INDIAN AND NORTHERN AFFAIRS CANADA

EVALUATION OF POTENTIAL SOURCES OF QUARRY ROCK FOR MARINE STRUCTURES IN THE BEAUFORT SEA REGION

1 OF 2

NOVEMBER, 1983

EBA Engineering Consultants Ltd.

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Prepared for:

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EXECUTIVE SUMMARY

At the request of Indian and Northern Affairs Canada, EBA has conducted a literature review, industry survey and short field reconnaissance program to evaluate sources of quarry rock for Beaufort Sea marine construction. The study was prompted by the desire to have appropriate information to assess several pending proposals relating to development along the Yukon Coast. These included an official announcement of the location and boundaries of a new national park, a proposed quarry site and associated harbour outside the proposed national park, and a proposed harbour and marine base inside the proposed national park.

In all, 29 sites were examined to assess their potential to supply quarry rock for Beaufort construction. Fourteen sites inside the proposed park were compared with 13 others along the Yukon coast and 7 along the Mackenzie Delta. Each one is rated according to the quality of quarry rock and technical feasibility of development. Generally environmental concerns have not been considered in relationship to the rating of sites.

The various grades of quarry rock that will be required for construction of Beaufort Sea hydrocarbon production facilities include concrete aggregate, general fill, rip rap and armour stone. One design concept for man-made islands will require 12 to 20 tonne armour stone blocks to resist wave erosion of core fill. Sources of such high quality rock are rare around the Beaufort Sea. The two sources that appear to have the best quality of rock are at Mount Sedgewick and Mount Fitton. Mount Sedgewick, however, is within the area of the proposed national park and Mount Fitton is about 90 km by haul road from a potential harbour site. The sources that appear to have the best overall potential are, unfortunately, within the proposed International Ecological Site south of Inuvik. Development here would be further complicated by the draught limitation of barges exiting the Mackenzie Delta. Two other prospects, at Mount Gifford near Aklavik, and at Mount Davies Gilbert have also been identified. These are somewhat lower quality rock and each site would have its own accessibility concerns.

A site proposed for a quarry to be developed by Kiewit/ACZ, a joint venture, was specifically examined. The site will provide a large volume of general fill quality sandstone but it is unlikely that higher grades of material can be obtained. The most attractive feature of the site is its relative nearness to the coast. It is felt that development of this site must be justified on the basis of exporting the quarried material to the Alaskan Beaufort. Canadian operators do not have a need for a large volume of fill rock at this time nor does it appear that quarried rock could compete with dredged sand for construction of an island core.

The Kiewit/ACZ proposal also includes a plan to develop a marine harbour at King Point for their own use. An initial suggestion was that the haul road between King Point and the Kiewit/ACZ site might form the first leg of an access corridor extending into Mount Fitton. The feasibility of a 90 km access road to Mount Fitton via the Kiewit/ACZ site is questionable because it must cross some difficult and thermally sensitive terrain. Alternately, an access route via Shingle Point and the Blow River valley would be approximately 10 to 15 km longer but over less demanding terrain. The impact of either of these long roads on the caribou migration routes must also be considered.

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EVALUATION OF POTENTIAL SOURCES OF QUARRY ROCK FOR BEAUFORT MARINE STRUCTURES

1.0 INTRODUCTION

The Department of Indian and Northern Affairs Canada (DIAND) retained EBA Engineering Consultants Ltd. (EBA) on September 16, 1983, to conduct the study reported herein. Specifically, Mr. C.J. Cuddy of the Land Management Division selected EBA, through a competitive proposal procedure, to undertake an overview of rock resources in the Beaufort Sea region. Such data was needed to prepare appropriate responses to pending quarry development proposals and to assist the Land Management Division in evaluating the relative abundance and importance of natural resources under its control.

Specifically, the study has been conducted with due consideration for its impact on several land use decisions that are forthcoming. These include:

- Establishing the boundaries of a Northern Yukon National Park.
- The concept of a Caribou Management Board and special caribou protection measures.
- Comprehensive regional land use planning of the northern Yukon.
- An application before the government for the development of a marine harbour and supply base at Stokes Point.
- An application before the government for the development of a large rock quarry 17 km south of King Point.
- A proposal to develop a marine terminal at King Point from which to ship quarry rock.

o Inventory and regulation of seabed granular materials.

The evaluation of potential quarry sites has been conducted in relationship to the petroleum industry's concepts for construction of marine exploration and production facilities in the Beaufort Sea region. These structures will require rock of various grades ranging from general fill to very durable and massive armour stone blocks. Therefore, the study has included both an informal survey of the petroleum industry's needs, and a review and assessment of the natural resources available.

A preliminary report, mostly summarizing published data, was transmitted to DIAND on September 28, 1983. A field reconnaissance study of selected sites along the Yukon coast was conducted between September 29 and October 2, 1983. A draft report summarizing field data and responding to the scope of work, outlined below, was presented on October 17, 1983.

2.0 PROJECT SCOPE

The scope of work for the study included:

a) Reviewing available government and industry data on rock resources for the Beaufort Sea coastal region.

b) Consulting with government and industry officials to obtain any available unpublished information.

c) Reviewing with industry personnel the perceived needs for various grades and quantities of quarry rock.

d) Identifying all potential rock quarry locations within the study area on the basis of accessibility, quality and quantity.

e) Conducting a field reconnaissance and sampling program of the priority sites.

f) Identifying gaps in material availability, a ranking of potential quarry sites, and constraints on development and useage.

g) Providing specific recommendations and budgetary guidelines for subsequent studies to complete a rock resource inventory at a level consistent with DIAND requirements.

The study area was defined as extending from the Yukon/Alaska border to 115° longitude (West) and extending inland from the coast approximately 48 km. In addition, sites adjacent to the Mackenzie River in the Inuvik and Aklavik areas, and sites on Banks and Victoria Islands were to be included. Because most of the specific concerns from which this study arose were related to the Yukon coastal area, the study was substantially oriented to exploring and interpreting resources in that region. Figure 1, shows the location of the primary study and the four isolated eastern sites.

3.0 RESOURCE REQUIREMENTS

3.1 Data Review

The first phase of this study consisted of a review of information in the public domain to identify sites for which previous exploration had been undertaken. For the Yukon region, studies by Canadian Arctic Gas Pipeline Ltd. for a pipeline route from Prudhoe Bay to the Mackenzie Valley, (CAGPL, 1971) along the coastal route, and subsequently a DIAND granular resource inventory (Hardy, 1976) constituted most of the publicly available data of a site specific nature. A series of Geological Survey of Canada (GSC) maps (Norris, 1982) were particularly useful for developing an understanding of the distribution of durable rock. For areas east of the Mackenzie Delta, including Banks Island and Victoria Island, most data has been gathered from GSC reports.

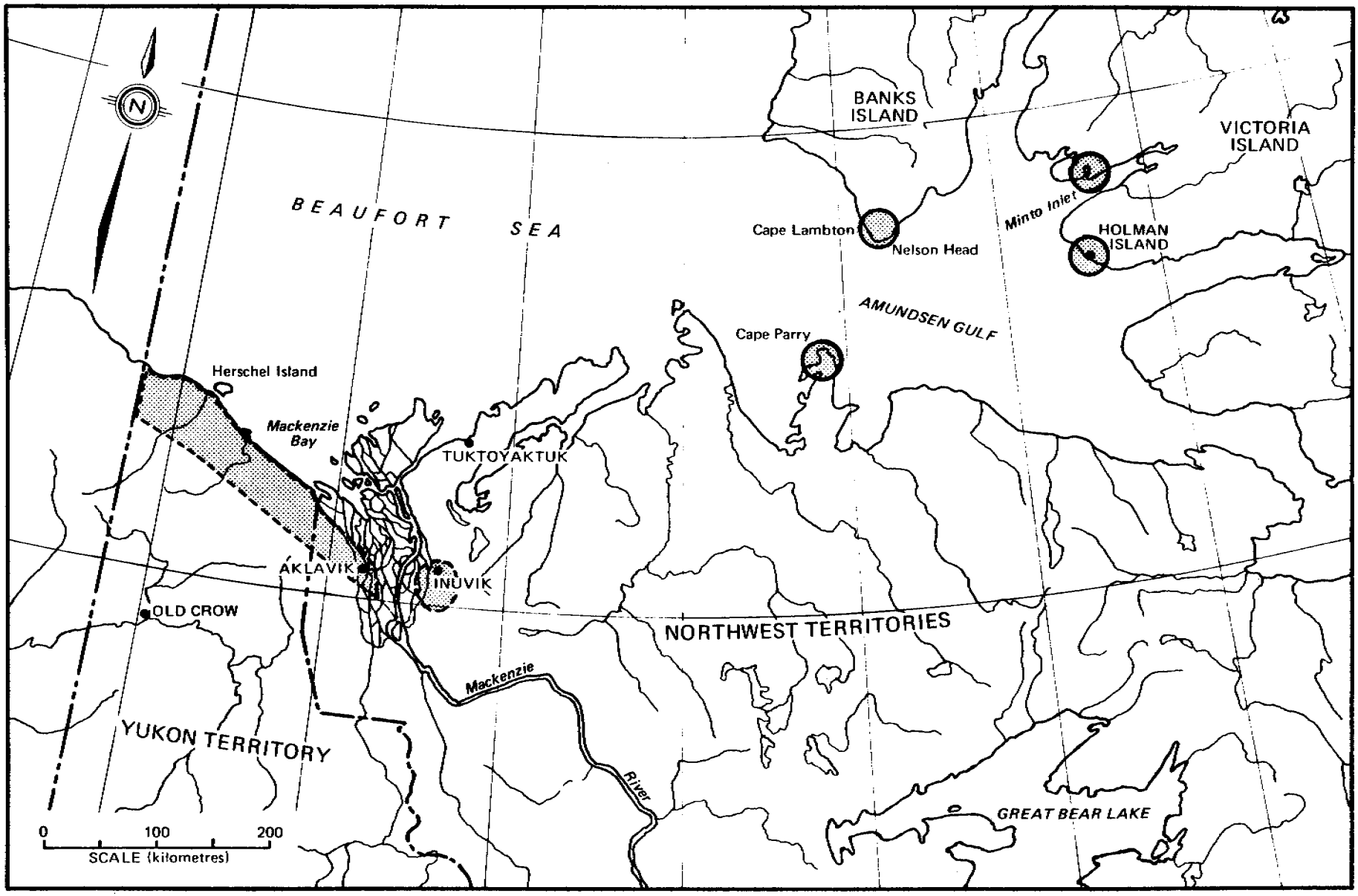


FIGURE 1 THE STUDY AREA AND EASTERN SITE LOCATIONS

Generally, it was found that these reports are very geologically oriented and do not provide much information on durability, jointing and accessibility of potential quarry sites.

3.2 Industry Requirements

3.2.1 In-House Studies

EBA has sought unpublished data from the petroleum industry on potential rock quarry sites. With the exception of some literature review studies (APOA Study 206, in preparation) and an application by ESSO in the mid '70's to develop a quarry rock site at Rocky Hill near Inuvik, it does not appear that the principle operators in the Canadian Beaufort Sea, ESSO Resources Canada Ltd. (ESSO), Dome Petroleum Ltd. (Dome), and Gulf Canada Inc. (Gulf) have conducted any detailed resource evaluation studies. The main reasons for this are:

- Beaufort Sea development is still in the exploration phase and the operations have not yet required large blocks of rock (rip rap to armour stone).

- Dredging techniques have been largely successful and economic studies have not justified quarry rock development.

- The caisson type exploration structures do not require rock larger than 0.3 metres cubed.

- The 1978 Land Withdrawal has essentially frozen any initiatives that may have led to further studies along the Yukon coast.

- The limited amount of rip rap sized rock that has been required has been procurred from existing quarries near Inuvik.

3.2.2 Quarry Rock Specifications

From its conceptual design studies, industry has developed a preliminary indication of its long term requirements for quarry rock. Primarily there are three uses; general fill, concrete aggregate, and wave erosion protection. Almost any rock quarry site will provide material adequate for fill; however, the other two uses have specific strength and size requirements.

In the Canadian Beaufort, dredged sand is generally available and quarrying for general fill is not economical. It is understood, however, that in the Alaskan Beaufort the economics of quarrying rock are to be compared with developing on-land gravel pits, because dredgeable sand is not available or environmentally acceptable. In fact, the Kiewit/ACZ quarry application appears to be based on the fact that quarry rock from the Yukon coast can be cost effectively exported to the Alaskan sites.

The use of blocks of rock to resist wave erosion of the core fill of marine structures is common. Engineers involved in island concepts design have indicated, through the EIS, that sea level piercing production islands (as opposed to caisson-type structures which are presently favoured) will be designed with side slopes of 1:3. These slopes have been chosen for cost efficient construction (volume of fill) and because of the reaction of sea ice when moving onto a steep slope. The 1:3 side slope would be protected with large quarry rock placed between -10 m and +15 m. Estimates for the size of rock range from 12 to 20 tonnes. Nominal dimensions for a 12 tonne block would be 2.0 m x 2.0 m x 1.5 m. Identifying the sites around the Beaufort Sea where blocks of rock of those dimensions with sufficient durability to last through the design life of marine structures was a major aspect of this study.

Discussions with representatives of the oil and gas industry have indicated that at present, production concepts utilizing concrete or steel structures to penetrate the wave zone are favoured. If these

require quarry rock for fill retention or erosion control, it will be smaller material (0.3 to 0.5 m cubed) placed below -10 m. Among the reasons given to explain why surface piercing island concepts are not favoured is that sources of 15 to 20 tonne armour stone have not been identified previously.

Smaller armour stone (5 tonne) also would be used to protect harbour facilities and berms built over pipelines at the shoreline. Furthermore, much of the locally required concrete aggregate could be derived from quarries because of problems associated with developing borrow pits in permanently frozen gravel deposits and because most of the local gravels have a high content of potentially deleterious material.

For this report, five (somewhat arbitrary) grades of rock have been considered. These are:

- Armour Stone - large blocks of intact and durable rock (in excess of 5 tonnes) that would be used on production structures in deep water to resist wave erosion.

- Rip Rap - smaller blocks of durable rock (1 to 5 tonnes) that would be used to resist wave erosion of shoreline structures and between -10 and -20 m on deep water structures and caisson type structures.

- Blast Rock - blocks of intact rock of up to 1 tonne that would be used in filters and protected water construction.

- General Fill - the lowest grade of rock that would be used as a substitute for gravel, durability is not essential.

- Concrete Aggregate - durable, clean and chemically compatable with Portland Cement, crushing and washing would be normal processing.

4.0 AVAILABILITY OF QUARRY ROCK

4.1 Distribution of Potential Sites

Beaufort Sea development will likely be concentrated north of the Mackenzie Delta between 132° and 139° west longitude. This would be roughly from Herschel Island to McKinley Bay. The Beaufort-Mackenzie basin is accessible by marine transport along the Yukon coastal plan to the west, from Amundsen Gulf to the east and up the Mackenzie River from the north. Sources of quarry rock along these three access routes have been considered; however, for geologic reasons, the distribution of potential sources is far from even.

To the east, the few source areas with access to tidewater are widely distributed. From the southern end of Banks Island (see Figure 1) where there are high rock bluffs that might provide quarry rock, it is about 430 km to the centre of the area of development. Other possible eastern sources and their distance to the centre of development are Cape Parry (400 km), Holman Island (625 km) and Minto Inlet (650 km). To the south, potential sources located near Inuvik are approximately 280 km by barge from the centre of development and sources near Aklavik are 250 km by barge. In comparison, the proposed harbour at King Point is 155 km distance and the best prospects are a further 15 to 100 km inland.

The relative distribution of sites selected for reconnaissance study are shown on Figure 2. The heavy concentration of sites west of the Mackenzie Delta is related, in part, to the interest in assessing the impact of the proposed National Park and Yukon coastal development plans but it is also related to the physical distribution of rock exposures.

There are other reasons for concentrating on the Yukon Coastal sites, as well. Barges moving out of the delta are generally limited to about 2 m draught. Those shallow draught barges are generally unsafe on the open sea. Therefore, the Aklavik and Inuvik sites loose some of their

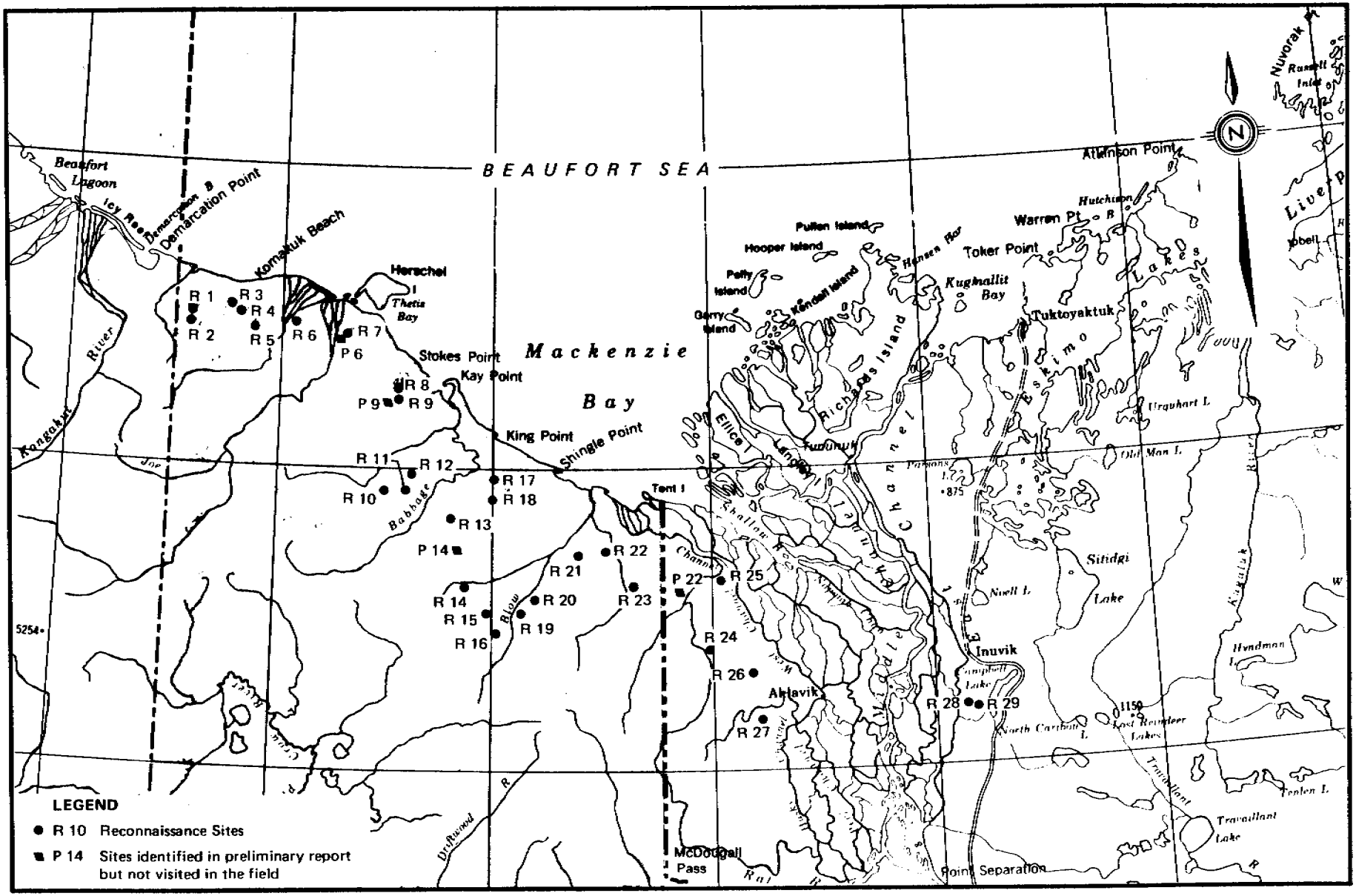


FIGURE 2 POTENTIAL QUARRY SITES INVESTIGATED

appeal because additional handling to transfer quarry rock to deeper draught barges outside the delta may be necessary.

Sites within a reasonable haul distance to King Point, where a deep water harbour could be developed, have the highest potential for development. Sites east of Shingle Point have a lower potential for development because of accessibility. The shallow bathymetry or the long distance to King Point adversely influenced the rating of those sites. Furthermore, if the national park boundary is set at the Babbage River, as proposed, sites west of R12 will be unavailable.

4.2 Assessment of Sites

4.2.1 Reconnaissance Program

In the field reconnaissance program conducted along the Yukon coast, 29 sites were examined. Most of these were identified in the preliminary report; however, some of the preliminary report sites didn't warrant further considerations. It should be noted that only 21 sites including all of the highly rated sites were actually examined on the ground.

The examination of outcrops in parts of this area proved to be less revealing than expected. Many of the outcrops of more durable rock, higher in the mountains had a relatively thick covering of frost shattered detritus or felsenmeer. The reason for this is that only the low areas along the Yukon coast east of Herschel Island and in the Mackenzie Valley were glaciated. When glaciated any loose material on the surface of an outcrop is generally scraped away and a sound surface is exposed. The felsenmeer in the high areas is a product of a surface that has been exposed for tens of thousands of years. The relative size of felsenmeer block from these areas is representative of the durability of the parent rock to many thousands of years of frost shattering. It is interesting to speculate what size of block would be stable for the 20 to 30 years design life of a production structure.

Observations on site conditions such as size of felsnmeer blocks, degree of weathering of samples, consistency of the rock and characteristics of any exposed intact rock were important to interpreting the rock quality. For example, the fissile or platy Tertiary sandstones of several sites were easily broken and even where steam erosion had exposed new material there were few intact blocks or outcrops greater than 20 cm thick. It was, therefore, concluded that blocks of quarry rock having the durability to withstand wave and ice attack could not be quarried here. Such sites would be rated suitable for general fill. Similarly the weak rock and dirty sandstone would not make quality concrete aggregate.

4.2.2 Quality Assessment

A specific report for each site is presented in Appendix A along with a location map. A summary of interpreted potential and an overall rating for each site is presented in Table 1. The reconnaissance sites are designated by an R-number; whereas, those with a P-number were identified in the preliminary report but not located or visited in the field.

The general assessment of the quarry potential for each site required consideration of the nature and quality of the rock and of the development aspects of the site. The general quality of material was considered relative to the five grades or uses indicated in Section 3.2.2. The sites that would provide armour stone blocks were rated highly compared to those producing smaller size stone. Those sites that could provide concrete aggregate also were given a high rating.

