REPORT
TO
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT
ON
BEAUFORT REGION QUARRY ROCK STUDY

Golder Associates

24.

Golder Associates
CONSULTING GEOTECHNICAL AND MINING ENGINEERS

REPORT
TO
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AND NORTHERN DEVELOPMENT
ON
BEAUFORT REGION QUARRY ROCK STUDY

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* This volume is available at DIAND headquarters, regional and district offices and/or libraries.

1.0 INTRODUCTION

This report presents the results of a study carried out by Golder Associates to evaluate a number of potential quarry rock sources in the western Arctic. The study was commissioned by the Department of Indian Affairs and Northern Development (DIAND) to identify technically feasible quarry prospects in the vicinity of the Mackenzie Delta which may be used to provide a variety of grades of rock at some time in the future. The rock would be needed for the development of shore protection for port facilities, concrete structures associated with those or off-shore facilities, or for the construction of artificial drilling islands in the Beaufort Sea.

In a solicitation dated August 14, 1986, the Bid Receiving Unit of the Department of Supply and Services, Hull, Quebec invited tenders for a quarry rock study in the Beaufort region of the western Arctic. Golder Associates (Golder) was awarded Contract 38ST.A7134-6-0016 early in September 1986 to carry out the geotechnical characterization of the rock mass at six specified sites in the Northwest Territories and Yukon Territory close to the Mackenzie Delta, see Table 1 and Figure 1. The prime objective of the study was evaluate all of these sites and assess the technical feasibility for their potential development as rock quarries to supply various grades of material from concrete aggregate to armour rock.

Golder was also requested to evaluate other sites which, on a preliminary assessment, might be considered as alternatives to the six quoted in the RFP. Golder and the Scientific Authority discussed a number of sites west of the Delta in the Richardson Range near the Dempster Highway which had been referred to by the Geological Survey of

TABLE 1
QUARRY SITES AND ROCK GRADES

Quarry Sites

The study involved the following potential quarry rock sources:

Site 1.	Mount Fitton, Yukon:	68°27'N, 137°58'W
Site 2.	Mount Davies Gilbert, Yukon:	68°33'N, 136°43'W
Site 3.	Mount Gifford, N.W.T.:	68°09'N, 135°26'W
Site 4.	Gull Creek Quartzite, N.W.T.:	68°11'N, 133°48'W
Site 5.	Gull Creek, Dolomite, N.W.T.:	68°10'N, 133°45'W
Site 6.	Delta Outliers, N.W.T.:	68°03'N, 134°00'W

Additionally, three other sites were reviewed:

Site 3C.	West Delta roche moutonee, N.W.T:	68°29'N, 135°45'W
Site X1.	DPW Quarry, N.W.T:	68°11'N, 133°25'W
Site X2.	Campbell Pit, N.W.T:	68°17'N, 133°19'W

Rock Grades

The following five grades of rock were considered:

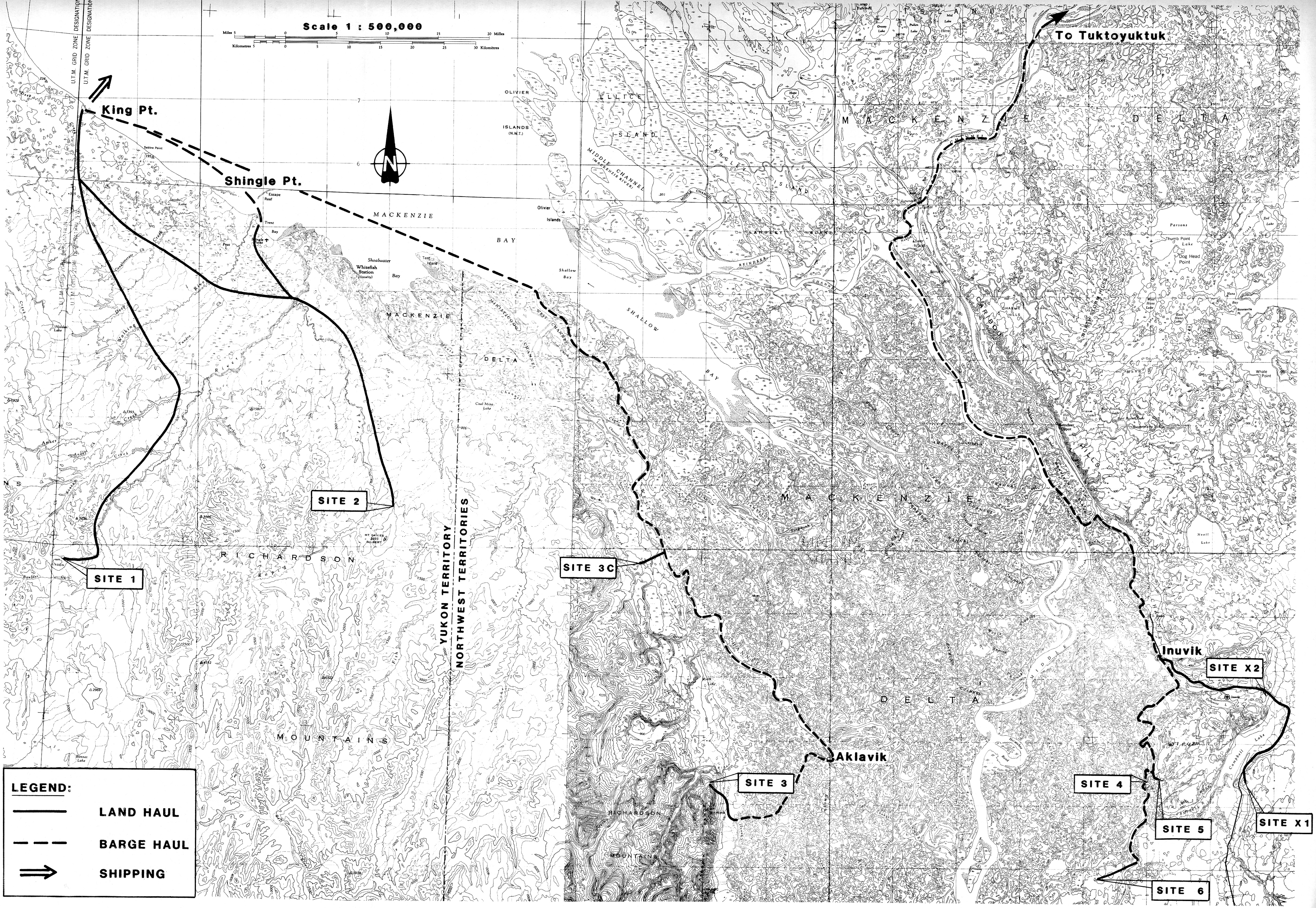
- Armour Stone - large blocks of intact and durable rock (in excess of 5 tonnes) that would be used on production structures in deep water to resist wave erosion.

- Rip-Rap - smaller blocks of durable rock (1 to 5 tonnes) that would be used to resist wave erosion of shoreline structures and at between -10 m and -20 m depth 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 in 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 compatible with Portland Cement; crushing and washing would be normal processing.



Scale 1 : 500,000
To Tuktoyuktuk
King Pt.
Shingle Pt.
MACKENZIE BAY
MACKENZIE DELTA
RICHARDSON MOUNTAINS
YUKON TERRITORY
NORTHWEST TERRITORIES
SITE 1
SITE 2
SITE 3C
SITE 3
Aklavik
Inuvik
SITE X2
SITE 4
SITE 5
SITE X1
SITE 6
LEGEND:
LAND HAUL
BARGE HAUL
SHIPPING

Canada (GSC) in a previous preliminary assessment of potential quarry sites (EBA, 1983). It was mutually agreed that the long haulage route from this area would mean that technically feasible sites would be very costly to develop and that the further evaluation of potential quarry sources was outside the scope of this study. Further discussions with regard to existing quarries along the Dempster Highway close to Campbell Lake concluded that a more detailed inspection would be warranted if time permitted during the field program. Two of these sites were investigated along with a third additional site northwest of Aklavik.

The study was undertaken in a phased approach with a review of each phase being carried out by the Scientific Authority before proceeding with the subsequent phase. The Scientific Authority for this project was Mr. R.J. Gowan, Geotechnical Advisor, Natural Resources and Economic Development Branch, Department of Indian Affairs and Northern Development (DIAND). The phases of the project were:

- Phase 1, Data Review and Evaluation;
- Phase 2, Field Investigation, detailed geologic reconnaissance and mapping;
- Phase 3, Laboratory Testing;
- Phase 4, Analysis; and
- Phase 5, Presentation of Data

At the conclusion of the initial data review and evaluation, Golder staff met with the Scientific Authority to review progress and discuss the field investigation program. Authorization to proceed with Phase 2, Field Investigation, was given verbally at that meeting in Vancouver, B.C. on 25th September, 1986.

In order to complete as much of the field work as possible before the onset of winter conditions, Golder engineers mobilized from Vancouver to Inuvik 2 days later and essentially completed the second phase of the study on 10th October, 1986. A brief field report was presented to DIAND, dated October 15th, 1986 and an album of all field photographs was sent on November 17th, 1986.

Laboratory testing was started as soon as the rock samples arrived back in Vancouver and continued through to December. Analysis and engineering were undertaken in late December 1986 and early January 1987, leading to the presentation of data in draft form in February 1987.

As part of the airphoto interpretation and data review, Golder reviewed potential alternative sources of high grade quarry rock in the vicinity of the Mackenzie Delta. It was noted at that time that a number of quarries and pits had been partially exploited along the Dempster Highway and near Inuvik. Further investigations in Inuvik confirmed that two quarries had been able to provide large-sized rock. Enquiries among the producers of quarry rock in Aklavik, N.W.T. lead to the examination of another site on the west of the delta. During the field investigation, nine sites were visited; the original six, an isolated roche moutonee just west of the delta and some 35 km north of Mount Gifford, and two existing quarries close to the highway near Campbell Lake, N.W.T. A tenth site, the Hoidal Cupola about 14 km northwest of Mount Fitton, was briefly appraised from the air but a ground based survey was not considered to be justified based on the limited size of the prospect. Potential quarry rock sites in the Richardson Mountains along the Dempster Highway which had been suggested by GSC in the EBA (1983) report were considered beyond the scope of the present study.

This report is presented as a single volume with a supplementary volume of supporting documents being lodged with DIAND Headquarters, regional and district offices and/or libraries.

The report volume contains the text and appendix dealing with the site specific appraisals. The supplementary volume contains supporting documents which include lists of contacts, references to the photo album, laboratory test results, and data listings (see Table of Contents).

2.0 DATA REVIEW AND EVALUATION (Phase 1)

2.1 Methodology

In the initial phase of work, Golder staff members consulted with various federal government officials to assess the data availability for each potential source designated in the study, and any significant alternatives. This was followed by a review of geological and geotechnical literature pertinent to each potential quarry site from sources within the public domain and privately where possible. Supporting Document A contains a listing of all contacts made during the study and the network of these contacts. A number of contacts were maintained in Inuvik during the field program to augment the information collected as part of Phase 1 of the study. Supporting Document B lists the available reports, maps and aerial photographs which were used in the review. Specific references are given following the text in this report.

