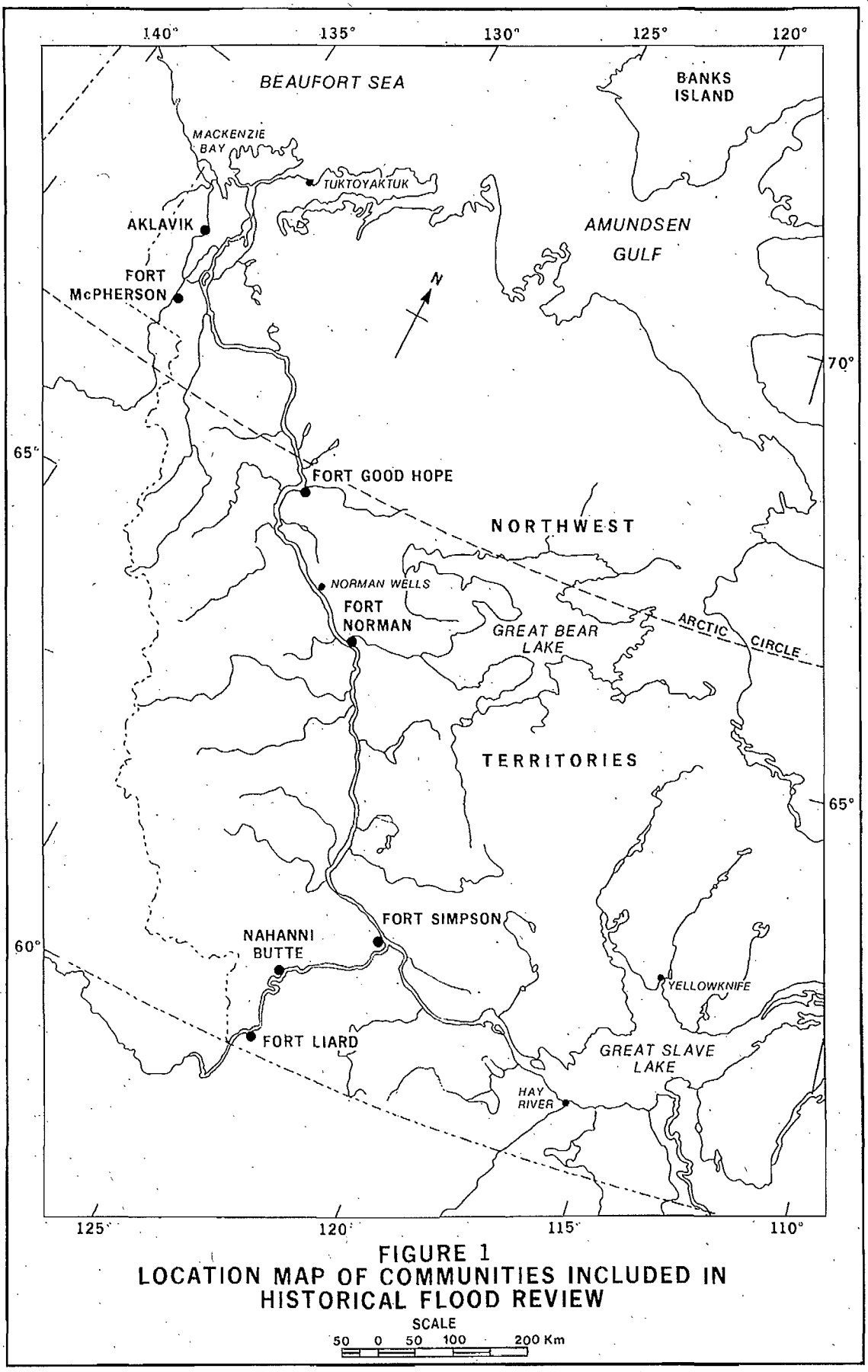


FIGURE 1
LOCATION MAP OF COMMUNITIES INCLUDED IN HISTORICAL FLOOD REVIEW

Section II begins with a discussion of the methods used in data acquisition. This is followed by a presentation of the data limitations. In Section III descriptions of the single past extreme flood event experienced in each community are presented. For Fort Simpson and Aklavik, where flooding has been the most severe, detailed accounts of the two largest recorded floods have been included. All reported floods of "less-than-extreme" extent are documented in the Appendix to this report. Also appended are descriptions of the bench marks used for the flood level surveys undertaken in each community.

II. METHODOLOGY

A. Data

Because gauging station records for most of the communities along the Mackenzie River and in the Delta do not extend much further back than the last 20 years, and even then are generally limited to the ice free season, other sources of flood level information had to be used to establish historical floodlines.

a. Historical Documents - The historical documents reviewed included:

(1) Hudson's Bay Company records

(2) Royal Canadian Mounted Police diaries

(3) Roman Catholic Church diaries

(4) local newspapers and files

Annual observations of spring break-up were commonly noted in these documents. In the event of flooding, descriptive information on the date, areal extent, and, often, the cause was recorded. This information could then be quantified by going into each settlement and actually surveying the level of the areas or features described. For example, if floodwaters were described as having reached the church porch in 1963, the level of the church porch would then be surveyed to local datum, and, a specific 1963 water level would be known.

b. Photographs - Photographs offered valuable evidence of maximum flood extent, provided they were taken at the time of peak stage. The exact timing of the photographs could often not be determined; in most instances, only the flood-year was provided. The photographs were useful, nonetheless, in depicting limits of ice shove activity as well as showing the general level reached by flood waters.

c. Personal Recollections - Interviews with long-term residents in each of the communities were undertaken. Personal recollections on the date, timing, and cause of past flood events were noted; and, information on high water levels was surveyed to local datum.

d. Physical Evidence - When possible, personal recollections and historical data were supplemented by physical evidence of past flood events and ice shove activity. Field surveys were undertaken to determine high water levels by using such evidence as stranded driftwood, sediment lines and floodwater marks. Evidence of ice shove limits was provided by vegetation trimlines and ice scars on trees. The elevations of these high water and ice level indicators were surveyed to local datum.

A 1982 record spring flood in the Mackenzie Delta made first hand field observations possible in Aklavik. Reconnaissance aerial surveys over the Delta enabled the cause of the flood to be determined; a detailed chronology of the flood event was obtained; and, a water level survey of flood debris was undertaken after the passage of the flood peak.

B. Data Limitations

The sources of data used in this study varied widely from word-of-mouth recollections to physical field evidence. Consequently, a limiting factor to the delineation of historical floodlines was the inherent variation in data reliability. To determine the validity of each floodline, the sources of flood level information were ranked according to their reliability, as shown in Table 1.

TABLE 1.
RANKED RELIABILITY OF FLOOD INFORMATION SOURCES

Physical Evidence	1
Photographs	2
Historical Documents	3
Personal Recollections	4

Note: Information sources are listed in order of decreasing reliability as subjectivity becomes necessary in their interpretation.

When a combination of flood information sources was available for one flood event, the historical floodline was automatically based on the elevation given by the most reliable data source.

Physical evidence is the most reliable data source because the specific levels of high water indicators (driftwood, sediment, etc.) could be surveyed in and around a settlement. Similarily, the extent of flooding, as depicted in photographs, can be quantified. Water level

information on the photograph can be transferred to present features and a level survey can then be undertaken.

Descriptive historical documents are of limited value because of the difficulty in quantifying such information. In order to quantify the areal extent of flooding described, certain assumptions had to be made:

(1) maximum water levels of past floods were uniform throughout the settlement (i.e. no obstruction to backwater flow) and,

(2) changes in ground elevations from the time historical records were taken to the present are negligible.

In most historical accounts reviewed, the extent of flooding in the settlement is referred to only in general terms (e.g. low-lying parts, northern end, etc.) or to landmarks no longer existent or familiar (e.g. Batture, Byre, mission field or trading post). In some cases these landmarks were located with the aid of historical settlement plans, enabling past water levels to be established by using existing features in the survey. In the absence of specific, quantitative details (e.g. "water rose 3' inside the HBCo store") a range of "possible" maximum flood levels was interpreted.

Personal recollections are the least reliable data source because a certain amount of subjectivity is necessary in assessing the

observor's perception of the flood event. Perceptions, unlike a sediment line or a high water mark, cannot be easily quantified. Factors that can account for differences among peoples' perceptions of the same flood event include: (1) the number of floods experienced in the past; (2) the time during the flood when high water was observed; (3) where the observation was made (i.e. proximity to the river) and, (4) personal threat or inconvenience. Personal perceptions of a settlement's worst flood-year can also be influenced by physical changes such as road upgrading and drainage ditch construction. All these factors had to be considered when assessing the credibility of the observor's perceptions of the past flood event.

Local obstructions to backwater flow from one ice jam can cause maximum flood levels to vary considerably within one settlement (as was the case in Fort Simpson in 1976). To illustrate the effects of flow obstruction on flood levels it is often appropriate, provided there is sufficient accurate peak water level data, to plot a flood profile.

In each of the seven communities studied, the data collected are inadequate to this task. For most of the historical flood events reviewed, there was no systematic collection of water level data at the time of flooding. Other sources of flood level information (resident recollections, photographs, archives) could not, in all cases, be provided from locations along the entire river reach of the community. Furthermore, discrepancies between a recollected maximum water level and an actual peak floodstage would limit the accuracy of a flood profile.

Alternatively, the depiction of flood level differences for each extreme event was achieved by referencing all levels to their source on the community maps. Rather than defining a flood level with varying elevations, a single flood elevation, based on the most reliable source, was delineated.

III. DESCRIPTION OF PAST FLOOD EVENTS

The location and general setting are briefly discussed for each community. Sites prone to ice jamming during spring break-up are also described. A chronology of historical flood levels is presented for each community (Figures 3, 5, 7, 9, 11, 13, 15). On each figure sources of flood information are indicated, and, a horizontal bar illustrates the number of years covered by each source. For years when no information was available, no assumptions can be made about flooding; a break in the record merely shows that journals were missing or that break-up observations were not available. Specific water levels are marked where records indicate a number of maximum water levels for one flood event. For some flood-years, a range of "possible" maximum levels is given; this range accounts for any ambiguities in the information available.

Break-up water levels below the "perceived minimum flood level" (comparable to "perception stage" in Gerard and Karpuk, 1979) indicated on each figure would not have entered any of the settled areas. Consequently, no flooding would have been documented or recollected. The "perceived minimum flood levels" defined for each community can be useful data for flood frequency analyses. In the years when break-up observations were made but no flooding was recorded, it can safely be concluded that the maximum water level would have been below the "perceived minimum flood level". In years when no records are available, no such conclusions can be made.

Each flood chronology is accompanied by a description of the worst flood event in the community's history. The sources of information are referenced to the flood risk maps for easy location.

A. Fort Simpson

Fort Simpson is situated on the largest of a series of alluvial islands at the confluence of the Liard and Mackenzie Rivers (Figure 2). The island, 4 km long and 1 km wide, is separated from the mainland by a channel (locally referred to as the Snye), 200 metres wide.

A 12 metre scarp rises from the left shore of the Mackenzie River to the highest point on the island (129.5 m); from this elevation three terraces slope gradually in a northwesterly direction toward the Snye. The majority of the settlement occupies the middle and upper terraces of the island. Abandoned channels and sloughs predominate in the undulating, low-lying flats. (Photograph 1)

Past flooding events experienced in Fort Simpson have invariably been caused by ice jams during spring break-up. Factors affecting the repeated occurrence of ice jams and subsequent backwater flooding at this site include:

(1) the sudden release of Liard ice/water on stronger intact Mackenzie ice cover;

(2) ice passage constriction by a left bank shoal at the downstream end of Fort Simpson island; and,

(3) another ice passage constriction 19 km downstream by an abrupt bend in the Mackenzie River.

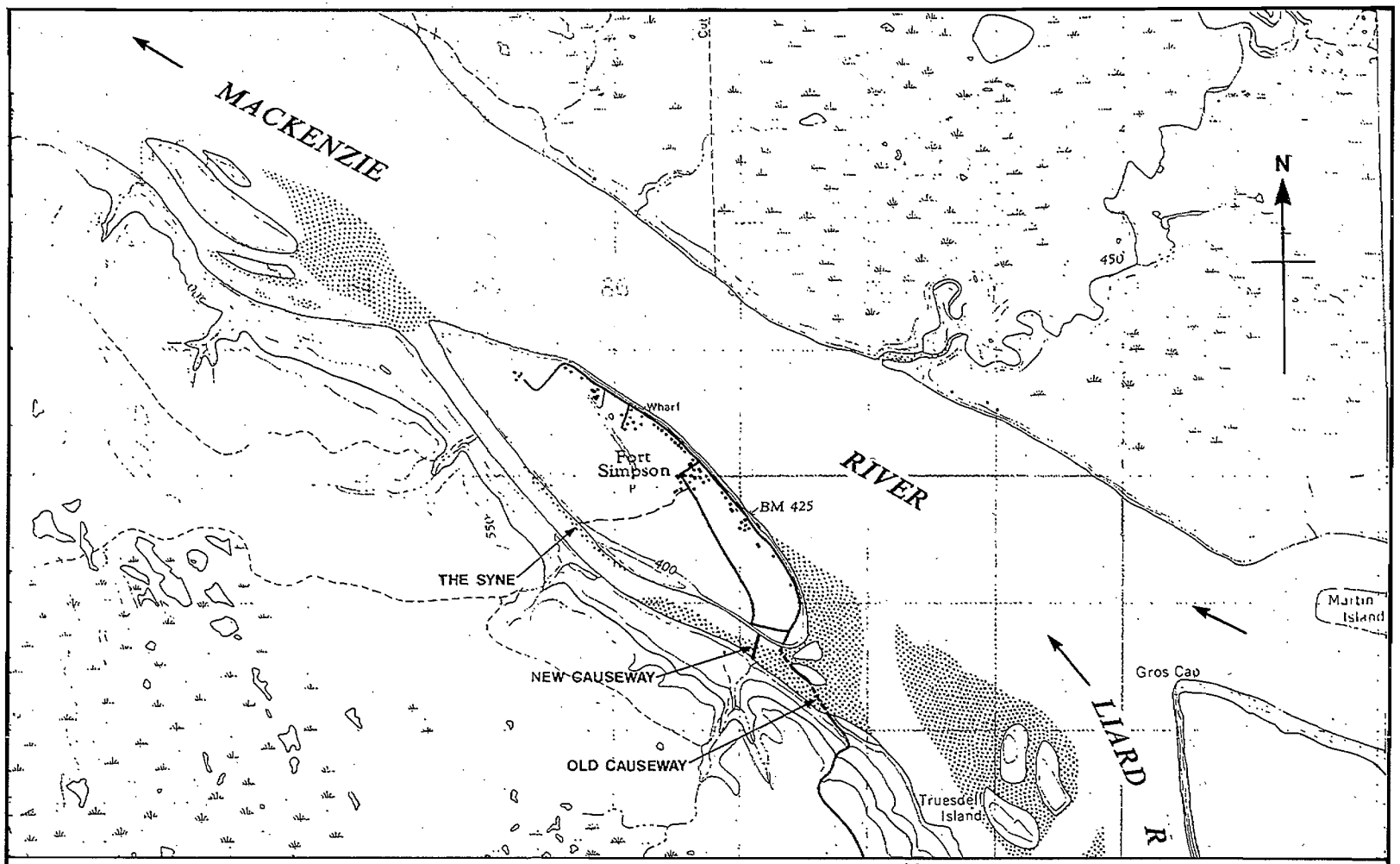


FIGURE 2 LOCATION MAP, FORT SIMPSON, N.W.T.