To establish the overall rating access, harbour and bathymetric conditions were considered as well as quarrying problems such as overburden and drainage. Generally, however, environmental concerns such as caribou migration routes and considerations for the location of

TABLE 1

SUMMARY OF QUARRY POTENTIAL AT THE SITES INVESTIGATED

SITE NO.	LOCATION	QUALITY OF MATERIAL FOR MARINE CONSTRUCTION	QUALITY OF AGGREGATE	DEVELOPMENT POTENTIAL	OVERALL RATING
A. SITES WEST OF THE BABBAGE RIVER (WITHIN THE PROPOSED NATIONAL PARK)					
R1	S. of Clarence Lagoon	Good general fill	Poor	Access over sensitive terrain.	Poor
R2	S. of Clarence Lagoon	Fair blast rock	Fair - Good	Access over sensitive terrain.	Fair
R3	S. of Backhouse River	Fair blast rock	Good	Volume limited by overburden.	Fair-Poor
R4	S. of Backhouse River	Good general fill	Poor	Poor quality and access.	Unsuitable
R5	Fish Creek	Good rip rap	Good	Long access to good harbour.	Fair
R6	Malcolm River	Good general fill	Poor	Very poor accessibility.	Unsuitable
P6	W. of Roland Bay	General fill	Poor	Poor material and access.	Poor
R7	Buckland Hills	Good blast rock	Good	Reasonably close to Stokes Pt.	Fair
R8	S.W. of Stokes Point	Good general fill	Poor	Poor quality material.	Poor
R9	Buckland Hills	Fair blast rock	Good	Reasonably close to Stokes Pt.	Fair
P9	Spring River	General fill	Poor	Quality to poor.	Poor
R10	Mt. Sedgewick	Good armour stone	Good	Top quality material likely.	Good
R11	Mt. Sedgewick	Good blast rock	Good	R10 would be developed first.	Fair
R12	Mt. Sedgewick	Fair rip rap	Good	R10 would be developed first.	Fair-Good

TABLE 1 (continued)

SUMMARY OF QUARRY POTENTIAL AT THE SITES INVESTIGATED

SITE NO.	LOCATION	QUALITY OF MATERIAL FOR MARINE CONSTRUCTION	QUALITY OF AGGREGATE	DEVELOPMENT POTENTIAL	OVERALL RATING
B. SITES IN THE YUKON, WEST OF THE BABBAGE RIVER					
R13A	N. of Sleepy Mt.	Fair blast rock	Good	Too high (see R13B)	Fair
R13B	N.E. of Sleepy Mt.	Fair blast rock	Good	Good for both aggregrate and construction rock	Fair-Good
P14	Sleepy Mountain	Fair blast rock	Good	Too high	Fair-Poor
R14	Hoidahl Cupola	Fair blast rock	Good	Poor prospect. Too high/low quality.	Fair-Poor
R15	The Twins Mtns.	Fair rip rap	Fair - Good	Unlikely. Too near R16.	Fair
R16	Mount Fitton	Good armour stone	Good	Very high potential.	Good
R17	Kiewit Site	Good general fill	Poor to Unsuitable	Low quality but close to harbour.	Fair-Poor
R18	S. of Kiewit Site	Fair blast rock	Poor	Too near R17 for development	Fair-Poor
R19	N.E. of Mt. Fitton	Good general fill	Unsuitable	Not for offshore construction	Unsuitable
R20	N.E. of Mt. Fitton	Good general fill	Poor to Unsuitable	Not for offshore construction	Unsuitable
R21	Purkis Creek	Good general fill	Poor to Unsuitable	Too far to deep water.	Unsuitable
R22	Rapid Creek	Good blast rock	Fair	Limited quantity of good rock.	Fair-Poor
R23	Mt. Davis Gilbert	Fair armour stone	Good	Access to tidewater too difficult.	Fair-Good

TABLE 1 (continued)

SUMMARY OF QUARRY POTENTIAL AT THE SITES INVESTIGATED

SITE NO.	LOCATION	QUALITY OF MATERIAL FOR MARINE CONSTRUCTION	QUALITY OF AGGREGATE	DEVELOPMENT POTENTIAL	OVERALL RATING
C. SITES IN THE NORTHWEST TERRITORIES, WEST OF MACKENZIE DELTA					
P22	Coal Mine Lake	Good general fill	Unsuitable	Poor quality and no tidewater	Unsuitable
R24	Cache Creek	Good general fill	Poor	Too distant to tidewater.	Unsuitable
R25	S. of Shallow Bay	Fair rip rap	Fair - Good	Modest development possible.	Fair
R26	N.W. of Aklavik	General fill	Poor	Not recommended	Poor
R27	Mt. Gifford	Good rip rap	Good	Alternate to R25, seems ok.	Good
D. SITES EAST OF MACKENZIE DELTA (WITHIN PROPOSED INTERNATIONAL ECOLOGICAL SITE)					
R28	Gull Creek (Quartzite)	Good armour stone	Good	Barge access limited by shallow draught.	Good
R29	Gull Creek (Dolomite)	Fair armour stone	Good	Barge access limited by shallow draught.	Good
	Cape Parry	Good blast rock	Good	Good harbour at Wise Bay would avoid proposed IBP site.	Fair
	Cape Nelson	Good (?)	Good	Steep cliffs and poor harbour.	Fair
	Holman Island	Good (?)	Good	Very short shipping season.	Poor
	Minto Inlet	Good (?)	Good	Even shorter shipping season.	Poor

the proposed national park and International Ecological Sites were not considered.

Accessibility was a primary consideration influencing the overall rating of the deposit. In Section 4.1 marine transportation distances and difficulties were indicated. The general requirements of haul roads to the potential harbour point were also evaluated. The haul roads will be built to fairly high standards, if large quantities or large blocks of rock are to be moved. While specific details of road layout were beyond the scope to this study, obvious problems such as approach grades, river crossings, thermally sensitive terrain and overall distance were considered.

4.3 Quality of Material

4.3.1 Armour Stone

The Yukon coastal plain is a narrow lowland region backed by the Richardson Mountains to the southeast and the Barn Mountains to the southwest. The relief afforded by these mountains exposes a variety of rock ranging from weakly bonded Cretaceous sandstones to intrusive granites of Ordovician age and older Precambrian limestone and argillite. It is the granites and better bonded sandstones (silica, cemented or quartzitic) that appear to offer the most promise as a source of large rock blocks.

There are two major granite intrusions that are of prime interest. The Mount Sedgewick site (Reconnaissance Site No. R10, Appendix A) and the Mount Fitton site (R16) are the best prospects, on the Yukon Coast, for armour stone size blocks. Significantly, the Sedgewick site is within the proposed national park; whereas the Fitton site is not. However, the haul road from Fitton to King Point would be extremely long and costly to build. Furthermore, the road would perhaps have an unacceptable impact on the caribou migration. To the west of Sedgewick there does not appear to be another site of comparable quality. To the

east of Fitton the only alternates for armour stone are the quartzitic sandstone at Mount Davies Gilbert (R23), the quartzitic sandstone at Mount Gifford (R27) and either the Precambrian quartzite or the Ordovician - Silurian Dolomites of the Rocky Hill area near Inuvik (R28 and R29, respectively).

For the most part, the other deposits are of low overall quality, although some of them are attractive because of their location relative to coastal access. In the area between the Yukon - Alaska border and the Babbage River (the area of the proposed national park) only Site R5 had above average potential. Similarly, between the Babbage and the Yukon - N.W.T. border only the two sites, Fitton and Davies Gilbert, of the thirteen examined, had any significant potential. In the N.W.T. west of the Mackenzie Delta, of five sites examined only two appear to have significant potential. East of the delta, the deposits near Inuvik have a high armour stone potential.

In answer to two basic questions that were fundamental to initiating this study, it appears that there are at least four sites outside the proposed national park, from which armour stone might be developed. Furthermore, there does not appear to be any uniqueness to the Mount Sedgewick deposit as a source of armour stone other than perhaps a more favourable access corridor.

4.3.2. Concrete Aggregate

The petroleum industry has indicated that large volumes of aggregate will be needed to support Beaufort construction. Previous studies of gravel deposits around the Beaufort - Mackenzie have shown that there is a general lack of gravel and that developing pits in permafrost bonded gravels can be difficult and expensive. Therefore, it is reasonable to consider that aggregates might be produced from crushed rock where quarry operations are underway for armour stone. Whether it would be economical to process the rock (crushing and clearing) and to haul aggregates from the armour stone quarry sites is not clear;

however, the quality of rock at any of the recommended armour stone source sites would be suitable for aggregate.

The summary of potential sites, provided in Table 1, identifies the potential for obtaining aggregate quality material from each site. As with the armour stone, there does not appear to be any resources within the proposed park area that cannot be found outside it.

4.4 Eastern Sites

There are four sites east of the Tuktoyaktuk Peninsula from which quarry rock might be obtained. These are located at:

- Cape Parry - Wise Bay Region on the Parry Peninusla.
- Cape Lambton - Nelson Head on Banks Island.
- Holman Island at Victoria Island.
- Minto Inlet at Victoria Island.

A proposed International Biological Project zone at Cape Parry, like the proposed Dolomite Lake-Campbell Lake IBP zone near Inuvik, might affect development concepts there. Similarly, the Nelson Head area has been proposed for part of a national park or a "National Landmark" and near Cape Lambton there is another proposed IBP site.

The quality of rock that might be obtained from the four eastern areas is not clear. The literature that was reviewed for data on these sites has not provided much guidance as to the potential for obtaining 2.0 m blocks or larger.

A further aspect of the eastern sites is related to the restricted barging season created by seasonal ice patterns. Historical ice data suggest that barge traffic could operate (less than 2-tenths ice cover) about 85 days per year from King Point without extensive support. From Holman Island and Minto Inlet only 45 to 50 days per year would be suitable. The Parry Peninsula area has a more reasonable 75 day ice

free window. The Nelson Head area probably could be approached on 115 days, however, along the west side of Banks Island, only a few miles north of Cape Lambton where land access is more practical, the ice free season is probably only 70 days.

Without further information, and because it appears that armour stone can be obtained closer to the area where development will occur, no assessment of quality or potential is presented herein for the eastern sites.

5.0 CONCLUSIONS

5.1 Impact of North Yukon National Park

The quarry rock necessary for Beaufort Sea construction can be obtained outside the proposed park area. The only quality deposit within the park is the granite at Mount Sedgewick. With the data on hand, there is every reason to believe that armour stone blocks obtainable from one of four sites outside the park will be as good as that which can be obtained at Mount Sedgewick.

5.2 Construction Rock

There are two sites along the Yukon Coast and two or three others along the Mackenzie Delta that will provide armour stone blocks in excess of 5 tonnes. Whether 12 to 20 tonne stone could be developed at each is less clear. It is thought that the granites at Mount Fitton and the quartzite and/or dolomite at Gull Creek will probably yeild some 15 to 20 tonne blocks.

5.3 Kiewit/ACZ Sites

Site R17 is the site presently being considered for quarry development under an application by Kiewit/ACZ, a joint venture. At the site, in the fissile Tertiary sandstones, no prominent outcrops, or large blocks of intact rock were observed. Fragments of broken sandstone, covering the unvegetated parts of the deposit, were generally less than 5 to 10 cm thick. The evidence suggests that the quarry rock obtainable at this site will be good for general fill only.

The Canadian Beaufort Sea operators have indicated that they do not see a need for a large supply of quarry rock for general fill at this time. They are, however, aware of the proposed quarry and have conducted economic studies to identify the cost at which using quarry rock becomes advantageous. As noted previously, the availability of dredgeable sand for Beaufort construction would make it difficult for a quarry operation to succeed. It is therefore suggested that the Kiewit/ACZ site must be justifiable on the basis of exported material alone for the next few years. If the quarry is developed, it will provide the Canadian operators with an alternate source for gravel sizes for the exploration islands. However, the volumes required will be very minor until production structures are commissioned.

5.4 Access Corridor

DIAND personnel have suggested that they would like to confine haul road development south from King Point within one corridor. The access corridor from Mount Fitton either crosses difficult terrain to the north or it follows the Blow River. The direct access route north from Mount Fitton to tie in with the Kiewit/ACZ site would be about 90 km long but the route would be across the trend of surface drainage and over terrain that is sensitive to thermal disturbance. A direct haul road would have to be of exceptional quality and is probably prohibitively expensive to construct.

The alternative route that would be about 100 km long would follow the Blow River to Shingle Point and then swing northwest to King Point. It crosses less sensitive terrain but might require several crossings of the Blow River before reaching the lowland plain. Each of these long routes, however, cross the caribou migration routes and may not be acceptable for that reason.

5.5 Eastern Sites

There appears to be sufficient resources of potentially useable quarry rock along the Yukon Coast and down the Mackenzie Valley that the eastern sites are not essential. This conclusion is subject to:

- Cost comparison of haul road construction, say from Mount Fitton to the coast, versus the several hundred kilometres of additional barge haul distance and reduced barging season due to ice conditions between Nelson Head and the centre of the Beaufort oilfields.

- As an alternate to Mount Fitton, developing the sites at Gull Creek within the proposed IBP zone.

- Finding an economic means to move deep draught barges out of the Mackenzie Delta or developing a means to use shallow draught barges in the open sea.

6.0 RECOMMENDATIONS FOR FURTHER WORK

Relative to the subject of quarry rock development and the assessment reported herein, some further studies are suggested below.

a) Detailed studies of five sites are recommended. These sites from which armour stone may be obtainable are Mount Fitton, Mount Davies Gilbert, Mount Gifford, the Gull Lake quartzites and the Gull Lake dolomites. If Mount Sedgewick is not included in the

proposed national park, it should also be investigated. Drilling and perhaps test blasting to indicate the size of rock blocks that might be obtained and laboratory testing to establish physical characteristics of the rock should be undertaken. Furthermore, access problems should be addressed and preliminary cost benefit studies should be completed. The trade off between a very difficult haul road out of Mount Fitton and barging problems coming out of the Mackenzie Delta need to be addressed. As well, trade offs must be evaluated between the ecological value of the Dolomite Lake-Campbell Lake International Biological Site and the impact on the caribou of a long haul road into a site in the northern Yukon.

b) Further work is needed to examine the potential eastern sites. The literature review reported herein was not satisfactory. The level of geologic studies reported to date suggest that good quarry rock should be available; however, site specific data needed to evaluate the potential size of blocks and accessibility was inadequate.

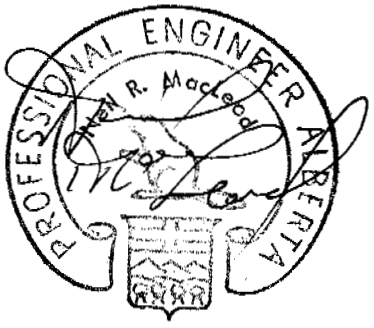
c) In discussions with the Institute of Sedimentary and Petroluem Geology personnel (D.K. Norris, T.P. Poulton, J. Dixon) it was suggested that potential sources of large quarry stone might be found where the Dempster highway crosses the Richardson Mountains. Although this may seem like a long way from the Beaufort, a quality haul road already exists and barging from Fort McPherson is not unreasonable. Further consideration of this option is warranted.

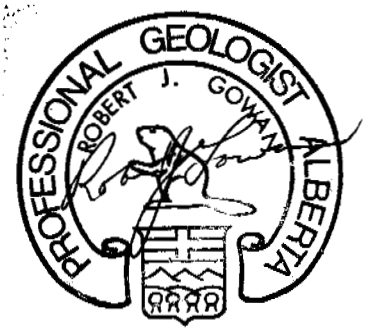
d) An airphoto study of two access corridors are linking the Mount Fitton site, the Keiwit/ACZ site and a suggested harbour development at King Point study and another along the coast from King Point via Shingle Point and the Blow River to Mount Fitton, may be justified. The airphoto coverage available to this study was incomplete through the region of interest.

e) Studies of concrete aggregate sources in the Beaufort Region and its suitability will be necessary. Much of the local gravel and bedrock is very cherty. As Portland Cement can react chemically with chert (alkali-reactivity), it is suggested tht research into the suitability of concrete aggregates be undertaken. Selected sampling of obvious source sites and trial batches tested to ASTM C441 specifications would be valuable.

Respectfully submitted,

EBA ENGINEERING CONSULTANTS LTD.





N.R. MacLeod, P.Eng. R.J. Gowan, P.Geol.

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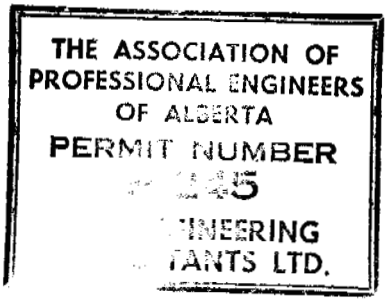

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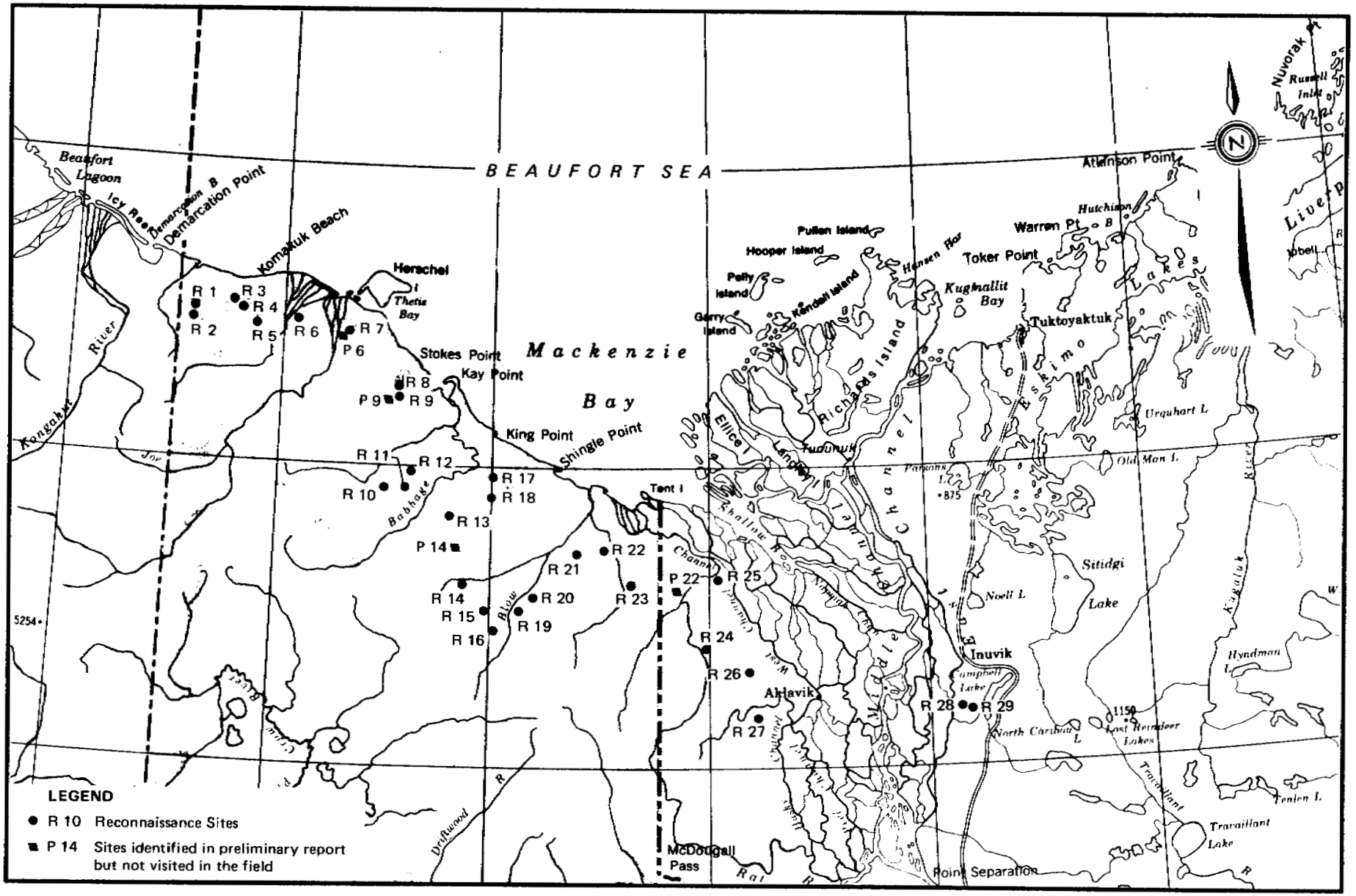

FIGURE A - 1 POTENTIAL QUARRY SITES INVESTIGATED

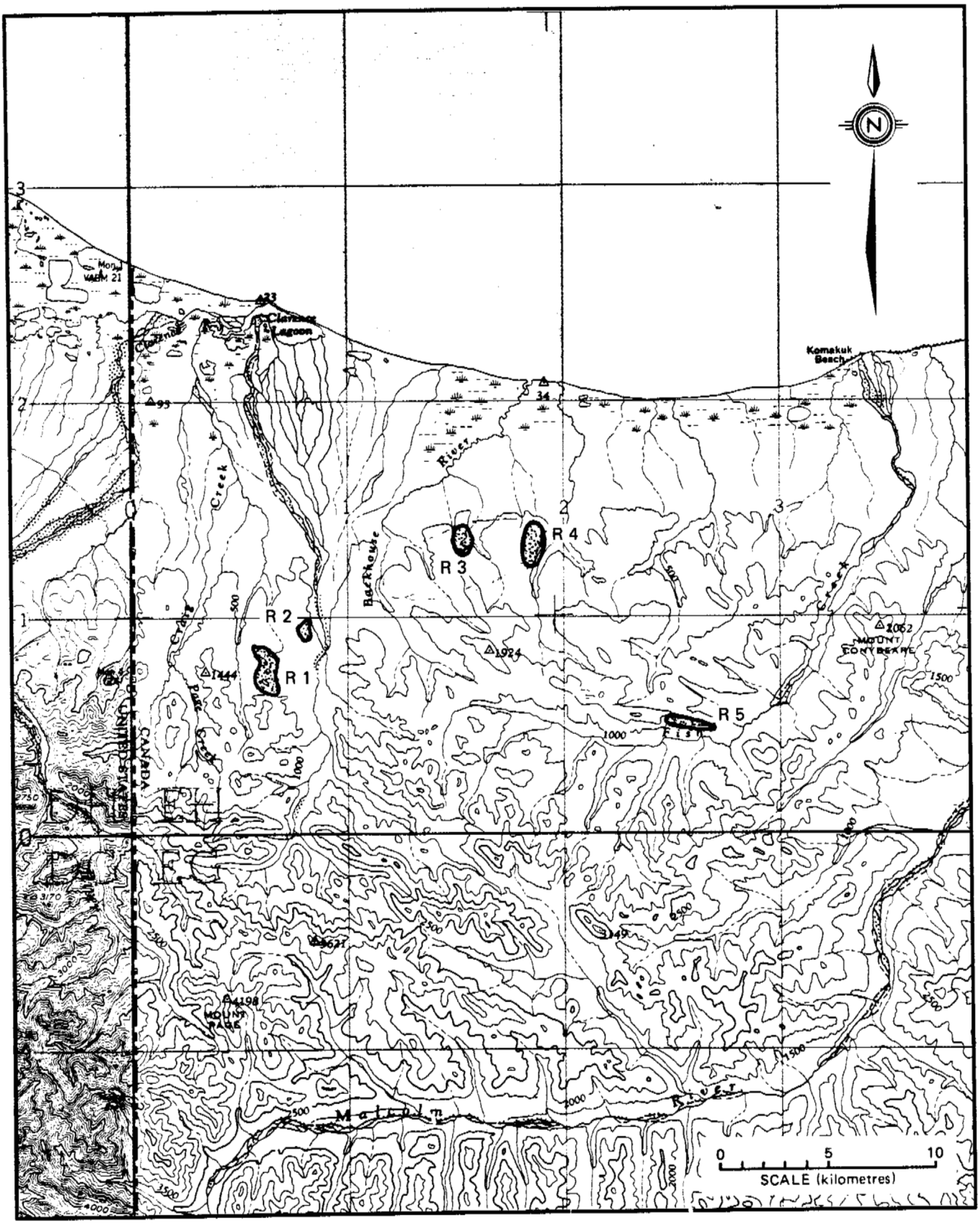

FIGURE A - 2 LOCATION OF SITE R 1

A. Site No: R1

B. Overall Rating: Poor

C. Location: Ridge Between Clarence River and Page Creek

D. Latitude: 69° 28' N.
Longitude: 140° 50' W.

E. Region: Backhouse River, Yukon Within proposed National Park.

F. Reconnaissance Level: Aerial Only

G. Geologic Data

Formation:	Neruokpuk
Geologic Age:	Precambrian
Lithology:	Argillite
Description:	Thinly bedded to fissile rock, dipping, southerly, fine flakey detritus.

H. Site Data

Description:	150 to 200 m high rounded hills. Extensively covered by thin detritus. Best exposure 50 m high cut along river bank.
Base Elevation (m):	Approximately 250
Optimum Location:	Probably along river scarp
Local Access:	Low grades over colluvial slopes
Regional Access:	Must cross Clarence River fan
Likely Tidewater:	Clarence Lagoon
Direct Distance (km):	16
Quantity:	Not Applicable

I. Potential Uses

Armour Stone (> 5 tonnes):	Unsuitable
Rip Rap (1 to 5 tonnes):	Unsuitable
Blast Rock (< 1 tonne):	Unlikely
General Fill:	Good
Concrete Aggregate:	Poor because of platy or flaky argillite structure.

J. Previous References

Preliminary Report:	Site No. P1
Hardy Associates (1976):	Site No. Y5

K. General Comments: Most site specific data from Hardy (1976).

L. Development Feasibility: This site would not be developed because of its location in the proposed park and its non-essential quality.