Concurrently with the data review of the program, a detailed air photo interpretation was carried out to identify and delineate rock mass structures and outcrops around the selected sites. Reference to current geological and topographic maps assisted in defining possible quarry and infrastructure facilities sites at each source, and likely access routes to the nearest transportation corridor. Consideration was also given to possible physical, technical, environmental and economic constraints to development.

2.2 Results

The most pertinent previous studies which had been carried out relative to the six sites in the statement of work for the current study are the Imperial Oil Ltd. (IOL) (1976), Hardy (1977) and EBA (1976, 1983) reports. The purpose of these studies has not been clearly defined but is believed to be as follows.

- Imperial Oil - A number of studies in the period 1972 - 1976 suggested several potential riprap sources near the Beaufort Coast but found that "the rock type was either unsuitable for quarrying or the locality (was) so remote that quarrying and transportation would be very expensive." IOL (1976). A detailed evaluation of eight sites in the Campbell Hills and Delta Outliers region was conducted in June 1976 to determine suitable sites for further studies. A number of small test blasts were carried out but no details were recorded and inferences have not been attempted in the current study. Further work was recommended but not on a site specific basis. The highest ratings were given to the Gull Creek Dolomites followed by the Gull Creek Quartzite, one of the Outliers, and the existing quarries, sites X1 and X2 in this study. All of the above were considered suitable for the provision of riprap.

- Hardy - This study was essentially a granular borrow study, primarily related to pipeline routes, although the terms of reference included the provision of "detailed information to complete a comprehensive inventory of the principal rock ... sources in the study area." Hardy (1976). The study was intended to complement other work being carried out on granular material and rock sources for industry and government. Hogbacks north of and including Mt. Davies Gilbert were reviewed and assessed with just under 3 million cu.m. of rock and rubble suitable for riprap and aggregate production.

- EBA - Two studies were carried out by EBA Engineering Consultants Ltd. The 1976 study was an evaluation of potential rock quarries in the Rocky Hill - Campbell Lake area while the 1983 study was an evaluation of potential sources of quarry rock for marine structures in the Beaufort Sea region. The former was directed to industry and public demand for rock supplies in the Inuvik area for armour rock and general fill. Guidelines for quarry development and reclamation, which now form the basis for "Environmental Guidelines: Pits and Quarries." (DIAND 1982), were developed in EBA (1976). The scope of work in EBA (1983) was designed to generate data "needed to prepare appropriate responses to pending quarry development proposals and to assist (DIAND) in evaluating the relative abundance and importance of natural resources..." In the statement of work for that study a review of industry requirements in addition to technical feasibility issues was included. A broad study area was evaluated with recommendations for further work at Mount Fitton, Mount Davies Gilbert, Mount Gifford and the Gull Creek Quartzites and Dolomites as being sites from which armour stone may be obtainable. The recommendations called for drilling, test blasting, laboratory testing, access evaluation and preliminary cost studies, all of which lie outside the scope of this study with the exception of laboratory testing.

The previous site specific work by Hardy (1977) and EBA (1976, 1983), presented in the supplementary volume, gave initial, qualitative assessments of the potential for the six main sites to provide the different rock grades required. These are shown on Table 2 with the rock types taken from GSC maps; terrain, flooding potential and access/exit from the airphoto interpretation; and environmental concerns introduced from telephone contacts.

This table was drawn up to formalize the priorities for the field investigation phase of the program. Notes made during airphoto interpretation were transferred to this table for verification in the field, as were details of possible constraints.

TABLE 2

DSS/QUARRIES/BEAUFORT

QUARRY SITE ASSESSMENT - PREVIOUS STUDIES, AIRPHOTO INTERPRETATION, PHASE 1 RESULTS

862-1806

SITE NUMBER	NAME	ROCK TYPE *	TERRAIN **	PREVIOUS STUDIES	ASSESSED POTENTIAL FOR QUARRY ROCK * Armour Stone	Rip Rap	Blast Rock	General Fill	Concrete Aggregate	FLOODING POTENTIAL **	ACCESS/ EXIT **	ENVIRONMENTAL CONCERNS ***
1	MT. FITTON Yukon	Ord./Sil. Granite intrusion	Massive granite mountain	EBA - 1983 Site R16	Good	Good	Good	Good	Good	No problem	Very difficult >90 km to tidewater	Caribou trails High altitude Permafrost
2	MT. DAVIES GILBERT Yukon	Cretaceous Quartzitic Sandstone	Long sharp sandstone ridge	EBA - 1983 Site R23 Hardy 1976 Site Y98	Fair	Good	Good	Good	Good	No problem	Very difficult >80 km to tidewater	Caribou trails High altitude Permafrost
3	MT. GIFFORD N.W.T.	Cretaceous Quartzitic Sandstone	Linear sandstone outcrops	EBA - 1983 Site R27 Hardy 1976 Site 468	Fair	Good	Good	Good	Good	No problem	Difficult >5 km to shallow barge	Permafrost
4	GULL CREEK QUARTZITE N.W.T.	PreCambrian Quartzite	Rocky hill	EBA - 1983 Site R28 EBA - 1976 Site 10	Good	Good	Good	Good	Good	No problem	Very easy Adjacent to shallow barge	Proposed IBP zone Waterfowl
5	GULL CREEK DOLOMITE N.W.T.	Ord./Sil. Dolomite	Low lying rocky terrain	EBA - 1983 Site R29 EBA - 1976 Site 9	Fair	Good	Good	Good	Good	Quarry must be shallow	Easy Near to shallow barge	Proposed IBP zone Waterfowl
6	DELTA OUTLIERS N.W.T.	Devonian Dolomitic Limestone	Subdued relief	EBA - 1976 Site 11	Fair	Good	Good	Good	Good	Quarry must be shallow	Easy Near to shallow barge	Waterfowl

* Derived from previous studies
** Derived from airphoto interpretation
*** Derived from contacts

The statement of work called for assigning a priority rating for the field investigation for each source in the event that time or budgetary constraints prevented investigation of all six sites. It was decided that, weather permitting, all the proposed field work could be accomplished in the time available and without over-running the proposed budget and it was agreed between the Scientific Authority and Golder that this rating was not necessary.

A meeting was held in Vancouver on 25th September, 1986 between Golder and the Scientific Authority to present the results of the data review and evaluation, and to complete the finalization of the field program plan. Based on the results to date and the time of year, it was decided that the field program would start at the sites most distant from Inuvik if weather conditions would permit flights to be made. Telephone conversations with Sunrise Helicopter Ltd. Inuvik, N.W.T. indicated that partial snow cover was unlikely to melt before winter, but that flying conditions would likely be suitable for Phase 2 into early October. Verbal approval to proceed with Phase 2 was given at this meeting.

3.0 FIELD INVESTIGATION (Phase 2)

3.1 General Methodology

At the outset Golder recognized that limited funds were available for this study, and that time constraints meant that a well focussed team would be required. For that reason, it was considered essential that highly experienced personnel would be utilized to enable the field study to collect and assess the most important rock mass parameters. The study was therefore directed towards identifying, describing and quantifying (in broad terms) the most promising sources. Airphoto interpretation had been used to delineate the apparent outcrops of intact rock at each site, however, the degree of surface fracturing meant that many accessible outcrops did not comprise in-place rock material. Inaccessible cliffs above talus piles could not be used for detailed mapping and many smaller outcrops were too broken to yield reliable data. The required level of detailed geological mapping was therefore carried out only where good outcrop could be found. By contrast, rock mass assessments of block size, material strength, planes of weakness, seepage and so on could be made based on a number of different localities at each site. The idea of providing a focussed approach meant that a combination of detailed geological mapping from a number of outcrops and more general rock mass evaluations were carried out at each site. In this way superfluous information which would be later eliminated in the analysis phase was not recorded. The constraints of approaching freeze-up required that all field work was completed as soon as possible after award of the contract.

Golder staff mobilized into the field on 27th September, 1986 and carried out site evaluations of the proposed sources between 28th September and 3rd October, 1986. The two man study team made its base in Inuvik, N.W.T. and chartered the services of a Bell 206B helicopter from Sunrise Helicopter Ltd. to provide transport to and from the sites.

With the daylight hours available during the program being from about 8:30 a.m. to 9:00 p.m., it was found useful to occupy the early part of the morning making telephone contacts with government agencies, private companies and local individuals. Meetings were scheduled for early morning and, generally speaking, helicopter flying was not undertaken until about 10:30 or 11:00 a.m. each day.

Each of the site surveys comprised an overview from the helicopter to identify the general character of the rock mass at each locality, followed by closer aerial traverses of selected potential quarry sites. The helicopter pilot then found a suitable place to land and a detailed evaluation of the deposit was carried out from the ground. The rock mass was sampled at each site, if possible from at least two locations to gain representative specimens, and the samples transported back to the helicopter. Further low level photos were obtained for specific locations as the helicopter left the locality. It was found that two sites could be visited each day without fear of extending helicopter flying time after dusk, or jeopardizing the quality of aerial photography; over 270 photographs were taken during the field program. Flight paths were approximately sketched on 1:50,000 topographic maps and photo locations also shown for later indexing. This was also found invaluable for creating a daily log. Pertinent flight and photo information is shown on the site plans in Section 7. An album of all photographs with reference lists was sent to DIAND on November 17th, 1986.

The order in which the sites were visited depended on daily weather reports and flying time availability as discussed below. An overview of the Campbell Hills area was the first activity followed by mapping in detail on the Delta Outlier and the Gull Creek Dolomite. Mount Fitton and Mount Davies Gilbert were visited on the second day with excellent flying conditions and long daylight hours. Mount Gifford, Aklavik, the West-Delta roche moutonee were combined with a second inspection of the Delta Outliers on day 3 to collect samples. The remaining site evaluation, the Gull Creek Quartzite, and sample selection from the adjoining Dolomite was carried out on the following day under poor weather conditions. Two existing quarries on the Dempster Highway, near Campbell Lake, were visited and photographed on the final day. A log of the field activities and a brief report were submitted to DIAND in a letter dated October 15th, 1986. The log is included as Table 3.

Throughout the field work there was from 100-400 mm of snow cover in the Inuvik area. To some extent this obscured the outcrop or exposed rock mass at any particular location; it also made negotiation of colluvial slopes treacherous. It is noted that the build-up of snow cover was on horizontal or shallow dipping surfaces. Most detailed geological data is collected from outcrops with a strong vertical development; these were not obscured by snow. Golder does not believe, therefore, that the data collection was compromised by inclement weather.

3.2 Site Assessment Methodology

The statement of work for the study required investigation of "site conditions", description of "deposit characteristics" and determination of "rock properties" at each of the sites. These classifications were broken down into a number of parameters which could be quantitatively or qualitiative appraised during the field investigation. In order to formalize data collection and ensure that pertinent data was not omitted, two forms were generated to use as field sheets incorporating all of the parameters required in the statement of work. Blank copies of these forms appear as Tables 4a and b.