Photograph 1. Fort Simpson island viewed southeast, upstream the Liard River, left bank of the Mackenzie River in foreground. 07 May 1982, 1745 MDT.

Prior to 1970, a low causeway linked the southeast end of the island to the mainland. The elevation of the causeway was too low and was frequently overtopped during spring break-up. As a result, the Liard water and ice would flow through the Snye and enter the Mackenzie at the downstream end of the island. In 1970, construction of a higher causeway was completed. Although the Snye continues to fill with backwater from the downstream end of the island during break-up, the new causeway has forced the Liard to enter the Mackenzie upstream of the island. Also common during break-up is the flooding of both ends of the island where the lower terrace merges with the shoal area.

On the banks bordering the Snye, physical evidence of pre-1970 flooding and ice shove activity was observed. Driftwood, flood detritus and ice scars were surveyed at elevations of up to 125 metres (see Fort Simpson Flood Risk Map No. 1). Sloping willow stands, and deformed and uprooted tree growth indicated past ice shove activity having overtopped the banks.

Historical flood levels at Fort Simpson are presented in Figure 3. The settlement's history dates from 1804; a complete record of flood information is available from 1828. Inundation of 75% of the island by spring floodwater has not been uncommon. For all but three of the flood events documented in Hudson's Bay Company journals, a range of "possible" maximum flood levels is given. Descriptions of flood limits from the journals were interpreted and subsequently defined in terms of the elevations of the island's three terraces.

1. 1857 Flood

Date: 07 May 1857

Cause: ice jam at mouth of Liard River

Chronology: 05 May - Liard breaks in early morning, crosses Mackenzie in afternoon, water covers low flats

06 May - open water in front of Fort, ice choked at mouth of Liard; water rises a little; Liard moves in evening

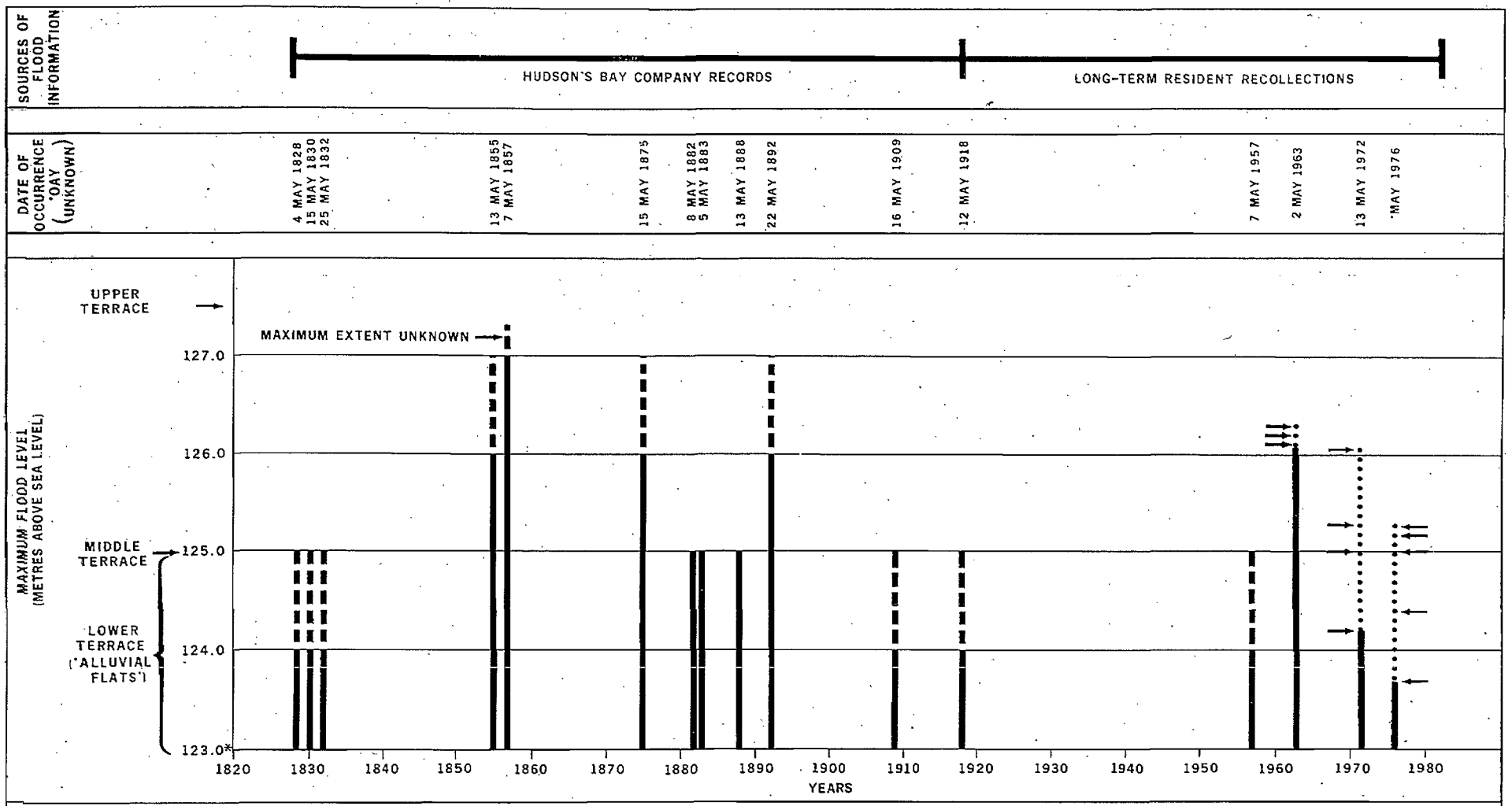
07 May - ice jams in morning; water is now very, very high; the whole island except for the ridge on which the Fort stands is now covered with water

10 May - river in same state; immense quantity of timber on ice

11 May - ice moves a little; water drops considerably in evening

---

Source: Hudson's Bay Company Archives (H.B.C.A.), Provincial Archives of Manitoba (P.A.M.), B200 a/32, fo. 47d)



LEGEND

- INDICATES LOWEST RECORDED MAXIMUM FLOOD LEVEL
- INDICATES RANGE IN RECORDED MAXIMUM FLOOD LEVELS
- ARROWS POINT TO SPECIFIC FLOOD LEVELS SURVEYED WITHIN RANGE
- INDICATES RANGE IN POSSIBLE MAXIMUM FLOOD LEVELS
- * PERCEIVED MINIMUM FLOOD LEVEL

FIGURE 3
HISTORICAL FLOOD LEVELS
FORT SIMPSON, N.W.T.

Extent: Maximum flood level is delineated by upper terrace on which original fort buildings were situated.

1857 FLOOD LEVEL INFORMATION

Map Reference Number	Source/Reliability	Water Level (metres asl)
1	Hudson's Bay Company journal / 3	127.5

1857 Floodline (127.5m) delineated on Fort Simpson Flood Risk maps

2. 1963 Flood (Extreme)

Date: 02 May 1963

Cause: ice jam at channel bend 19 km downstream of island

Chronology: 31 April - Liard ice broke, stopping above island; high flood wave behind

01 May - 1000 h - word that water level 50' above normal; Mackenzie ice black and solid had lifted; strong current in shore leads

1200 h - entire sheet of Mackenzie moves; spectacular strength thrusting 20' above banks covering half of Mackenzie Drive

1400 h - ice slows; jams few miles below island

1630 h - water approaching NCPC

1700 h - airstrip half flooded; water rushing behind Igloo Theatre, behind hostels, up to 7' at arena, and on across airstrip

1800 h - water covering Mackenzie Drive in front of hospital

2400 h - water levels drops 2'

02 May - 1400 h - water peaks even more than before

1000 h - rescue helicopters coming

1130 h - NCPC stops

1800 h - 125 men and dogs remain on island

03 May - in early hours water level drops, fear of upper Mackenzie ice

04 May - full evacuation to Yellowknife

05 May - 1200 h - water level rises at Jean Marie River; no sign of immediate break-up on upper Mackenzie

08 May - water level down a few feet

11 May - residents return to island

(Photographs 2, 3, 4)

(Source: "Fort Simpson News" in the Catholic Voice, No. 105, p. 7-8).

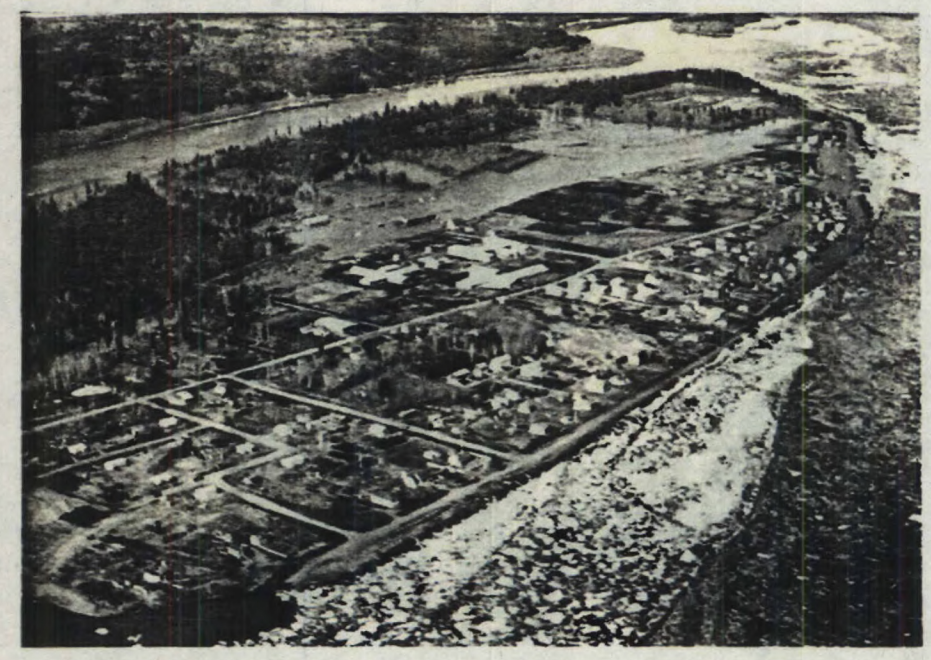
Extent: Maximum flood levels surveyed from available information sources are tabulated below. Location of sources are referenced for identification on settlement map.

1963 FLOOD LEVEL INFORMATION

Map Reference Number	Source/Reliability	Water Level (metres asl)
2	Photograph - high water on Arena / 2	126.1
3	Personal Recollection - Mackenzie Drive resident / 4	126.2
4	Photograph - High water behind RC Church / 2	126.1

1963 Extreme Floodline (126.1 m) delineated on Fort Simpson Flood Risk maps.

Extreme Ice Shove Limits: Observed limits of 1963 ice shove activity along Mackenzie Drive (126-127.5 m asl); ice shoved up to 6 m high on road, delineated on Fort Simpson Flood Risk maps.



Photograph 2. 1963 Flood at Fort Simpson, viewed from upstream end of island (timing of photograph unknown; believed to have been taken on 01 May 1963, one day prior to peak stage). Note in foreground that water has reached upper terrace, cutting off road to low-lying flats.

Photograph 3. 1963 flood at Fort Simpson, view of left bank of Mackenzie at mid-island.

Photograph 4. Long-time resident of Fort Simpson, Joe Lafferty, indicating high water level (126.1 m asl) of 1963 flood.

B. Fort Norman

Fort Norman is situated on the east bank of the Mackenzie River immediately upstream of the mouth of the Great Bear River (Figure 4). The settlement occupies two terraces, at elevations of approximately 60 and 70 metres above sea level, or 10 and 20 metres above the July 23, 1982 river level (48.15 m) (Photograph 5). An abandoned channel, aligned in an east-west direction to the north of the settlement, forms a depression which floodwaters have occupied.

The confluence of the Great Bear and Mackenzie Rivers, where Bear Rock rises to 400 metres, is prone to ice jamming. At this site during spring break-up, ice is commonly obstructed by Windy Island, extensive shoals and the intact ice cover at the mouth of the Great Bear (MacKay and Mackay, 1973).

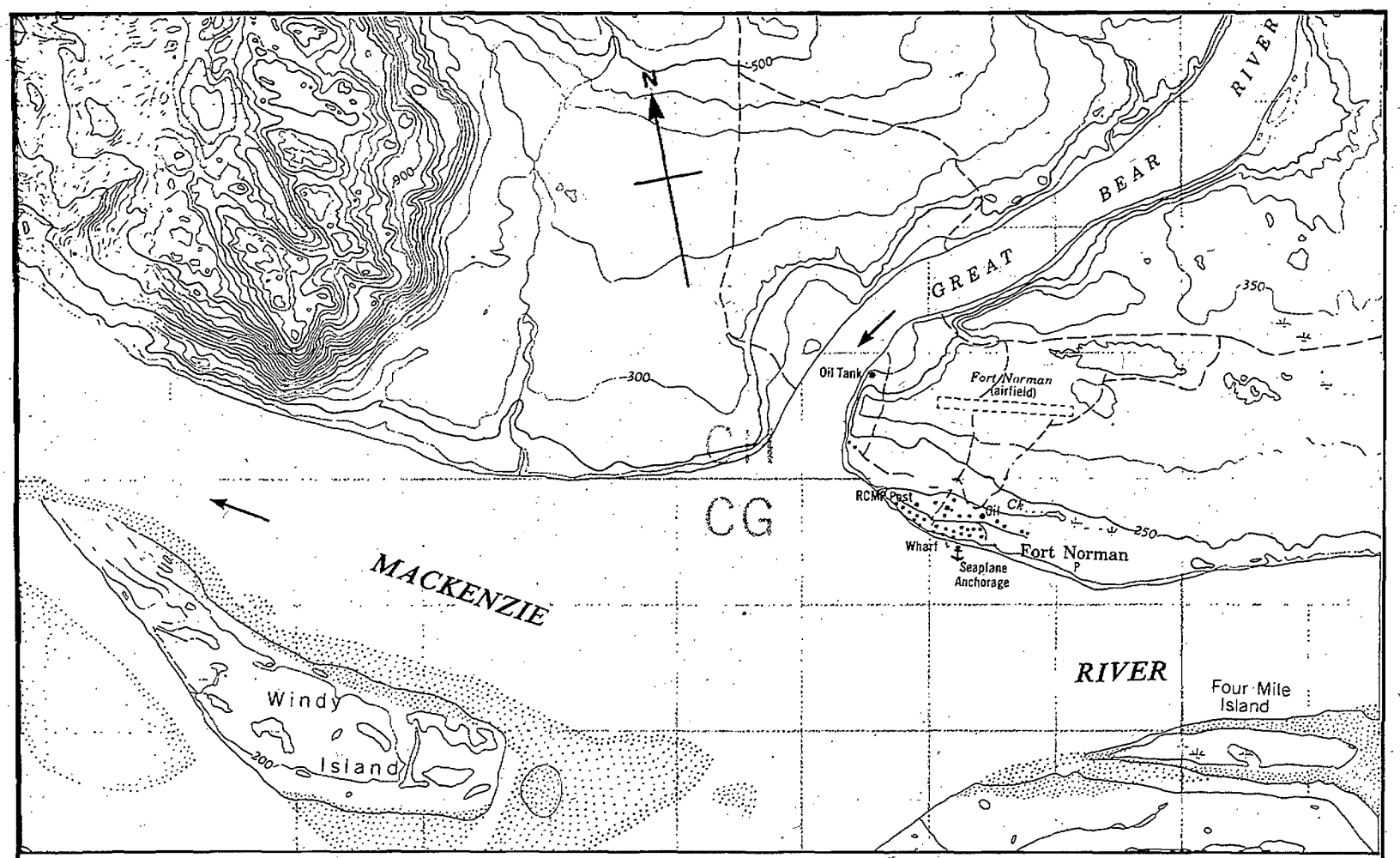


FIGURE 4 LOCATION MAP, FORT NORMAN, N.W.T.