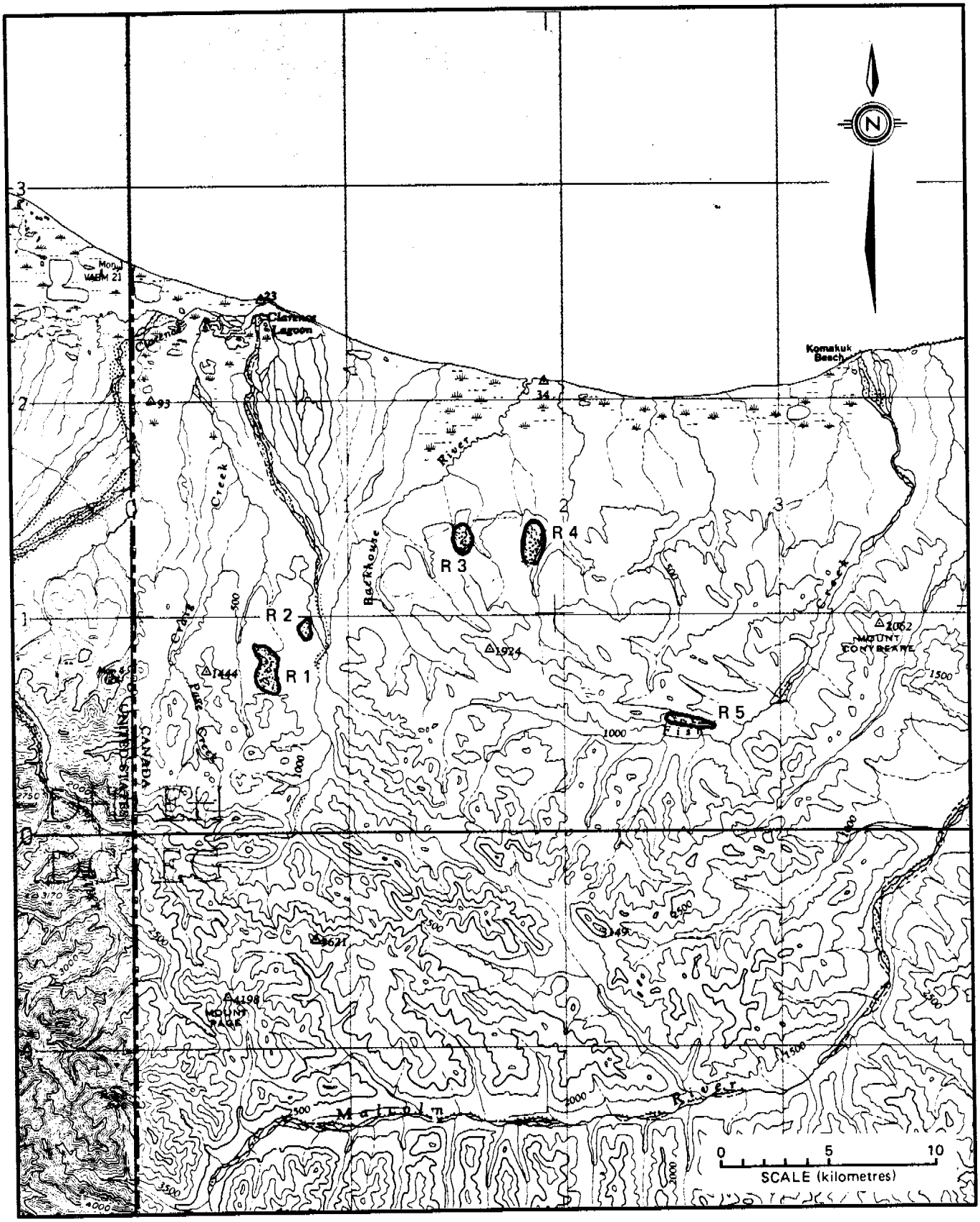

FIGURE A - 3 LOCATION OF SITE R 2

A. Site No: R2

B. Overall Rating: Fair

C. Location: Cut bank along Clarence River

D. Latitude: 69° 29' N.
Longitude: 140° 47' W.

E. Region: Backhouse River, Yukon
Within proposed
National Park.

F. Reconnaissance Level: Aerial Only

G. Geologic Data

Formation:	Neruokpuk
Geologic Age:	Precambrian
Lithology:	Limestone and Siltstone
Description:	Thinly bedded strata, steeply dipping to south.

H. Site Data

Description:	30 m high exposure on river eroded face. Top covered by unknown thickness of overbuden (probably thin to 2 m).
Base Elevation (m):	170
Optimum Location:	North slope beginning near the river.
Local Access:	Gentle colluvial slopes.
Regional Access:	Across Clarence River fan.
Likely Tidewater:	Clarence Lagoon
Direct Distance (km):	13
Quantity:	Not Applicable

I. Potential Uses

Armour Stone (> 5 tonnes):	Unsuitable
Rip Rap (1 to 5 tonnes):	Poor (small size only)
Blast Rock (< 1 tonne):	Fair
General Fill:	Good
Concrete Aggregate:	Fair to Good (might be dirty)

J. Previous References

Preliminary Report:	Site No. P2
Hardy Associates (1976):	Site No. Y6

K. General Comments: Geology Formation and age modified from Hardy (1976) to agree with GSC Map 1514A.

L. Development Feasibility: This site would not be developed because of its location within the proposed park and its non-essential quality.

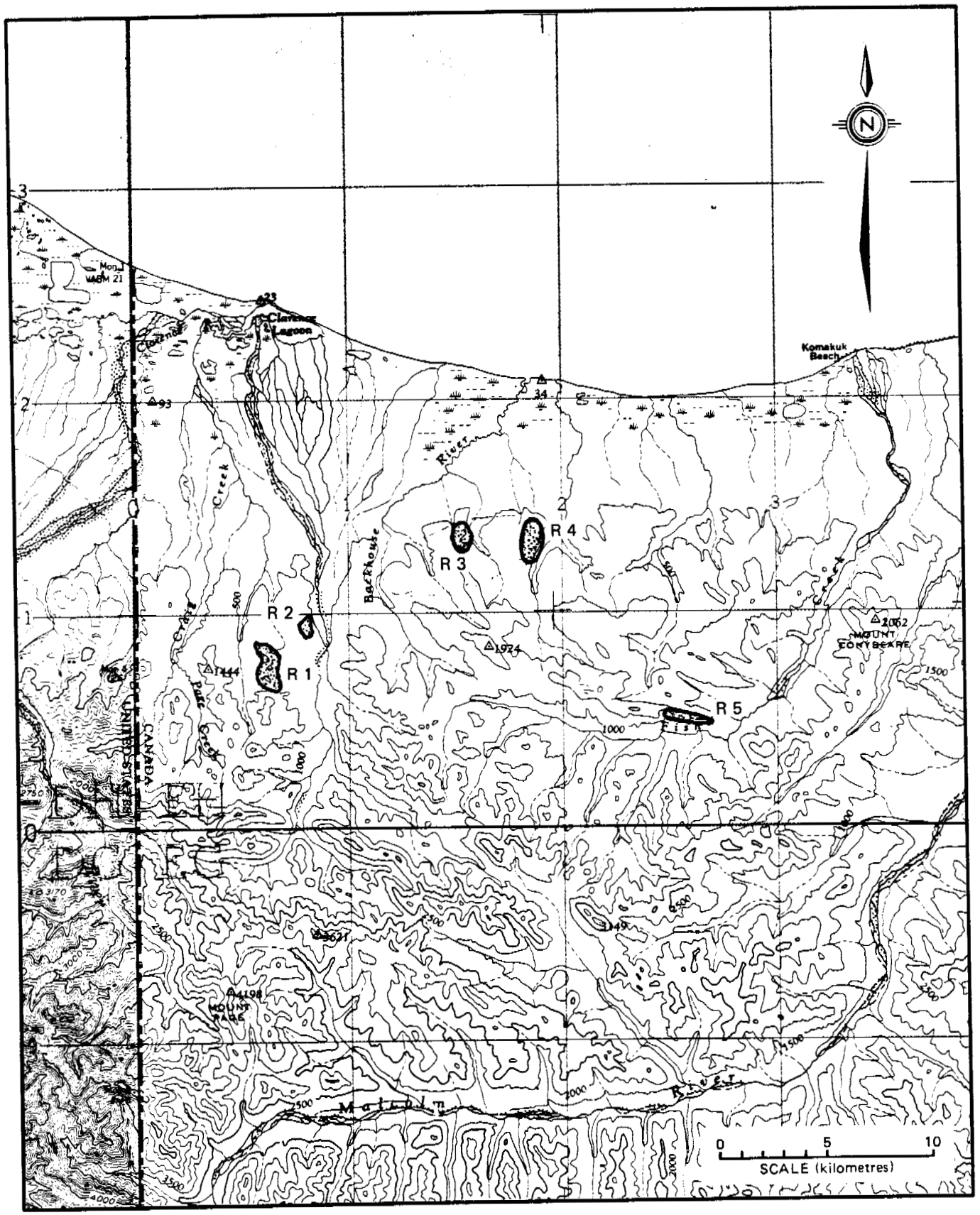

FIGURE A - 4 LOCATION OF SITE R 3

A. Site No: R3

B. Overall Rating: Fair to Poor

C. Location: South of Backhouse River

D. Latitude: 69° 32' N.
Longitude: 140° 37' W.

E. Region: Backhouse River. Within proposed National Park.

F. Reconnaissance Level: Ground

G. Geologic Data

Formation:	Wahoo
Geologic Age:	Carboniferous
Lithology:	Limestone
Description:	Crystalline, block, dipping steeply to SSW.

H. Site Data

Description:	15 m high outcrop along gully otherwise not well exposed. Probable thick overburden; detritus 15 to 20 cm commonly.
Base Elevation (m):	130
Optimum Location:	N.E. corner along stream.
Local Access:	Gentle slopes over well drained terrain.
Regional Access:	Would cross Backhouse River and eastern lobe of Clarence River fan.
Likely Tidewater:	Clarence Lagoon
Direct Distance (km):	12
Quantity:	No Applicable

I. Potential Uses

Armour Stone (> 5 tonnes):	Unsuitable
Rip Rap (1 to 5 tonnes):	Unsuitable
Blast Rock (< 1 tonne):	Fair
General Fill:	Good
Concrete Aggregate:	Good

J. Previous References

Preliminary Report: Site NO. P3(A)

K. General Comments: Fairly competent material; however, apparently thick overburden and relatively thin beds (30 cm) make it less appealing. This is the area of Kiewit's original application.

L. Development Feasibility: This site would not be developed because of its location within the park and its non-essential quality.

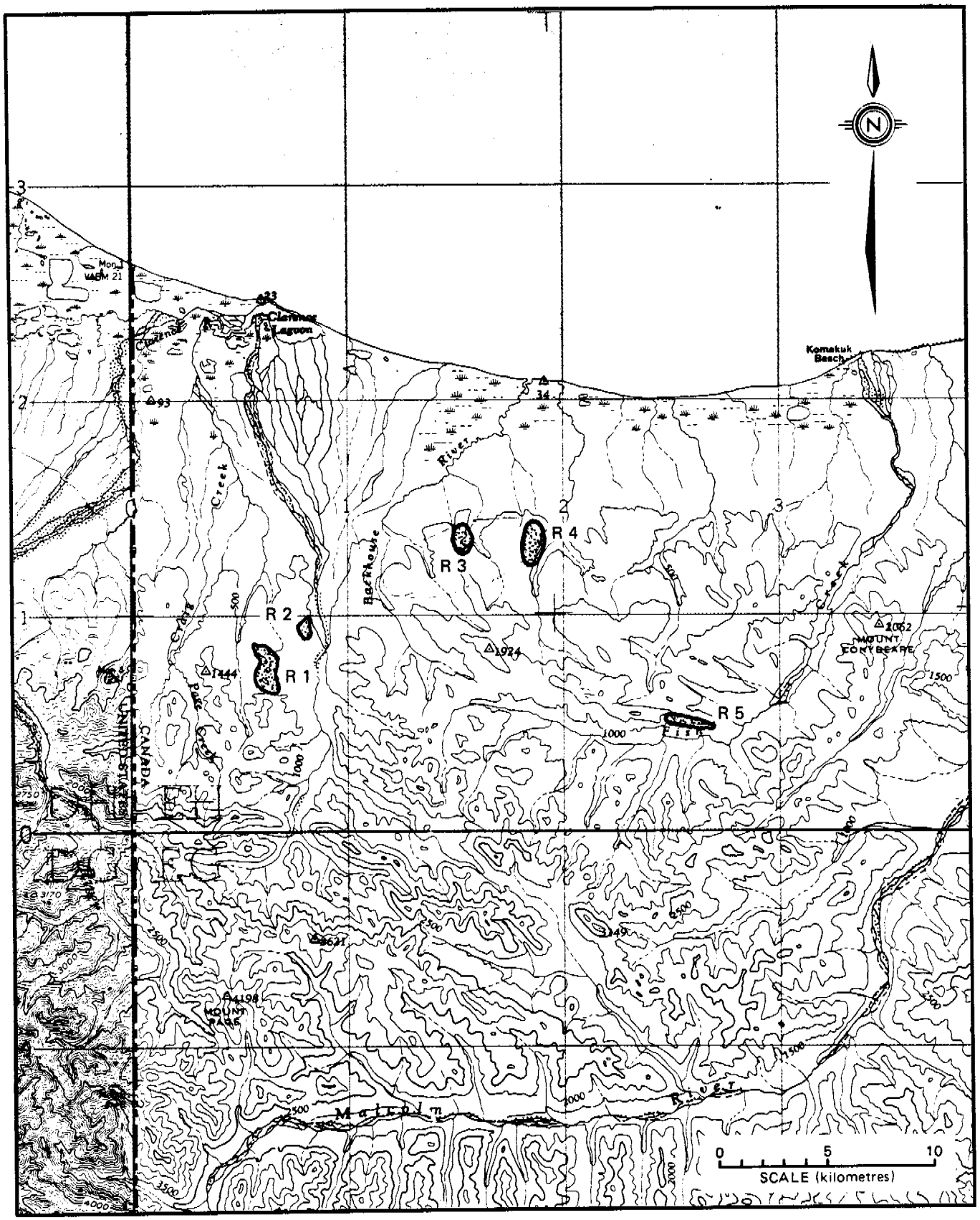

FIGURE A - 5 LOCATION OF SITE R 4

A. Site No: R4

B. Overall Rating: Unsuitable

C. Location: South of mouth of Backhouse River

D. Latitude: 69° 32' N.
Longitude: 140° 32' W.

E. Region: Backhouse River. Within proposed National Park.

F. Reconnaissance Level: Ground

G. Geologic Data

Formation:	Neruokpuk
Geologic Age:	Precambrian
Lithology:	Argillite to Shale
Description:	Thinly bedded and steeply dipping, 3 to 10 cm maximum thick units, fissile.

H. Site Data

Description:	75 to 100 m high river cut bank. Thick overburden except along river.
Base Elevation (m):	140
Optimum Location:	Northeast end by river
Local Access:	Moderate slopes, sensitive terrain.
Regional Access:	Must cross Backhouse River and part of Clarence River fan.
Likely Tidewater:	Clarence Lagoon
Direct Distance (km):	14
Quantity:	Not Applicable

I. Potential Uses

Armour Stone (> 5 tonnes):	Unsuitable
Rip Rap (1 to 5 tonnes):	Unsuitable
Blast Rock (< 1 tonne):	Poor
General Fill:	Good to Fair
Concrete Aggregate:	Poor (platey particles)

J. Previous References

Preliminary Report: Site No. P3(B)

K. General Comments: GSC map shows location to be in Wahoo Formation limestone and not argillite as observed. This is the area of Kiewit's original application.

L. Development Feasibility: This site would not be developed because of its location within the park and its non-essential quality.

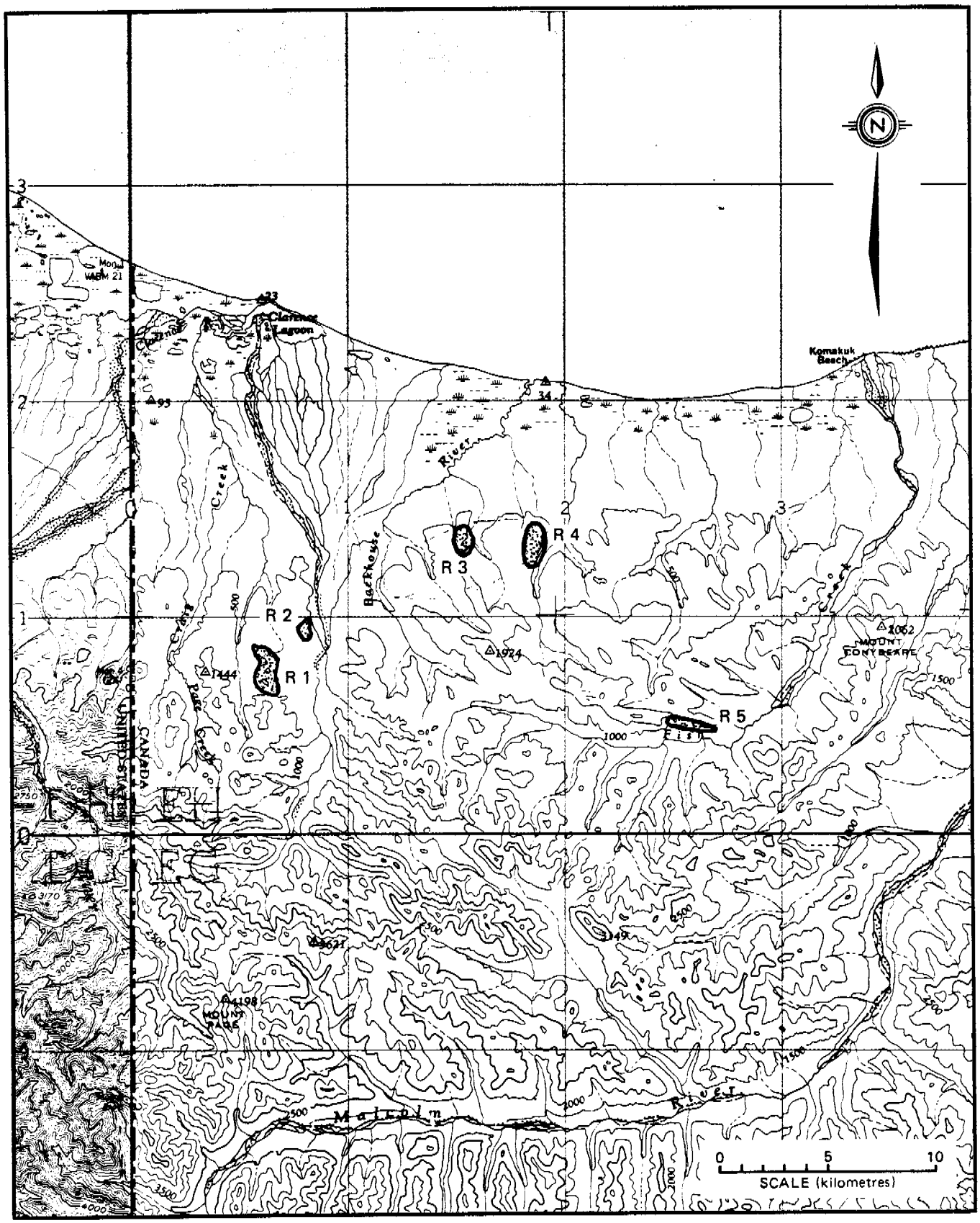

FIGURE A - 6 LOCATION OF SITE R 5

A. Site No: R5

B. Overall Rating: Fair

C. Location: Along Fish Creek SSW of Komakuk Dewline Site.

D. Latitude: 69° 27' N.
Longitude: 140° 21' W.

E. Region: Mt. Conybear. Within proposed National Park.

F. Reconnaissance Level: Aerial

G. Geologic Data

Formation:	Wahoo or Alapah
Geologic Age:	Carboniferous
Lithology:	Limestone or Dolomite
Description:	Ridge forming, blocky to massive.

H. Site Data

Description:	300 m high mountainous cliff face, with massive blocky rock ridges.
Base Elevation (m):	275
Optimum Location:	East end
Local Access:	Along Fish Creek
Regional Access:	Across poorly drained colluvial slopes.
Likely Tidewater:	Komakuk Beach
Direct Distance (km):	18
Quantity:	Not Applicable

I. Potential Uses

Armour Stone (> 5 tonnes):	Fair
Rip Rap (1 to 5 tonnes):	Good
Blast Rock (< 1 tonne):	Good
General Fill:	Good
Concrete Aggregate:	Good (some chert reported)

J. Previous References

Preliminary Report:	Site No. P4
Hardy Associates (1976):	Site No. Y8

K. General Comments: This is a bare rock ridge that was examined to see if more massive rock was available. Similar quality material may occur at ridges 4 to 5 km closer to the coast.

L. Development Feasibility: This site would not be developed because of its location within the proposed park.

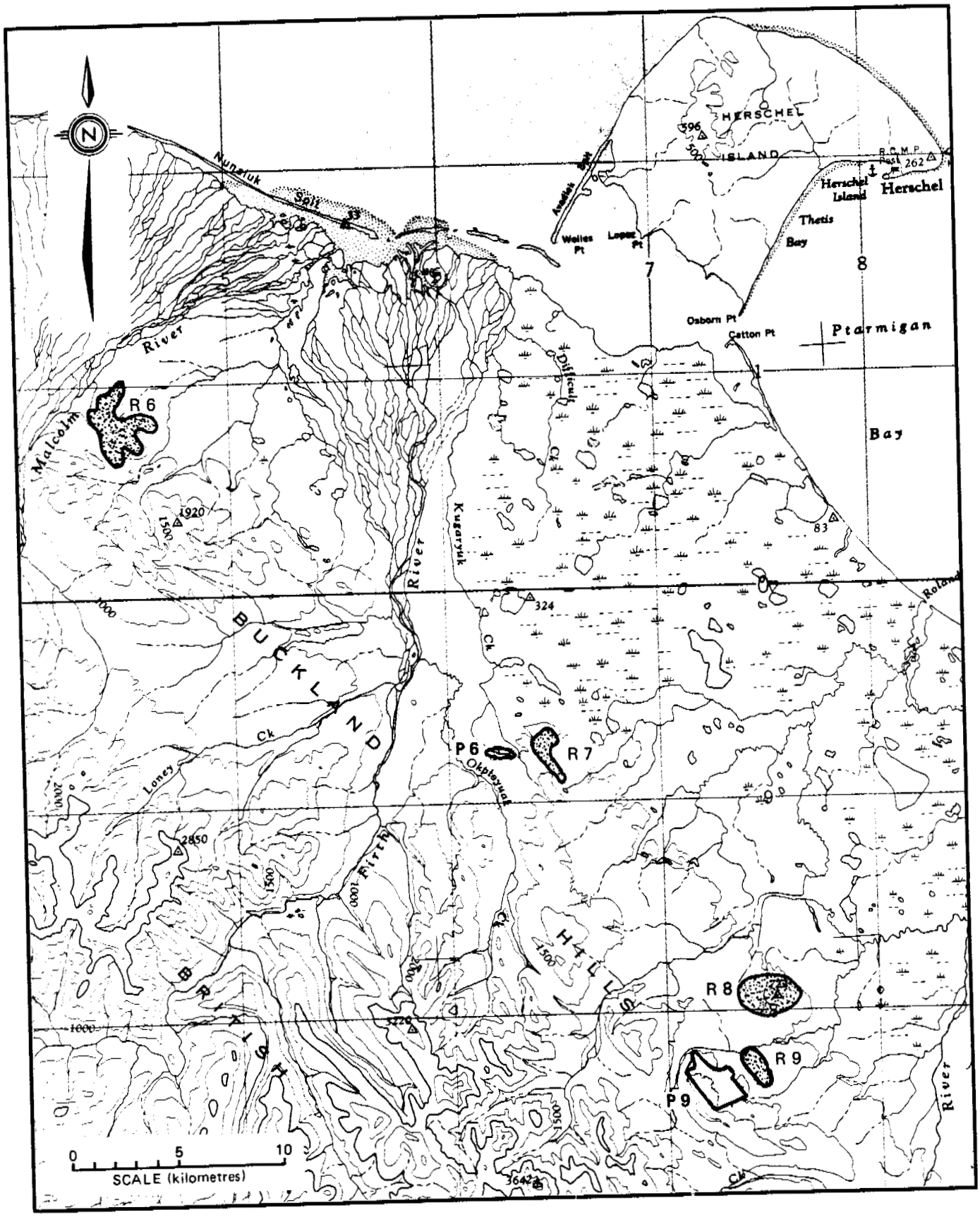

FIGURE A - 7 LOCATION OF SITE R 6

A. Site No: R6

B. Overall Rating: Unsuitable

C. Location: Malcolm River

D. Latitude: 69° 29' N.
Longitude: 139° 53' W.

E. Region: Malcolm River.
Within proposed
National Park.

F. Reconnaissance Level: Aerial Only

G. Geologic Data

Formation:	Neruokpuk
Geologic Age:	Precambrian
Lithology:	Argillite(?)
Description:	Fine detritus on surface.