The Rock Mass Description form, Table 4a, included a description of the site physiographically, topographically and geologically, with references to sketches or photographs taken during the site appraisal. A complete rock material description was made on site following the recommendations of the Geological Society of London (1977), see Appendix I. The degree to which the rock material is naturally discontinuous was

FIELD LOG

DATE:	ACTIVITIES CARRIED OUT:	WEATHER:
28SEP86	Overnight accomodation in Edmonton, travel to Edmonton Airport. Flight PW 561 to Inuvik, delayed 4 hours after relanding following equipment failure. Arrived Inuvik 6.00 pm, without airfreight items.	Temps. -5C to 0C Light snow Light winds
29SEP86	Morning spent making contacts with DIAND, GNWT, MOT, DOE, and local contractors. Collected air freight from airport, also weather records. Visited Rudy Cockney (DIAND), who suggested contacts with local contractors, Hunters & Trappers Assn., GNWT Economic Development & Tourism and Renewable Resources, transportation companies, MOT and DOE. Followed up by phone as shown on Table 2. Visited Renewable Resources to research wildlife concerns and Inuvialuit Final Agreement. Left Inuvik by helicopter 4.15 pm to overfly Gull Creek area en route for the Delta Outliers. Difficulty landing close to outcrop, awkward hike across ridges of limestone to do geol. mapping. Flew out to East Channel to review site access then to Gull Creek dolomite. Landed atop highest crest and hiked down gully to photograph and map potential deposit. Did not sample. Returned to Inuvik after 8.30pm. Helitime 1.3 hrs. Aeronautical maps also purchased, for magnetic declination.	Temps. -8C to 0C Snow flurries Moderate winds Overcast
30SEP86	Early morning spent in hotel continuing to make phone contacts with local contractors, notably Buck Storr of Aklavik and Gordie Campbell of Inuvik, also transportation companies, Arctic, Points North, Northern, Beluga, and Cardinal. Left Inuvik by helicopter at about 11.00 am heading west. Crossed MacKenzie Delta and south flank of Mt. Davies Gilbert. Circled Mt. Fitton counter clockwise from north and landed on eastern edge of upper plateau. Hiked to summit of mountain taking rock mass measurements and photos. Mapped outcrops and noted wildlife. Descended to southwest and traversed back to helicopter passing claim stakes of Anker Hoidal. Collected 2 sacks of samples before leaving. Headed north, passed Twins to view Hoidal Cupola, then east to Mt. Davies Gilbert. Circled as above then landed on crest of ridge to summit. Helicopter flew to lower altitude to wait. Descended from ridge on north side of mountain, mapping, sampling and photographing. Deep snow in drifts at lower elevations. Returned to Inuvik about 7.00 pm; 2.6 hrs helitime. Observed grizzly bear, caribou, ptarmigan, eagles. Helitime 2.6 hrs.	Temps. -15C to -5C Moderately windy Clear skies, sunny

01OCT86	Arranged to meet Buck Storr in Aklavik to discuss exploitation of colluvial slopes for rip rap on east side of Mt. Gifford. Continued to establish network of information sources locally. Left Inuvik about 10.00 am to head west across Delta. Overflew Aklavik and took low pass along Peel Channel to review rip rap shore protection alongside community. Landed to meet Storr and look at stockpile of material from Mt. Gifford. Very mixed grading of material, good quality. Left to fly over Husky Chn. and existing sources before circuit of Gifford. Landed to sample and map two areas. Took land and aerial photos. Best prospect appears inaccessible off east face of mntn. Left to fly west, up Willow Creek and Martin Creek canyons to appraise the sandstones exposed in the geological sequence. Both would make good prospects, but are not accessible. Headed north across Grizzly Creek to isolated roche moutonee (site 3C). Mapped area and collected samples for lab testing. Returned to east side of Delta to collect samples from Delta Outlier and carry out more mapping. Returned to Inuvik about 7.00 pm, made call to GA Vanc to report progress. Helitime 2.2 hrs.	Temps -10C to -5C Light to moderate winds Sunny periods
02OCT86	Tried to call Bob Gowan, DIAND Hull, will call later. Continue with local contacts and prepare to meet govt officials later. Left Sunrise hangar about 10.30 am heading for Inuvik airport. Flew over both airport quarries (1 MOT, 1 leased to town) then to Gordie Campbell's quarry northeast of Campbell Hills. Circled to photo then south to DPW quarry east of Campbell Lake as well as other gravel pits in the vicinity. Reviewed rock quality of dolomite exposed on nose immediately east of lake before heading west to Gull Greek Quartzite. Landed, mapped, photo'd and sampled in soft snow. Returned to site 5 to collect samples then overflew whole Gull Creek area to confirm potential sites. Returned to Inuvik after 3.00 pm, visited GNWT Tourism to review park potential, and Delta Council to check Dene/Metis land claim area. Informed DIAND in Inuvik and Hull of progress to date and reached Gordie Campbell. Helitime 1.0 hr.	Temps -15C to -5C Moderate winds Snow flurries
03OCT86	Heavy overnight snow, temperature dropped to approx. -20C. Completed Inuvik paperwork and organized air frieght for Vanc. Decided to ship samples by air, checked with PWA. Final visit to offices of GNWT in Inuvik then by chartered cab to DPW quarry east of Campbell Lake to photograph and map. From there to Campbell's operation to photograph and map. Evaluated potential for expansion of both quarries then returned to Inuvik airport. Confirmed freight shipments, clarified weather record from Dept. of Environment then left on PWA 562 for Edmonton and Vancouver.	Temps -20C to -10 C Moderate winds Snow flurries
06OCT86	Discussed progress with DSS in Hull, confirmed budget status,	

to 10OCT86	futher work to be carried out under GA 3.3.3 Task 8, and 3.3.5 Reporting. Prepared laboratory for arrival of samples, and test program. Commenced preparation of field report, and indexing of photos, both within Phase 2 budget.
	Phase 2 - Field Investigation completed 10 Oct 1986.

TABLE 4A

DSS/QUARRIES/BEAUFORT 862-1806 ROCK MASS DESCRIPTION

FIELD CHECKLIST - ALL ENTRIES TO BE COMPLETED

MAPPED BY DFW/RSR

SITE NUMBER -----------

DATE

LOCATION

- -

LOCALITY TYPE	Bedrock			
	felsenmeer	colluvium		moraine
SIZE		metres X	metres	horizontal
ELEVATION RANGE		metres to	metres	

- -

IMAGE	Sketch	no. of photos
	Air photos	sequence
	Land photos	sequence

- -

SAMPLE Location

Size

- -

ROCK MATERIAL	Colour		
	Grain size	mm	
	Weathering		
	Strength		field est.
	ROCK TYPE		

- -

ROCK MASS	Fabric			
	Block size - minimum	m X	m X	m
	- maximum	m X	m X	m
	- average	m X	m X	m
	Discontinuity - set 1	orient.	m. spacing	type
	- set 2	orient.	m. spacing	type
	- set 3	orient.	m. spacing	type

Convention used Dip/Dip direction (true north)

Significant weakness

Seepage

- -

COMMENTS

TABLE 4B

DSS/QUARRIES/BEAUFORT 862-1806 QUARRY DESIGN PARAMETERS

FIELD CHECKLIST - ALL ENTRIES TO BE COMPLETED

MAPPED BY DFW/RSR

SITE NUMBER	---------		DATE	
LOCATION	Local topography			>200 m2
	Deposit topography			200 m2
	Deposit orientation			azimuth
ACCESS	Personnel/supplies	km dist.	direction	rating
	Product/delivery	km dist.	direction	rating
	Distance to tidewater	km dist.	direction	rating
	Distance to barge	km dist.	direction	rating
OVERBURDEN	Type(s)			
	Extent - depth	m measured	m estimated	
	area	m2 meas.	m2 est.	
	Disposal area(s)	m2 est.		location
QUARRY	Size	m2 est.		
	Depth	m est.		
	Working space	m2 est.		location
	Stockpile space	m2 est.		location
	Facilities			
	Camp			
HYDROLOGY	Surface water	vol. est.		location
	Pit drainage	vol. est.		location
	Water supply	vol. est.		location
PERMAFROST	Evidence			location
	Potential change			
CONSTRAINTS	Environmental			type
	Archeological			type
	Recreational			type
	Proximity to water	m est.		direction
	Wildlife observed			type
	Reclamation			
	Restoration			

REMARKS

determined in the rock mass description; this section was completed in the field using measured block sizes and detailed joint set mapping of particular families of discontinuities which may influence quarrying. Discontinuity types included joints of varying importance and bedding plane separations or planes of weakness parallel to bedding. The spacing of adjacent discontinuities in each set was also measured. The combination of discontinuity descriptions and rock material type gives a rock mass description for each site.

The Quarry Design Parameters forms, Table 4b, were partially completed in the field, and partially by reference to existing material. To a large extent Table 4b comprised ground truthing of interpreted data from Phase 1 of the study. For example, access had been identified from airphoto interpretation and then confirmed and refined in Phase 2 both from the helicopter and on the ground. The potential quarry dimensions and layouts were established by a combination of site evaluation and later measurements from the 1:50,000 scale topographic maps. Hydrological and permafrost characteristics were assessed from the air and ground, and locations checked on the topographic maps. Constraint evaluation, discussed below in Section 4 was also carried out by ground truthing the results of earlier discussions.

The forms were completed by the addition of information taken from other sources. For example, elevation range was taken from 1:50,000 topographic maps and distance to tidewater from 1:250,000 topographic maps.

At each site an attempt was made to identify blocks of rock about 0.1 m x 0.2 m x 0.3 m in size which formed representative samples of the rock material at that site. The total sample, which varied from 12.5

and 55 kg in weight, was made up of a number of blocks of rock, selected from at least two different locations. Golder believes that this method of sampling provided specimens of rock which could be taken as representative of the rock mass at each site. The samples were placed into gunny sacks and carried to the helicopter for shipment to Vancouver for laboratory testing. The physical difficulty of carrying rock samples across rugged terrain meant that individual blocks in excess of 12.5 kg could not be selected. The lowest sample weight of 12.5 kg was taken from site 3C, the West Delta roche moutonee; this small sample was felt justified since the field mapping gave clear evidence that the prospect was of limited size.

Mapping was carried out at two existing quarries along the Dempster Highway near Campbell Lake, but samples were not selected during the field program for a number of reasons. Firstly, it was decided that the Scientific Authority should be consulted before proceeding with what would effectively be a 30 per cent increase in the scope of work. Secondly, the appearance of the rock in situ at a developed quarry can yield far more semi-quantitative data than exposed outcrop at an undeveloped potential quarry source. Finally, it was interpreted from field conditions, that, although earlier studies had only considered these sites as sources of blast rock, more massive rock sizes could be won from both of the existing quarries than had been attempted previously. It has subsequently been proposed that a laboratory testing program be carried out on rock material from these prospects.