SCALE 1:50,000

Km 1 0. 1 2 3 Km

Photograph 5. Fort Norman settlement at confluence of Great Bear and Mackenzie Rivers, viewed downstream the Mackenzie with Great Bear entering from the north, 20 July 1982, 1700 MDT.

Historic flood levels at Fort Norman are presented in Figure 5. The Fort was established in 1810 and available flood records date from 1822. According to resident recollections, spring floodwaters have overtopped the lower terrace of the settlement on two occasions in the past 72 years. A significant break exists in the records between 1946 and 1905.

1. Extreme Flood Event: 1964

Date: 28 May 1964

Cause: major ice jam at junction of Great Bear and Mackenzie Rivers; "massive rafting of pans and compression of ice wreckage resulted in the development of an immense ice structure standing more than 9 m above winter ice level and extending 24 km upstream" (MacKay, 1965)

Chronology:
23 May - ice moved 500 yards and stopped at Bear Rock
24 May - river 10' above winter ice level
28 May - river still rising
29 May - river holding, then breaking
03 June - jam broken wide open
04 June - river all clear
(Photographs 6, 7, 8, 9)

(Source: MacKay, 1965)

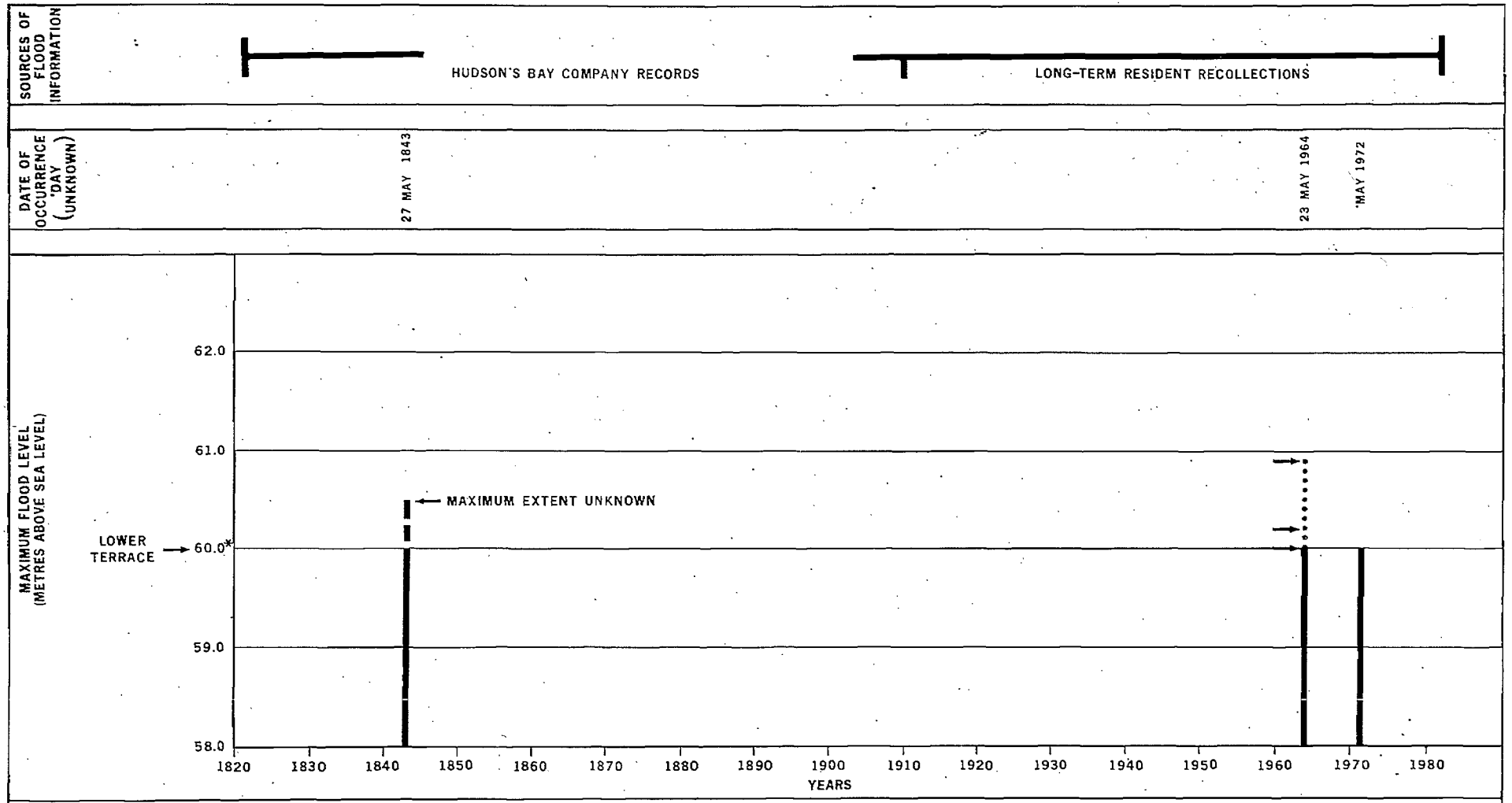


FIGURE 5
HISTORICAL FLOOD LEVELS
FORT NORMAN, N.W.T.

Extent: Maximum flood levels surveyed from available information sources are tabulated below. Location of sources are referenced for identification on settlement map.

1964 FLOOD LEVEL INFORMATION

Map Reference Number	Source/Reliability		Water Level (metres asl)
1	Personal Recollection - water to fence on lower terrace	/ 4	60.0
2	Personal Recollection - water to house on lower terrace	/ 4	60.2
3	Personal Recollection - water to garden on lower terrace	/ 4	60.9
4	Photograph (no. 8) - water level at bank below old Hudson's Bay Company store	/ 2	60.9

1964 Extreme Floodline (60.9 m) delineated on Fort Norman G.N.W.T. map.

Extreme Ice Shove Limits: Observed limits of 1964 ice shove activity along lower terrace of settlement (60.5-60.9 m asl) delineated on Fort Norman GNWT community map (information provided from Photographs 7 & 9).

Photograph 6. Lower terrace of Fort Norman, viewed downstream the Mackenzie from old HBCo. yard on upper terrace, 21 July 1982, 1020 MDT. Offers a comparative view with photograph 7, taken from same vantage point.

Photograph 7. Extent of ice shove (60.5-60.9 m) on lower terrace of Fort Norman settlement, 28 May 1964.

Photograph 8. 1964 flood at Fort Norman, viewed upstream the Mackenzie River to road below old HBCo. yard, 28 May 1964. Water level surveyed at 60.9 m asl.

Photograph 9. 1964 ice shove on lower terrace of Fort Norman Settlement, 28 May 1964.

C. Fort Good Hope

Fort Good Hope is situated on the east bank of the Mackenzie River at the mouth of Jackfish Creek, 3.2 km downstream of the northern end of the Ramparts (Figure 6). The settlement extends over a series of river terraces and abandoned stream courses which slope southward to the mouth of Jackfish Creek. The Fort was removed from its old site on Manitou Island in the spring of 1831 when the release of an ice jam at the Ramparts sent a mass of ice and water down upon the island.

Subsequent break-up flooding at the present site, 20 metres above July 18, 1982 river level, (21.28 m), has been a result of ice jamming 7.5 km downstream at an island below the mouth of the Hare Indian River. Backwater has entered the settlement via Jackfish Creek, occupying the low-lying gully (a past stream course of the creek) northeast of the Hudson's Bay Company store.

Driftwood was observed along the banks of Jackfish Creek but levels were not surveyed because of access difficulties.

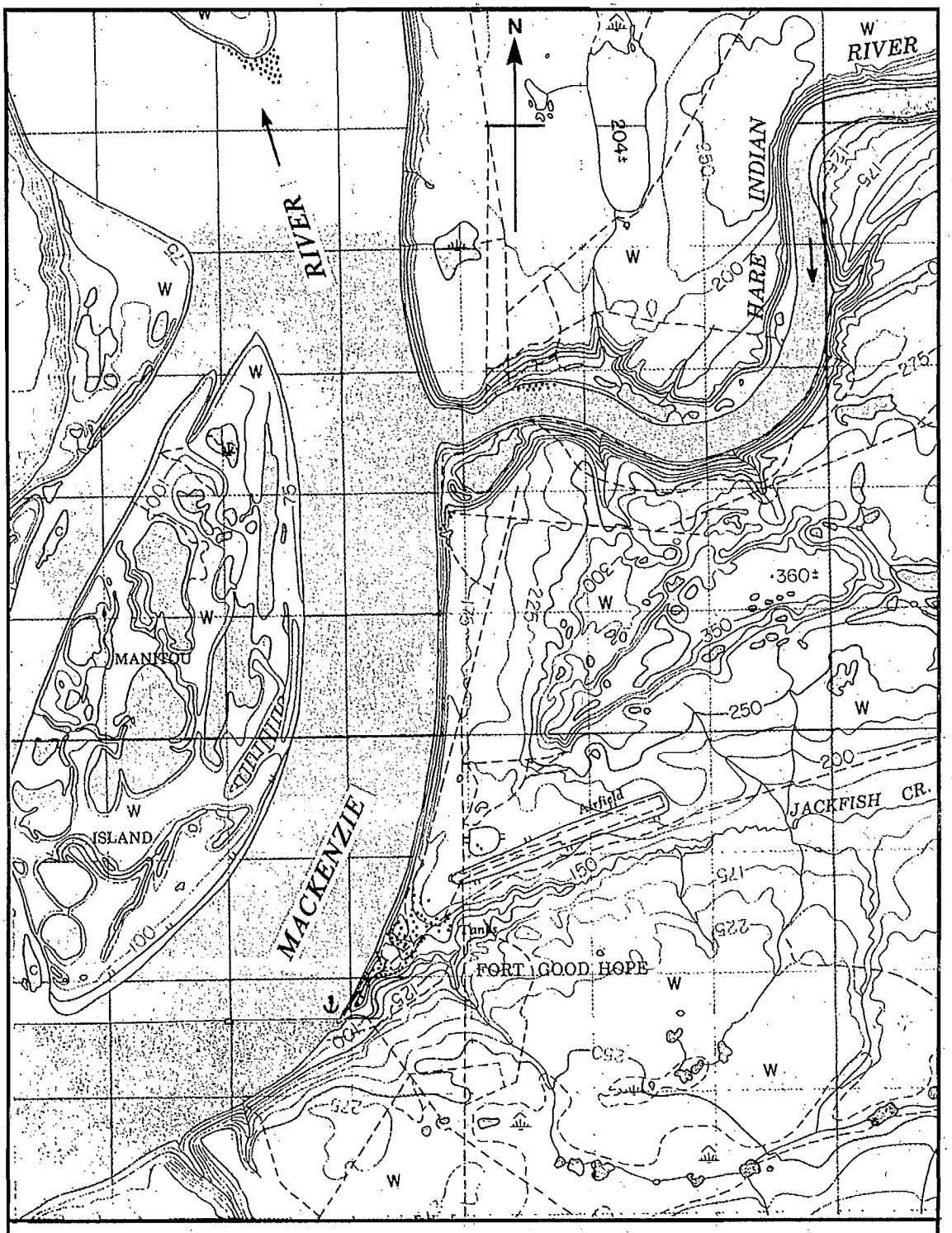


FIGURE 6 LOCATION MAP, FORT GOOD HOPE, N.W.T.

SCALE 1:50,000

Km 1 0 1 2 3 Km

Historical flood levels at Fort Good Hope are presented in Figure 7. Records of flooding date back to 1823 when the fort was located on Manitou Island. Since 1831, records and personal recollections indicate that the lower parts of the settlement have experienced flooding on three occasions, the highest occurring in 1961.

1. Extreme Flood Event: 1961

Date: May 1961 (day unknown)

Cause: ice jam 5 km downstream at mouth of Hare Indian River

Chronology: not available

Extent: Maximum flood levels surveyed from available information sources are tabulated below. Location of the sources are referenced for identification on settlement map.

1961 FLOOD LEVEL INFORMATION

Map Reference Number	Source/Reliability		Water Level (metres asl)
1	Personal Recollection - water in gully below HBCo store	/4	33.7
2	Personal Recollection - water in gully below HBCo store	/ 4	33.4
3	Personal Recollection - water in gully below HBCo store	/ 4	33.7

1961 Extreme Floodline (33.7 m) delineated on Fort Good Hope Flood Risk map.
Extreme Ice Shove limits: no evidence available.