H. Site Data

Description:	Gentle slope and rounded hills, gravel sizes exposed on surface. Generally thin overburden.
Base Elevation (m):	150
Optimum Location:	Lower slope, nearest coast.
Local Access:	Thermally sensitive colluvial slope
Regional Access:	Must cross either Malcolm or Firth alluvial fans to reach coast.
Likely Tidewater:	Nunaluk Spit
Direct Distance (km):	12
Quantity:	Not Applicable

I. Potential Uses

Armour Stone (> 5 tonnes):	Unsuitable
Rip Rap (1 to 5 tonnes):	Unsuitable
Blast Rock (< 1 tonne):	Unlikely
General Fill:	Good
Concrete Aggregate:	Poor

J. Previous References

Preliminary Report:	Site No. P5
Hardy Associates (1976):	Site No. Y16

K. General Comments: Access to coastline is over very unstable terrain.

L. Development Feasibility: This site would not be developed because of its location within the proposed park and non-essential quality.

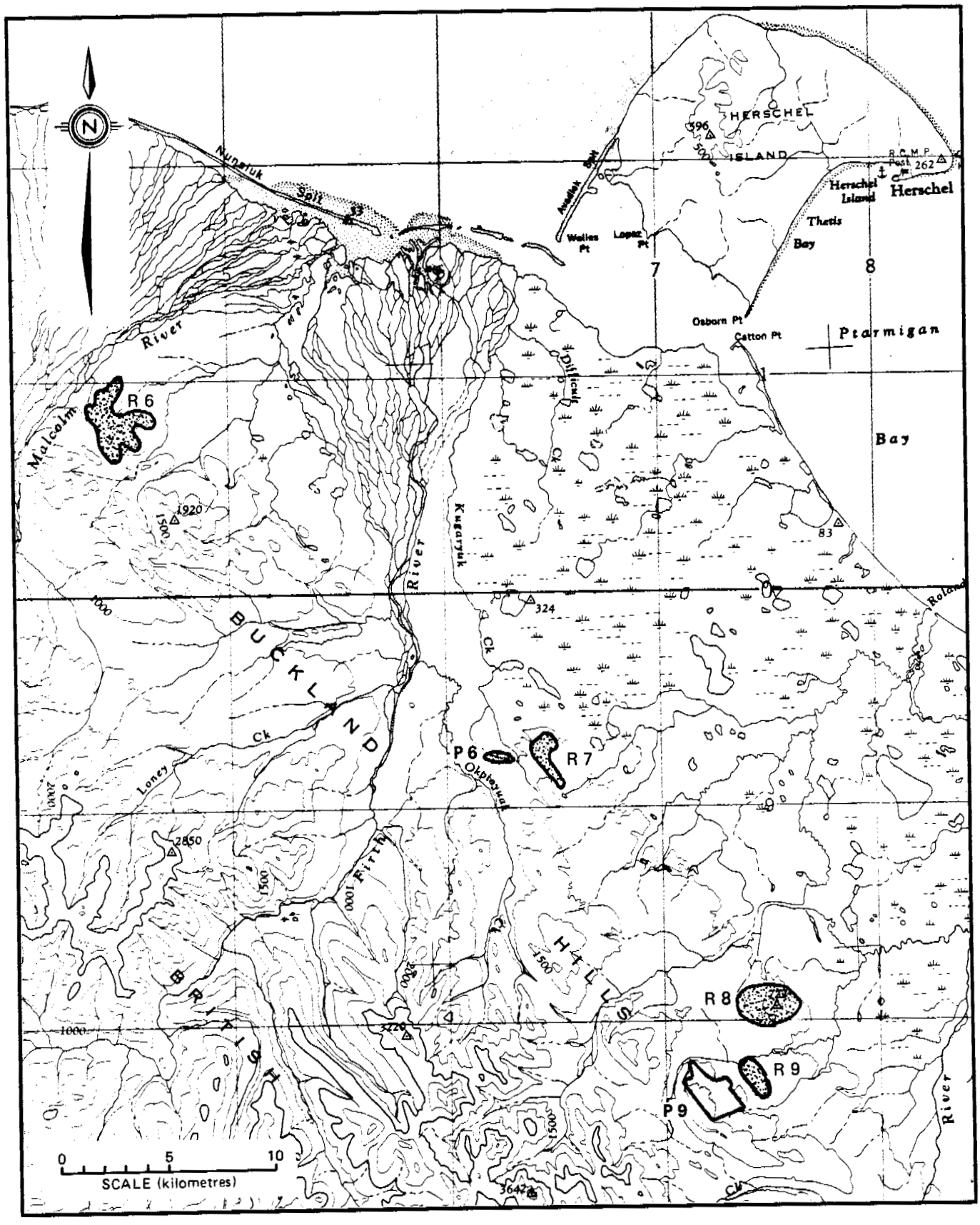

FIGURE A - 8 LOCATION OF SITE R 7

A. Site No: R7

B. Overall Rating: Fair

C. Location: Buckland Hills

D. Latitude: 69° 21' N.
Longitude: 139° 18' W.

E. Region: Stokes Point.
Within proposed
National Park.

F. Reconnaissance Level: Aerial Only

G. Geologic Data

Formation:	Neruokpuk
Geologic Age:	Precambrian
Lithology:	Quartzite
Description:	Blocky

H. Site Data

Description:	Steeply dipping to vertical bedding. Large blocks on surface.
Base Elevation (m):	150
Optimum Location:	North side, nearest coast.
Local Access:	
Regional Access:	Flat and wet, thermally sensitive morainal plain.
Likely Tidewater:	Stokes Point
Direct Distance (km):	23
Quantity:	Not Applicable

I. Potential Uses

Armour Stone (> 5 tonnes):	Unsuitable
Rip Rap (1 to 5 tonnes):	Smallest sizes possibly suitable
Blast Rock (< 1 tonne):	Fair to Good
General Fill:	Good
Concrete Aggregate:	Good

J. Previous References

Preliminary Report:	Site No. P7
Hardy Associates (1976):	Site No. Y27

K. General Comments:

L. Development Feasibility: Site has potential because it is relatively close to a possible deep water harbour at Stokes Point. However, it is within the area of the proposed national park.

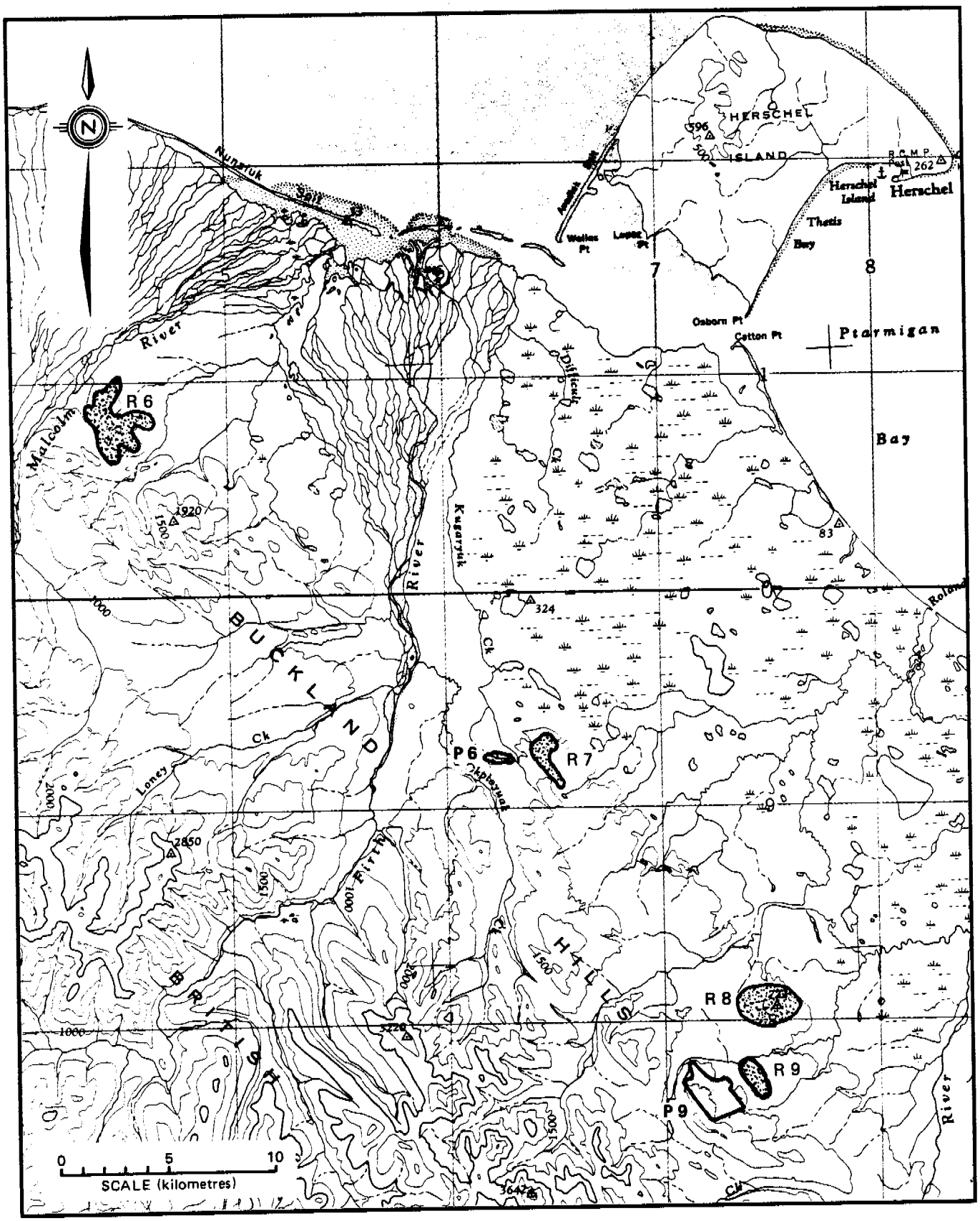

FIGURE A - 9 LOCATION OF SITE R 8

A. Site No: R8

B. Overall Rating: Poor

C. Location: West of Spring River

D. Latitude: 69° 13' N.
Longitude: 139° 05' W.

E. Region: Stokes Point. Within proposed National Park.

F. Reconnaissance Level: Aerial Only

G. Geologic Data

Formation:	Kingak
Geologic Age:	Jurassic - Cretaceous
Lithology:	Shale and Siltstone
Description:	Thinly bedded and fissile.

H. Site Data

Description:	Well rounded hill with frost shattered rock covering much of surface. No ridge forming outcrop and little overburden.
Base Elevation (m):	Approximately 150
Optimum Location:	
Local Access:	Gentle to moderate slopes.
Regional Access:	Crosses poorly drained thermokarst sensitive morainal plain.
Likely Tidewater:	Stokes Point
Direct Distance (km):	18
Quantity:	Not Applicable

I. Potential Uses

Armour Stone (> 5 tonnes):	Unsuitable
Rip Rap (1 to 5 tonnes):	Unsuitable
Blast Rock (< 1 tonne):	Poor
General Fill:	Good
Concrete Aggregate:	Poor

J. Previous References

Preliminary Report: Site No. P8

K. General Comments: This is the rock source nearest Stokes Point.

L. Development Feasibility: Should Stokes Point be developed as a harbour site this source could be developed for local construction materials. However, it is within the area of the proposed national park.

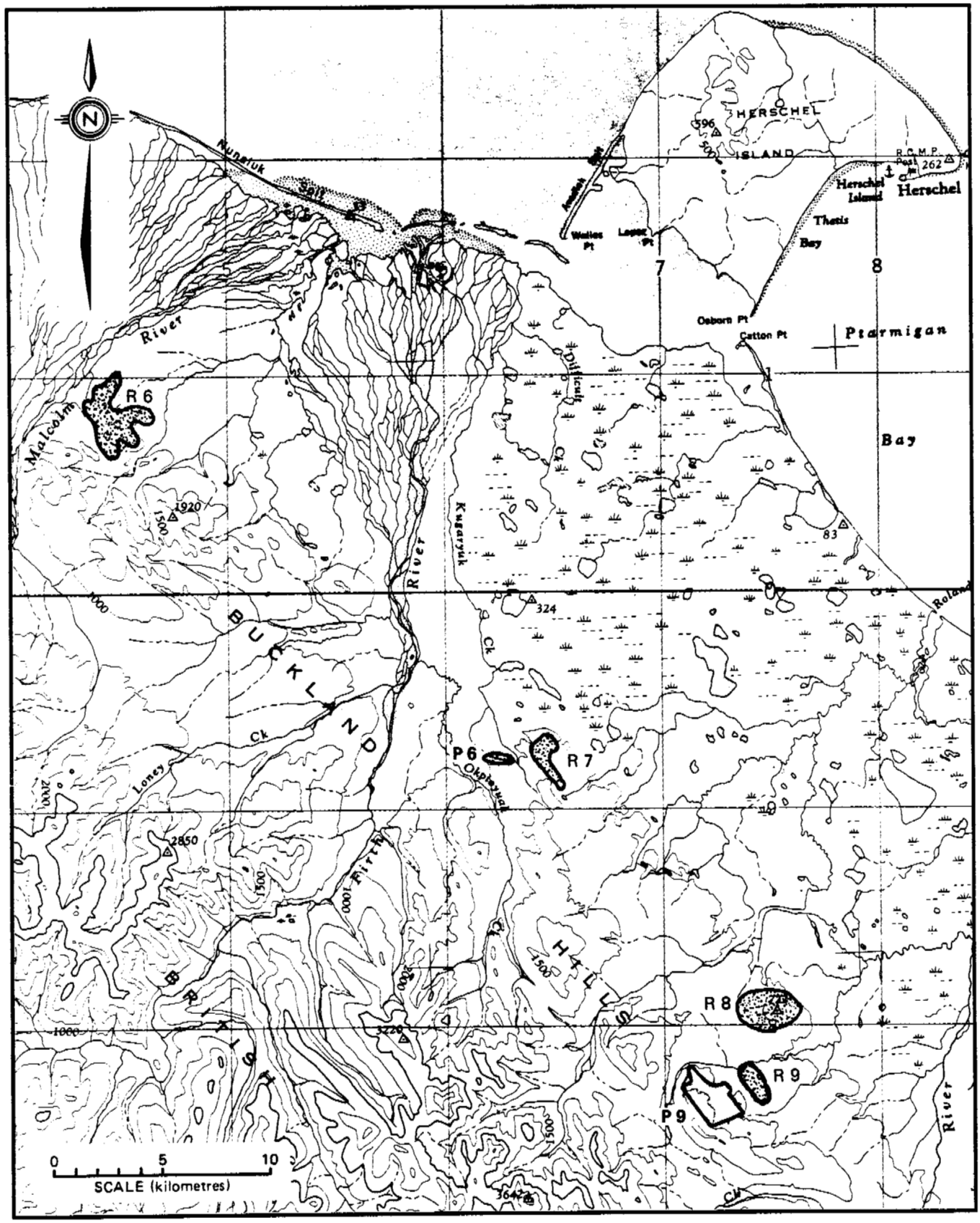

FIGURE A-10 LOCATION OF SITE R 9

A. Site No: R9

B. Overall Rating: Fair

C. Location: Buckland Hills

D. Latitude: 69° 13' N.
Longitude: 139° 11' W.

E. Region: Stokes Point.
Within proposed
National Park.

F. Reconnaissance Level: Ground (partial)

G. Geologic Data

Formation:	Neruokpuk
Geologic Age:	Precambrian
Lithology:	Argillite and Limestone
Description:	Fissile to blocky. Argillite is fissile and particles 5 to 10 cm. Limestone is blocky with 30 to 50 cm pieces.

H. Site Data

Description:	Narrow bedrock gorge, probably fault line, with 60 m high rock.
Base Elevation (m):	260
Optimum Location:	Southwest end of gorge has most competent rock.
Local Access:	Moderate to difficult grades, must follow river valleys out of foothills to morainal plain.
Regional Access:	Morainal plains and river valleys to coastline.
Likely Tidewater:	Stokes Point
Direct Distance (km):	20
Quantity:	Not Applicable

I. Potential Uses

Armour Stone (> 5 tonnes):	Unsuitable
Rip Rap (1 to 5 tonnes):	Unlikely
Blast Rock (< 1 tonne):	Fair (Limestone only)
General Fill:	Good
Concrete Aggregate:	Good (Limestone)

J. Previous References

Preliminary Report: None

K. General Comments: Argillite was examined on the ground; however, blocky looking rock, presumably the limestone, was only examined from the air.

L. Development Feasibility: Site could potentially be developed if a harbour were constructed at Stokes Point. However, it is within the area of the proposed National Park.

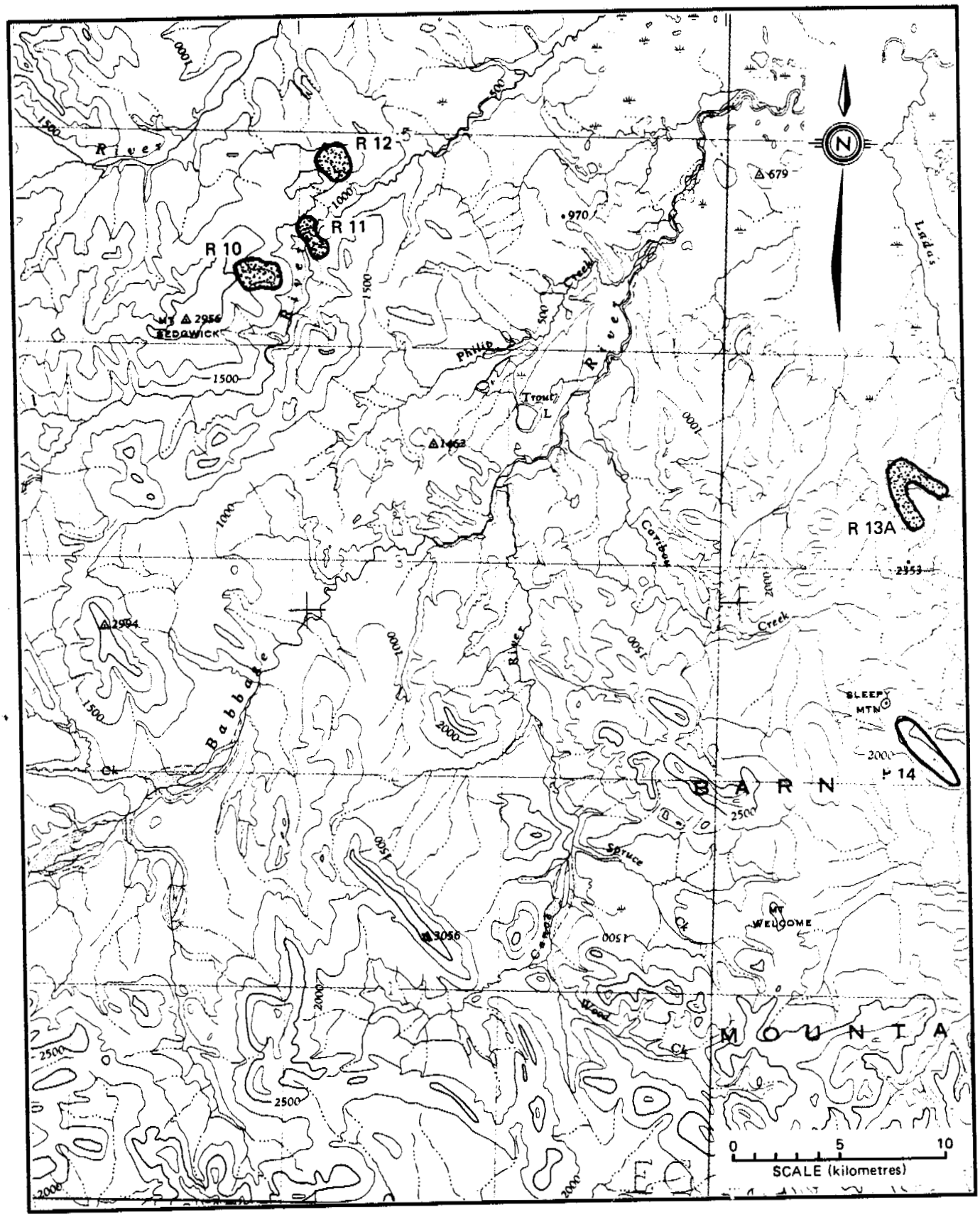

FIGURE A - 11 LOCATION OF SITE R 10

A. Site No: R10

B. Overall Rating: Good

C. Location: Mount Sedgewick

D. Latitude: 68° 53' N.
Longitude: 139° 03' W.

E. Region: Mount Sedgewick.
Within proposed
National Park.

F. Reconnaissance Level: Ground

G. Geologic Data

Formation:	Sedgewick Granites
Geologic Age:	Ordovician to Silurian
Lithology:	Granite
Description:	Blocky, angular.

H. Site Data

Description:	Felsenmeer covered surface, large rounded hills, no overburden largest surface blocks approximately 0.5 m.
Base Elevation (m):	Approximately 600
Optimum Location:	Lower slopes near northeast along Trail River.
Local Access:	Steep slopes and confined route through incised river valley.
Regional Access:	Either out Crow River Valley to Stokes Point or out Trail River, across Babbage River to King Point.
Likely Tidewater:	King Point
Direct Distance (km):	48
Quantity:	Not Applicable

I. Potential Uses

Armour Stone (> 5 tonnes):	Good
Rip Rap (1 to 5 tonnes):	Good
Blast Rock (< 1 tonne):	Good
General Fill:	Good
Concrete Aggregate:	Good

J. Previous References

Preliminary Report:	Site No. P10

K. General Comments: Although blocks of intact rock, larger than 0.5 cu.m. were not evident, larger blocks to 5 tonnes are reported by geologists from GSC.

L. Development Feasibility: It would be necessary to show that larger blocks could be obtained to justify any arguments for development. Access route across Babbage River would be very difficult as would route along Trail River.