3.3 Summary of Preliminary (Field) Results

Copies of the completed Rock Mass Description and Quarry Design Parameter forms on a site-by-site basis are to be found in Section 6, Site Evaluations; relevant data from the earlier studies by Hardy (1977) and EBA (1976, 1983) is included in Supporting Document C. The combination of these data form the basis of the overall quarry evaluation which is discussed in Section 6.

Based on the field program discussed above, a number of preliminary conclusions were reached.

- All of the sources investigated could provide some of the specified rock grades, however, block sizes of natural rock detritus indicated that only Sites 1 and 5 appeared able to provide armour rock, and all other grades. The other sites appeared able to provide rip rap and other grades.

- General sites conditions are conducive to quarrying at all sites, except Sites 2 and 6. The former source comprises a very steep bedrock ridge which would make quarrying difficult although not impossible, and the latter has low topography which would probably mean developing a quarry below the natural ground water table. Space for a quarry, storage, waste, roads and infrastructure facilities could be found at all sources, although at Sites 1, 3, 4, 5, 6 and X2 local relief indicates that some work areas would be more distant from the quarry than would normally be considered acceptable.

- Deposit characteristics at all sources indicated that the rock mass would be suitable for quarrying, although the precise extent, both horizontally and vertically, of a prospect could only be estimated. Thus recoverable volumes of particular product sizes have only been estimated, see Section 6.2.1. If a quarry were to be developed for armour stone and riprap then it is likely that only 25-30 per cent of the in place rock would meet design specifications after blasting. The remainder, however, would likely be used for the other three grades of rock, blast rock, general fill and concrete aggregate.

- Rock properties were briefly appraised on site pending a full evaluated after the suite of laboratory tests had been completed. Abrasion resistance, durability and crushability were quantitatively assessed by determining block sizes of the rock mass debris at each site, while weathering and deleterious material character was noted by the physical appearance of the outcrop.

The following provides a brief summary of significant results of the detailed geologic reconnaissance and mapping of the exposed material at each source. A more complete site-by-site evaluation is included in Section 6 of this report.

- o The massive granites of the plutonic stock at Mount Fitton appeared to be an excellent source of armour rock and other grades. The moderate topographic relief would lead to a quarry with a large surface area. Adjoining flat lands could be used for infrastructure facilities and valleys could be used for waste storage. A long overland haul to the coast would require careful evaluation to determine the best route and the most appropriate time of the year for hauling. Water supply should be relatively easy to obtain and drainage would not be an issue for a quarry at this site.

- o The broken quartzites which form the very steep hogsback ridge to the north of Mount Davies Gilbert did not appear to favour this prospect as a source of armour stone. The average block size was in the order of 0.2 - 0.3 m across. The steep topography would make quarrying difficult and the flatter areas surrounding the ridge, where facilities would be required, are generally poorly drained. Haulage would require a road to the coast and either small barge to King Point or an extension of the haul road to truck the product to shipping facilities at King Point. Rehandling of the product would be required if a shorter access haul were to be considered.

- o The inter-bedded sandstones and siltstones near Mount Gifford are topographically suitable for quarry development although the geological strata which could produce the best grades of rock appeared to be inaccessible. Overland access from Husky Channel would be reasonably straightforward for winter development at which time further haul may be considered by ice road. Local use of the Mount Gifford sandstone by Aklavik residents has been restricted to blocks less than about 1 m across as shore protection. Summer access for product haulage would involve difficult road construction in combination with a long haul in small barges.

- o Site 3c refers to an isolated roche moutonee about 38 km NNW a of Mount Gifford. The rock mass appeared to have the potential to yield high quality rock, however the outcrop is of limited extent. Access to the West Channel would be relatively easy to achieve and the product would require transshipment to small barges at this location for summer haul or by ice road in the winter.

- The Gull Creek Quartzite appeared to be a good rip rap prospect and the Dolomite an excellent source of armour stone. Both areas are close to the East Channel where shallow barging or ice road haulage to Tuktoyaktuk would be needed. Re-shipment of the product would be required for offshore development. The outcrops of quartzite were found to be highly broken and more susceptible to degradation than the coarsely crystalline dolomite prospect. Both sites could be developed with work crews residing in Inuvik which would reduce the need for infrastructure facilities in the Gull Creek area. Suitable terrain for waste disposal and produce stock piling could be found adjacent to the proposed quarry sites.

- The Delta Outliers are notable for their low topographic relief which would mean either very large excavations or a quarry extending below the natural water table. The degree of surface fracturing of the rock seen during this phase of the study indicated that these rock masses would comprise poor armour stone and only fair rip rap prospects. Access and product handling considerations in the Gull Creek area apply equally to these outliers.

At the culmination of Phase 2 of the study, the granites of Mount Fitton and the Gull Creek Dolomite appeared the most promising prospects of the six sites mentioned in the statement of work. In addition, the physical character of the rock in the two existing quarries near Campbell Lake (sites X1 and X2) led to a field conclusion that more work would be warranted to determine their potential for expansion. Both of these quarries have already received permits for quarrying and access has been established.

Detailed evaluations of each site, based on the results of the field investigation and refined on the basis of laboratory testing are included in Section 6 of this report. Laboratory testing has yet to be undertaken for sites X1 and X2.

4.0 CONSTRAINT EVALUATION

Under Phase 1 of the project it was required to determine any obvious physical, environmental and economic constraints to future development for the purpose of assigning a priority rating for the field investigations phase. This section discusses the procedures followed in this evaluation.

4.1 Methodology

Although technical feasibility of quarrying could be assured at most of the sites examined, there are various constraints to development at each site. The main thrust of the evaluation of constraints was to identify the complete range of potential difficulties in quarry development at the sites visited and to establish a network of contacts who may be able to provide timely advice in the future if any site is selected for further studies.

Part of the evaluation of each site involved investigation of site conditions, in which drainage, access and environmental compatibility were assessed. The first two form part of the technical feasibility of a particular source while the latter is a more general appraisal of visual and noise screening. Drawing together portions of the data review and evaluation phase of the project with these aspects of the field investigation, the main constraints which were identified in this study were:

- o hydrological, for example flooding;
- o access, problems with location, permafrost;
- o recreational, conflict with GNWT* park plans;
- o archaeological, native sites;
- o environmental, habitat or migratory conflict;
- o sociological, land claims conflict of interest;
- o other, local hunters and trappers associations, visual screening.

*GNWT - Government of the Northwest Territories.

The first two constraints were evaluated initially from air photo interpretation and subsequently on site and from the helicopter reconnaissance. The latter criteria were explored through the network of contacts developed in the data review phase of the project and while in Inuvik for the field program. A complete listing of contacts may be found in Supporting Document A.

4.2 Constraint Evaluation Results

The physical constraint associated with hydrology refers to topographic relief in the vicinity of the prospect, the nature of low-lying terrain in the same general area, the presence of stationary ground water (lakes), surface run-off (streams) and major navigation channels (the Mackenzie River Delta). Sites 1, 3, X1 and X2 are free from hydrological constraints, Site 2 has a potential drainage problem in the low-lying land surrounding the proposed quarry site, Sites 3c and 6 would require quarrying below the natural ground water table and dewatering and/or pumping would likely be required, Sites 4 and 5 could most likely be developed above the water table but some bodies of standing water may require draining before full production could be achieved. Water supply can be assured to all sites for camp facilities or quarrying.

In general terms, access refers to both the influx of equipment and work crews to carry out quarrying, and to the supply of product to market. The physical distance of sites from the nearest existing or developable transportation corridor is the main constraint in this regard, although permafrost terrain and river crossings will also require detailed evaluation in subsequent phases of investigation.

Sites 1 and 2 are fairly remote from the nearest existing transportation corridor and both would require careful studies to determine whether winter or summer haul roads to the coast would provide the best access. In either situation, major product rehandling facilities would be required to trans-ship the product to deep water vessels, probably at King Point. Personnel and supplies would have to come about 175 km from Inuvik or 70 km from the proposed port at King Point to Site 1 by air, and construction of an all-weather haul road to the coast could present considerable difficulties. Analyzing the economics of traversing permafrost areas, poorly drained flat-lying country, streams and rivers, and the coastal plain to a proposed tidewater dock facility at King Point will need to be addressed and compared to costs of product delivery from other sources of acceptable material.

The remaining sites are all relatively close to the MacKenzie Delta and access to each site is reasonably straightforward. Product shipping would almost inevitably require an overhand haul to barge loading sites (Site 3 to Husky Channel, Site 3c to the West Channel, and Sites 4, 5, 6, X1 and X2 to the East Channel) and shallow barging to King Point

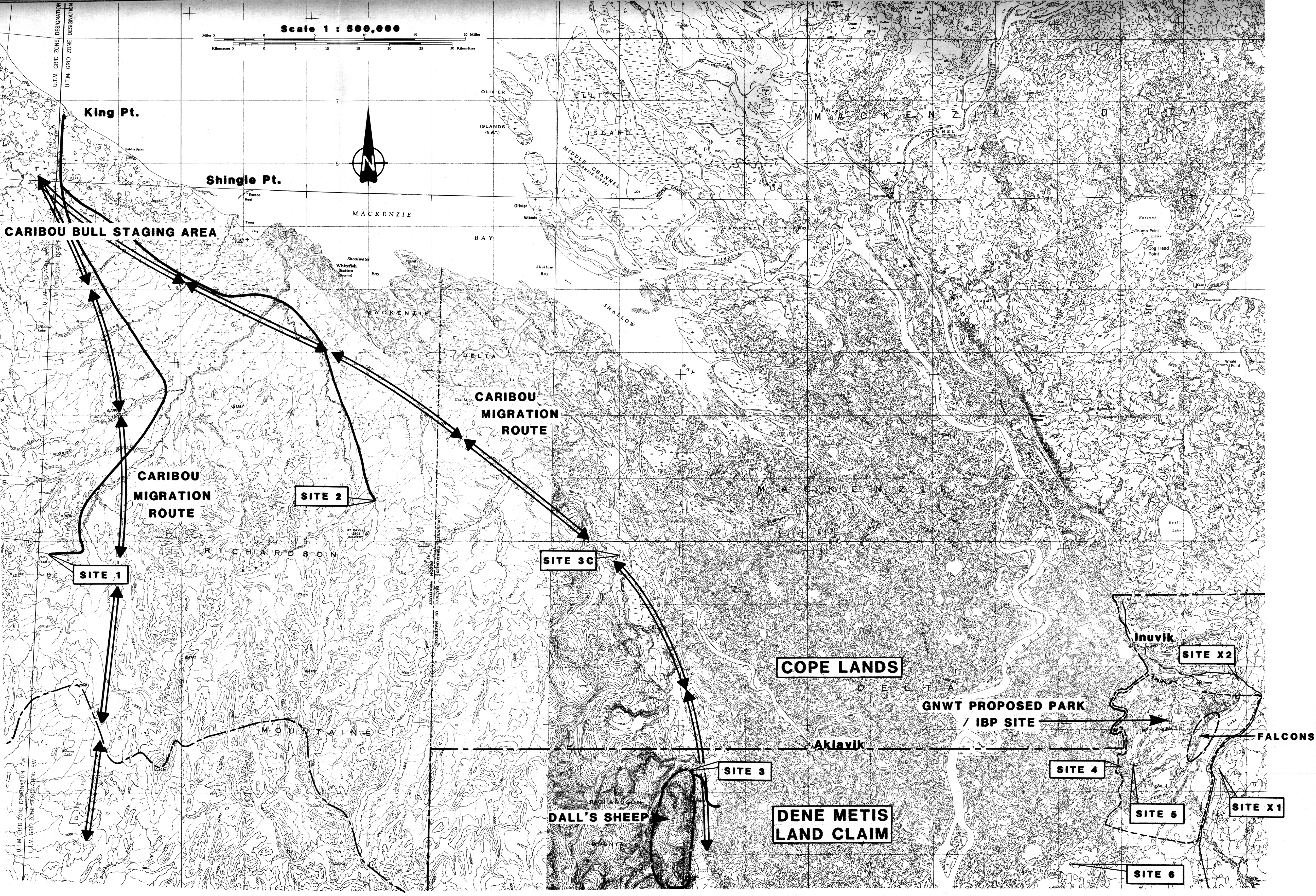
(Sites 3 and 3C) or Tuktoyaktuk (Sites 4, 5, 6, X1 and X2). Product rehandling at the tidewater port would then be required to transport the product to the offshore market.