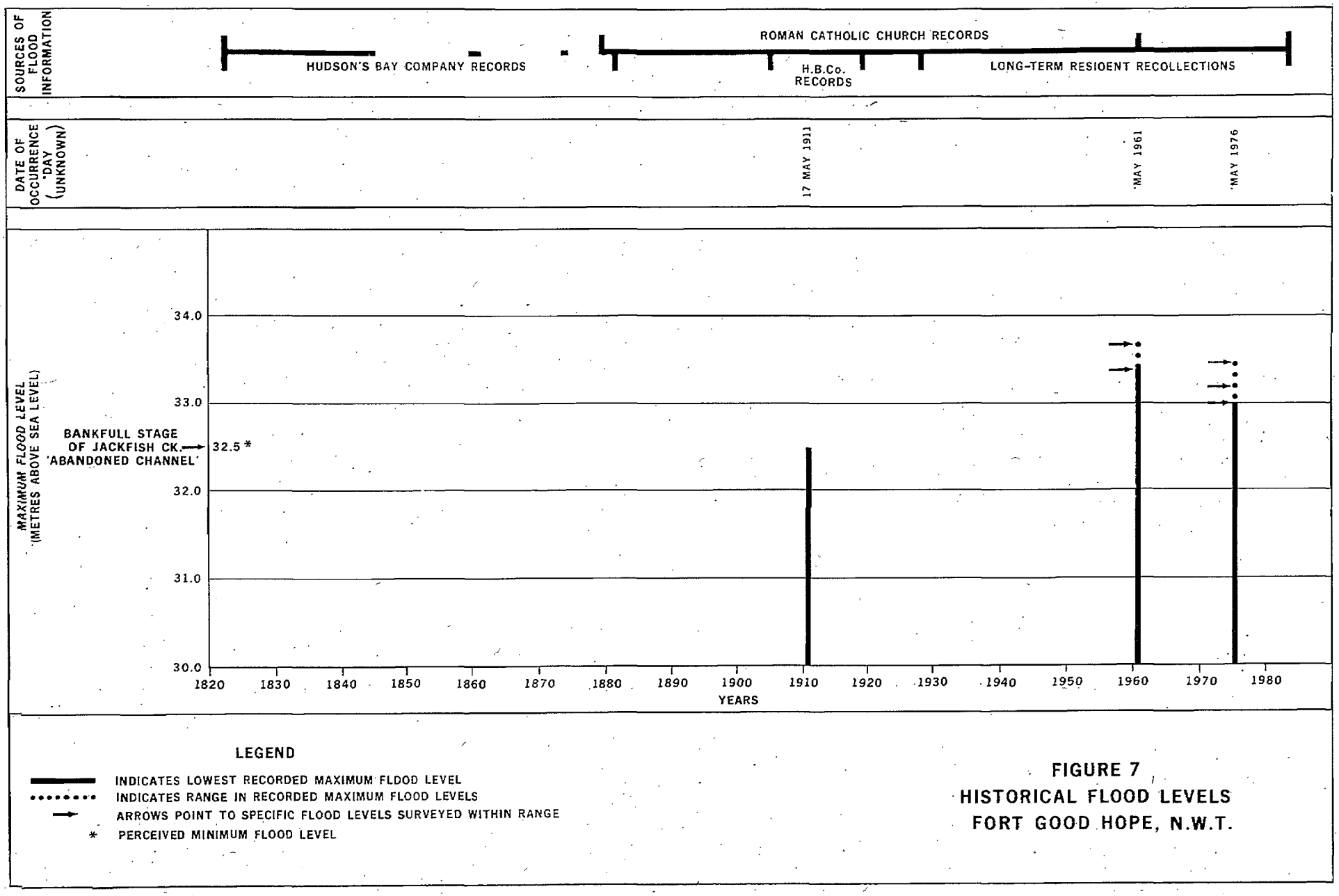


FIGURE 7
HISTORICAL FLOOD LEVELS
FORT GOOD HOPE, N.W.T.

D. Fort McPherson

Fort McPherson is situated on a terrace, 30 metres above sea level, on the east bank of the Peel River on the southern fringe of the Mackenzie Delta (Figure 8). Two lower flood terraces lie between the community and the river (Photograph 10). An alluvial plain with numerous lakes and swamps surrounds the settlement on the landward sides.

"Last Dock" Road, which follows along the lower flood terrace (10.5 metres asl) to the north of the settlement, is subject to seasonal break-up flooding and ice shove activity (Photograph 11).

Factors contributing to the high water levels experienced during spring break-up at Fort McPherson include:

(1) spring meltwater flowing from the Richardson Mountains into tributary streams of the Peel River and,
(2) backwater flooding in the Peel River as a result of ice jamming downstream of the Peel/Mackenzie confluence.

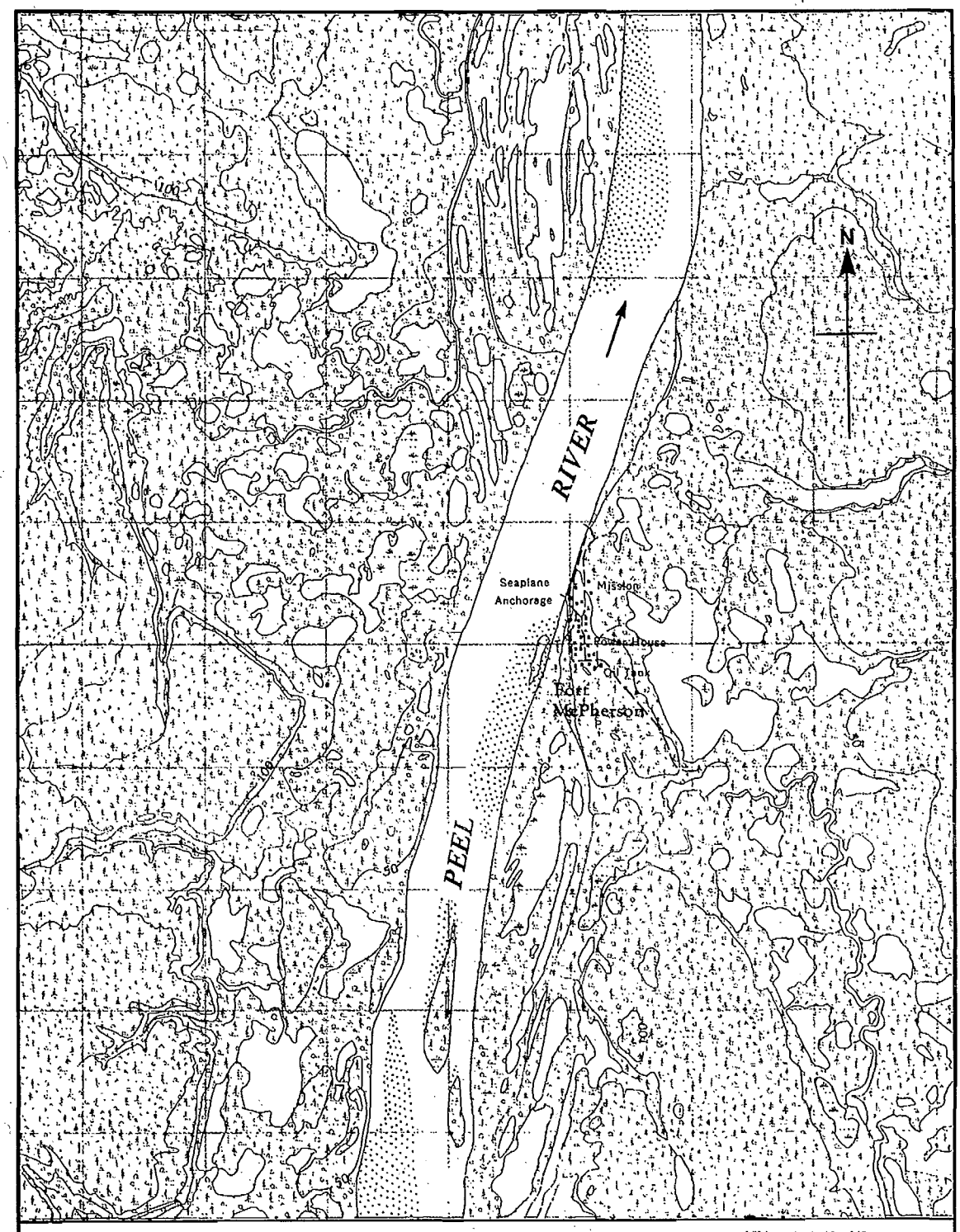
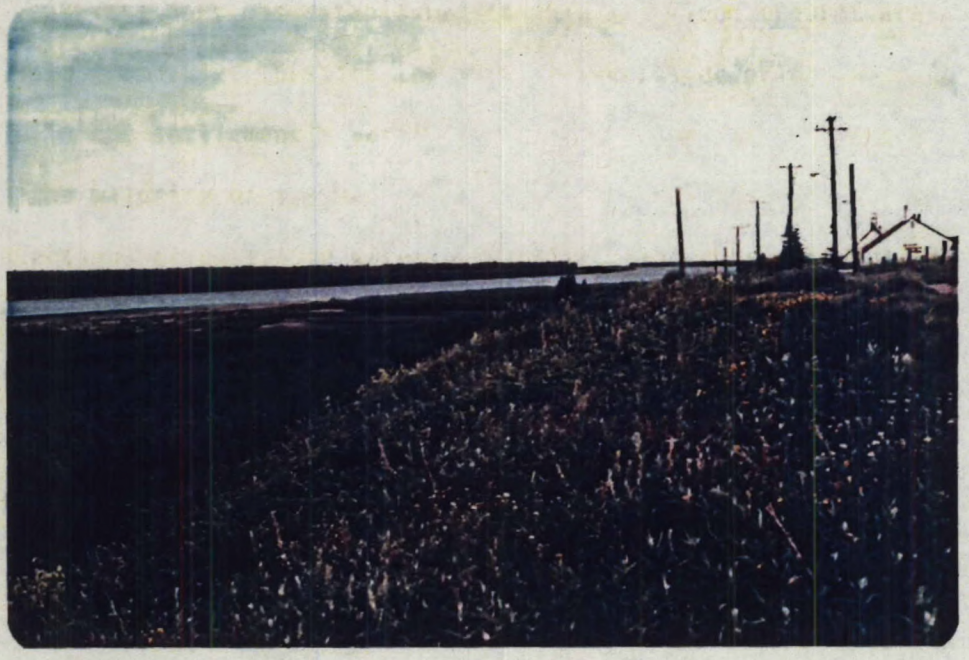


FIGURE 8 LOCATION MAP, FORT McPHERSON, N.W.T.

SCALE 1:50,000

Km 1 0 1 2 3 Km



Photograph 10. Peel River flood terrace 15 metres below settlement of Fort McPherson, viewed north, downstream the Peel River. 08 July 1982, 1614 MDT.

Photograph 11. Trees damaged by spring break-up ice shove on "Last Dock Road" - north of Fort McPherson settlement. 06 July 1982, 1800 MDT. Ice shove levels surveyed between 10.5-11.0 m asl.

Historic flood levels at Fort McPherson are presented in Figure 9. The Fort was established in 1840 and flood records are available from 1842. Despite the lack of records covering break-up events in the settlement's earlier years, it is believed that the hill which the majority of the settlement occupies, has never been flooded. Recollections of past high water were only provided by residents living at the northern base of the hill (Photograph 12). Flooding in 1957 is reported to have been the highest ever experienced.

1. Extreme Flood Event: 1957

Date: May 1957 (day unknown)

Cause: unknown

Chronology: unknown

Extent: Maximum flood level was surveyed from 1 location at the northern base of the hill occupied by the settlement. Location of the source is referenced below for identification on settlement map.

1957 FLOOD LEVEL INFORMATION

Map Reference Number	Source/Reliability	Water Level (metres asl)
1	Personal Recollection (Photograph 12) / 4	14.4

1957 Extreme Floodline (14.4 m) delineated on Fort McPherson Flood Risk map.

Ice Shove Limits: Observed limits of 1982 ice shove activity along "Last Dock Road" (10.5-11.0 m asl) delineated on Fort McPherson Flood Risk map.

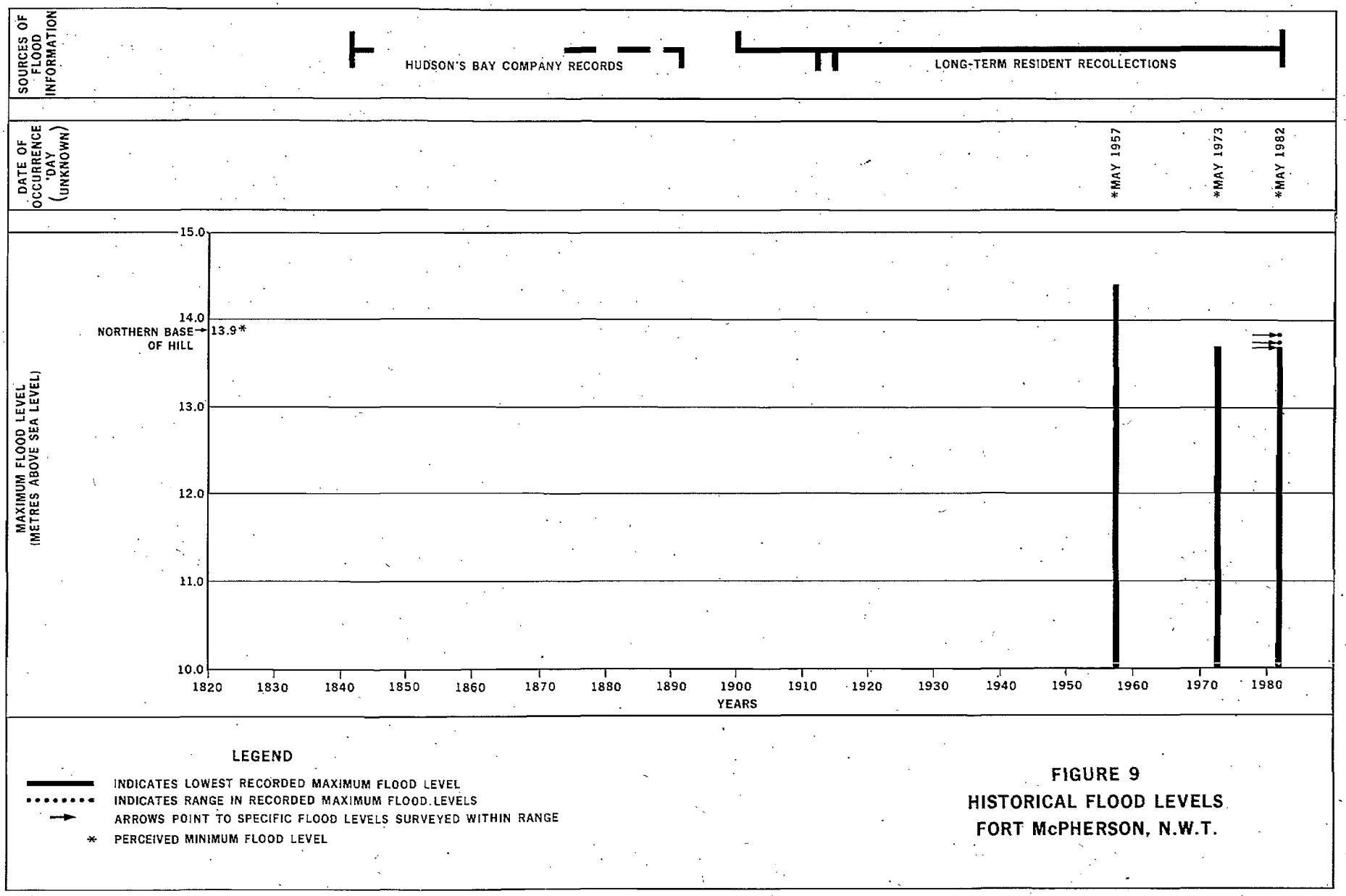


FIGURE 9
HISTORICAL FLOOD LEVELS
FORT McPHERSON, N.W.T.

Photograph 12. Fort McPherson settlement, viewed north to base of hill where 1957 floodwaters reached an elevation of 14.4 m asl.

E. Aklavik

Aklavik is situated on the Peel Channel, a main distributary of the Mackenzie River, in the Mackenzie Delta (Figure 10). The settlement occupies a promontory where the Peel Channel bends sharply to the northwest. The Enoch and Pokiak Channels flow into the Peel from the southeast. An upgraded airstrip occupies a sand bar bordering the east side of the point. A low-lying area of muskeg and swamp is extensive to the north of the settlement (see report frontispiece).

Aklavik is built entirely on deltaic sediments and is subject to poor drainage. Nowhere does the elevation exceed 14 metres above sea level. With a mean elevation of approximately 10 metres above sea level, Aklavik has frequently been inundated by spring floodwaters.

Extensive shoal areas and meandering channels make ice jamming a frequent occurrence in the Delta. Two notable ice-jam prone sites are Point Separation and Horseshoe Bend. Subsequent backwater flow is diverted into distributary channels in the Mackenzie Delta, among them the Aklavik and the Peel. It is through these channels that floodwaters have backed up to the Aklavik settlement.