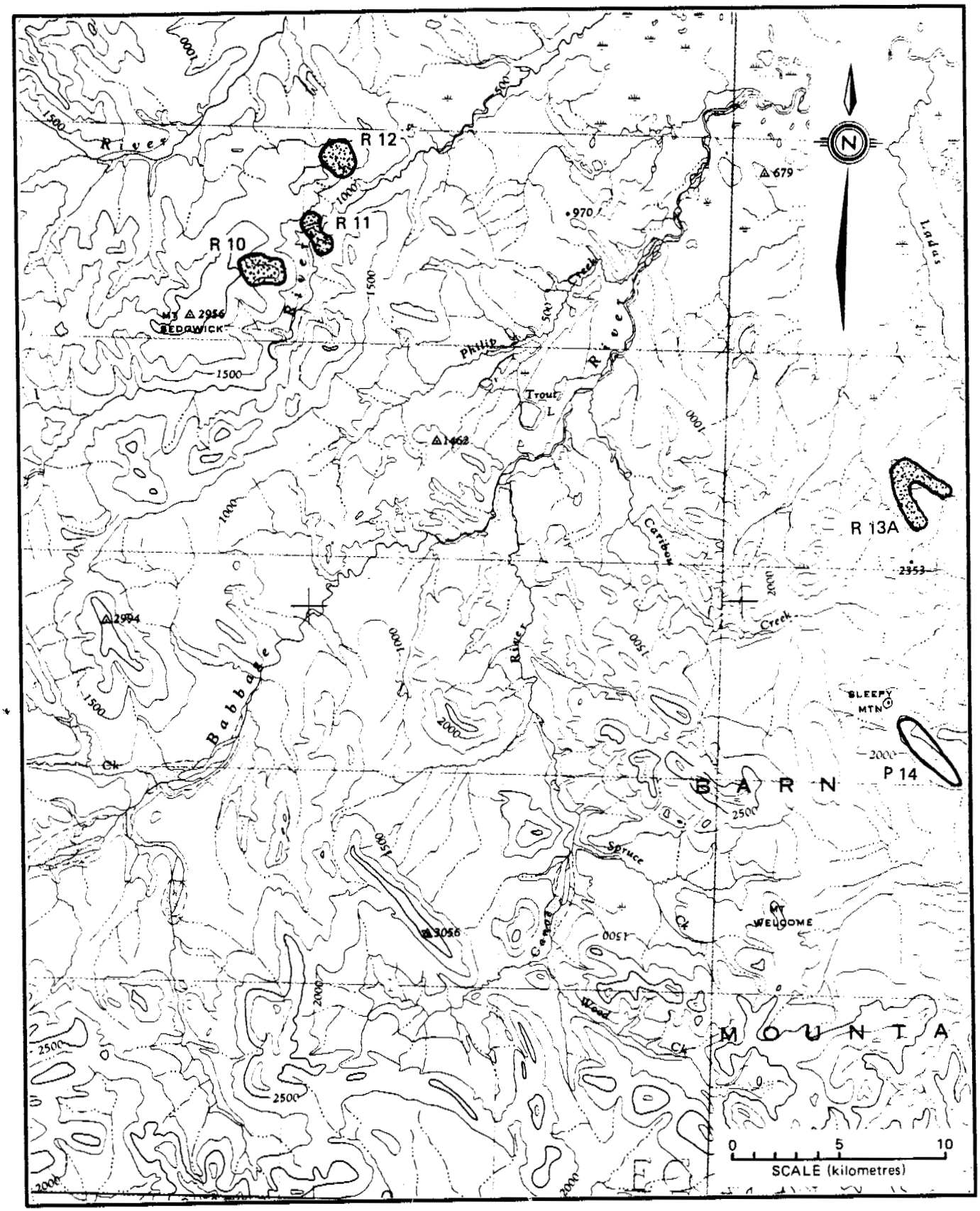

FIGURE A-12 LOCATION OF SITE R 11

A. Site No: R11

B. Overall Rating: Fair

C. Location: Lower slopes of Mount Sedgewick

D. Latitude: 68° 54' N.
Longitude: 138° 59' W.

E. Region: Mount Sedgewick. Within proposed National Park.

F. Reconnaissance Level: Ground

G. Geologic Data

Formation:	Neruokpuk
Geologic Age:	Precambrian
Lithology:	Limestone
Description:	Blocky, crystalline, durable.

H. Site Data

Description:	30 m high rock face cut by the Trail River and large rock knob immediately eastward.
Base Elevation (m):	240
Optimum Location:	
Local Access:	Along Trail River in deeply cut gorge.
Regional Access:	Trail River to morainal plains. Route to harbour must cross Babbage.
Likely Tidewater:	Stokes Point
Direct Distance (km):	45
Quantity:	Not Applicable

I. Potential Uses

Armour Stone (> 5 tonnes):	Unlikely
Rip Rap (1 to 5 tonnes):	Unlikely
Blast Rock (< 1 tonne):	Good
General Fill:	Good
Concrete Aggregate:	Good

J. Previous References

Preliminary Report: Site No. P10B

K. General Comments: Locally the bedrock might provide one tonne blocks.

L. Development Feasibility: This site would not be developed because of its location within the proposed park and its non-essential quality.

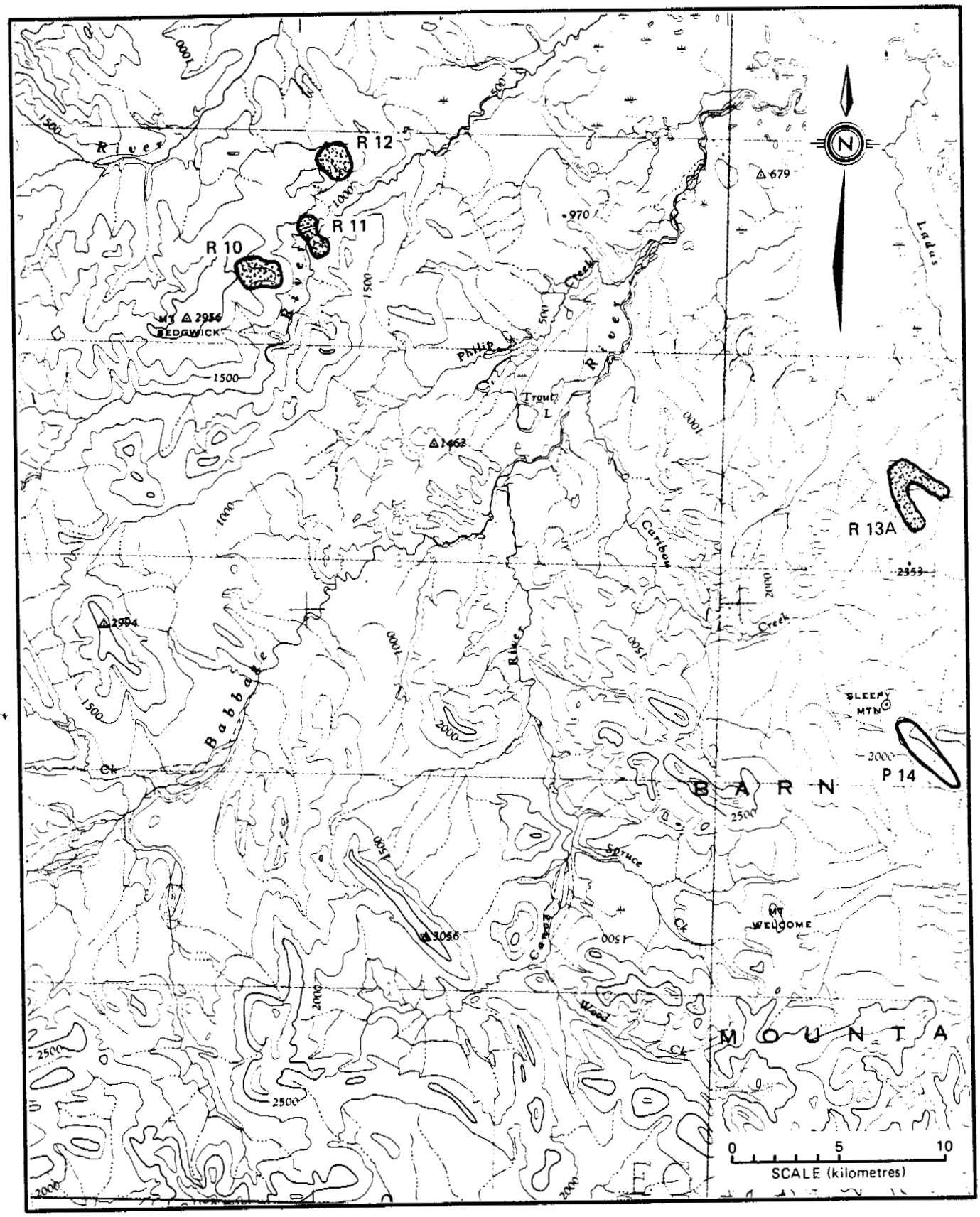

FIGURE A -13 LOCATION OF SITE R 12

A. Site No: R12

B. Overall Rating: Fair to Good

C. Location: Northeastern flank of Mount Sedgewick

D. Latitude: 68° 57' N.
Longitude: 138° 53' W.

E. Region: Mount Sedgewick. Within proposed National Park.

F. Reconnaissance Level: Ground

G. Geologic Data

Formation:	Neruokpuk
Geologic Age:	Precambrian
Lithology:	Limestone
Description:	Blocky, steeply dipping to vertical bedding.

H. Site Data

Description:	Rounded hill top, relatively high on slope ovelooking coastal plain. Felsenmeer patches indicate little overburden locally.
Base Elevation (m):	320
Optimum Location:	
Local Access:	Steep, even grades to climb to elevation of limestone.
Regional Access:	Must cross Babbage River and thermokarst sensitive terrain.
Likely Tidewater:	Stokes Point
Direct Distance (km):	40
Quantity:	Not Applicable

I. Potential Uses

Armour Stone (> 5 tonnes):	Unsuitable
Rip Rap (1 to 5 tonnes):	Smaller Sizes to about 1 tonne
Blast Rock (< 1 tonne):	Good
General Fill:	Good
Concrete Aggregate:	Good

J. Previous References

Preliminary Report: Site No. P10C

K. General Comments: This material has as much potential as the granite located 300 m higher and 8 km further up the mountain.

L. Development Feasibility: This site would not be developed beause of its location within the proposed park and its non-essential quality.

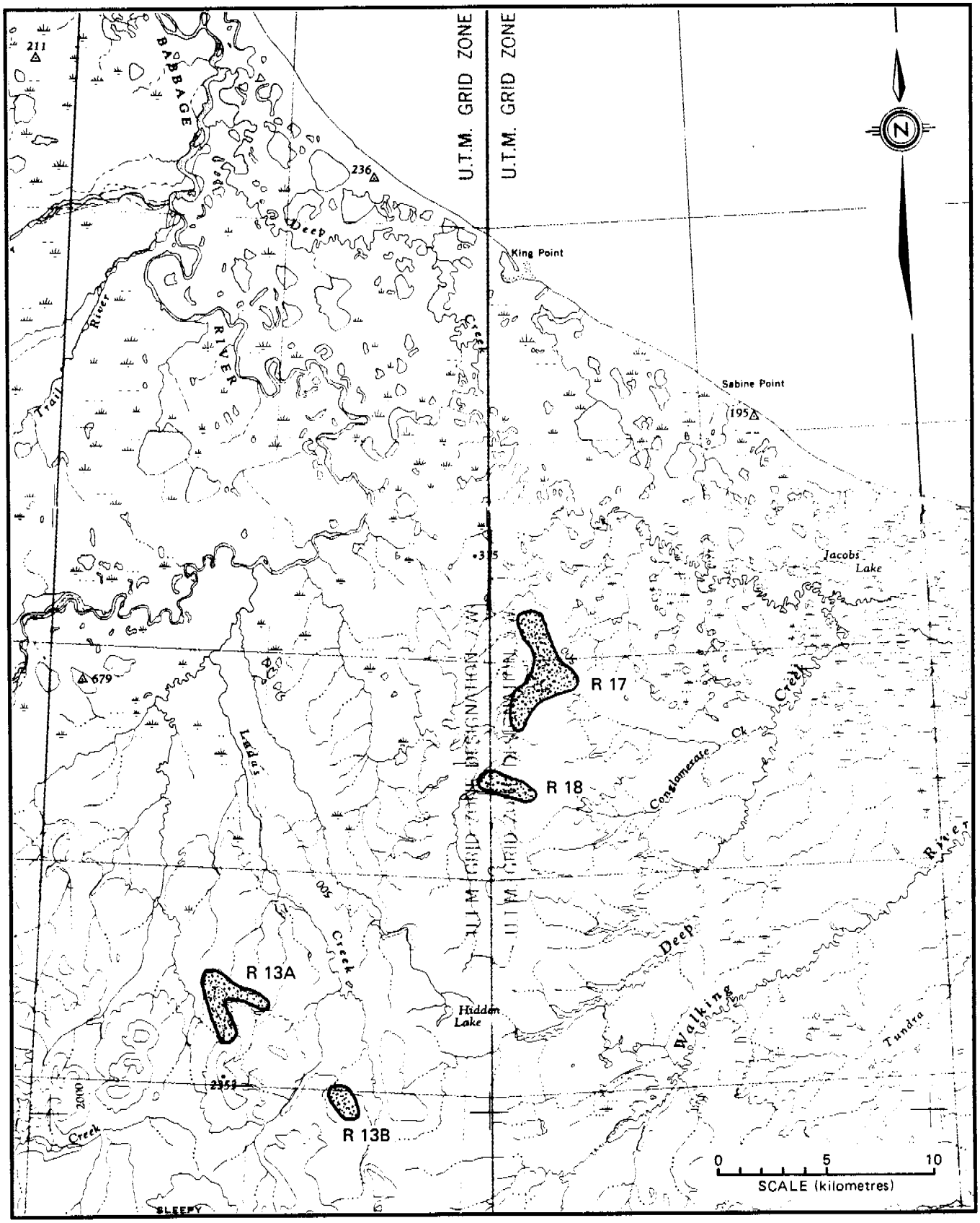

FIGURE A -14 LOCATION OF SITES R 13A &13B

A. Site No: R13A & R13B

B. Overall Rating: Fair to Good

C. Location: 10 km North of Sleepy Mountain

D. Latitude: 68° 48' N.
Longitude: 138° 18' W.

E. Region: Babbage River. East of proposed Park boundary.

F. Reconnaissance Level: Ground

G. Geologic Data

Formation:	West Channel
Geologic Age:	Cretaceous
Lithology:	Quartzitic Sandstone
Description:	Fine grained quartzitic sandstone, durable, blocky.

H. Site Data

Description:	Flat top ridge with vegetation cover. West slope felsenmeer covered 20 to 30 cm blocks common top size.
Base Elevation (m):	500
Optimum Location:	North end nearest coastline
Local Access:	Steep Slopes
Regional Access:	Across thermokarst sensitive morainal plain.
Likely Tidewater:	King Point
Direct Distance (km):	35
Quantity:	200 million cubic metres

I. Potential Uses

Armour Stone (> 5 tonnes):	Unsuitable
Rip Rap (1 to 5 tonnes):	Unsuitable
Blast Rock (< 1 tonne):	Fair to Poor
General Fill:	Good
Concrete Aggregate:	Good

J. Previous References

Preliminary Report:	Site No. P13

K. General Comments:

L. Development Feasibility: The relatively durable rock is located too high to warrant development. Better prospect (R13B) 7 km southeast appears to be more accessible.

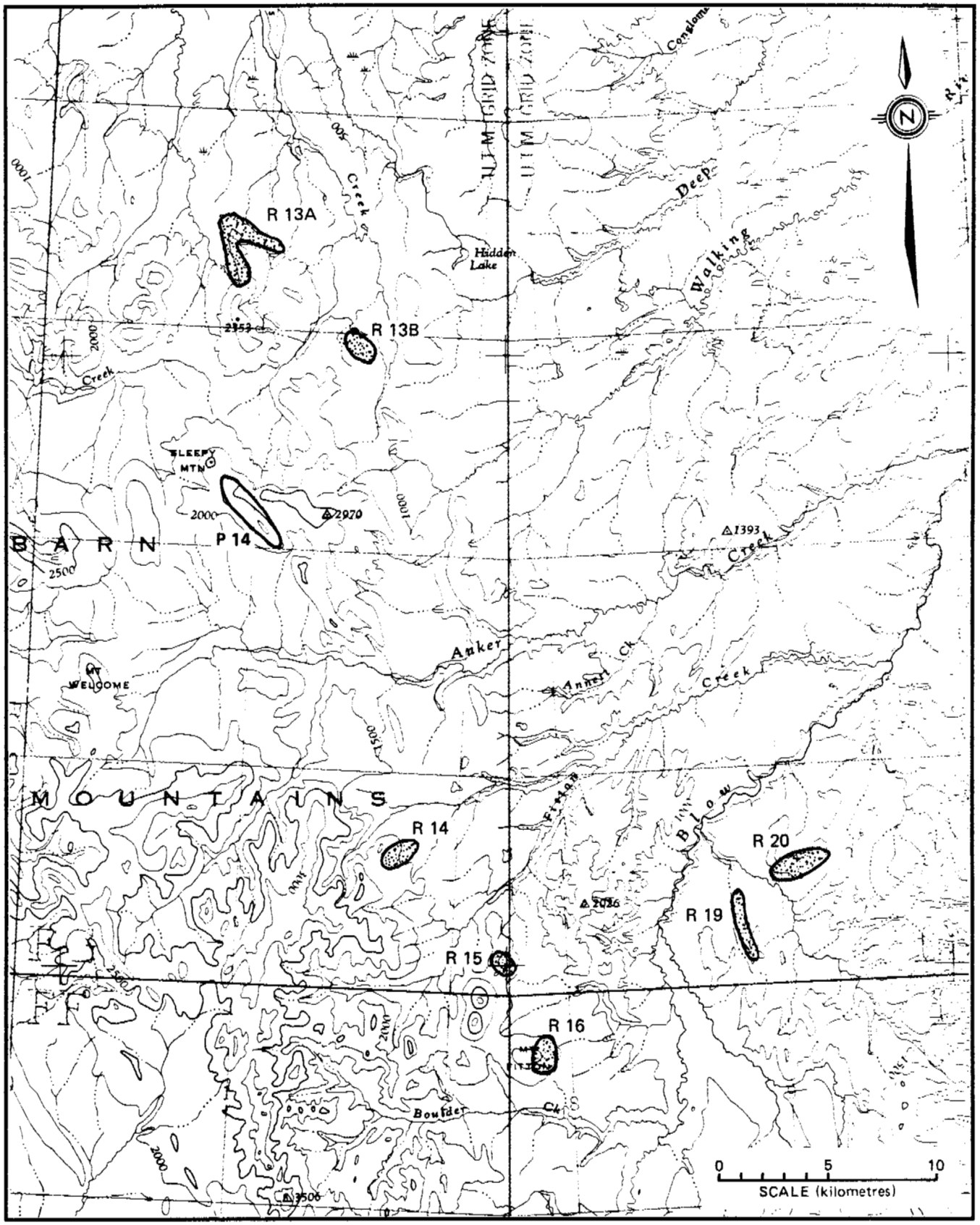

FIGURE A -15 LOCATION OF SITE R 14

A. Site No: R14

B. Overall Rating: Fair to Poor

C. Location: Hoidahl Cupola

D. Latitude: 68° 33' N.
Longitude: 138° 07' W.

E. Region: Blow River, Yukon

F. Reconnaissance Level: Ground

G. Geologic Data

Formation:	Fitton Granite
Geologic Age:	Ordovician - Silurian
Lithology:	Granite
Description:	Medium to fine grained grey brown granite. Slightly higher in elevation, contact with Ordovician - Silurian quartzite is evident.

H. Site Data

Description:	Saddle ridge, felsenmeer covered surface, blocks from gravel sizes to 50 cm. Quartzite blocks are 50 to 80 cm.
Base Elevation (m):	450
Optimum Location:	Northeast side
Local Access:	Very long steep grade.
Regional Access:	Would have to follow creek beds to Blow Valley to get out of mountains.
Likely Tidewater:	Single Point
Direct Distance (km):	57
Quantity:	5 million cubic metres

I. Potential Uses

Armour Stone (> 5 tonnes):	Unsuitable
Rip Rap (1 to 5 tonnes):	Unlikely
Blast Rock (< 1 tonne):	Fair
General Fill:	Good
Concrete Aggregate:	Good

J. Previous References

Preliminary Report: Site No. P15

K. General Comments: Access to the coast and tidewater is difficult and long.

L. Development Feasibility: It is unlikely that this site would be developed unless a higher grade of quarry stone could be proven.

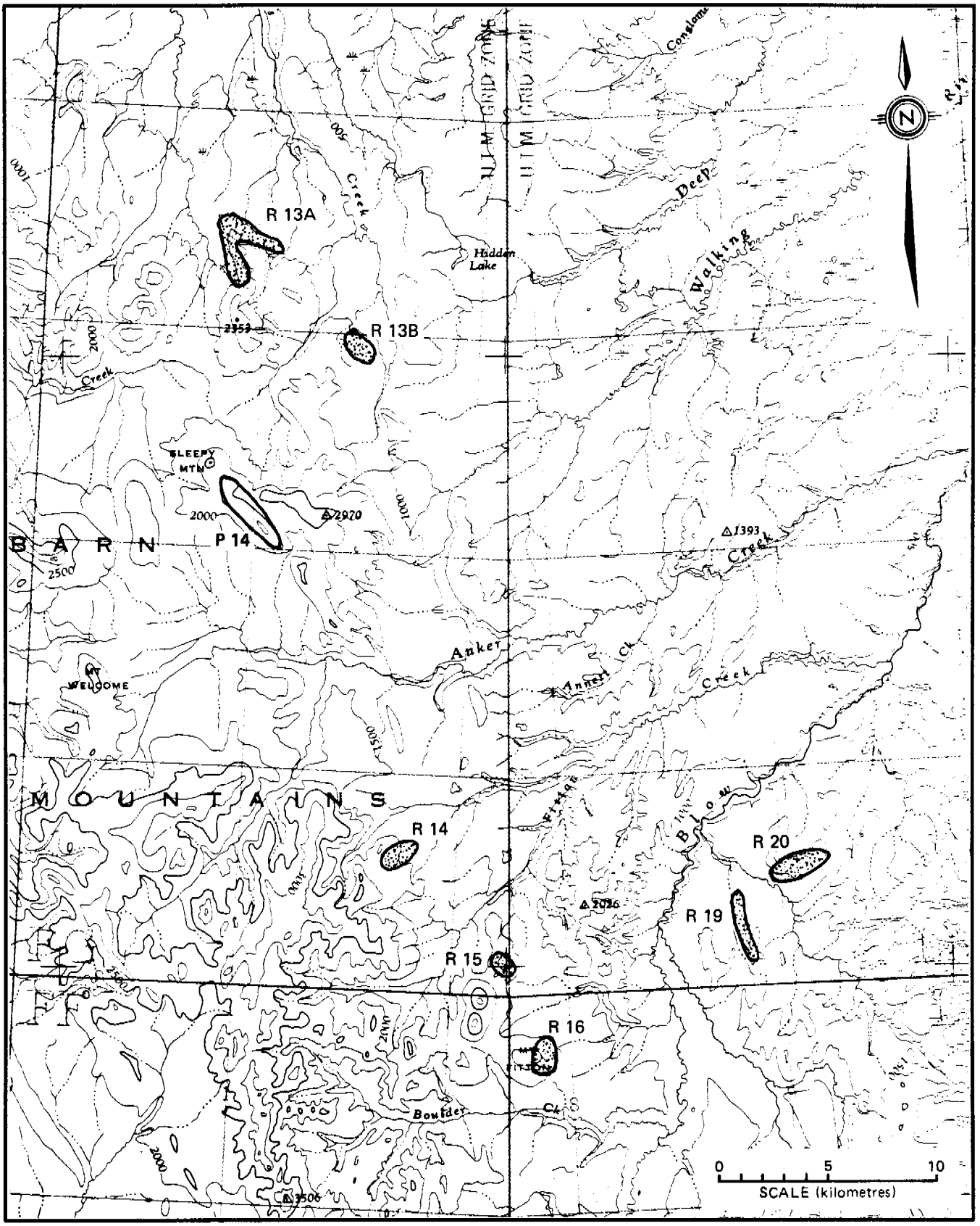

FIGURE A-16 LOCATION OF SITE R 15

A. Site No: R15

B. Overall Rating: Fair

C. Location: The Twins Mountains

D. Latitude: 68° 29' N.
Longitude: 138° 00' W.

E. Region: Mt. Fitton, Yukon

F. Reconnaissance Level: Ground

G. Geologic Data

Formation:	Unnamed
Geologic Age:	Ordovician and Silurian
Lithology:	Quartzite Conglomorate
Description:	Blocky, hard, durable, 5 to 10 mm pebbles cemented into competent rock.

H. Site Data

Description:	Saddle between two knobs. The two knobs are craggy outcrop; whereas the saddle was fine sandstone and shale (Kingak Fm.).
Base Elevation (m):	550
Optimum Location:	N/A
Local Access:	Steep Grades
Regional Access:	Along Fitton Creek
Likely Tidewater:	Shingle Point
Direct Distance (km):	60
Quantity:	1.5 million cubic metres

I. Potential Uses

Armour Stone (> 5 tonnes):	Unsuitable
Rip Rap (1 to 5 tonnes):	Smaller sizes to 2 tonnes
Blast Rock (< 1 tonne):	Good
General Fill:	Good
Concrete Aggregate:	Good

J. Previous References

Preliminary Report:	None

K. General Comments:

L. Development Feasibility: Development unlikely to occur at this site because a superior quality rock could be obtained at the nearby (5 km) Mt. Fitton site.