Recreational constraints involve a proposal to dedicate the Campbell Hills area to the Government of the Northwest Territories (GNWT) for a combination of park interpretive centres and trails for a variety of recreational purposes (naturalist park, conservation park, recreation park). The limits of the GNWT park as included in their proposal as of October, 1986 are shown on Figure 2, which should also be referred to for locations of environmental and other constraints included in this section. Sites 4 and 5 fall within the proposed park.

As far as has been determined there are no archaelogical constraints to development at any of the proposed sites, although the Campbell Hills area may have some aboriginal sites.

Environmental constraints comprise the anticipated sensitivity of the ecosystem to disturbance. Particular species of wildlife seasonally use parts of the study area for feeding, nesting, denning, and migrating which may limit activities at particular times of the year. The following environmental concerns have been identified:

- Falcon, and other raptor, nesting sites near Campbell Lake, Campbell Hills, Mount Gifford and Mount Davies Gilbert area;
- Dall's sheep wintering grounds on the slopes of Mount Gifford, and proximity to Mount Goodenough, where lambing and rutting give rise to major concentrations of the local Dall's sheep population;
- Grizzly bear habitat throughout the area west of the MacKenzie Delta, with specific denning sites being of major concern (one



Scale 1 : 500,000
King Pt.
Shingle Pt.
MACKENZIE
BAY
OLIVIER
ISLANDS
ELLICE
ISLAND
MIDDLE CHANNEL
MACKENZIE DELTA
CARIBOU BULL STAGING AREA
CARIBOU
MIGRATION
ROUTE
CARIBOU
MIGRATION
ROUTE
SITE 2
SITE 1
SITE 3C
RICHARDSON
MOUNTAINS
MACKENZIE
Inuvik
SITE X2
COPE LANDS
DELTA
GNWT PROPOSED PARK
/ IBP SITE
FALCONS
Aklavik
SITE 3
SITE 4
SITE 5
SITE X1
DALL'S SHEEP
DENE METIS
LAND CLAIM
SITE 6

such den was encountered near the peak of Mt. Davies Gilbert);

- Seasonal migration of the Porcupine Caribou herd along the Yukon Coastal Plain and through the Richardson Mountain between its Alaskan summer grazing and its wintering grounds in the southern part of the Richardson Range; bull staging in the Blow River valley;

- Muskrat, fox and marten are sources of fur for a number of trappers in the Delta region;

- Ducks, geese and swan use much of the Delta area as staging points during spring and fall migrations.

Sociological constraints relate largely to native land claims. Firstly, the lands west of the East Channel of the MacKenzie and north of Aklavik (including Sites 1 and 2 in the Yukon Territories and Site 3 in the Northwest Territories) are within the Inuvialuit Final Agreement (IFA) lands. Therefore, any proposed development would require hearings through the Environmental Screening Committee (ESC), and the Environmental Review Board (ERB). Secondly, the lands south of the IFA lands are included within the Dene Metis Land Claim currently being reviewed. This area covers Sites 3, 4, 5 and 6 and the existing quarries.

Other constraints include potential concerns of local trappers working the Delta; Hunters and Trappers Associations in Inuvik (HTAI) and Aklavik (HTAA) (Sites 3, 3c, 4, 5, 6); the impact of quarry development adjacent to various corridors (East and West Channels and Dempster Highway) used for local transportation (Sites 3, 3c, 4, 5, 6 X1 and X2); these routes; and, finally, the problems with aesthetic screening of some of the sites (Sites 2, 3, 4, 6, X2).

Each of the above have been evaluated on a site-by-site basis, and assessments are included on the field sheets which appear in Section 6. A summary appears as Table 5.

5.0 LABORATORY TESTING (Phase 3)

Phase 3 of the project included an appraisal of rock material conditions using laboratory testing. Original requirements were for uniaxial compressive strength, Los Angeles abrasion and sulphate soundness testing with an allowance for other appropriate testing to be negotiated between the Scientific Authority and Golder. A description of the test program, and the results of the complete suite of tests, which included the three mentioned in the statement of work in addition to slake durability, petrography, point load, unit weight and specific gravity, are discussed below. Samples were shipped by air freight from Inuvik to Vancouver for testing in Golder Associates' laboratory.

In order to maximize the use of the samples collected, the laboratory testing was carried out in an order which would allow sample preparation, non-destructive testing and destructive testing to proceed in a logical manner. Rock blocks were cored, cores weighed and measured for unit weight determination, then loaded in uniaxial compression. Point load index testing was then used to break rock lumps to smaller sizes as the initial phase of crushing. Crushing and grading was then carried out for Los Angeles abrasion, sulphate soundness and slake durability testing. Isolated specimens of rock from the middle of each block were then petrographically examined in thin section, and the fines remaining from all other tests were used for specific gravity determination.

TABLE 5

CONSTRAINT EVALUATION

CONSTRAINTS	Site 1	Site 2	Site 3	Site 3C	Site 4	Site 5	Site 6	Site X1	Site X2
Hydrology		●		●	○	○	●		
Local Access	●	●	○	●	○	○	○	○	○
Regional Access									
o overland	●	●	○	○	○	○	○	●	●
o shallow barge			●	●	●	●	●	●	●
o tidewater	○	○	●	●	●	●	●	●	●
o deep barge	○	○	○	○	○	○	○	○	○
Recreational					●	●			
Archeological									
Environmental	●	●	●	○	●	●	○	○	○
Sociological	○	○	○	○	○	○	○	○	○
Hunter & Trapper			○	○	○	○	○		
Local Transportation			○	○	○	○	○	○	○
Screening		○	○		○		○		○

Note: A qualitative assessment only has been attempted. Relative ranking of contraints is outside the scope of this study.

● More significant, ○ Less significant

Photographs were taken before and after most tests, and these have been presented in a separate album. A listing of these photos is included in Supporting Document D with the complete laboratory test results. The following sections summarize each test performed.

5.1 Rock Strength

In order to evaluate the intact strength of the rock material from each source, two tests were performed. Two specimens were cored from samples from each source with a diameter of 43.6 mm and a length to diameter ratio of 2:1 where possible. These cores were then prepared for uniaxial compression testing by trimming and grinding the ends, and loaded to failure in accordance with ASTM D2938-79.

In order to assess strength variability, point load index testing was also carried out according to the International Society of Rock Mechanics (ISRM) specifications (1972) for irregular lump specimens. Instead of uniaxial testing of three representative samples per source, as recommended in the original statement of work, the Scientific Authority agreed to testing two samples in uniaxial compression and eight to ten in point load. This also gave the opportunity to assess qualitatively the breakage characteristics of the rock material. The point load testing was carried out during the initial phases of rock crushing to prepare samples for subsequent durability and abrasion testing.

Table 6 shows a summary of the results of uniaxial compressive strength testing and the minimum, mean and maximum values of the point load index approximation of uniaxial strength. This is found by normalizing the Point Load Index, I_s, for a 50 mm diameter specimen,

$I_s(50)$, following the methods recommended by ISRM. The approximate uniaxial strength is given by the relationship:

$$\text{Uniaxial Compressive Strength} = 24\ I_s(50).$$

Insufficient uniaxial compressive strength testing was carried out to develop a specific correlation between uniaxial and point load strength for each site.

The scatter of results and the apparently higher approximate uniaxial strength for the point load testing can be explained in a number of ways. The standard deviation of point load results for irregular lump tests is commonly 2-3 times higher than that for diametral or axial tests. Secondly, the standard deviation of results tends to increase with increase in rock material strength; thus a very strong quartzite could be expected exhibit a higher scatter of results than a limestone or sandstone which is intrinsically weaker. Thirdly, with the irregular lump test, it is more difficult to determine the platen spacing at failure since the conical loading platens tend to shift during testing. Finally, a high degree of scatter is to be expected, since the rock samples were taken from loose surface blocks which will undoubtedly have undergone some degree of weathering. There will therefore have been some weaker surface and some stronger interior specimens tested under point load.

It was found that the limestone samples recovered from the Delta Outliers, Site 6, could not be successfully cored for uniaxial testing. The results for this site in Table 6 are for point load testing only.

TABLE 6

ROCK STRENGTH RESULTS

SITE NUMBER	UNIAXIAL COMPRESSIVE STRENGTH (MPa)		APPROXIMATE UNIAXIAL COMPRESSIVE STRENGTH* (MPa)			ROCK STRENGTH RANKING**
	Low	High	Low	Mean	High	
1	52.1	85.0	75	125	178	2
2	89.3	111.2	111	140	164	1
3	52.1	106.4	86	106	130	2
3C	85.9	87.0	99	105	110	2
4	87.1***		117	163	206	1
5	71.1	105.2	49	85	132	3
6	No cored specimens		40	72	106	3

NOTES:

* Approximate uniaxial compressive strength = 24 I_s (50), based on Point Load index.

** All rock material strengths are in the range of 'strong' to 'very strong'. Ranking is based on an interpretation of a small range of strengths.

*** Only one specimen could be cored for uniaxial testing.

The results show a relatively small spread of rock strengths. Mean values are generally in the range of 85 to over 100 MPa, all of which reflect high strength rock material. The quartzite and quartzitic sandstones of Sites 2 and 4 slightly outperform the granite at Site 1 and the sandstones of Sites 3 and 3C. The calcareous rocks at Sites 5 and 6 are marginally weaker, although they are still considered to be strong to very strong.

5.2 Unit Weight and Specific Gravity

Unit Weight

A high unit weight would be desirable for both rip rap and armour stone in order to minimize the volume required for a particular block weight. This would also yield a lower surface area per block which would enhance erosion resistance and durability. Further, a lighter rock would require a greater thickness, and hence vastly increased total volume, in order to achieve the same results as a denser rock.