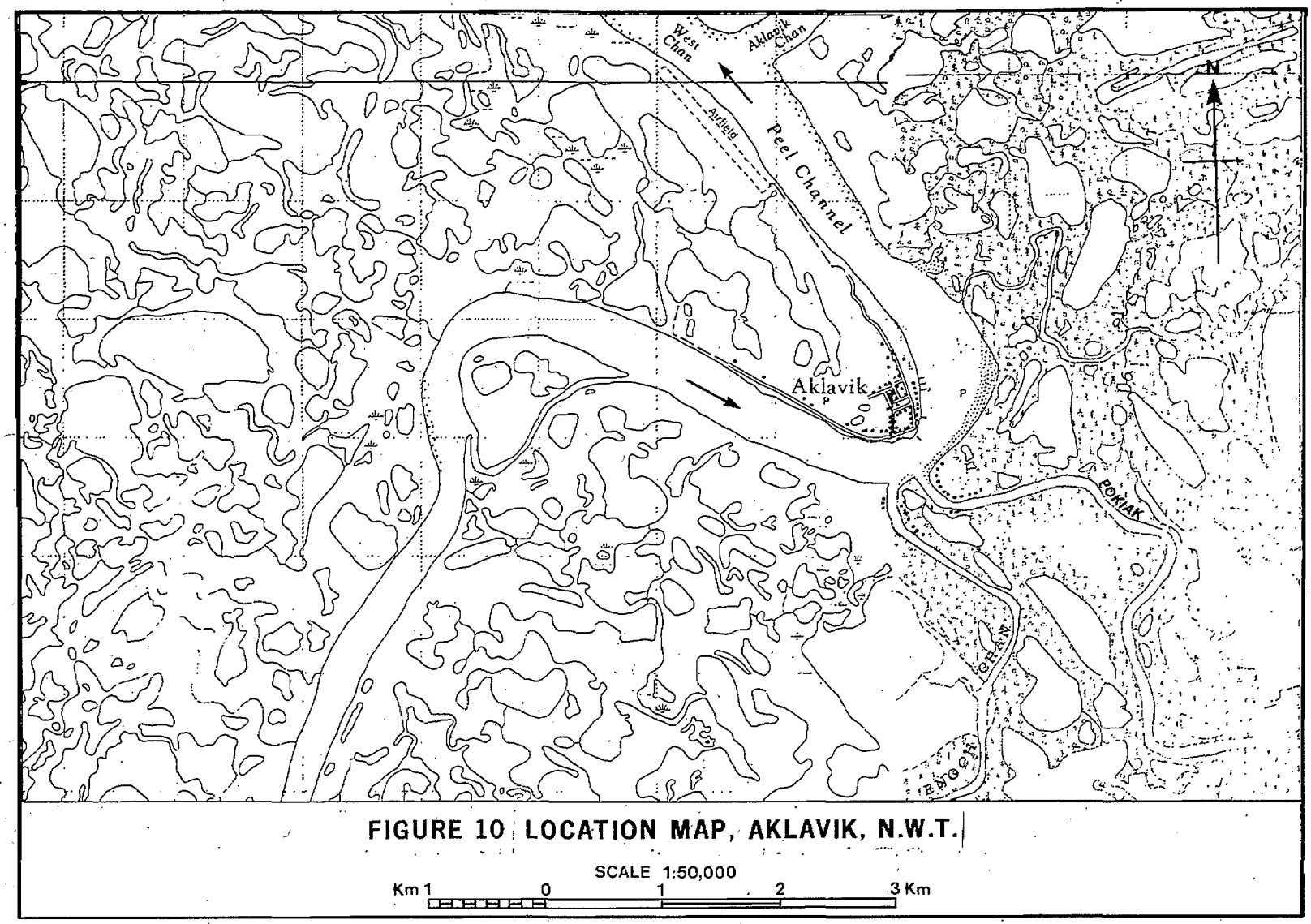


FIGURE 10 LOCATION MAP, AKLAVIK, N.W.T.

SCALE 1:50,000

Km 1 0 1 2 3 Km

Historical flood levels at Aklavik are presented in Figure 11. The settlement was established in 1918; sources of flood information were available from 1929. The worst flooding in the settlement's history was experienced during the spring of 1982, when maximum water levels were surveyed at elevations exceeding 11 metres. Flooding of comparable extent occurred in the spring of 1961; visual estimates in both years suggested that over 95% of the Mackenzie Delta was under water.

1. Extreme Flood Event: 1982

Date: 03 June 1982

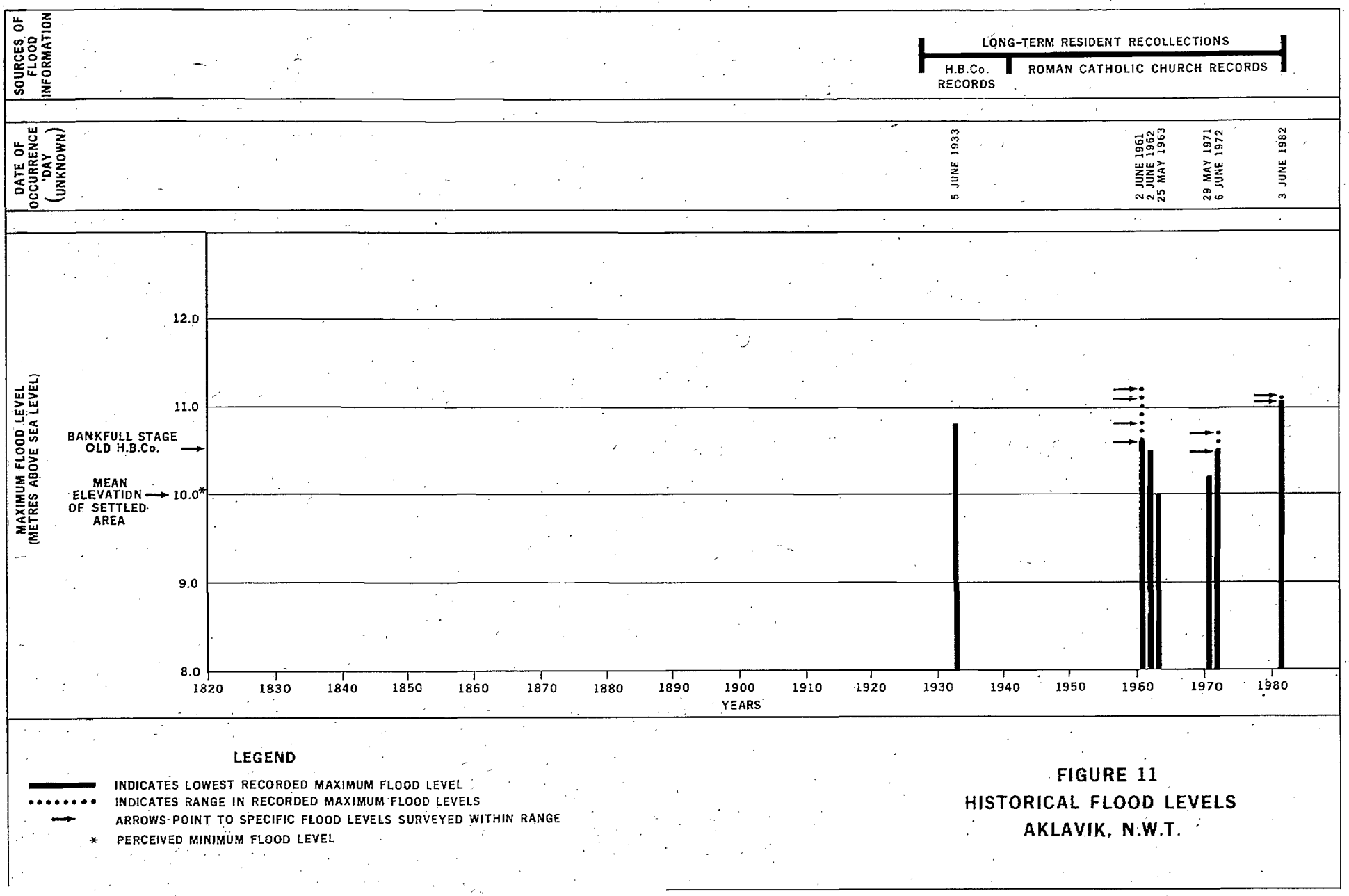
Cause: Three ice jamming events occurred downstream of Point Separation between 24-30 May (Figure 12); subsequent backwater flow was diverted down Peel Channel to Aklavik

Chronology: 01 June - Mackenzie flow diverted down Peel Channnel reaches low-lying areas of Aklavik

02 June - 1050 MDT - ice moves in front of settlement; black ice (with thicknesses of 1.6 - 1.8 metres thrust on top of bank.

1530 MDT - water level 15 cm below top of bank at Roman Catholic mission; water rising at rate of 3 cm per hour, entering the settlement from the northwest and via a low-lying depression 1400 m upstream of the promontory

2300 MDT - Peel Channel clear of ice along airstrip



LEGEND

- INDICATES LOWEST RECORDED MAXIMUM FLOOD LEVEL
- INDICATES RANGE IN RECORDED MAXIMUM FLOOD LEVELS
- ARROWS POINT TO SPECIFIC FLOOD LEVELS SURVEYED WITHIN RANGE
- * PERCEIVED MINIMUM FLOOD LEVEL

FIGURE 11
HISTORICAL FLOOD LEVELS
AKLAVIK, N.W.T.

03 June - Flood level peaks between 0130 and 0700 MDT
1020 MDT - photograph 16 indicates extent of water in settlement

04 June - Water level drops 0.5 metres

06 June - Water level receeds to low-lying area northwest of the settlement

(Photographs 13, 14, 15, 16)

(Observations made by Andy Tardiff from Aklavik airport terminal and L.A. Kriwoken).

Extent: Water levels surveyed at Aklavik airport prior and subsequent to peak stage were as follows:

Date	Time (MDT)	Water Level (metres a.s.l.)
28 May	1637	8.30
30 May	1432	8.74
31 May	1500	9.05
01 June	1823	9.72
02 June	1400	10.60
	1710	10.69
	2300	10.90

Date	Time (MDT)	Water Level (metres a.s.l.)
03 June	0130-0700	10.96 (peak stage)
	1100	10.78
	1130	10.84
	1640	10.78
04 June	1045	10.49
	1315	10.46
08 June	1215	9.35
	1425	9.31

(Water levels surveyed from TBM (nail in power pole at NE corner of airport terminal building, elevation - 11.754 m) by F.E. Parkinson and A.C.D. Terroux.)

Maximum flood levels surveyed from other locations in the settlement are tabulated below. Location of sources are referenced for identification on settlement map.

1982 FLOOD LEVEL INFORMATION

Map Reference Number	Source/Reliability		Water Level (metres asl)
1	Physical Evidence - sediment line on fence (Photograph 17)	/ 1	11.08

2	Physical Evidence - flood debris on airstrip	/ 1	11.05
3	Physical Evidence - sediment line RC Mission	/ 1	11.09
4	Physical Evidence - high water mark on house	/ 1	11.09
5	Personal Recollection	/ 4	11.01
6	Physical Evidence - high water mark on house	/ 1	11.02
7	Personal Recollection	/ 4	11.07
8	Personal Recollection	/ 4	11.04

Extreme 1982 Floodline (11.09 m) delineated on Aklavik Flood Risk map.

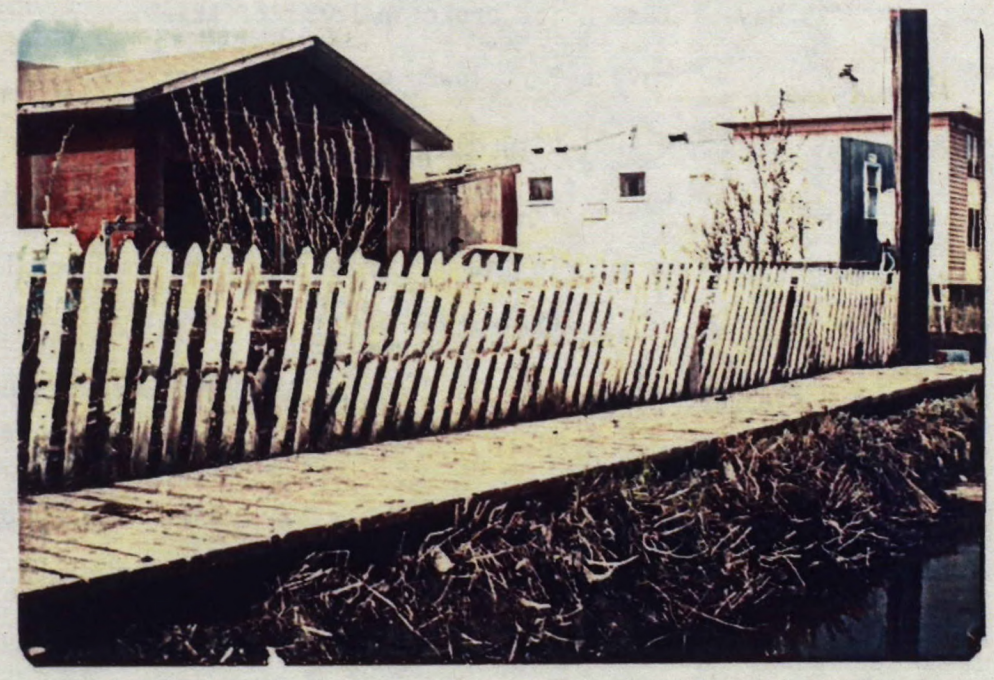
Extreme Ice Shove Limits: Observed limits of 1982 ice shove activity along west side and southern tip of promontory (10.5 - 11.0 m asl); grounded ice pans at northern end of airstrip (11.0 m asl), delineated on Aklavik Flood Risk Map.

Photograph 13. 1982 flood at Aklavik, viewed upstream Peel Channel from in front of Roman Catholic Mission, 02 June 1982, 1400 MDT.

Photograph 14. Ice shove on road in front of old HBCo. store, Aklavik, 02 June 1982, 1350 MDT (black ice thicknesses between 1.5-1.8 m).

Photograph 15. Floodwaters inundating main road in Aklavik, viewed 1 block north of HBCo. store, 02 June 1982, 1305 MDT.

Photograph 16. 1982 Flood at Aklavik, viewed upstream Peel Channel, 03 June 1982, 1020 MDT, between 3¼ and 9 hours after peak stage.



Photograph 17. Sediment line on fence indicating high water level of Aklavik flood (11.08 m asl), 18 June 1982, 1400 MDT.

2. 1961 Flood

Date: 02 June 1961

Cause: ice jam at mouth of Aklavik Channel entering West Channel; ice jam at mouth of Peel Channel at Middle Channel.

Chronology:

29 May 1632 h ice broke in front of Aklavik and began to move out followed by large amounts of silt-discoloured Mackenzie 'black ice'. The Mackenzie black ice moved through the southwest side of the delta via the 'mouth of the Peel' (where it enters the Mackenzie River) and also through other channels, such as Esau and Enoch channels.

Late in the day an ice jam formed at the mouth of Aklavik Channel where it enters West Channel, thus backing Peel Channel water into the lower portions of Aklavik. The ice jam formed from ice moving down Peel and Aklavik channels.