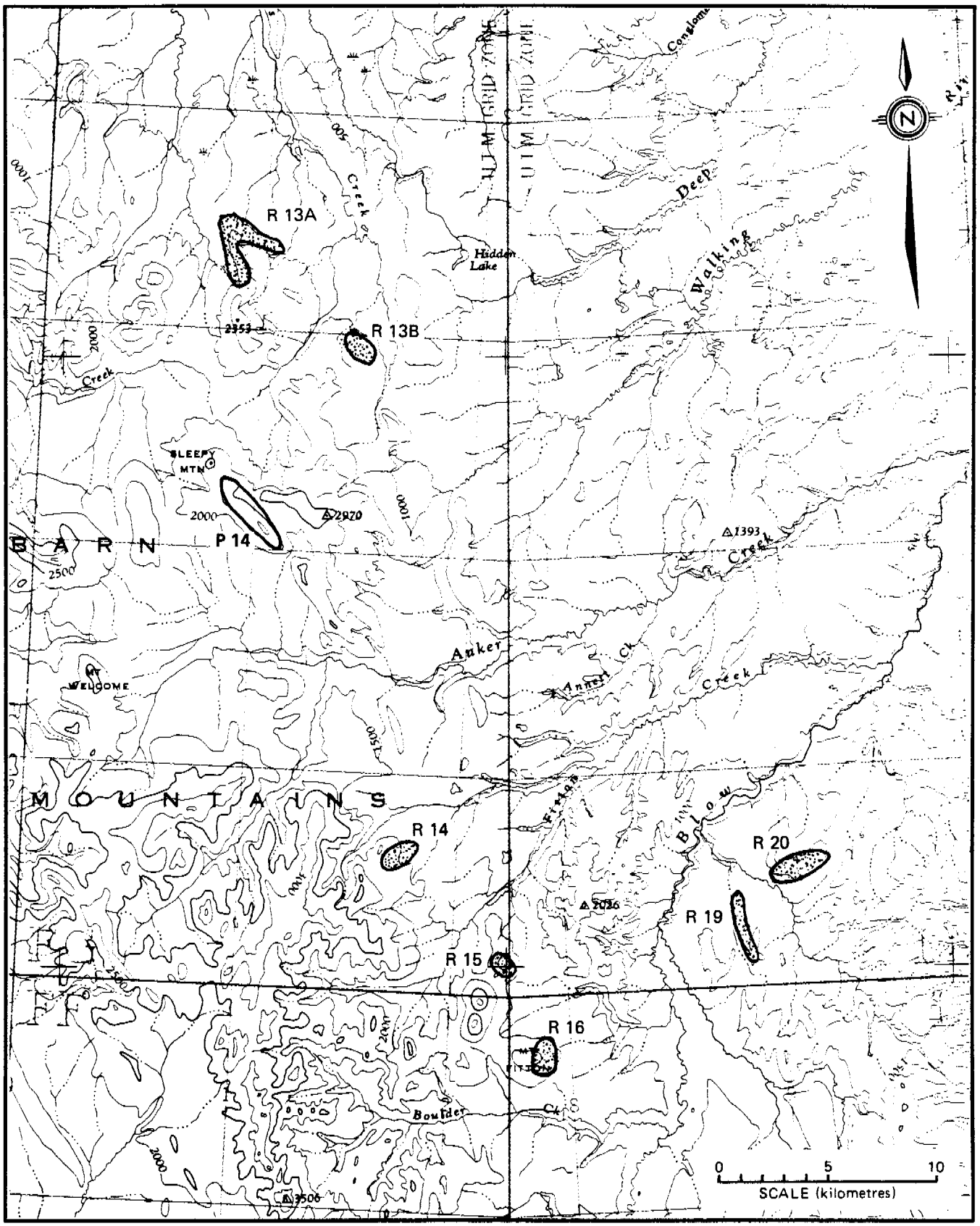

FIGURE A -17 LOCATION OF SITE R 16

A. Site No: R16

B. Overall Rating: Good

C. Location: Mount Fitton

D. Latitude: 69° 27' N.
Longitude: 137° 58' W.

E. Region: Mount Fitton, Yukon

F. Reconnaissance Level: Ground

G. Geologic Data

Formation:	Fitton
Geologic Age:	Ordovician and Silurian
Lithology:	Granite
Description:	Porphryitic granite, large blocky outcrops.

H. Site Data

Description:	Large blocky outcrop. Typical blocks to 10 tonne size. Lower on slopes somewhat smaller blocks (to 0.5 tonnes) are common.
Base Elevation (m):	440
Optimum Location:	Northeast slope
Local Access:	Long moderate to steep grades and minor gullies.
Regional Access:	Difficult access along Blow River Valley which is locally confined by steep banks and sharp gullies.
Likely Tidewater:	King Point
Direct Distance (km):	69
Quantity:	500 million cubic metres

I. Potential Uses

Armour Stone (> 5 tonnes):	Fair to Good
Rip Rap (1 to 5 tonnes):	Good
Blast Rock (< 1 tonne):	Good
General Fill:	Good
Concrete Aggregate:	Good

J. Previous References

Preliminary Report: Site No. P16

K. General Comments: The higher material is very durable and one suspects that below the surface felsenmeer similar durable rock can be obtained at lower elevations.

L. Development Feasibility: Superior quality material invites development; however, access would be difficult and costly. It would be 87 km by haul road north to King Point and about 100 km via Blow River and Shingle Point to King Point. Access roads might conflict with caribou protection requirements.

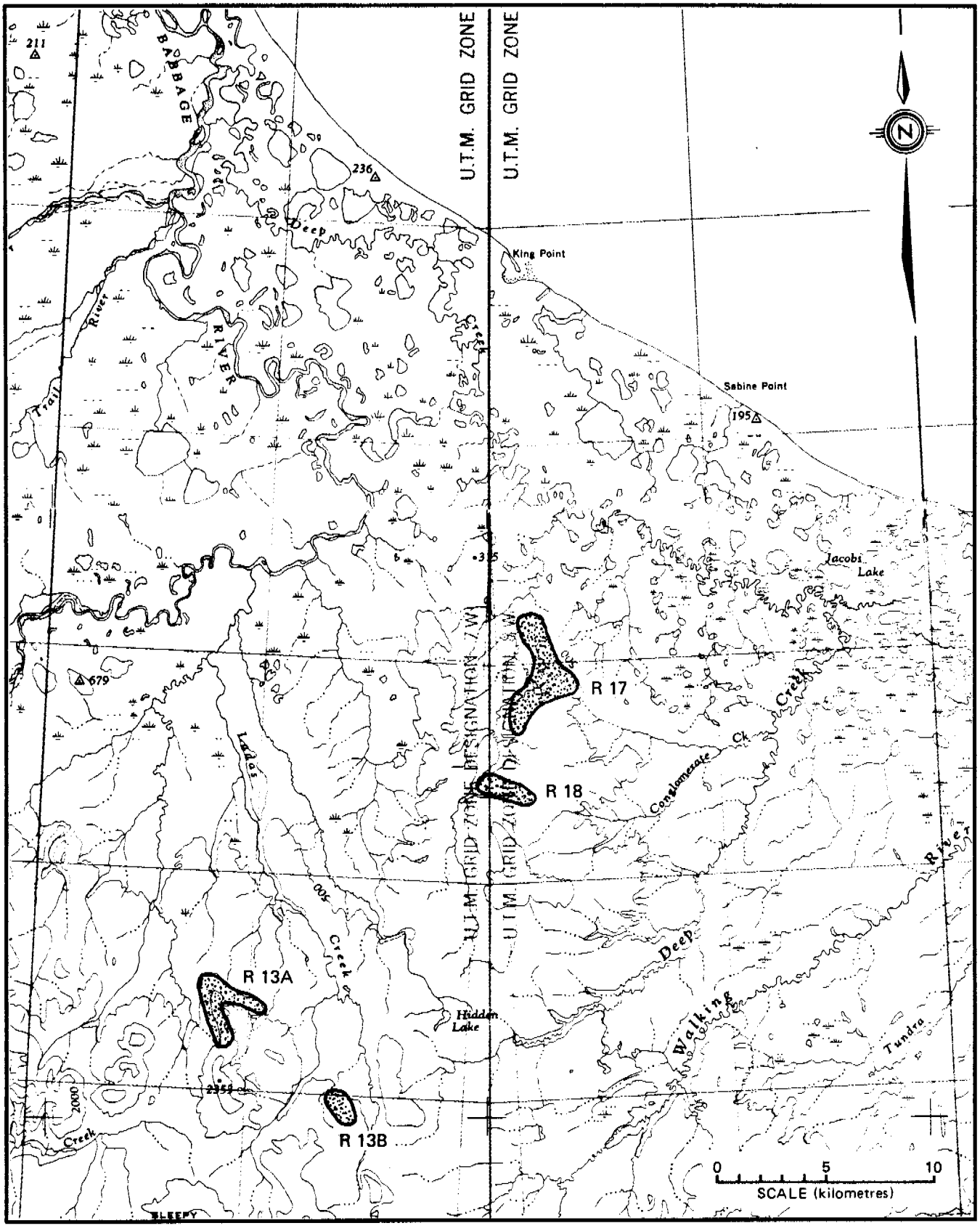

FIGURE A - 18 LOCATION OF SITE R 17

A. Site No: R17

B. Overall Rating: Fair to Poor

C. Location: Kiewit Site

D. Latitude: 68° 57' N.
Longitude: 137° 57' W.

E. Region: King Point, Yukon

F. Reconnaissance Level: Ground

G. Geologic Data

Formation:	Moose Channel
Geologic Age:	Tertiary
Lithology:	Sandstone
Description:	Flaggy to platey fragments 20 to 40 mm thick x20x30 cm. Weakly bonded. To south at second area an irregularity bedded conglomerate is exposed on the nose of a ridge. It is not very durable but there are a few 2 to 3 m blocks (may be Cuesta Creek Fm.).

H. Site Data

Description:	Rounded hills with felsenmeer cover. No apparent outcropping strata. Bedding is only distinguishable from air.
Base Elevation (m):	150
Optimum Location:	Northwest corner of ridge along unnamed creek.
Local Access:	Short moderately steep slope.
Regional Access:	Crosses themokarst sensitive morainal plain. Generally poorly drained.
Likely Tidewater:	King Point
Direct Distance (km):	17
Quantity:	200 million cubic metres

I. Potential Uses

Armour Stone (> 5 tonnes):	Unsuitable
Rip Rap (1 to 5 tonnes):	Unsuitable
Blast Rock (< 1 tonne):	Poor
General Fill:	Good
Concrete Aggregate:	Poor to Unsuitable (too weak)

J. Previous References

Preliminary Report:	Site No. P11
Hardy Associates (1976):	Site No. Y73
NES (1975):	Site NO. 117A-B1

K. General Comments: There are no significant outcrops of durable looking rock. On the northern (main) ridge bedding is not evident on the ground. The lack of prominent outcrop in the 50 to 75 m high hills, some with stream cut banks, suggests that more durable rock is unlikely to be found at depth.

L. Development Feasibility: Good location near coast and harbour. Unfortunately, a poorer grade of rock.

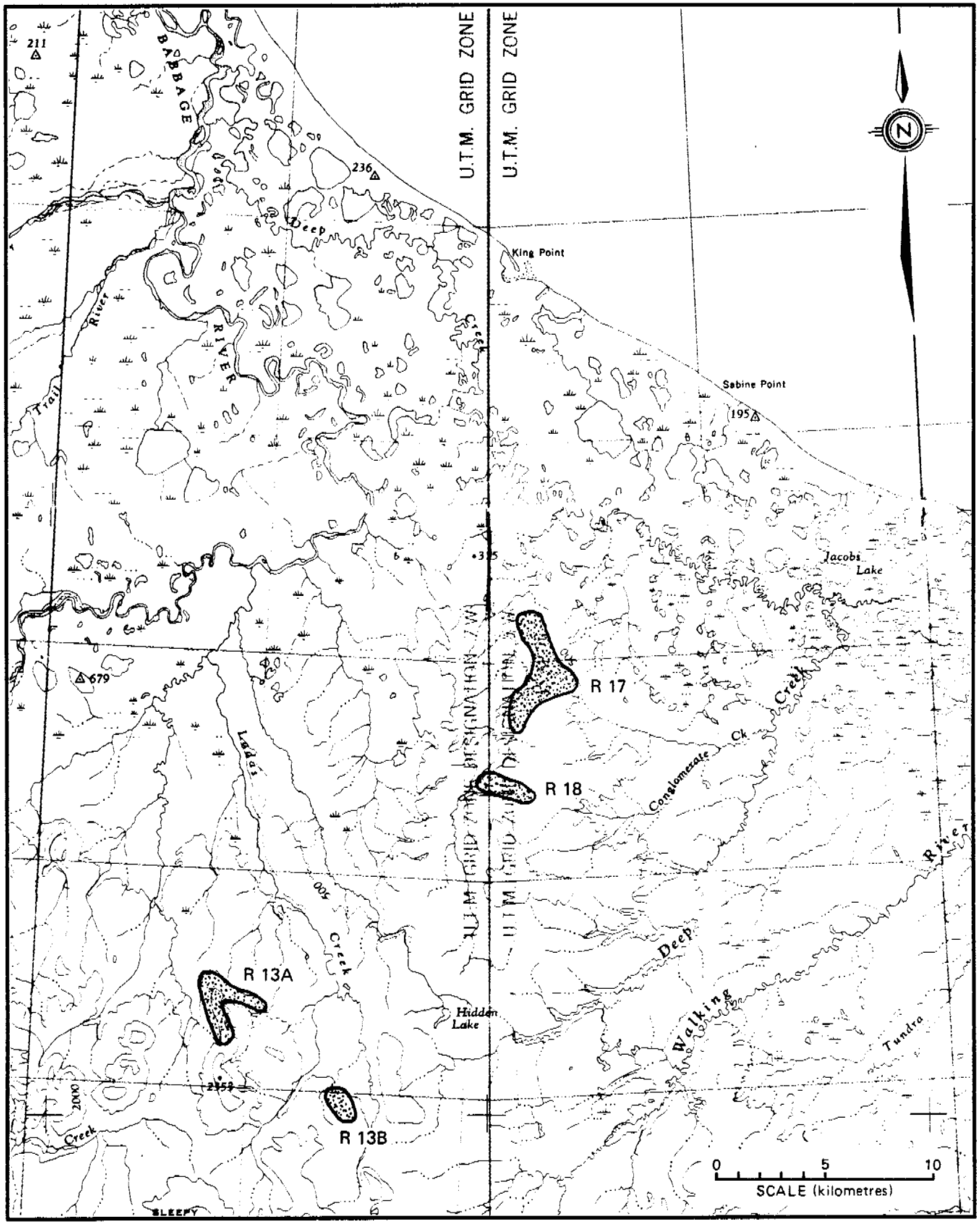

FIGURE A -19 LOCATION OF SITE R 18

A. Site No: R18

B. Overall Rating: Fair to Poor

C. Location: South of Kiewit Site

D. Latitude: 68° 53' N.
Longitude: 138° 00' W.

E. Region: King Point

F. Reconnaissance Level: Ground

G. Geologic Data

Formation:	Moose Channel
Geologic Age:	Tertiary
Lithology:	Sandstone
Description:	Thinly bedded (3 to 6 cm) with some conglomerates, blocky.

H. Site Data

Description:	Outcrop exposed at top of ridge is 2 to 3 m high. Distinct 2 dimensional jointing at 1.5 to 2 m spacing.
Base Elevation (m):	150
Optimum Location:	West end
Local Access:	Steep slope up from creek elevation.
Regional Access:	Crosses wet, thermokarst sensitive terrain.
Likely Tidewater:	King Point
Direct Distance (km):	23
Quantity:	50 million cubic metres

I. Potential Uses

Armour Stone (> 5 tonnes):	Unsuitable
Rip Rap (1 to 5 tonnes):	Unlikely
Blast Rock (< 1 tonne):	Poor to Fair
General Fill:	Good
Concrete Aggregate:	Poor

J. Previous References

Preliminary Report: Site No. P12(B)

K. General Comments: Better outcrop than R17. It appears more competent looking. To the south about 2.5 km distance, higher more durable looking rock outcrops.

L. Development Feasibility: Unlikely to be developed because large volume of similar quality material can be obtained nearer the coast at Site R17.

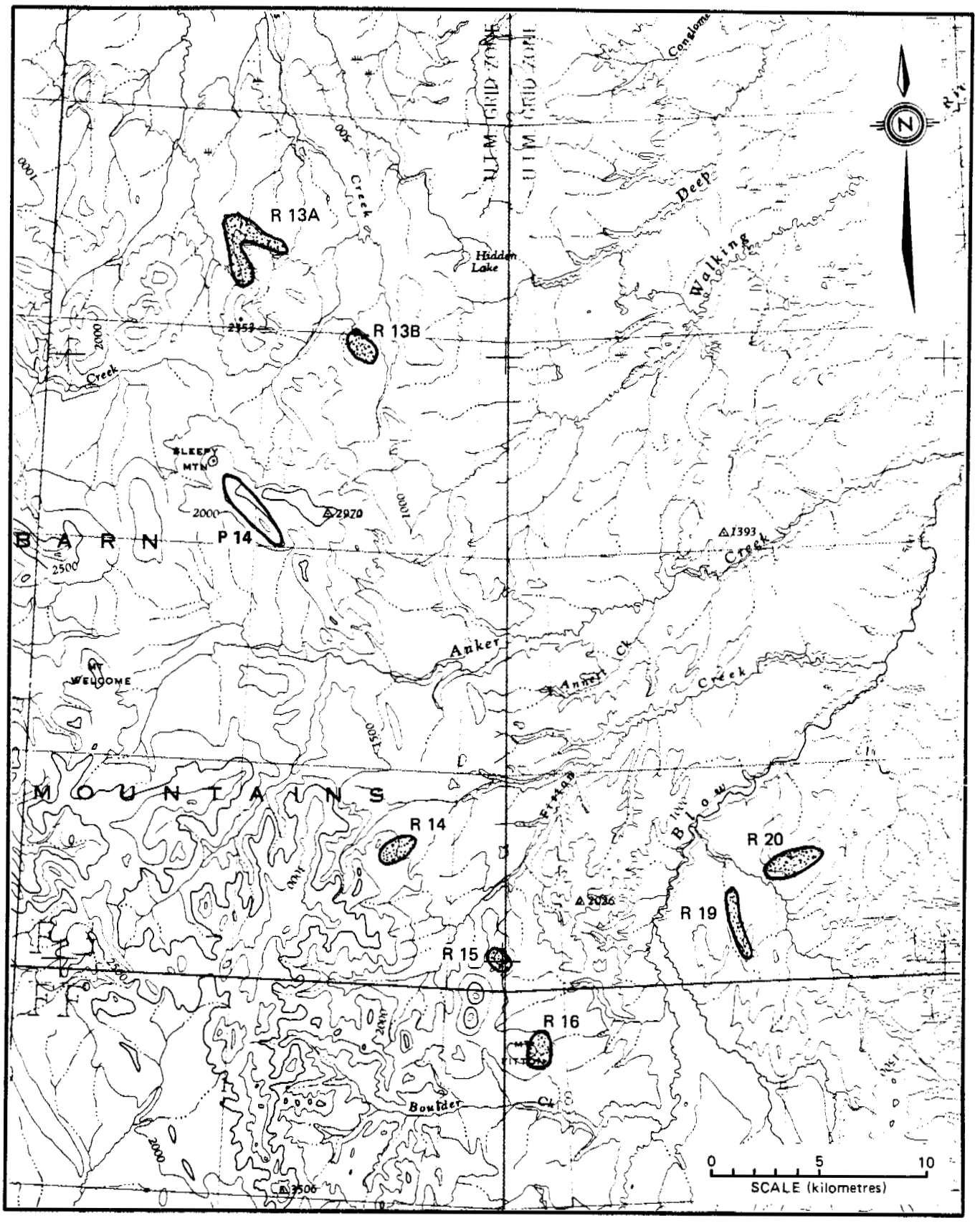

FIGURE A - 20 LOCATION OF SITE R 19

A. Site No: R19

B. Overall Rating: Unsuitable

C. Location: 12 km Northeast of Mount Fitton

D. Latitude: 68° 31' N.
Longitude: 137° 43' W.

E. Region: Mount Fitton - Blow River

F. Reconnaissance Level: Ground

G. Geologic Data

Formation:	Cuesta Creek
Geologic Age:	Cretaceous
Lithology:	Sandstone and Conglomerate
Description:	Thinly laminated sandstone and very weak conglomerate.

H. Site Data

Description:	Sharp ridge with small areas of outcrop along western flank.
Base Elevation (m):	300
Optimum Location:	N/A
Local Access:	Moderate to gentle slope up from Blow River Valley.
Regional Access:	Along Blow River
Likely Tidewater:	Shingle Point
Direct Distance (km):	55
Quantity:	Not Applicable

I. Potential Uses

Armour Stone (> 5 tonnes):	Unsuitable
Rip Rap (1 to 5 tonnes):	Unsuitalbe
Blast Rock (< 1 tonne):	Unlikely
General Fill:	Good
Concrete Aggregate:	Unsuitable

J. Previous References

Preliminary Report:	Site No. P18

K. General Comments: Might be developed for road building materials to access Mount Fitton granites.

L. Development Feasibility: Not a prospect for offshore construction.

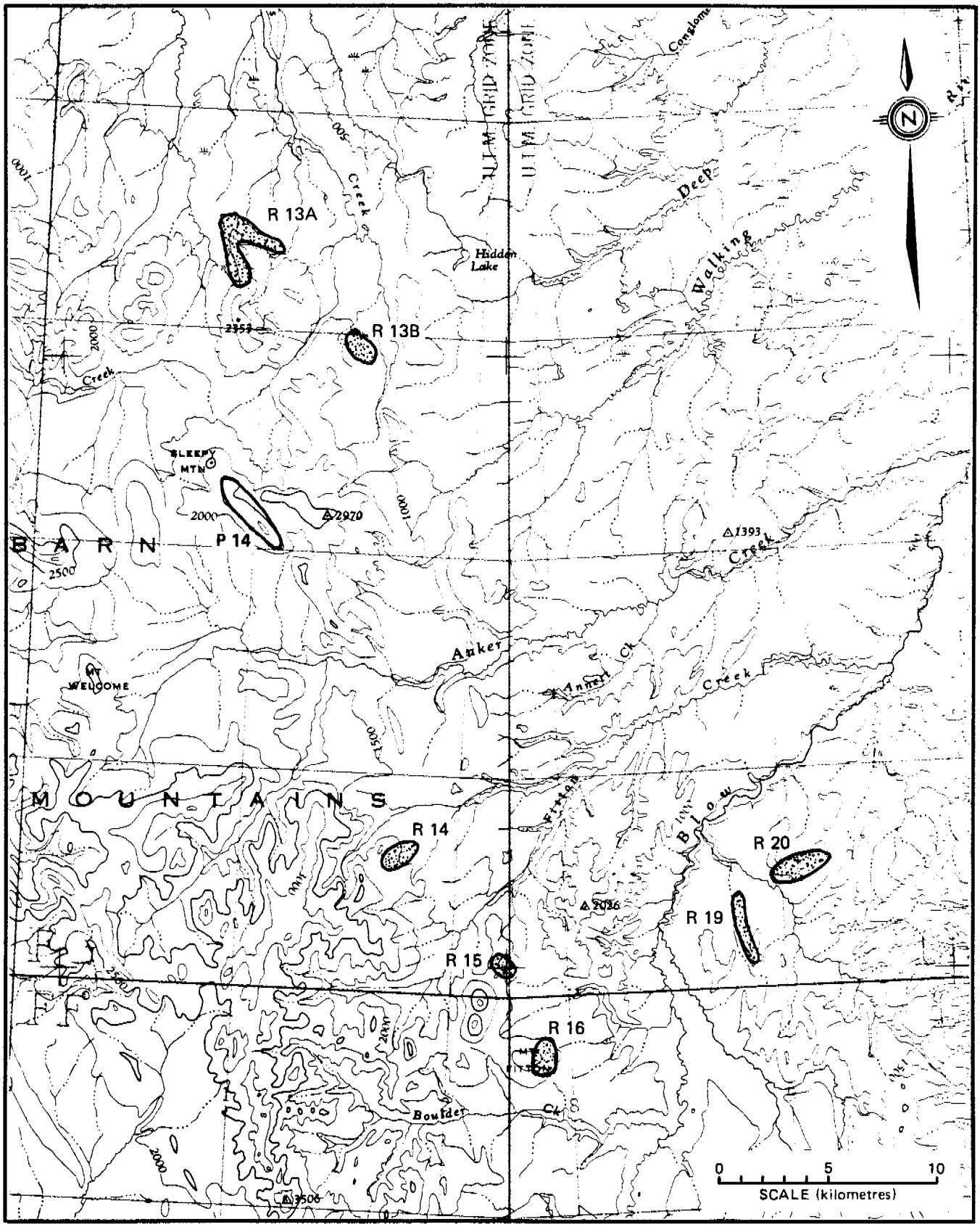

FIGURE A - 21 LOCATION OF SITE R 20

A. Site No: R20

B. Overall Rating: Unsuitable

C. Location: 14 km Northeast of Mount Fitton

D. Latitude: 68° 33' N.
Longitude: 137° 41' W.

E. Region: Mount Fitton - Blow River

F. Reconnaissance Level: Ground

G. Geologic Data

Formation:	Moose Channel
Geologic Age:	Tertiary
Lithology:	Sandstone
Description:	Flaggy to platy, 4 to 5 cm thick x20 cm square, weakly cemented.