Unit weight determination has been carried out on all sources investigated in the current study in order to obtain a relative evaluation of different rock materials for use as rip rap or armour stone. Unit weights were calculated using weight to volume ratios for all core specimens prepared for uniaxial testing, and using the submerged wax block method for the limestone of Site 6.

Table 7 shows average values of unit weight for each of the sources, and includes a brief rock description. The highest unit weight recorded was for the Gull Creek Dolomite followed by the limestones of the Delta Outliers and Mount Fitton granite. The quartzite materials of

TABLE 7

UNIT WEIGHT AND SPECIFIC GRAVITY

SITE NUMBER	ROCK TYPE	UNIT WEIGHT (kN/m^3)	SPECIFIC GRAVITY (Gs)	RANKING*
1	Porphyritic Granite	26.1	2.66	2
2	Quartzite	25.2	2.62	3
3	Quartz Sandstone	23.8	2.67	4
3C	Quartz Sandstone	22.5	2.65	5
4	Quartzite	25.0	2.66	3
5	Crystalline Dolomite	27.4	2.86	1
6	Biomicritic Limestone	26.1	2.70	2

* The ranking is a qualitative interpretation of the materials tested.

Gull Creek and Mount Davies Gilbert followed; the weaker sandstones of the Mount Gifford area and roche moutonee were found to be the lightest.

Specific Gravity

In addition to unit weight, an evaluation of specific gravity was made in accordance with ASTM D854-83. This is a significant material property for the design of concrete products where particle sizes are closer to grain sizes in the blended aggregate. The results, also included in Table 7 clearly show the superiority of the carbonate rocks in producing high quality concrete aggregate, and the difference between the unit weight and specific gravity of the sandstone from Site 3C illustrates the effects of high porosity.

All samples would be considered acceptable from these tests.

5.3 Los Angeles Abrasion

Following some material breakage for point load testing, the samples were further crushed and graded in order to derive specimens for testing using the Los Angeles abrasion equipment in accordance with ASTM C535. For the original six sites, the coarse grading number 1 was used; due to the limited sample size of the additional Site 3C, the finer grading number 2 was adopted.

Table 8 shows the results of the testing, and indicates quite clearly that the roche moutonee and the Delta outliers make unsuitable sources of rip rap or armour stone due to their weak abrasion resistance. The sandstone from the roche moutonee, Site 3C, was noted as

TABLE 8

LOS ANGELES ABRASION

SITE NUMBER	PHYSICAL DESCRIPTION OF AGGREGATE	LOS ANGELES ABRASION (% Loss)	ABRASION RANKING***
1	Very hard, angular, some equidimensional	27.7	1
2	Hard, angular	27.1	1
3	Hard, angular, some platy and prismatic	33.4	2
3C	Hard, subangular**	52.9	3*
4	Hard, angular some prismatic	26.8	1
5	Hard, angular to subangular	27.1	1
6	Moderately hard, angular, some platy	54.2	3*

* Unacceptable, based on maximum permissible loss of 45% for ASTM C535.

** ASTM C535 grading 2, all others grading 1.

*** Based on qualitative interpretation of laboratory testing.

being porous and friable in petrographic analysis, and broke fairly easily in preparing the specimen for abrasion testing. The limestone from the Delta outlier performed well in most tests but one block which had been recovered intact was observed to have almost disintegrated in transit from Inuvik to Vancouver. It is, therefore, concluded that the outlier limestone and the roche moutonee sandstone would likely make poor quarry rock prospects for the larger gradations of rock.

The acceptance criterion for rock block slope protection of shore structures is usually taken as 45% maximum loss under ASTM C535, Los Angeles Abrasion.

5.4 Sulphate Soundness

Of the two sulphate soundness tests described in ASTM C88-76, it was decided to carry out the more aggressive, sodium sulphate test, rather than the milder, magnesium sulphate test. This decision was based on the potentially demanding environment of sea water, wave action and freeze/thaw activity. The specimens were derived from crushed samples of rock following mechanical testing described above and blended into a coarse or fine aggregate according to the test requirements. The initial sizes of the crushed rock fragments dictated the aggregate blending gradation.

Table 9 shows the results of the tests, the grading used for each source material and the soundness ranking. Commonly accepted standards suggest that rocks which show a loss of less than 5 percent for either grading should be satisfactory in respect of sulphate soundness. The current tests show that Site 3C would be unacceptable, Site 3 would be marginally acceptable and the other sites would all be satisfactory.

TABLE 9

SODIUM SULPHATE SOUNDNESS

SITE NUMBER	GRADING	SODIUM SULPHATE SOUNDNESS (% Loss)	SOUNDNESS RANKING
1	Coarse	0.94	1
2	Fine	2.98	2
3	Coarse	4.15	3
3C	Fine	27.28	4*
4	Coarse	0.86	1
5	Coarse	0.76	1
6	Coarse	0.86	1

* Unacceptable, greater than 5 per cent

5.5 Slake Durability

Some rock materials deteriorate by slaking on cyclic wetting and drying. The slake durability test is designed to give a standard cycle of tumbling in a partially submerged wire mesh basket followed by oven drying to simulate periodic wetting and drying of riprap material used as shore protection.

Three cycles were used in the current study, and in all cases the first cycle led to a greater loss than the next two cycles. This is most likely due to the local abrasion of surface asperities in the initial tumbling cycle and also explains why the tests were run to three cycles compared to the ISRM recommended two cycles.

Compared to both the L.A. abrasion and sulphate soundness tests, where the test specimen is derived from a blended sample of a particular grading combination and weight loss is found by comparing initial and final gradings, the slake durability test uses ten similarly sized rock lumps and measures weight loss as any material lost from the 2 mm square mesh of the rotating basket.

The test was carried out according to the standard prescribed by ISRM (1971), and results show that all rock types have "extremely high" durability to slaking. This ISRM classification is given to materials with a slake durability index of 95-100% after two cycles. All of the Beaufort rocks showed a durability index greater than 98% after two cycles and the tests were continued for a further cycle; the values shown in Table 10 are after three cycles. No rock type ranking is given since their comparative performance is considered within the limits of testing variability.

TABLE 10

SLAKE DURABILITY INDEX

SITE NUMBER	ROCK TYPE	SLAKE DURABILITY INDEX (% retained)		
		1st Cycle	2nd Cycle	3 Cycle
1	Granite	98.8	98.3	97.8
2	Quartzite	99.4	99.1	98.9
3	Sandstone	98.8	98.4	97.9
3C	Sandstone	99.2	98.8	98.5
4	Quartzite	99.5	99.2	99.1
5	Dolomite	99.0	98.5	98.1
6	Limestone	99.2	98.9	98.6

All acceptable, extremely durable, better than 98 per cent after 2 cycles.

5.6 Petrography

In order to evaluate the mineralogical characteristics of the samples, thin sections were made and petrographic analyses carried out. These were subcontracted to a local geological consultant and the complete report is included in supporting Document D7. Two different thin section specimens were prepared from samples of rock from Mount Fitton and unfortunately none were done for Site 2, Mount Davies Gilbert. The crystalline quartzite exposed on the flanks of Site 2, examined in hand specimen, has been determined to contain essentially 100% quartz with minor chert in grains to less than 1 mm across. Recrystallization and regrowth of silica has given a very dense material with well interlocked grains and low porosity.

The petrographic analyses have not revealed any deleterious substances in any of the samples from a view point of concrete aggregate or select armour rock. Further, the analyses have confirmed the inferior quality of rock at Sites 3C and 6, the former by its porous and friable nature, the latter by its weakness caused by macrofossils which have been infilled by calcite and graphite.

5.7 Summary of Laboratory Testing Results

Different laboratory tests are used to determine the physical suitability of the rock material for producing the grades of rock called for in this study. For example, uniaxial strength, durability and resistance to weathering are critical factors for the selection of an armour stone prospect when considered in the light of rock mass parameters such as discontinuity orientation, spacing and hence block size. On the other hand, mineralogy and abrasion resistance in combination with weathering resistance and sulphate soundness are features to be considered when looking for a source of concrete aggregate.

Table 11 shows a summary of all laboratory tests with a ranking for the seven sites for which samples were recovered. Acceptability criteria have been based on recommendations from the testing methods quoted in the tests. From this table, it can be seen that the granite of Mount Fitton, the quartzite and dolomite of Gull Creek and the Mount Davies Gilbert quartzite are essentially equal, and generally superior to the Mount Gifford sandstone. The Delta Outlier limestone and the sandstone from the isolated roche moutonee did not perform adequately for the full suite of tests with unacceptable values of L.A. abrasion for both sources and also unacceptable sulphate soundness results for the latter.

6.0 DATA ANALYSIS AND INTERPRETATION (Phase 4)

Phase 4 of the project called for the development of a series of matrices to give a rating to the sites under evaluation based on a wide range of characteristics. Tables 11, 12 and 13 present the results of this phase of the project. During the data analysis, the distinction between those sites feasible for development in contrast to those suitable for development became apparent.

A feasibility evaluation is typically based on technical factors, assessing whether a particular site can be developed to produce the required grades and qualities of rock to meet industrial needs. A suitability assessment, on the other hand, is based more on an evaluation of technical feasibility in the light of development constraints. Some of these constraints have been identified and discussed in this report, although their relative importance may not be the same in, say, 5 or 10

TABLE 11

DSS/QUARRIES/BEAUFORT — SUMMARY OF LABORATORY TEST RESULTS — 862-1806

SITE AND ROCK TYPE	ROCK STRENGTH	UNIT WEIGHT	L.A. ABRASION	SULPHATE SOUNDNESS	SLAKE DURABILITY	PETROGRAPHY	OVERALL RANKING
Mt. Fitton Granite	2	2	1	1	1	1	1
Mt. Davies Gilbert Quartzite	1	3	1	2	1	1	1
Mt. Gifford Sandstone	2	4	2	3	1	1	2
Roche Moutonee Sandstone	2	5	3*	4*	1	2	4
Gull Creek Quartzite	1	3	1	1	1	1	1
Gull Creek Dolomite	3	1	1	1	1	1	1
Delta Outlier Limestone	3	2	3*	1	1	2	3

* Denotes unacceptable value.

Numbers in table refer to laboratory test ranking in detailed tables 6 to 10.