30 May 1200 h the ice jam at the mouth of Aklavik Channel broke, rapidly lowering the water level upstream at Aklavik. Mackenzie River ice continued to flow and jam, with a resulting rise in water at Aklavik.

By evening water level had reached the floors of the tents and shacks situated on the river bank opposite the Anglican Mission.

31 May — Water continued to rise during the day at an average rate of 3/4" per hour. Several families were evacuated from low-lying areas inland to higher ground.

An aerial survey showed an unbroken ice sheet across Middle Channel immediately above Horseshoe Bend. The Channel was plugged with loose ice back to Point Separation; the mouth of the Peel was blocked by Mackenzie ice but the Peel Channel itself was open to Aklavik. Half to three-quarters of the southwest part of the delta was inundated.

1 June — Water continued to rise all day, until it was 3 feet deep in the middle of the settlement, and reached a height of 16 to 17 feet above low water level. At this stage all the roads were inundated except for the strip extending from the river to the old North Star Hotel. Canoes were used throughout the greater part of the settlement. Rain fell in the evening and most of the night.

2 June — Rain fell during the day and the water continued to rise.

3 June — Rain fell during the night and all day. By 1200 h the ice-jam at the mouth of the Peel had broken. By 2400 h the water level had dropped 2".

4 June — Water level dropped 10" during the day.

5 June — Water began to rise slowly again. An aerial survey showed that ice was moving down Middle Channel 32 km downstream of Horseshoe Bend and was also going out the distributary channels. Over 95 percent (visual estimate) of the delta was under water.

6 June — Water level dropped 10" overnight.

7 June — Water level continued to drop steadily.

(Source: Chronology abstracted from Flood Report written by R.C. Timmins - Dept. of Northern Affairs and Natural Resources)

Extent: Maximum flood levels surveyed from available information sources are tabulated below.

1963 FLOOD LEVEL INFORMATION

Source/Reliability		Water Level (metres asl)
Personal Recollection	/ 4	10.6
Personal Recollection	/ 4	10.6
Personal Recollection	/ 4	10.8
Historic Document - Roman Catholic Church diary	/ 2	10.8
Personal Recollection	/ 4	11.1
Personal Recollection	/ 4	11.2
Personal Recollection	/ 4	11.2

F. Fort Liard

Fort Liard is situated on the south bank of the Liard River, 329 km upstream of the Mackenzie/Liard confluence (Figure 13). The Petitot River flows into the Liard immediately upstream of the settlement. The settlement occupies a river terrace that is approximately 8 metres above the shoals at the mouth of the Petitot; the elevation of the terrace decreases by 2 metres in a downstream direction. An abandoned channel of the Petitot River dissects the community's low-lying area below the RC mission and the old Hudson's Bay Company store.

Flooding caused by ice jams during spring break-up is not a common occurrence at Fort Liard. Past extreme flood levels experienced at Fort Liard have invariably occurred during open water season (typically in June and July). Factors causing the higher summer stage include: (1) intense storm events and, (2) subsequent rapid snowmelt in the mountainous regions of the basin.

Ice jamming during spring break-up, however, has caused the settlement to flood on occasion. The Petitot River, which normally breaks up prior to the Liard River (late April-early May) may jam at the mouth, forcing backwater to flow through the community via the abandoned Petitot Channel. In the absence of Petitot ice jamming at the Liard/Petitot confluence, the Petitot will initiate the movement of lower

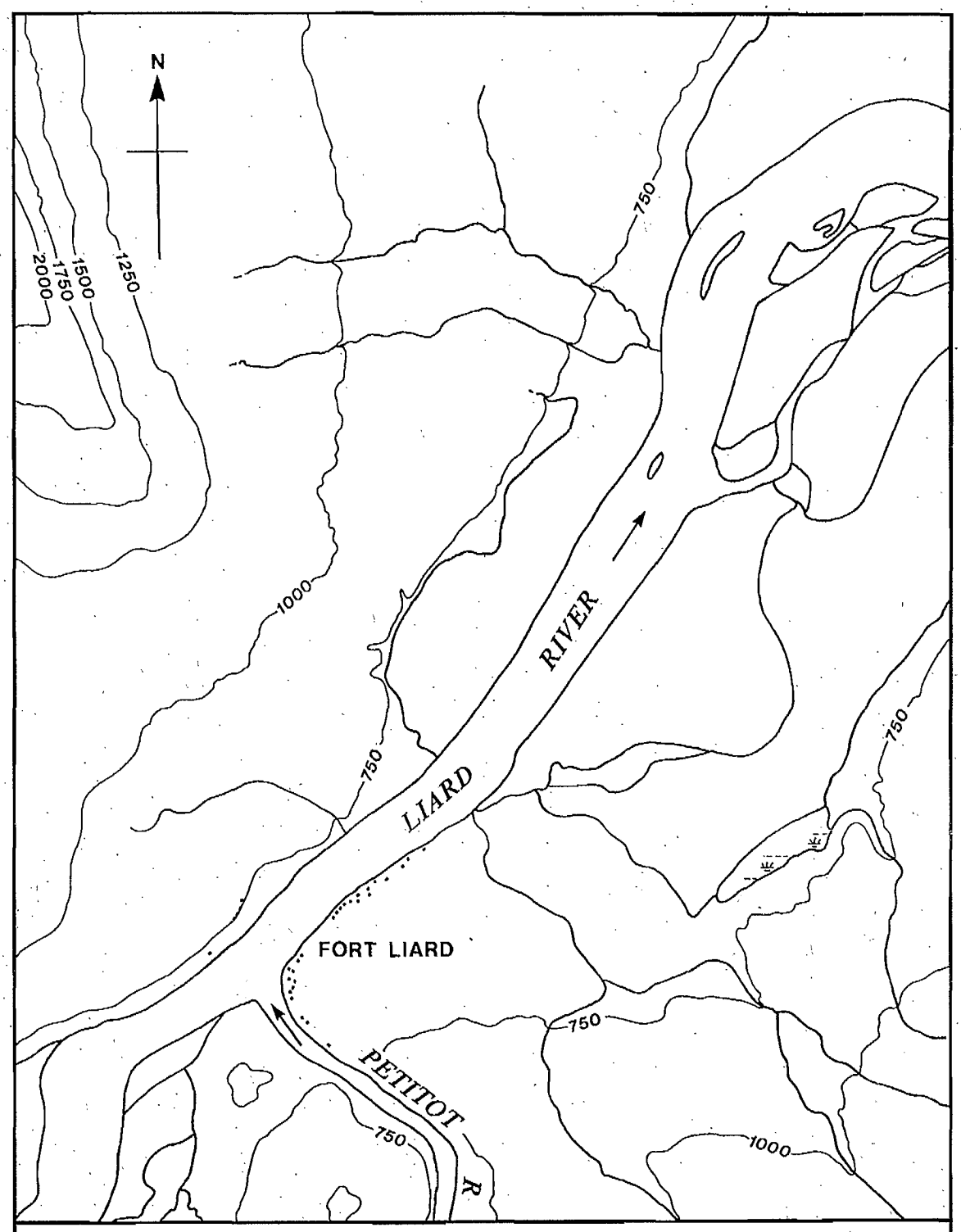


FIGURE 13 LOCATION MAP, FORT LIARD, N.W.T.

Liard ice (ice downstream of the confluence). Ice jam prone sites include an island in a river bend approximatley 5 km downstream, and at a series of islands, including Big Island, first appearing 15 km downstream of the townsite.

Historical flood levels at Fort Liard are presented in Figure 14. The settlement was established in 1822 and available flood records date back as far. Summer floods in 1920 and 1977 were the worst experienced in the settlement's history.

1. Extreme Flood Event: 1977

Date: 2-6 June 1977 (Grey and Jasper, 1978)

Cause: extreme summer storm event: heavy precipitation, rapid snowmelt in the mountains and subsequent rapid local runoff.

Chronology: not available

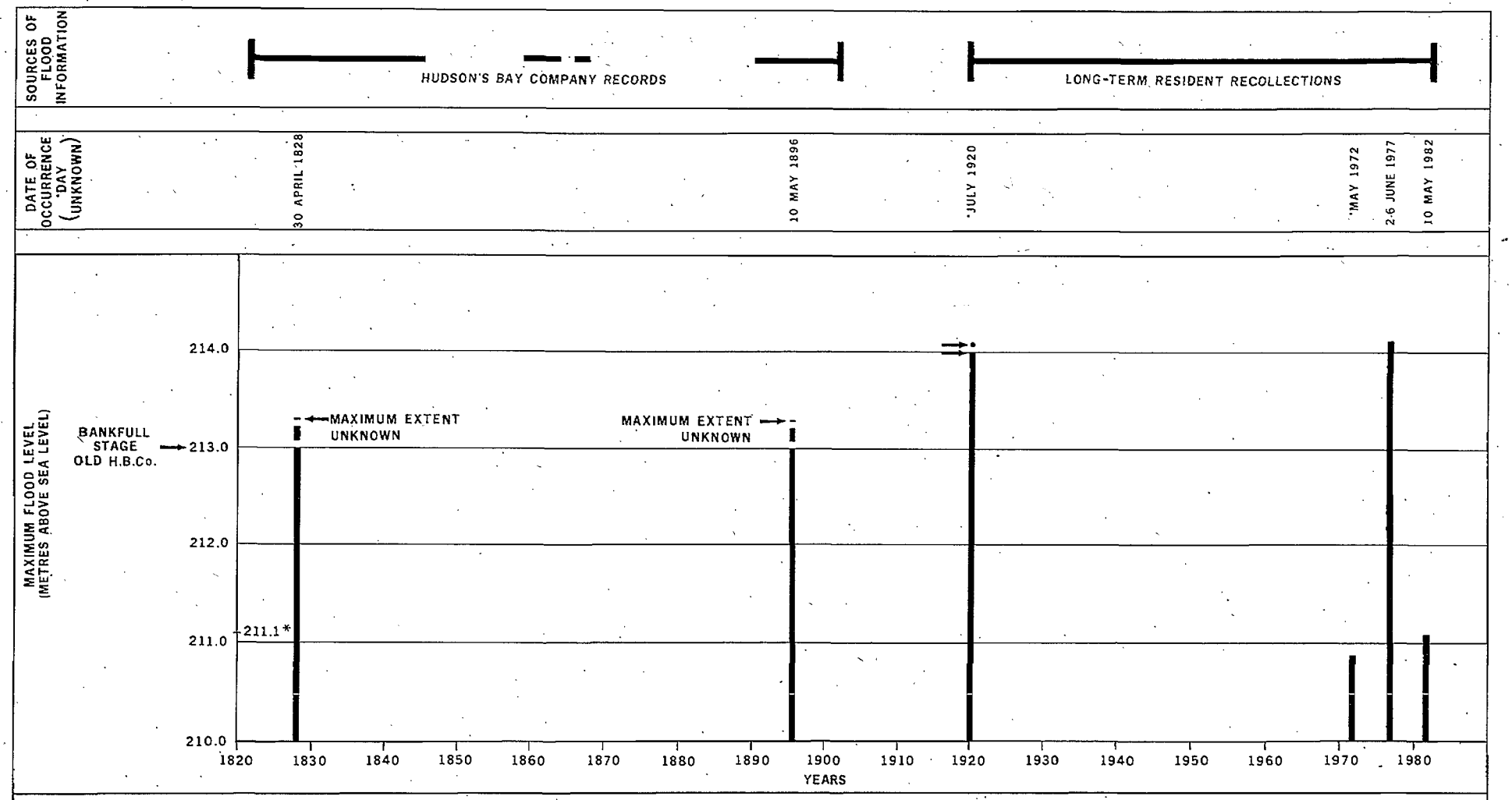
Extent: Maximum flood levels surveyed from available information sources are tabulated below. Location of sources are referenced for identification on settlement maps.

1977 FLOOD LEVEL INFORMATION

Map Reference Number	Source/Reliability	Water Level (metres asl)
1	Personal Recollection / 4 - water across main road east of Beaver Ent. store	214.1
2	Personal Recollection / 4 - water below RC mission house	214.1

1977 Extreme Floodline (214.1 m) delineated on Fort Liard G.N.W.T. map.

Extreme Ice Shove Limits: no evidence available.



LEGEND

- INDICATES LOWEST RECORDED MAXIMUM FLOOD LEVEL
- INDICATES RANGE IN RECORDED MAXIMUM FLOOD LEVELS
- ARROWS POINT TO SPECIFIC FLOOD LEVELS SURVEYED WITHIN RANGE
- INDICATES RANGE IN POSSIBLE MAXIMUM FLOOD LEVELS
- * PERCEIVED MINIMUM FLOOD LEVEL

FIGURE 14
HISTORICAL FLOOD LEVELS
FORT LIARD, N.W.T.

G. Nahanni Butte

Nahanni Butte is situated at the confluence of the South Nahanni and Liard Rivers, 146 km upstream of the Liard/Mackenzie junction. The settlement occupies a relatively flat river terrace on the south bank of the South Nahanni River (Figure 15). The mean elevation of the settled area is 182 m above sea level, or approximately 6 metres above the August 16, 1982 river level (176.33 m).

No past flooding incidents caused by spring break-up of the Liard River have been reported at Nahanni Butte. Summer flooding (June, July) however, has occurred. The late break-up of the South Nahanni River (due to late snowmelt in the mountains) and extreme summer storm events have, on three occasions, caused summer river levels to exceed bankfull stage at the settlement.

On the north bank of the South Nahanni River, the Parks Canada field headquarters is approximately 3 metres above the August 16, 1982 river level (3 m below the elevation of Nahanni Butte) Consequently, flooding on this low-lying river terrace is common during the break-up of the South Nahanni.