H. Site Data

Description:	High south facing scree slope. Very little outcorp.
Base Elevation (m):	300
Optimum Location:	N/A
Local Access:	From Blow River
Regional Access:	Along Blow River Valley
Likely Tidewater:	Shingle Point
Direct Distance (km):	51
Quantity:	Not Applicable

I. Potential Uses

Armour Stone (> 5 tonnes):	Unsuitable
Rip Rap (1 to 5 tonnes):	Unsuitable
Blast Rock (< 1 tonne):	Unlikely
General Fill:	Good
Concrete Aggregate:	Poor to Unsuitable

J. Previous References

Preliminary Report:	Site No. P17

K. General Comments: Would likely be developed for access road construction to Mount Fitton granites. Material is very similar to Cuesta Creek Fm. at Site R19.

L. Development Feasibility: Not a prospect for offshore construction.

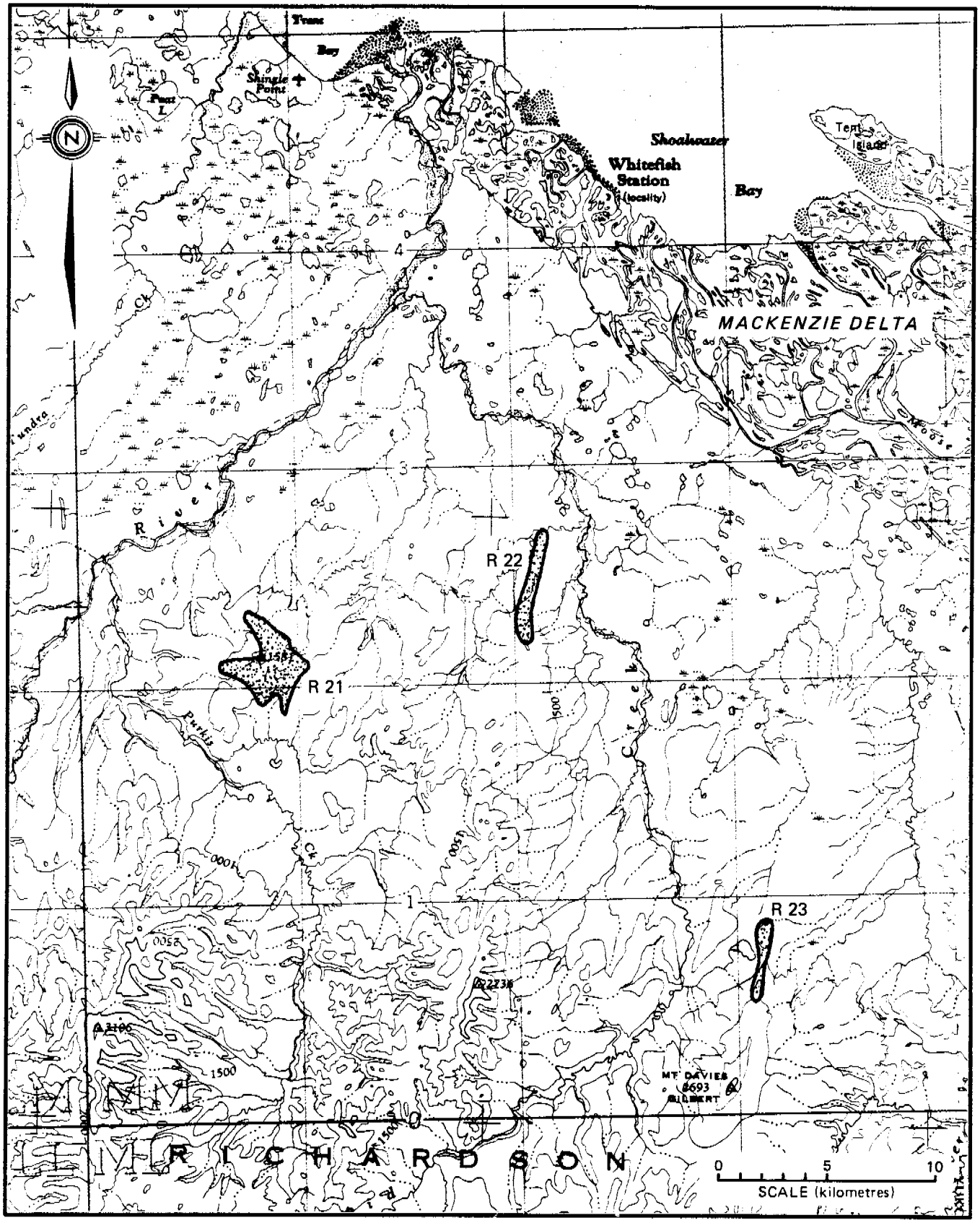

FIGURE A - 22 LOCATION OF SITE R 21

A. Site No: R21

B. Overall Rating: Unsuitable

C. Location: Purkis Creek

D. Latitude: 68° 42' N.
Longitude: 137° 12' W.

E. Region: Shingle Point, Yukon

F. Reconnaissance Level: Ground

G. Geologic Data

Formation:	Not Named
Geologic Age:	Cretaceous
Lithology:	Sandstone
Description:	Thin platey sandstone.

H. Site Data

Description:	Rounded fill with felsenmeer cover. No prominent outcrops.
Base Elevation (m):	170
Optimum Location:	Northern end
Local Access:	Gentle Slopes
Regional Access:	Crossing of thermally sensitive morainal plain. To reach tidewater several large river valleys must be crossed.
Likely Tidewater:	Shingle Point
Direct Distance (km):	34
Quantity:	Not Applicable

I. Potential Uses

Armour Stone (> 5 tonnes):	Unsuitable
Rip Rap (1 to 5 tonnes):	Unsuitable
Blast Rock (< 1 tonne):	Unsuitable
General Fill:	Good
Concrete Aggregate:	Poor to Unsuitable

J. Previous References

Preliminary Report:	Site No. P19
Hardy Associates (1976):	Site No. Y89

K. General Comments:

L. Development Feasibility: Not likely to be developed for offshore construction because of distance to deep water and rivers to be crossed.

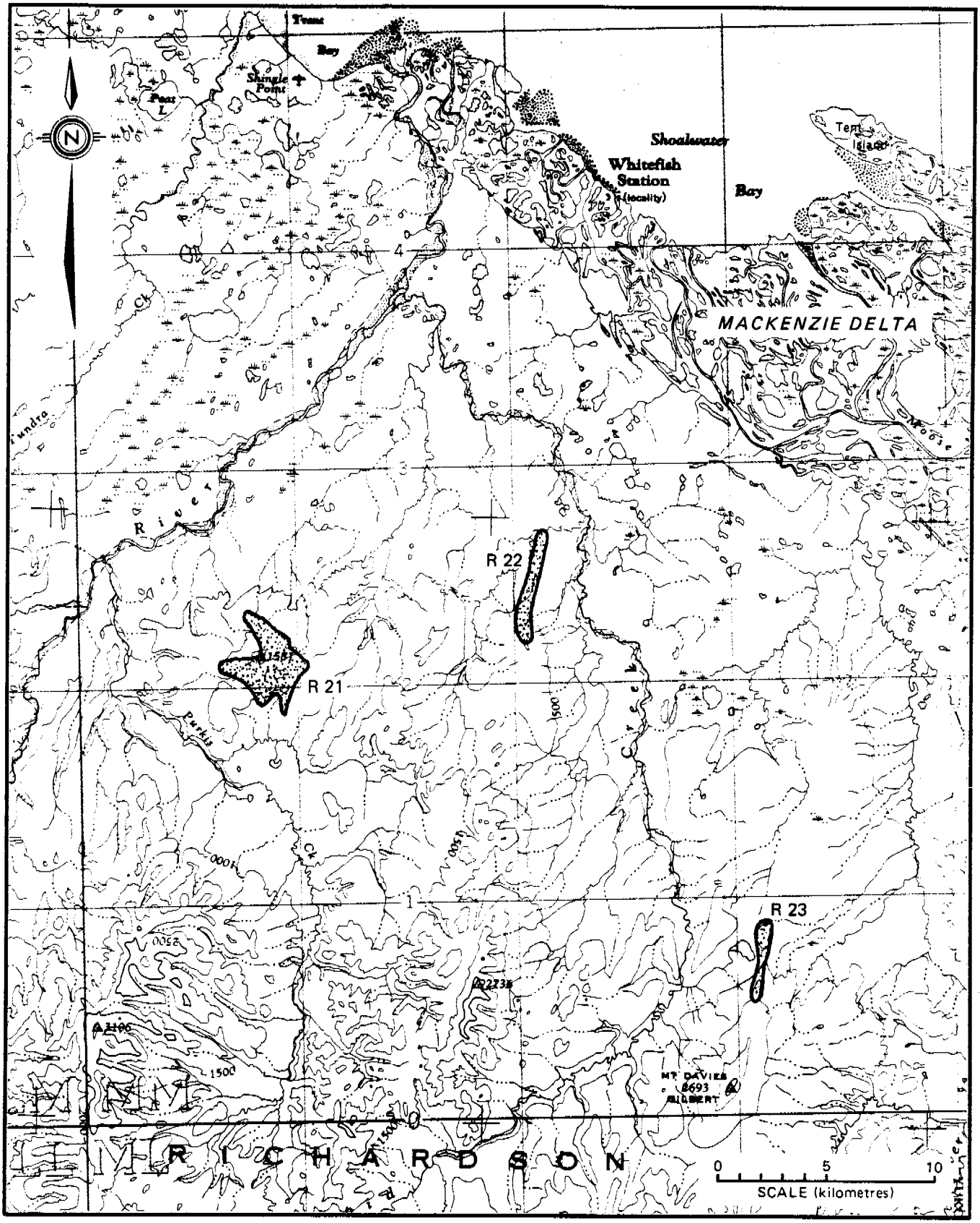

FIGURE A - 23 LOCATION OF SITE R 22

A. Site No: R22

B. Overall Rating: Fair to Poor

C. Location: Rapid Creek

D. Latitude: 68° 43' N.
Longitude: 136° 47' W.

E. Region: Richardson Mountains, Yukon

F. Reconnaissance Level: Ground

G. Geologic Data

Formation:	Cuesta Creek
Geologic Age:	Cretaceous
Lithology:	Sandstone and some Conglomerate
Description:	Durable quarzite conglomerate, blocky (1.5 x 1.0 x 0.7).

H. Site Data

Description:	5 m to 15 m thick strata as cap rock in high areas. Lower areas are not protected by cap rock. Underlying strata are thin, platey sandstone.
Base Elevation (m):	130
Optimum Location:	North end, nearest coastline.
Local Access:	Gentle rolling morainal hills.
Regional Access:	Must cross Blow River and several large creeks to reach tidewater.
Likely Tidewater:	Shingle Point
Direct Distance (km):	39
Quantity:	64 million cubic metres

I. Potential Uses

Armour Stone (> 5 tonnes):	Unlikely
Rip Rap (1 to 5 tonnes):	Fair (up to 2 tonnes)
Blast Rock (< 1 tonne):	Good
General Fill:	Good
Concrete Aggregate:	Fair

J. Previous References

Preliminary Report:	Site No. P20
Hardy Associates (1976):	Site No. Y94

K. General Comments: There is probably a limited quantity of larger material because cap rock is only 5 to 15 m thick.

L. Development Feasibility: Difficult access to deep water and limited quantity of larger stone make this an unlikely prospect for development.

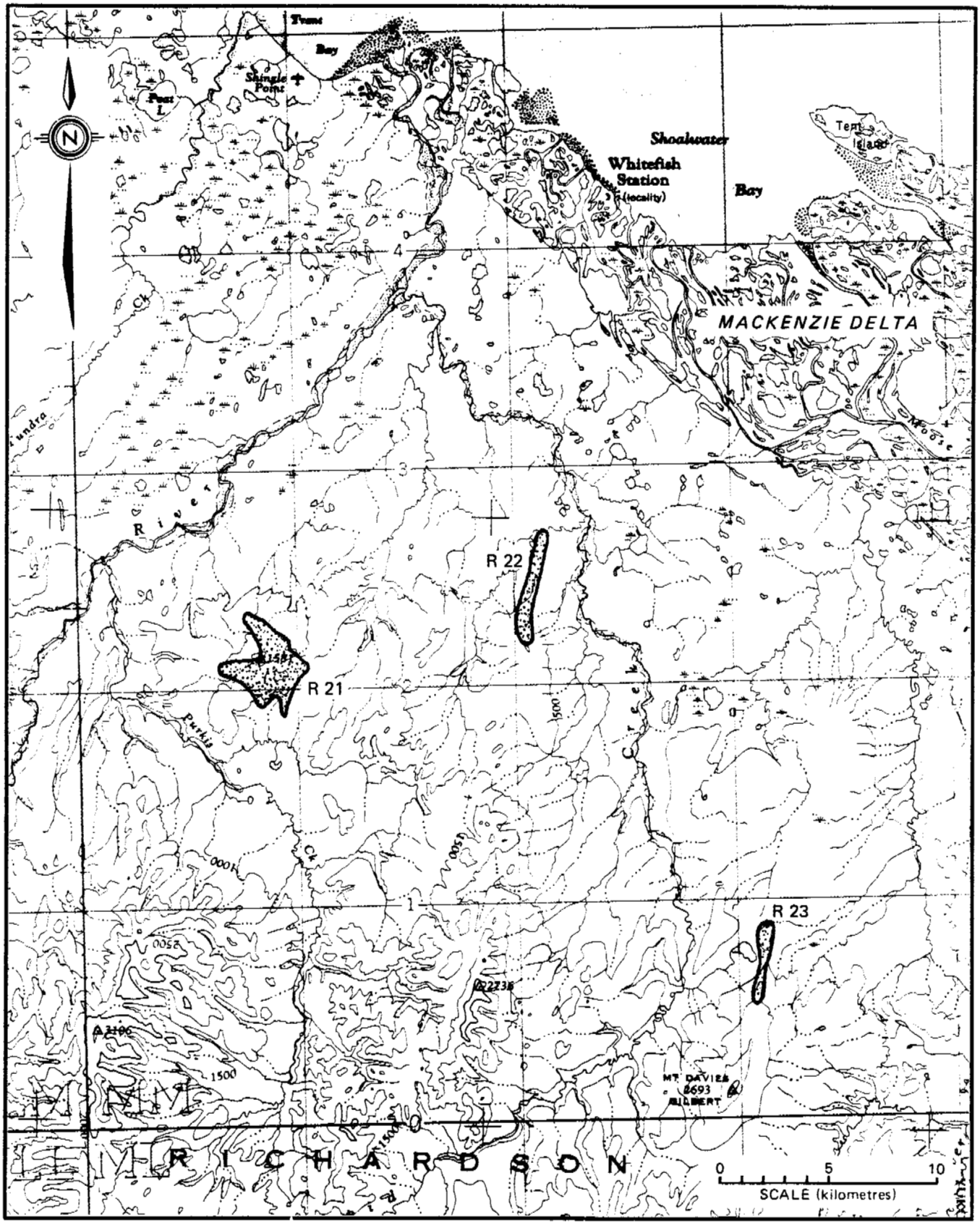

FIGURE A - 24 LOCATION OF SITE R 23

A. Site No: R23

B. Overall Rating: Fair to Good

C. Location: Mount Davies
Gilbert

D. Latitude: 68° 33' N.
Longitude: 136° 43' W.

E. Region: Richardson Mountains, Yukon

F. Reconnaissance Level: Ground

G. Geologic Data

Formation:	West Channel
Geologic Age:	Cretaceous
Lithology:	Quartzitic Sandstone
Description:	Hard, blocky, fine to medium grained, clean sandstone.

H. Site Data

Description:	Felsenmeer, scree covered lower slopes. Blocks 30 to 60 cm are common.
Base Elevation (m):	300
Optimum Location:	Near unnamed lake separating two sections of the ridge.
Local Access:	Poorly drained, low relief plain.
Regional Access:	Poorly drained, flat lying morainal plain.
Likely Tidewater:	Shingle Point
Direct Distance (km):	58
Quantity:	40 million cubic metres

I. Potential Uses

Armour Stone (> 5 tonnes):	Fair to Good
Rip Rap (1 to 5 tonnes):	Good
Blast Rock (< 1 tonne):	Good
General Fill:	Good
Concrete Aggregate:	Good

J. Previous References

Preliminary Report:	Site No. P21
Hardy Associates (1976):	Site No. Y98

K. General Comments: GSC/ISPG geologist report 15 tonne blocks are evident in higher areas.

L. Development Feasibility: Not a likely prospect because of distance to tidewater.

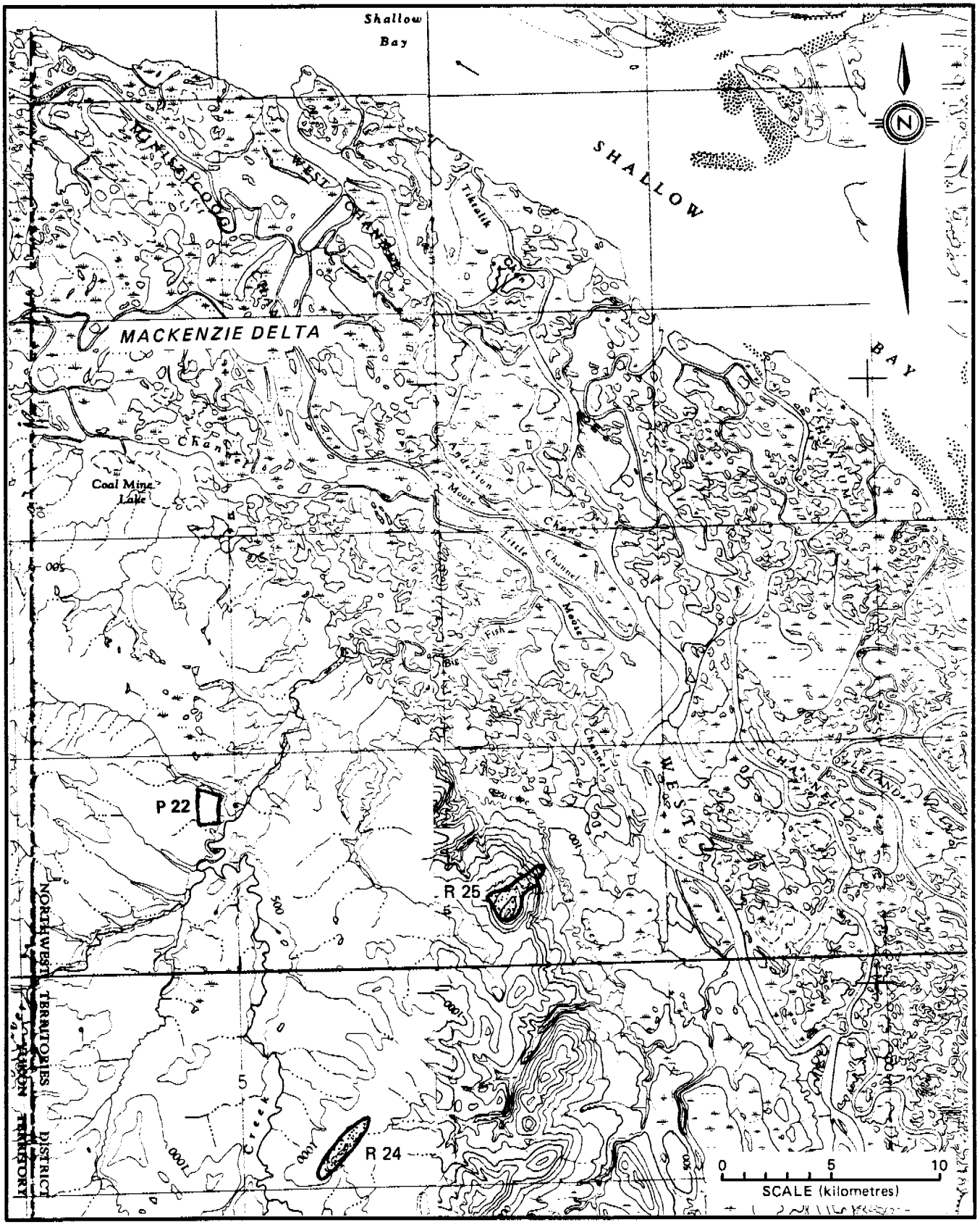

FIGURE A - 25 LOCATION OF SITE R 24

A. Site No: R24

B. Overall Rating: Unsuitable

C. Location: East of Cache Creek

D. Latitude: 68° 26' N.
Longitude: 136° 07' W.

E. Region: Richardson Mountains, N.W.T.

F. Reconnaissance Level: Ground

G. Geologic Data

Formation:	Bug Creek Group
Geologic Age:	Jurassic
Lithology:	Sandstone
Description:	Blocky to platy, fine grained.

H. Site Data

Description:	20 cm blocks of felsenmeer ridge crest. No outcrop evident, modest relief.
Base Elevation (m):	240
Optimum Location:	N/A
Local Access:	Moderate, long grades.
Regional Access:	N/A
Likely Tidewater:	N/A
Direct Distance (km):	
Quantity:	Not Applicable

I. Potential Uses

Armour Stone (> 5 tonnes):	Unsuitable
Rip Rap (1 to 5 tonnes):	Unsuitable
Blast Rock (< 1 tonne):	Poor
General Fill:	Good
Concrete Aggregate:	Poor

J. Previous References

Preliminary Report:	Site No. P23
Hardy Associates (1976):	Site No. 463

K. General Comments:

L. Development Feasibility: Unlikely prospect, too far to tidewater unspectacular quality.

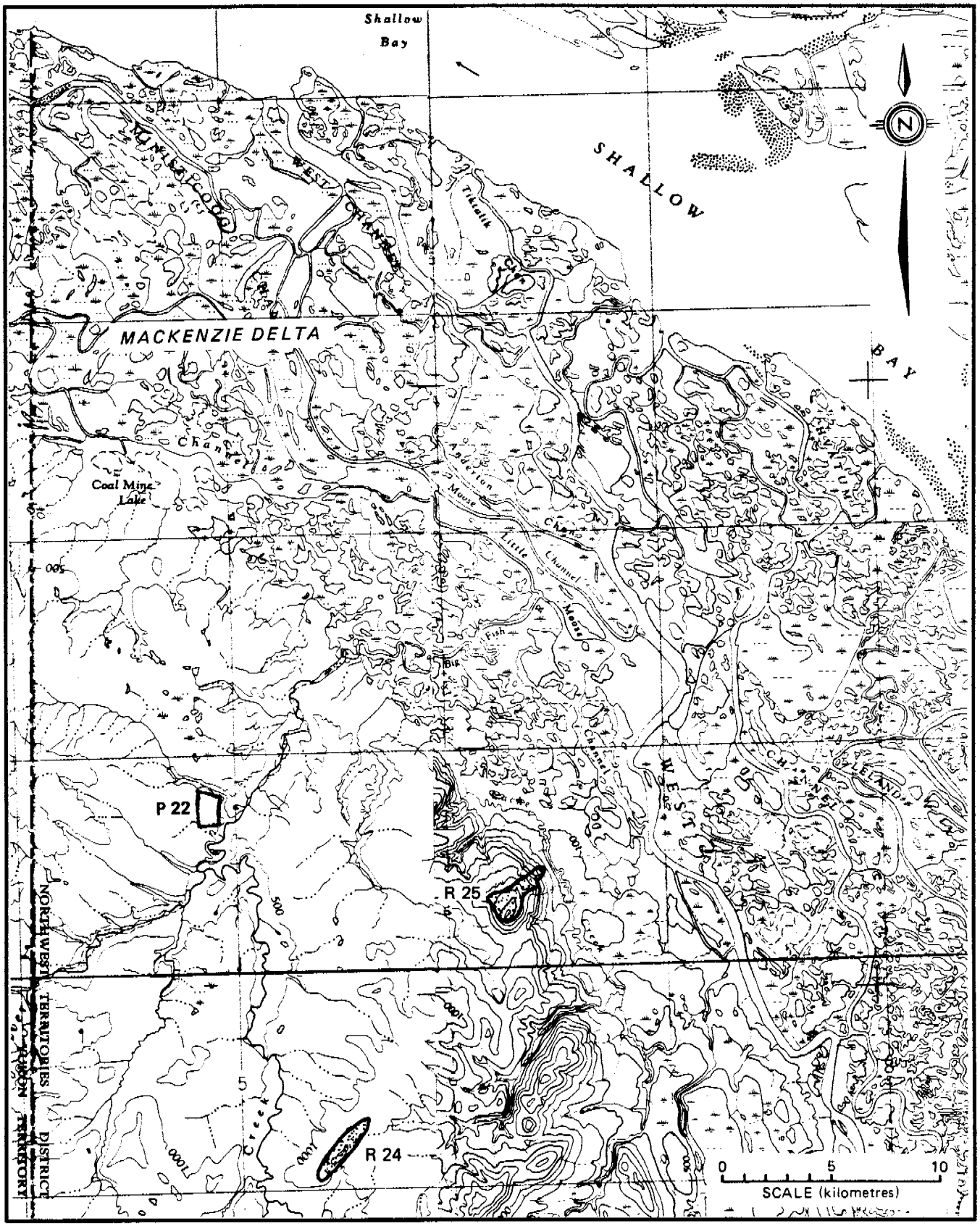

FIGURE A - 26 LOCATION OF SITE R 25

A. Site No: R25

B. Overall Rating: Fair

C. Location: South of Shallow Bay, N.W.T.

D. Latitude: 68° 33' N.
Longitude: 135° 54' W.

E. Region: West Channel

F. Reconnaissance Level: Ground

G. Geologic Data

Formation:	Martin Creek
Geologic Age:	Cretaceous
Lithology:	Sandstone
Description:	Clean, blocky, durable, flat lying.