TABLE 12

SUMMARY OF ROCK MASS DESCRIPTIONS

Site and Rock Type	Overburden	Outcrop	Fabric	Average Block Size (cu.m)	Joint Sets	Weakness	Seepage
Mt. Fitton Granite (1)	Light Felsenmeer	Granite Tors	Blocky	0.5	3	None	None
Mt. Davies Gilbert Quartzite (2)	Heavy Felsenmeer	Limited intact	Blocky to Tabular	0.02	3	None	None
Mt. Gifford Sandstone (3)	Rock Detritus	Limited	Slabby	0.0015	2	Siltstone Interbeds	None
Roche Moutonee Sandstone (3c)	None	Roche Moutonee	Blocky	0.75	3	None	None
Gull Creek Quartzite (4)	Organics, Felsenmeer	Limited intact	Blocky	0.3	2	None	None
Gull Creek Dolomite (5)	Colluvium	Massive intact	Massive to Blocky	0.4	3	None	None
Delta Outlier Limestone (6)	Organics, Colluvium	Massive	Massive to Blocky	0.3	2	Weak Bedding	None
DPW Quarry Limestone (X1)	None (stripped)	Massive	Blocky	0.3	3	Weathered Zones	None
Campbell Pit Limestone (X2)	None (stripped)	Massive	Blocky	0.5	3	None	None

TABLE 13

SUMMARY OF QUARRY DESIGN PARAMETERS

Site	Local Topography	Access: Personnel	Access: Product	Quarry Size (x 10^3 m^2)	Stockpile (x 10^3 m^2)	Infrastructure at Site
Mt. Fitton (1)	Low rounded mountain	175 km Inuvik	75 km King Point Overland	250	100	Camp required Suitable space available
Mt. Davies Gilbert (2)	Steep bedrock ridge, poorly drained base	125 km Inuvik	80 km King Point Overland	1,000	2,500	Camp required Space available
Mt. Gifford (3)	Flat topped spur, steep access	20 km Aklavik	150 km King Point Barge	360	1,000	Aklavik base. Facilities on site
Roche Moutonee (3c)	Whaleback ridge, poorly drained base	85 km Inuvik	145 km King Point Barge	12.5	100	Small prospect. Space for camp facilities
Gull Creek Quartzite (4)	Benched ridge in smooth hills	34 km Inuvik	205 km Tuktoyaktuk Barge	180	300	Barge dock, site offices, space available
Gull Creek Dolomite (5)	Rock bluff in rounded hills	28 km Inuvik	200 km Tuktoyaktuk Barge	280	200	Space available for site offices
Delta Outlier (6)	Low hills, poorly drained base	54 km Inuvik	225 km Tuktoyaktuk Barge	1,000	400	Dewatered area for possible camp. Potential for flooding.
DPW Quarry (X1)	Rounded hills Existing quarry	39 km Inuvik	209 km Tuktoyaktuk Barge	5	2.5	Sizes given for existing operation, expansion potential good
Campbell Pit (X2)	Rounded hills Existing quarry	23 km Inuvik	193 km Tuktogaktuk Barge	20	10	Expansion of existing quarry by factor of 10

years time. It is outside the scope of the present study to predict the impact of constraints in the future, therefore the suitability of a prospect has not been considered further.

6.1 Site Evaluations

On completion of the data collection phase of the project and the subsequent laboratory testing, the results were evaluated to determine:

- which grades of rock could be produced at each site;
- potential quantities of various grades of rock available at each site;
- which sites were technically feasible for development;
- site specific concerns relating to preliminary quarry planning and development, and;
- potential difficulties in gaining access to a site, or from a site to the nearest barging point.

The evaluation was carried out in a combination of subjective and objective steps whereby visual appraisal of the rock mass, gained during the field investigation, for example, could be compared to measured block sizes and the results of laboratory testing to determine whether or not the largest sizes of quarry rock could be generated at a particular site.

The field data has been included in the next sections of this report to gain a complete understanding of each site. The figures for each site show the general topography, flight lines, sample locations and mapping traverses; while photographs show salient features.

It is noted that the original six sites and the isolated roche montanee have a data base of comparable detail, including rock mass, rock material, quarry deposit and quarry location evaluations in addition to the full suite of laboratory tests on representative samples of the rock material. The last two sites adjoining the Dempster Highway do not have laboratory test results to confirm the field appraisals.

MOUNT FITTON

SITE 1

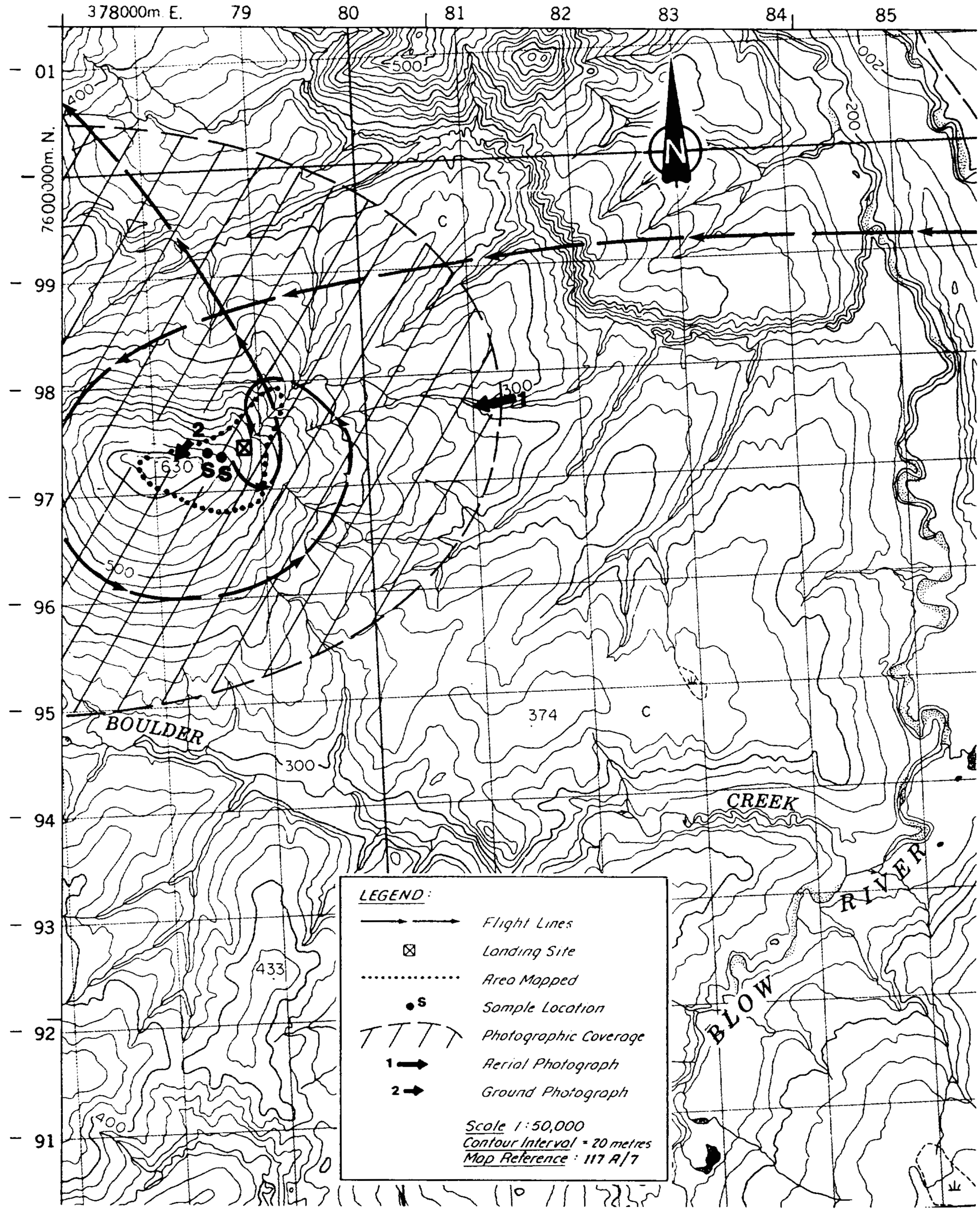
6.1.1 Site 1 - Mount Fitton

A granite intrusion outcrops across the crest of Mt. Fitton, which rises to an elevation of approximately 630 m. on the west side of the Blow River in the Yukon Territory, some 70 km. inland from Shingle Point on the coast of the Beaufort Sea. Outcrop of the granite is limited to tors on the crest of the rounded mountain. However, all available data suggests that the granite underlies colluvium over the top of the mountain, but is in faulted contact with Palaeozoic and Cretaceous sediments on the eastern flank.

The north face of the mountain has low bluffs along the crest, and then slopes down evenly, but quite steeply, to an east-flowing tributary of the Blow River. To the south, the mountain slopes gently down into the valley of Boulder Creek. Local topographic relief on both sides of the mountain is approximately 350 m.

The porphyritic granite of Mount Fitton would make an excellent quarry source for all grades of rock required. There is plenty of space around the potential quarry site for facilities infrastructure, stockpile, working space and camp. Summer quarrying is indicated, since water supply is likely to be limited to non-freezing conditions without drilling wells near to the quarry site, since the Blow River is reported to freeze solid. The rock mass appears ideal for blasting and producing a durable product, with little weathering noticed in outcrop and good laboratory test results.

SITE 1 - MOUNT FITTON | **Figure 1-1**



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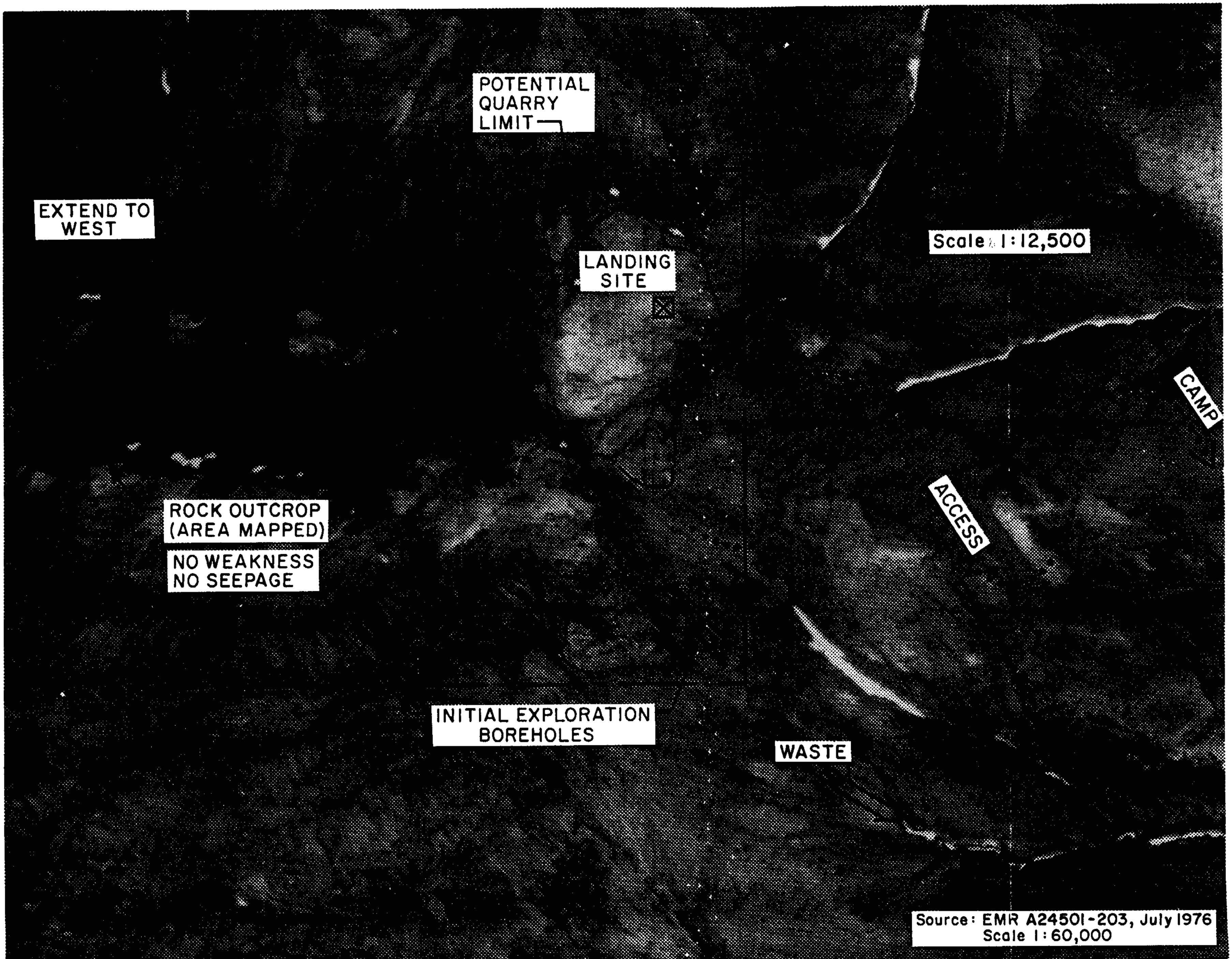
PROJECT NO. 862-1806 DRAWN BAD REVIEWED .... DATE June '87