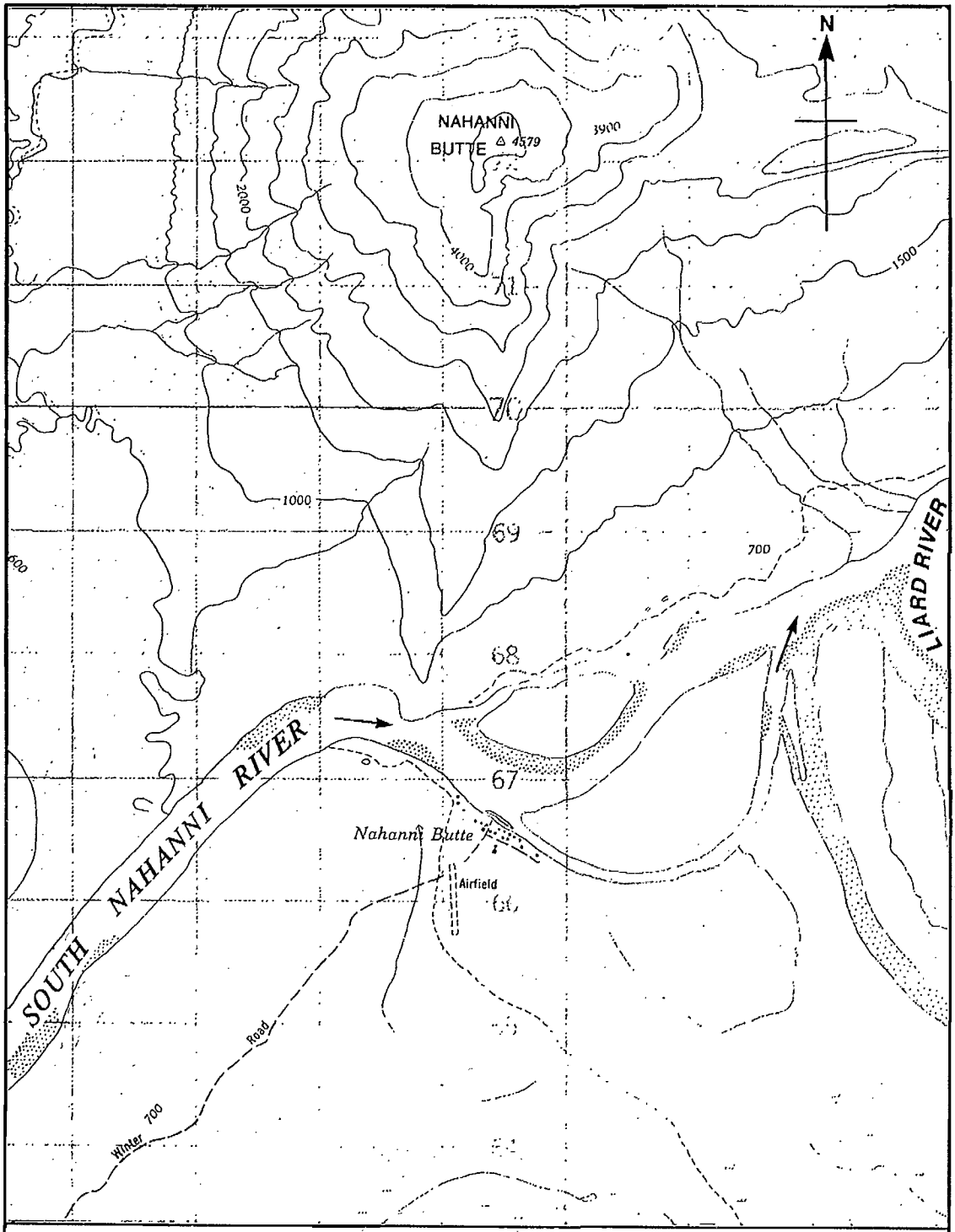


FIGURE 15 LOCATION MAP, NAHANNI BUTTE, N.W.T.

Historical flood levels at Nahanni Butte are presented in Figure 16. The settlement has only expanded to its present population in the past twenty years as people moved in from their bush camps. Recollections of past flooding date from 1919. The summer flood of 1977 was recalled as being the highest experienced since the early 1900s.

1. Extreme Flood Event: 1977

Date: 2-6 June 1977 (Grey and Jasper, 1978)

Cause: summer flood: intense storm event, rapid runoff from mountains

Chronology: not available

Extent: Maximum flood levels surveyed from available information sources are tabulated below. Location of sources are referenced for identification on settlement map.

1977 FLOOD LEVEL INFORMATION

Map Reference Number	Source/Reliability		Water Level (metres asl)
1	Photograph - water level on porch of teacher's house	/ 2	182.1
2	Photograph - water level at nursing station	/ 2	181.8
3	Photograph - water level on road west of school	/ 2	181.7

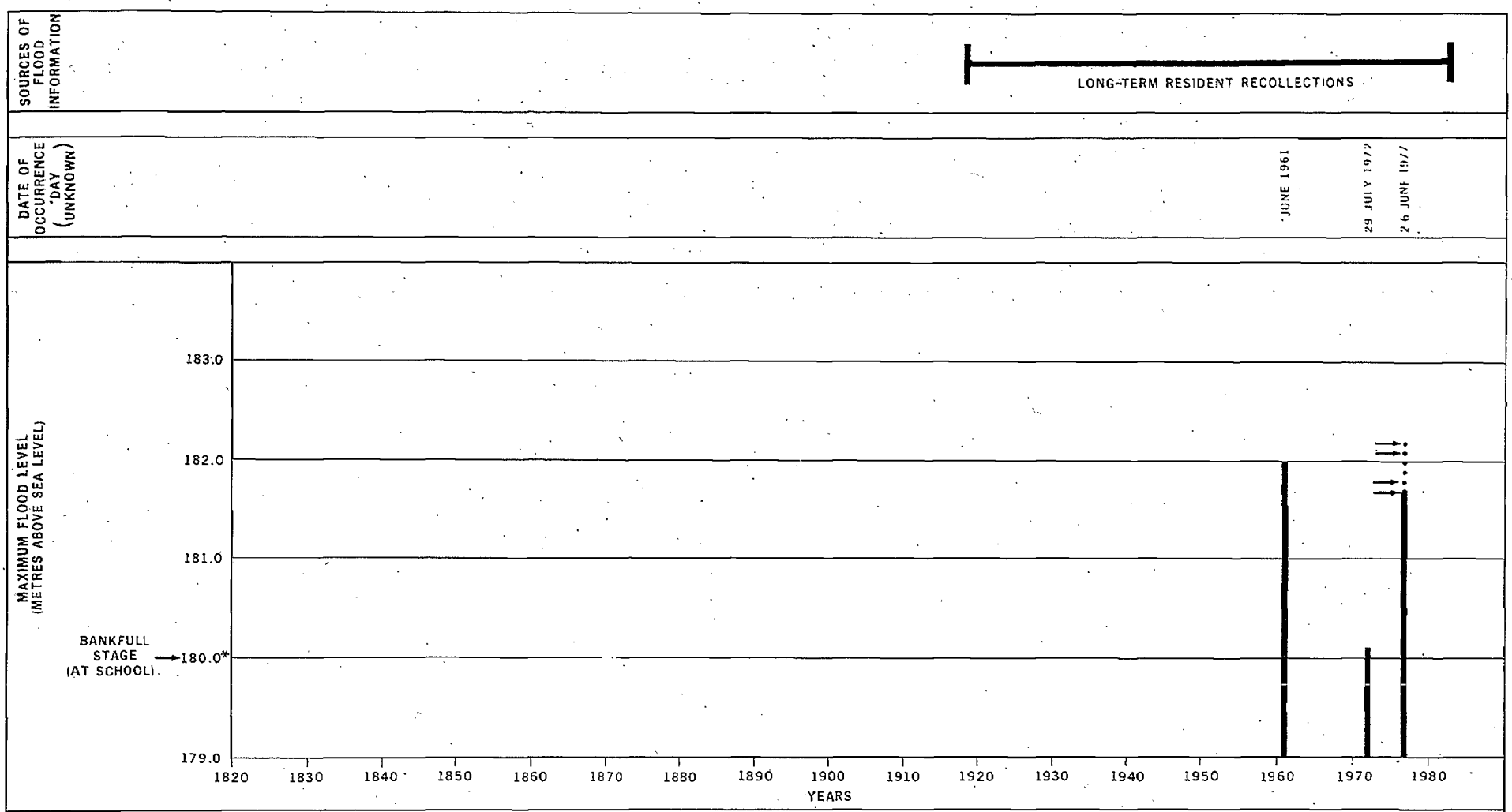


FIGURE 16
HISTORICAL FLOOD LEVELS
NAHANNI BUTTE, N.W.T.

4	Photograph - water level on fence at school	/ 2	182.2
5	Personal Recollection	/ 4	182.2

(Photographs used as evidence are on file in the Nahanni National Park field headquarters at Nahanni Butte, N.W.T.)

1977 Extreme Floodline (182.0 m) delineated on Nahanni Butte G.N.W.T. map. (Because the exact timing of the photography is unknown, the average of the water levels (182.0 m) is designated as the extreme floodline)

Extreme Ice Shove Limits: no evidence available.

CONCLUSIONS

Floodlines for seven Mackenzie Basin communities have been established on the basis of extreme historical flood events. Sources of water level data varied in reliability. As a consequence, the accuracy of floodline delineation was limited in some communities.

Three of the seven designated floodlines were established entirely on the basis of long-term resident recollections: Fort McPherson (14.4 m), Fort Good Hope (33.7 m) and Fort Liard (214.1 m). More reliable floodlines for Fort Norman (60.9 m) and Nahanni Butte (182.0 m) were based on personal recollections substantiated by photographs of extreme events. The 1857 floodline for Fort Simpson (127.5 m) was interpreted from a Hudson's Bay Company diary account. Because of the ambiguities in the information provided, an extreme 1963 floodline (126.1 m), based upon more reliable information, was defined. A 1982 record flood at Aklavik enabled water level surveys to be conducted prior, during and subsequent to inundation of the settlement. The extreme floodline (11.09 m) was based entirely upon physical evidence.

The limits of ice shove varied considerably within areas of one settlement during the same flood event. Because of the unpredictability involved with the random occurrence of ice shove activity, no single extreme ice limit was delineated on the settlement maps. Rather, the use of arrows on the maps indicates observed areas of past ice shove activity.

Ice shove limits for specific flood events include: Aklavik: 10.5-11.0 m (1982), Fort Simpson: 126-127.5 m (1963), Fort Norman: 60.5-60.9 m (1964) and Fort McPherson: 10.5-11.0 m (1982).

For the most part, flooding in the Mackenzie valley communities was caused by spring ice jams, whereas, flooding in Fort Liard and Nahanni Butte was related to summer storm events.

Bibliography

Dawson City Museum and Historical Society (1981)
Historical Review of Dawson City Flood Data, 1898-1975. Prepared for M. Orecklin, Water Resources. Department of Indian and Northern Affairs. Whitehorse, Yukon.

Environment Canada. Inland Waters Directorate (1979)
Flood Risk Mapping for Hay River, Northwest Territories. Underwood McLennan (1977) Ltd.

Gerard, R. and E.W. Karpuk (1979)
Probability Analysis of Historical Flood Data. ASCE, Journal of Hydraulics Division, V. 105, No. HY9, Sept., pp. 1153-1165.

Grey, B.J. and J.N. Jasper (1978)
Hydrologic Studies along the Liard Highway, Spring and Summer 1977. A Progress Report for the Northern Roads Environmental Working Group, Department of Indian Affairs and Northern Development, March. pp. 14-15.

Grey, B.J., D.A. Sherstone, J.C. Anderson and S. Fogarasi (1981)
Liard River Basin Spring Flood. A report submitted to the Department of Indian Affairs and Northern Development under the 1978-1981 Federal Provincial Study Agreement Respecting the Water and Related Resources of the Mackenzie River Basin. Department of the Environment. Inland Waters Directorate. Hull, Quebec.

Hudson's Bay Company Archives (H.B.C.A.)
Provincial Archives of Manitoba (P.A.M.). (1821-1935, outside dates). B200 a/9, 11, 13, 32, 33, 36, 38, 39; B152 a/23; B80 a/9, 30; B378 a/2; B116 a/6, 25.

Kates, R.W. (1962)
Hazard and Choice Perception in Flood Plain Management. Department of Geography Research Paper No. 78. University of Chicago. Illinois.

MacKay, D.K. (1965)
Break-up on the Mackenzie River and Its Delta, 1964. Geographical Bulletin, Vol. 7, No. 2, pp. 117-128.

MacKay, D.K. and J.R. Mackay (1973)
Locations of Spring Ice Jamming on the Mackenzie River, N.W.T. in Hydrologic Aspects of Northern Pipeline Development. Report No. 73-3, April. pp. 233-253.

Mackay, J.R. (1963)
Progress of Break-up and Freeze-up along the Mackenzie River. Geographical Bulletin No. 19, May. pp. 103-116.

Northern Settlements Series (1966)
Settlements of the Northwest Territories. Descriptions prepared for the Advisory Commission on the Development of Government in the Northwest Territories. Department of Indian Affairs and Northern Development, Ottawa. 4 Volumes.

Orecklin, M. (1981)
Dawson Flood Study. Ice Jam of May 3, 1979. 1980-1981 Break-up. Department of Indian and Northern Affairs, Whitehorse, Yukon.

Possett, Fr. H. (1963)
Fort Simpson News. The Catholic Voice. No. 105, May. pp. 7-8.

Roman Catholic Church
Aklavik, N.W.T. Mission. Personal Diaries 1941-1981.

Roman Catholic Church
Fort Simpson, N.W.T. Mission. Film coverage of 1963 flood.

Royal Canadian Mounted Police
Fort Simpson, N.W.T. Detachment. Journals 1938-1961.

Water Planning and Management Branch (1976)
Hydrologic and Hydraulic Procedures for Floodplain Delineation. Inland Waters Directorate. Environment Canada. Ottawa.

Wolman, M.G. (1971)
Evaluating Alternative Techniques of Floodplain Mapping. Water Resources Research, Vol. 7, No. 6. pp. 1383-1391.

APPENDICES

APPENDIX A

DESCRIPTIONS OF BENCH MARKS USED IN WATER LEVEL SURVEYS

At the time field work was carried out, Flood Damage Reduction (FDR) Flood Risk maps were available only for Fort Simpson and Aklavik. For the remaining communities, Government of Northwest Territories (GNWT) Community maps were used. Bench marks used in the water level surveys are described below:

Fort Simpson	BM-3	Iron post driven in ground, located 7 m SE of Water Survey of Canada (WSC) gauging station and 2 m upstream of 15 cm poplar.
	Elevation:	124.192 m (tied into Geodetic Survey of Canada, GSC).
Fort Norman	P30E1	Brass tablet in top of concrete incinerator pad (1.5 m square), 9 m E of old HBCo. warehouse.
	Elevation:	70.519 m (established by Dept. of Public Works, tied into GSC).
Fort Good Hope	75T005	Brass tablet in south face of concrete foundation of Our Lady of Good Hope Church.
	Elevation:	39.978 m (GSC)
	75T008	Brass tablet in NW foundation of NCPC building along road at north end of town.
	Elevation:	43.801 m (GSC) (Note: foundation has shifted; elevation is inaccurate.) An assumed elevation of 44.801 m was used for the water level surveys; this elevation corresponds to the contour elevations given on the Fort Good Hope Flood Risk map.

Fort McPherson	78T029	Brass tablet 4 m from NE corner of foundation of RCMP building.
	Elevation:	23.858 m (GSC)
Aklavik	AK-5	Iron post driven in ground, located 20 m S of RCMP building on N site of road leading to DPW Transient House.
	Elevation:	10.97 m (FDR Flood Risk map)
	TBM	Nail in power pole at NE corner of airport terminal building.
	Elevation:	11.754 m (local datum tied into AK-5)
Fort Liard	BM	Spike in tree, located at NE corner of WSC gauging station.
	Elevation:	213.29 m (established by B.C. Hydro/Underhill surveys, tied into GSC)
Nahanni Butte	TBM	Bottom spike on flagpole, located 10 m W of school building in school yard.
	Elevation:	183.1 m (local datum with assumed elevation to correspond to contour elevations on Nahanni Butte GNWT map.

The error of closure is less than 0.015 m for closed circuit surveys. For surveys undertaken in the outer limits of a community (e.g. south bank bordering Snye, Fort Simpson) the nearest spot height on the FDR or GNWT map was used as survey datum.

APPENDIX B

PAST FLOODS OF "LESS-THAN-EXTREME" EXTENT

PAST FLOOD EVENTS
Fort Simpson, N.W.T.