H. Site Data

Description:	Large blocks and outcrops, thick sandstone at top of slope from West Channel, blocks commonly 0.5 to 1.0 m.
Base Elevation (m):	110
Optimum Location:	N.E. end at lower outlier.
Local Access:	Steep climb from lowlands bordering the delta.
Regional Access:	Lowland plain extends most of the distance to West Channel. A road across morainal plain to the channel would be difficult.
Likely Tidewater:	Mouth of West Channel
Direct Distance (km):	6 km to West Channel
Quantity:	20 million cubic metres

I. Potential Uses

Armour Stone (> 5 tonnes):	Unsuitable
Rip Rap (1 to 5 tonnes):	Fair
Blast Rock (< 1 tonne):	Good
General Fill:	Good
Concrete Aggregate:	Fair to Good

J. Previous References

Preliminary Report:	Site No. P24
Hardy Associates (1976):	Site No. 464

K. General Comments: The West Channel sites assume that a reasonable method of barging and/or over ice haul can be established to reach tidewater. ISPG/GSC geologist indicate that rock is poorly cemented and may not be as durable as first thought.

L. Development Feasibility: Subject to general comment above, this might be feasible for modest development.

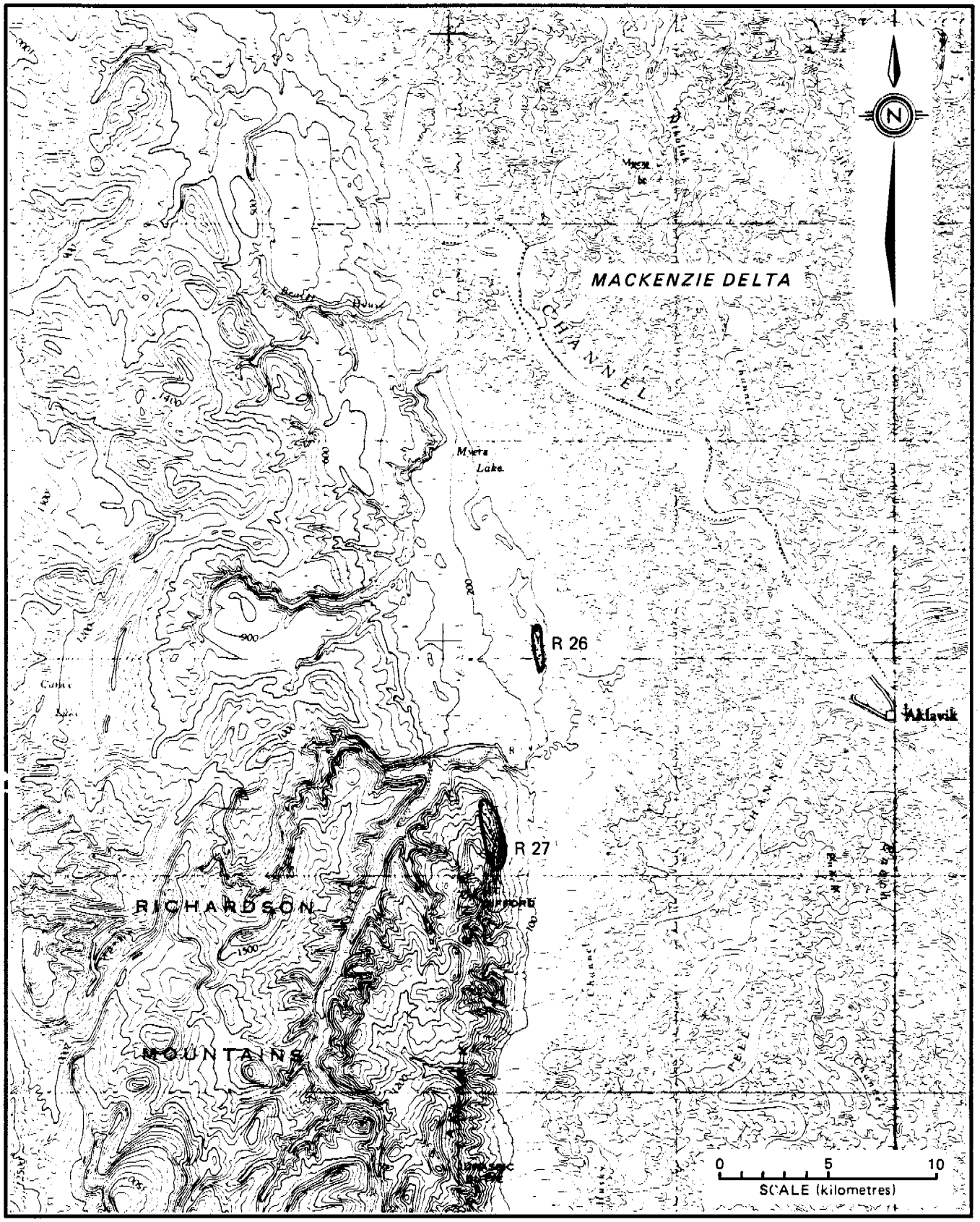

FIGURE A - 27 LOCATION OF SITE R 26

A. Site No: R26

B. Overall Rating: Poor

C. Location: 16 km West-Northwest of Aklavik, N.W.T.

D. Latitude: 68° 14' N.
Longitude: 135° 24' W.

E. Region: Aklavik

F. Reconnaissance Level: Ground

G. Geologic Data

Formation:	Mount Goodenough
Geologic Age:	Cretaceous
Lithology:	Sandstone/Siltstone
Description:	Sandstone, thinly bedded and pitted by erosion of soft zones, dipping slightly eastward, some competent blocks but generally not very clean.

H. Site Data

Description:	Low ridge of outcropping rock, locally blocky but generally not durable looking.
Base Elevation (m):	30
Optimum Location:	North end
Local Access:	Gentle, low relief
Regional Access:	Must cross 9 km of Mackenzie Delta to reach West Channel.
Likely Tidewater:	Mouth of West Channel
Direct Distance (km):	9 km to West Channel
Quantity:	5 million cubic metres

I. Potential Uses

Armour Stone (> 5 tonnes):	Unsuitable
Rip Rap (1 to 5 tonnes):	Unsuitable
Blast Rock (< 1 tonne):	Unlikely
General Fill:	Fair
Concrete Aggregate:	Poor

J. Previous References

Preliminary Report:	Site No. P26
Hardy Associates (1976):	Site No. 469

K. General Comments: The soft easily eroded beds are an indication of weak rock.

L. Development Feasibility: Not a likely prospect for quarry rock development because of deep water access limitation and inconsistent durability.

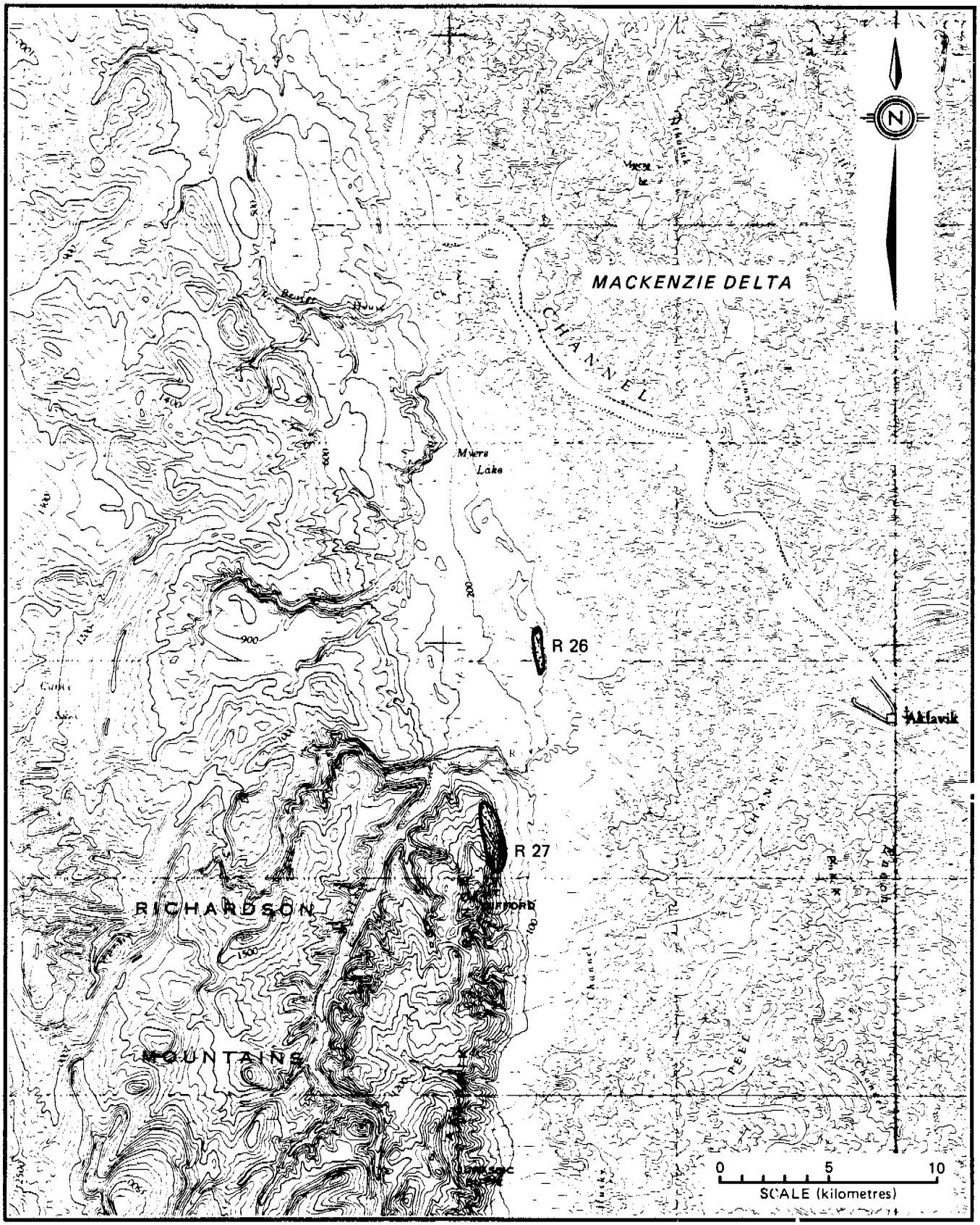

FIGURE A - 28 LOCATION OF SITE R 27

A. Site No: R27

B. Overall Rating: Good

C. Location: Mount Gifford, N.W.T.

D. Latitude: 68° 09' N.
Longitude: 135° 26' W.

E. Region: Aklavik

F. Reconnaissance Level: Ground

G. Geologic Data

Formation:	Martin Creek
Geologic Age:	Cretaceous
Lithology:	Sandstone
Description:	Clean, blocky, durable, 70 to 100 cm bedding.

H. Site Data

Description:	On eastern edge of mountain ridge, dipping northerly. Provides large blocks of durable talus. Ridge forming member commonly 20 to 30 m thick.
Base Elevation (m):	125
Optimum Location:	Lower end of the ridge near north end of the mountain.
Local Access:	Moderate climb to area of site. Morainal terrain is moderately wet and may be thermally sensitive.
Regional Access:	West Channel to river mouth.
Likely Tidewater:	Mouth of West Channel
Direct Distance (km):	5 km to West Channel access.
Quantity:	5 to 10 million cubic metres

I. Potential Uses

Armour Stone (> 5 tonnes):	Fair (some talus blocks are 5 to 10 tonne size)
Rip Rap (1 to 5 tonnes):	Good
Blast Rock (< 1 tonne):	Good
General Fill:	Good
Concrete Aggregate:	Good

J. Previous References

Preliminary Report:	Site No. P25
Hardy Associates (1976):	Site No. 468

K. General Comments: The area examined is less than a kilometer from the borrow pit used by Aklavik residents to obtain gravel.

L. Development Feasibility: Locally available labour and accomdations might be enough to justify development.

Sec. A - Outlook

MF R16
MDG R23 498
MG R27, 468

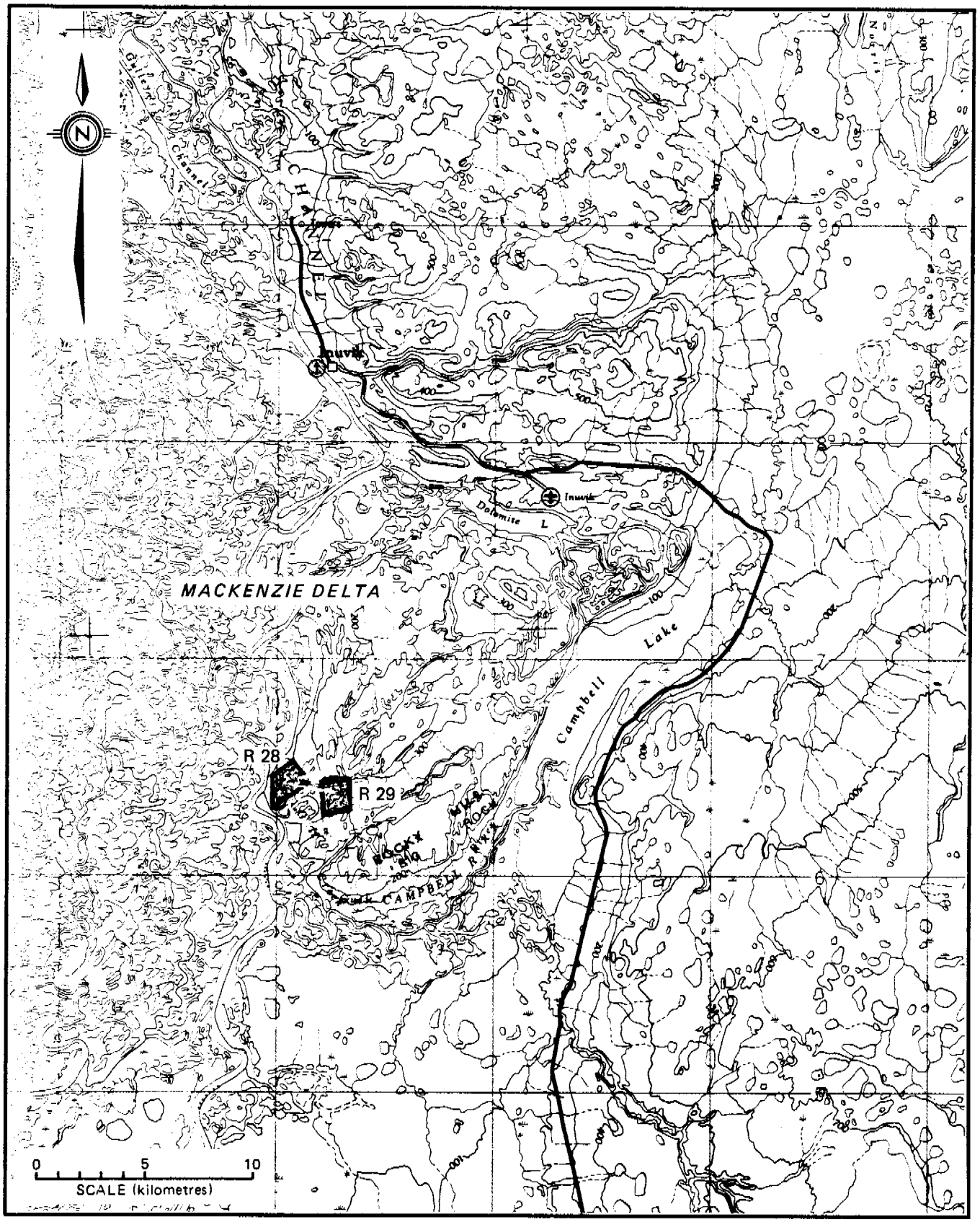

FIGURE A - 29 LOCATION OF SITE R 28

A. Site No: R28

B. Overall Rating: Good

C. Location: Gull Creek, N.W.T.

D. Latitude: 68° 10' N.
Longitude: 133° 47' W.

E. Region: Inuvik

F. Reconnaissance Level: Aerial Only

G. Geologic Data

Formation:	Undifferentiated
Geologic Age:	Precambrian
Lithology:	Quartzite
Description:	Massive to blocky.

H. Site Data

Description:	Pronounced cliff of 75 m.
Base Elevation (m):	20
Optimum Location:	
Local Access:	Barge by river.
Regional Access:	Middle Channel of Mackenzie River Delta.
Likely Tidewater:	Mouth of the River.
Direct Distance (km):	Less than a kilometer to water.
Quantity:	15 million cubic metres (plus)

I. Potential Uses

Armour Stone (> 5 tonnes):	Good
Rip Rap (1 to 5 tonnes):	Good
Blast Rock (< 1 tonne):	Good
General Fill:	Good
Concrete Aggregate:	Good

J. Previous References

Preliminary Report:	Site No. P27
EBA (1976):	Report No. 1-1537

K. General Comments: This area is within the proposed Dolomite Lake - Campbell Hill IBP site.

L. Development Feasibility: A good prospect with available local harbour and infrastructure.

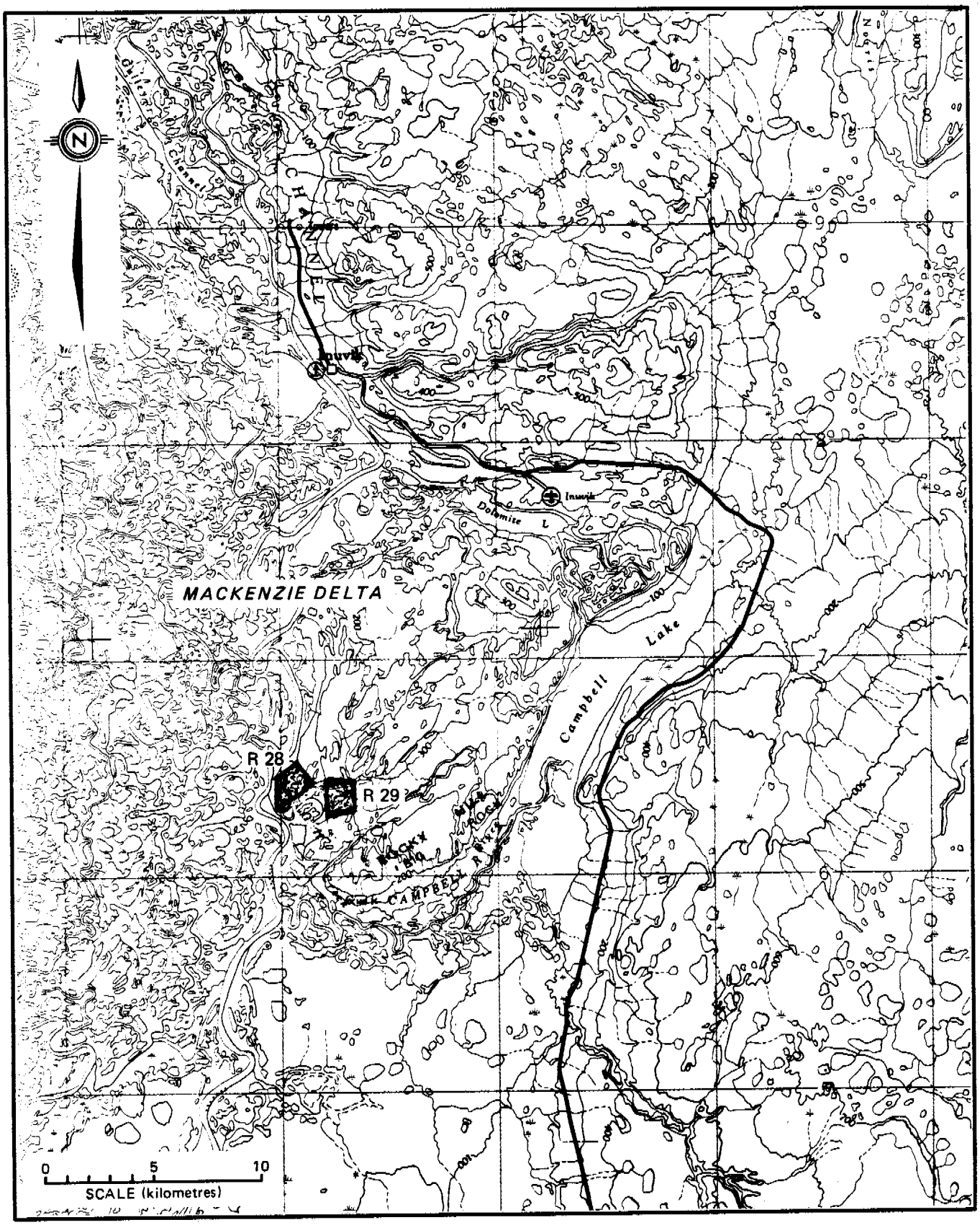

FIGURE A - 30 LOCATION OF SITE R 29

A. Site No: R29

B. Overall Rating: Good

C. Location: Gull Creek, N.W.T.

D. Latitude: 68° 10' N.
Longitude: 133° 47' W.

E. Region: Inuvik

F. Reconnaissance Level: Aerial Only

G. Geologic Data

Formation:	Vunta
Geologic Age:	Cambrian - Silurian
Lithology:	Dolomite (Cherty)
Description:	Blocky

H. Site Data

Description:	Moderate ridges and low scarp 15 to 25 m high.
Base Elevation (m):	20
Optimum Location:	Near river
Local Access:	By river barge
Regional Access:	Middle Channel of Mackenzie River
Likely Tidewater:	Mouth of river
Direct Distance (km):	Less than 1 km to river
Quantity:	5 million cubic metres

I. Potential Uses

Armour Stone (> 5 tonnes):	Fair
Rip Rap (1 to 5 tonnes):	Good
Blast Rock (< 1 tonne):	Good
General Fill:	Good
Concrete Aggregate:	Good

J. Previous References

Preliminary Report:	Site No. P27
EBA (1976):	Report No. 1-1537

K. General Comments: This area is within the proposed Dolomite Lake - Campbell Hills IBP site.

L. Development Feasibility: A good prospect with available local labour and good development infrastructure.