DATE	CAUSE	CHRONOLOGY	WATER LEVEL EXTENT	SOURCE OF FLOOD LEVEL INFORMATION
04 May 1828	ice jam downstream	27 April - Liard R. breaks up 04 May - Mackenzie breaks through - ice thrusts on bank preventing vision of people on right bank.	lower part of island under water: 124 - 125 m	H.B.C.A., P.A.M., B200 a/9
15 May 1830	Liard ice impeded by intact Mackenzie ice	04 May - water visible on ice; very cold, very little thaw. 15 May - ice up Liard as far as can be seen is broken. - kept back by Mackenzie ice; broken ice topped over bank level. - water all over lower parts of island 18 May - water still rising; fell over night.	lower part of island under water: 124 - 125 m	H.B.C.A., P.A.M., B200 a/11
25 May 1832	ice jam downstream	16 May - Liard moves and jams; water still. 20 May - Liard water level rising; ice moves in p.m. 22 May - Liard ice heaps across Mackenzie; 2 pm Mackenzie in motion, stopped at sundown. 23 May - ice stationary 25 May - water level rises; lower parts of island flooded.	lower part of island under water: 124 - 125 m	H.B.C.A., P.A.M., B200 a/13

PAST FLOOD EVENTS
Fort Simpson, N.W.T.

DATE	CAUSE	CHRONOLOGY	WATER LEVEL EXTENT	SOURCE OF FLOOD LEVEL INFORMATION
13 May 1855	ice jam downstream	12 May - Liard breaks in a.m.; cuts across Mackenzie in evening 13 May - Mackenzie drifting full all day until stoppage at 4 p.m.; water rises instantaneously drowning most parts of the island. - ice thrust dangerously high 14 May - Liard drifing ice all day	- most parts of the island flooded; rose over the terrace at the end of the field: 126 - 127 m	H.B.C.A., P.A.M., B200 a/32
15 May 1875	sudden break-up	13 May - Liard cuts half way across Mackenzie in p.m. 15 May - Liard cuts across Mackenzie all the way. - Mackenzie ice drifting; water very high; half of the island is drowned. 16 May - conditions the same. 17 May - water very high; into the mission field and all around the church and part of the company field.	- half of the island drowned: 126 - 127 m	H.B.C.A., P.A.M., B200 a/33
08 May 1882	ice jam downstream	06 May - water on ice; Liard breaks in a.m.; water covered Batture (causeway) 08 May - water rose 4' above bank below Byre (barn).	- water covered old causeway; over bank at barn: 125 m	H.B.C.A., P.A.M., B200 a/36

PAST FLOOD EVENTS
Fort Simpson, N.W.T.

DATE	CAUSE	CHRONOLOGY	WATER LEVEL EXTENT	SOURCE OF FLOOD LEVEL INFORMATION
05 May 1883	Liard ice impeded by intact Mackenzie ice and Ice jam downstream	01 May - Liard came down very suddenly at 2 a.m.; ice covering the Batture; remained stationary until p.m. and then cut across Mackenzie. 02 May - Liard starts and moves. 03 May - Mackenzie ice very strong Liard water rises 4'. 05 May - at 1 a.m. ice from the round island made a move then blocked, shoving up well onto the bank over 30'; Ice jammed downstream water rose 15' covering the bank at the barn. 07 May - water level down 5' 08 May - water gradually falling	- water covered old causeway; over bank at the barn: 125 m	H.B.C.A., P.A.M., B200 a/36
13 May 1888	sudden break-up; ice jam below island.	12 May - at midnight Liard came down, cutting across Gros Cap then jammed. 13 May - at 4 p.m. water/ice came down with big rush; jammed again; water from the Snye came in over the island by the Byre and made a regular river - ice piled high on causeway. 15 May - water falling very fast.	- water over bank at barn: 125 m	H.B.C.A, P.A.M, B200 a/38

PAST FLOOD EVENTS
Fort Simpson, N.W.T.

DATE	CAUSE	CHRONOLOGY	WATER LEVEL EXTENT	SOURCE OF FLOOD LEVEL INFORMATION
22 May 1892	ice jam downstream	17 May - Liard R. breaks up at 0645 h. 21 May - ice jam forms bank to bank at Willow Island 22 May - water level rises 25'; covering bank below Byre, and over bank at mission, running through garden. 23 May - water rises 2' more in morning; water down 15' in evening	- over bank at RC mission: 126 - 127 m	H.B.C.A., P.A.M., B200 a/39
16 May 1909	ice impeded in front of Fort by intact Mackenzie ice	16 May - ice from Liard moves down with a rush at 0130, filling bank to bank; water rises 20-25'. - lower flats flooded; water within 6' from top of bank at mission; 1530 ice jams in front of fort 17 May - water up and down all day 18 May - jam still holds in front of Fort 20 May - jam breaks; water drops	- flats flooded; water running through middle of island; within 6' of top of bank at mission: 124 - 125 m	H.B.C.A., P.A.M., B200 a/
12 May 1918	ice jam at lower end of island	07 May - water visible on ice 08 May - Liard breaks across Mackenzie. 09 May - ice jams lower end of island, flooding flats	- lower part of island under water: 124 - 125 m	H.B.C.A., P.A.M., B200 a/

PAST FLOOD EVENTS
Fort Simpson, N.W.T

DATE	CAUSE	CHRONOLOGY	WATER LEVEL EXTENT	SOURCE OF FLOOD LEVEL INFORMATION
07 May 1957	ice jam in front of settlement	05 May - sunny and warm; Liard breaks 06 May - ice moves in front of settlement; jams at 1141. 07 May - water level reaches bankfull, partially flooding flats and in front of experimental farm. 10 May - ice moves in mid-channel	- bankfull stage, partially flooding flats: 124 - 125 m	Royal Canadian Mounted Police diary
13 May 1972	ice jam downstream	13 May - peak water level (detailed chronology not available)	124.2 m 125.0 m 125.0 m 125.0 m 125.3 m 126.1 m	- Personal Recollection (end of airstrip) - Photograph (water at fence at Forestry) - Photograph (Simpson Air hangar) - Photograph (Mackenzie Drive - north end) - Personal Recollection (cabin on flats) - MacKay, 1973 (1.5 m in Esso supply depot
May 1976 (day unknown)	unknown	(detailed chronology not available) * Discrepancy of 1.5 m in flood levels surveyed at air strip and Mackenzie Dr.* - according to calculations made by F.E. Parkinson (Lasalle Hydraulic Laboratory Ltd.) an ice plug would have had to push up into Snye 735 m to account for extra 1.5 m water level rise at air strip	123.7 m * 124.4 m 124.4 m 125.0 m 125.2 m * 125.3 m	- Personal Recollection (water just across top of Mackenzie Drive in front of Forestry) - Personal Recollection (SW side of town) - Personal Recollection (cabin on flats) - Personal Recollection (trailer on flats) - Personal Recollection (Simpson Air hangar) - High water mark (cabin on flats)

PAST FLOOD EVENTS
Fort Norman, N.W.T.

DATE	CAUSE	CHRONOLOGY	WATER LEVEL EXTENT	SOURCE OF FLOOD LEVEL INFORMATION
27 May 1843	ice jam downstream	17 May - water level rising 21 May - water immensely high; ice still firm. 25 May - ice starts in p.m.; stops 27 May - ice took a start today and at present the water is at our door. 28 May - water level down, ice left.	- maximum extent unknown; minimum level: 60.0 m (bankfull)	H.B.C.A., P.A.M., B152 a/23
May 1972 (day unknown)		(not available) - no flooding of settlement but ice blocked channel from bank to bank for a week; ice shove extensive along bank of lower terrace	- bankfull stage: 60.0 m (lower terrace)	Personal Recollection & Photograph

PAST FLOOD EVENTS
Fort Good Hope, N.W.T.

DATE	CAUSE	CHRONOLOGY	WATER LEVEL EXTENT	SOURCE OF FLOOD LEVEL INFORMATION
26 May 1831 (original site of fort on Manitou Is.)	release of ice jam at Ramparts	24 May - water level rising; ice breaks up; moves for one hour downstream then stops. 26 May - water at bankfull - at sunrise Upper Ramparts ice comes down with great velocity; soon after water was rushing into the fort, reaching 3' in the stores and houses. - by noon water drops 2', drawing off gradually 27 May - water rises a second time, again rushing into the fort 28 May - ice piled high (20') on banks. 30 May - water receding fast	- Manitou Island entirely under water: 3' over bankfull stage.	H.B.C.A., P.A.M., B80 a/9
17 May 1911 (present site)	Ramparts ice jams downstream	07 May - ice level on Mackenzie rises 16 May - Ramparts ice comes down and jams downstream 17 May - ice moves; river clears - 730 p.m. water rises fast, overflows low point at the mission - 1000p.m. Mackenzie ice down, all broken.	32.5 m 32.5 m	H.B.C.A., P.A.M., B80 a/30 (water rises to low point at mission Personal Recollection (gully below HBCo.

PAST FLOOD EVENTS
Fort Good Hope, N.W.T.

DATE	CAUSE	CHRONOLOGY	WATER LEVEL EXTENT	SOURCE OF FLOOD LEVEL INFORMATION
May 1976 (day unknown)	ice jam 8 km downstream; backwater entered gully below HBCo via Jackfish Creek	(not available)	33.2 m 33.5 m 33.0 m	Personal Recollection - house in gully below HBCo. Personal Recollection - house in gully below HBCo. Personal Recollection - house on east bank of Mackenzie

PAST FLOOD EVENTS
Fort McPherson, N.W.T.

DATE	CAUSE	CHRONOLOGY	WATER LEVEL EXTENT	SOURCE OF FLOOD LEVEL INFORMATION
May 1973 (day unknown)	unknown	(not available)	13.70 m	High water mark drawn on old water treatment plant building
24-29 May 1982 (day of peak flow unknown)	Mackenzie River ice jammed 35 km downstream of Point Separation from 24-29 May	(detailed chronology not available) - flood peak between 24 - 29 May	13.8 m 13.7 m 13.7 m 13.9 m	- sediment lines visible on trees near tank farm, north of settlement. - Personal Recollection (water to fork on "Last Dock" road)

PAST FLOOD EVENTS
Aklavik, N.W.T.

DATE	CAUSE	CHRONOLOGY	WATER LEVEL EXTENT	SOURCE OF FLOOD LEVEL INFORMATION
05 June 1933	unknown	05 June - River breaks; ice movement commences - water is very high and over 1' of our plank walk at the edge of the river. 06 June - ice moving out 08 June - ice thrust into HBCo. yard.	- water over 1' over bank in front of HBCo. yard: 10.8 m	H.B.C.A., P.A.M., B378 a/2
02 June 1962	ice jam downstream	01 June - ice moves at 630 p.m.; stops and moves and stops; ice starts to pile up on bank and road. 02 June - 7 p.m. INUNDATION. 03 June - water very high; boardwalks displaced. 04 June - water down 4". 06 June - water retreats.	- water over bank at RC mission: 10.5 m	Roman Catholic Church diary, 1962
25 May 1963	unknown	21 May - ice breaks, moves 200 m then stops. 22 May - ice pushes 9a.m., stops. 23 May - river clear by noon 25 May - water rises; at 4p.m. lower parts of Aklavik are flooded. - in evening water drops 2"	- lower parts of Aklavik flooded: 10.0 m	Roman Catholic Church diary, 1963

PAST FLOOD EVENTS
Aklavik, N.W.T.

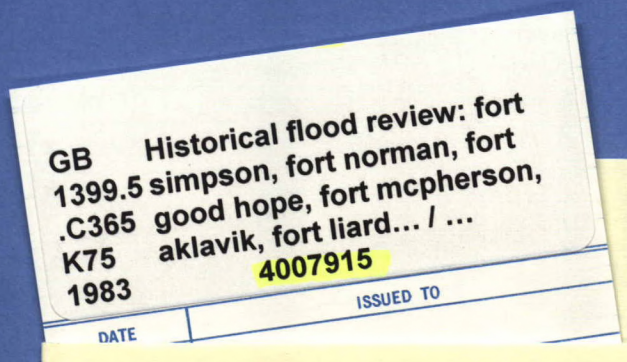
DATE	CAUSE	CHRONOLOGY	WATER LEVEL EXTENT	SOURCE OF FLOOD LEVEL INFORMATION
29 May 1971	ice jam downstream	27 May - ice moving 29 May - ice leaves for good 1p.m. - water high: 1' from top of bank in front of mission. 30 May - water drops 6" 31 May - water drops 1' 01 June - water drops 4'	water flooded lower parts of village; 1' from top of bank in front of mission: 10.2 m	Roman Catholic Church diary, 1971
05 June 1972	unknown	03 June - ice moves a little 04 June - ice moves; water is 2' from top of bank 05 June - Peel Channel clear in front; lower parts of village flooded. 06 June - water goes over bank in front of mission 07 June - water drops slightly	10.5 m 10.7 m 10.7 m	- Roman Catholic Church diary, 1972 (water over top of bank) - Personal Recollection (west side) - Personal Recollection (central)

PAST FLOOD EVENTS
Fort Liard, N.W.T.

DATE	CAUSE	CHRONOLOGY	WATER LEVEL EXTENT	SOURCE OF FLOOD LEVEL INFORMATION
30 April 1828	ice jam downstream of settlement	23 April - Petitot R. breaks up. 24 April - Liard ice shorefast 29 April - water rising fast 30 April - water all about fort; ice level with banks 01 May - ice jam released below; water drops 10'.	- maximum extent unknown: minimum water level of 213.0 m	H.B.C.A., P.A.M., B116 a/6
10 May 1896	ice jam downstream	08 May - Petitot R. breaks up. 10 May - Liard breaks early in a.m. and jammed below; water and ice over bank covering fort for 4 days. 16 May - water level dropping	- maximum extent unknown: minimum water level of 213.0 m	H.B.C.A., P.A.M., B116 a/25
July 1920 (day unknown)	summer flood: heavy rainfall; Fort Nelson R. flooded.	(detailed chronology not available)	214.0 m 214.1 m	- Personal Recollection (3' HBCo. store) - Personal Recollection (water just below RC mission house)
June 1972 (day unknown)	ice jam downstream (spring break-up) ice jam downstream	Petitot R. pushed out Liard ice; ice jammed approx. 3 mi. below settlement; Liard backwater into abandoned channel in low-lying area of town.	210.9 m	- Personal Recollection (water filled abandoned channel near edge of Liard River bank.
10 May 1982	ice jam downstream	Prolonged ice jam downstream caused Liard water to back up into the downstream end of abandoned Petitot channel, and overflow halfway across the road.	211.09 m	- Personal Recollection (water across road at abandoned channel.

PAST FLOOD EVENTS
Nahanni Butte, N.W.T.

DATE	CAUSE	CHRONOLOGY	WATER LEVEL EXTENT	SOURCE OF FLOOD LEVEL INFORMATION
June 1961 (day unknown)	summer flood	(not available)	182.0 m	- Personal Recollection (old school surrounded by water)
29 July 1972	summer flood: heavy rainfall for duration of 1 week	(not available)	180.1 m	- Personal Recollection (bankfull stage)



GB 1399.5 .C365 K75 1983
Historical flood review: fort simpson, fort norman, fort good hope, fort mcpherson, aklavik, fort liard... / ...
4007915