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SITE 1 - MT. FITTON

Figure 1-2

PHOTOGRAPH 1: AERIAL VIEW OF MT. FITTON LOOKING SW

PHOTOGRAPH 2: GRANITIC BLOCKS NEAR SUMMIT OF MT. FITTON

DSS/QUARRIES/BEAUFORT 862-1806 ROCK MASS DESCRIPTION

FIELD CHECKLIST - ALL ENTRIES TO BE COMPLETED

MAPPED BY DFW/RSR

SITE NUMBER 1 Mt. Fitton, Y.T.

DATE 30-Sep-86

LOCATION Summit of Mt. Fitton

- -

LOCALITY TYPE Bedrock Porphyritic Granite, phenocrysts to 20mm

felsenmeer yes colluvium no moraine no

SIZE 200 metres X 200 metres horizontal

ELEVATION RANGE 440 metres to 630 metres

- -

IMAGE	Sketch	no	no. of photos	38 land, 8 air
	Air photos	yes	sequence	A23838/88-91 A24501/201-204
	Land photos	yes	sequence	0305-0324, 0415-0419, 0501-0513

- -

SAMPLE Location North slope of mountain

Size 55 kg

- -

ROCK MATERIAL	Colour	light pinkish grey
	Grain size	1-20 mm
	Weathering	very slight
	Strength	very strong field est.
	ROCK TYPE	Porphyritic GRANITE

- -

ROCK MASS Fabric blocky

Block size - minimum	0.1 m X	0.1 m X	0.1 m
- maximum	5 m X	3 m X	2 m
- average	0.8 m X	0.8 m X	0.8 m

Discontinuity - set 1	65/321	orient.	2 m. spacing	Joint
- set 2	58/192	orient.	0.8 m. spacing	Joint
- set 3	66/078	orient.	0.8 m. spacing	Joint

Convention used Dip/Dip direction (true north)

Significant weakness No jointing in undisturbed outcrop

Seepage None

- -

COMMENTS Very little in situ outcrop

Tors at crest - felsenmeer below

Lower slope smooth - shale and chert

DSS/QUARRIES/BEAUFORT 862-1806 QUARRY DESIGN PARAMETERS

FIELD CHECKLIST - ALL ENTRIES TO BE COMPLETED

MAPPED BY DFW/RSR

SITE NUMBER 1 Mt. Fitton, Y.T. DATE 30-Sep-86

LOCATION	Local topography	Low rounded mountain		>200 m2	
	Deposit topography	NE slope of hillside - uniform slope		200 m2	
	Deposit orientation	To Northeast		azimuth	
ACCESS	Personnel/supplies	175 km dist.	East direction	Poor rating	from Inuvik
	Product/delivery	75 km dist.	N-NE direction	Poor rating	to King Point
	Distance to tidewater	70 km dist.	NE direction	Poor rating	to Shingle Po
	Distance to barge	--- km dist.	--- direction	--- rating	
OVERBURDEN	Type(s)	felsenmeer			
	Extent - depth	Few m est.			
	area	250,000 m2 est.			
	Disposal area(s)	1,000,000 m2 est.		E or N location	
QUARRY	Size	250,000 m2 est.			
	Depth	100 m est.			
	Working space	100,000 m2 est.	towards East	location	
	Stockpile space	100,000 m2 est.	towards East	location	
	Facilities	To North or South			
	Camp	Required - plenty of space to North or South			
HYDROLOGY	Surface water	None vol. est.	---	location	
	Pit drainage	None vol. est.	---	location	
	Water supply	Unlimited vol. est.	Blow River	location	
PERMAFROST	Evidence	On lower slopes		location	
	Potential change	Access road to coast			
CONSTRAINTS	Environmental	Access road, caribou, grizzly		type	
	Archeological	Unlikely		type	
	Recreational	Unlikely		type	
	Proximity to water	6 km est. to Blow River, 2 km to Boulder Creek		direction E and S	
	Wildlife observed	Ptarmigan, fox, caribou remains, bears, rabbits		type	
	Reclamation	None			
	Restoration	None			
REMARKS	Possible mineral claims in area (A. Hoidal). River freezes in winter.				

MOUNT DAVIES GILBERT

SITE 2

6.1.2 Site 2, Mount Davies Gilbert

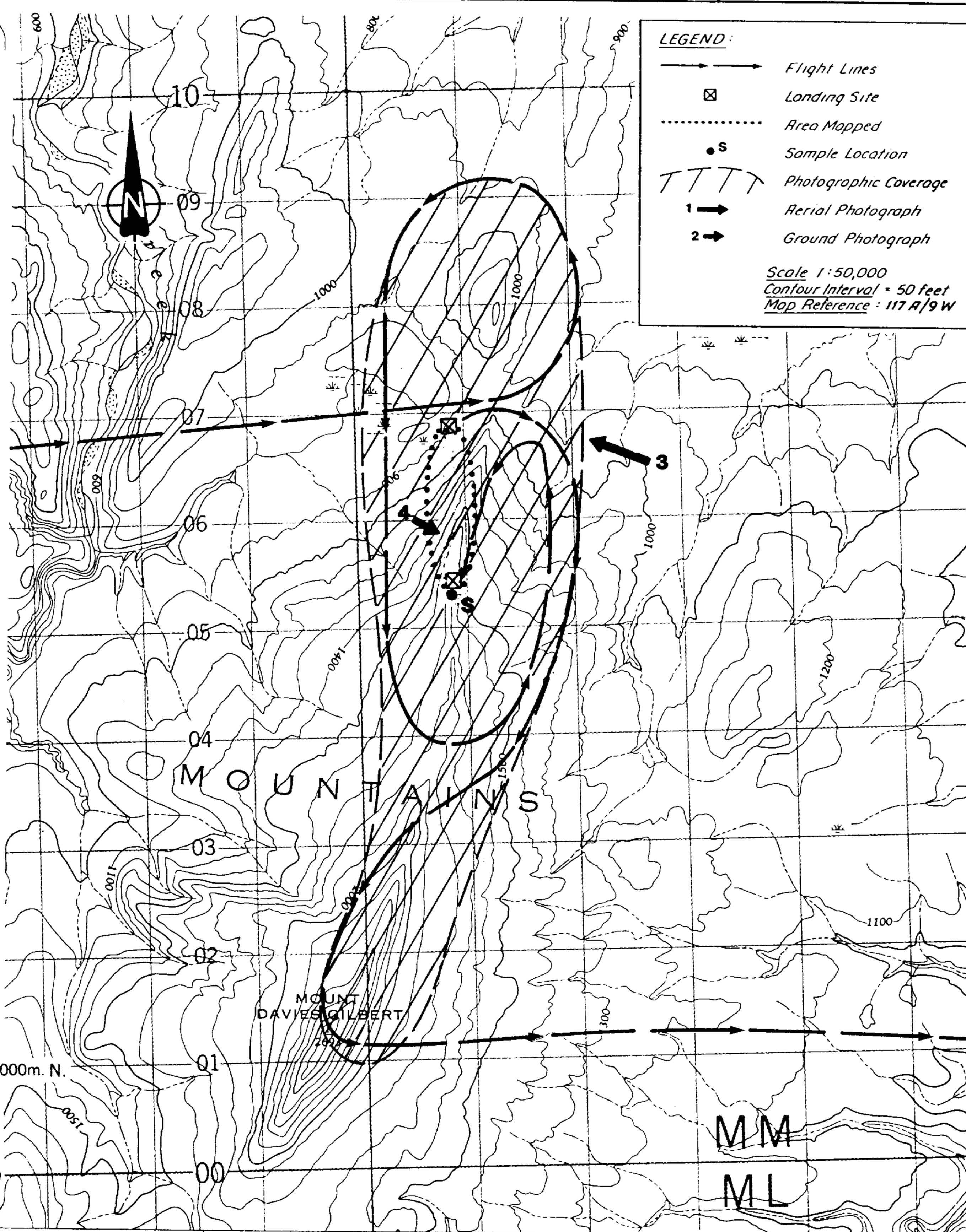
A hogback ridge of quartzite and quartzitic sandstone runs north from Mount Davies Gilbert, which has its summit at about 820 m some 50 km inland from Shingle Point on the coast of the Beaufort Sea. The ridge rises steeply from the surrounding plain with a relief of some 75 m. The surface of the ridge is made up almost exclusively of blocky, angular to tabular rock detritus with little undisturbed outcrop. Average block size is in the range 0.2 - 0.3 m across, with a maximum in the 0.5 - 1 cu. m range.

An extension of the ridge to the north is separated from the main deposit by a low lying, poorly drained area which transects the ridge and would make site access and trafficability difficult. The most likely quarry site would be on the west flank of the ridge but the steep terrain would make quarry planning difficult.

The crystalline quartzites on the northern spur of Mount Davies Gilbert would produce excellent quality rip-rap and blast rock. Unfortunately, it is doubtful that a source of armour stone could be efficiently won without excavating into the rock mass a significant distance. EBA (1983) rated Mount Davies Gilbert as a fair to good prospect for armour stone, although the one dimensional rock block size recorded was only 0.6 m maximum. Golder does not believe that this area could produce armour stone in the volumes anticipated. This would not present a problem if it were not for the very steep topography of the ridge itself and the access difficulties of developing high benches into the mountainside. Permafrost and poor drainage of the surrounding terrain would make site development difficult.

SITE 2 - MOUNT DAVIES GILBERT

Figure **2-1**



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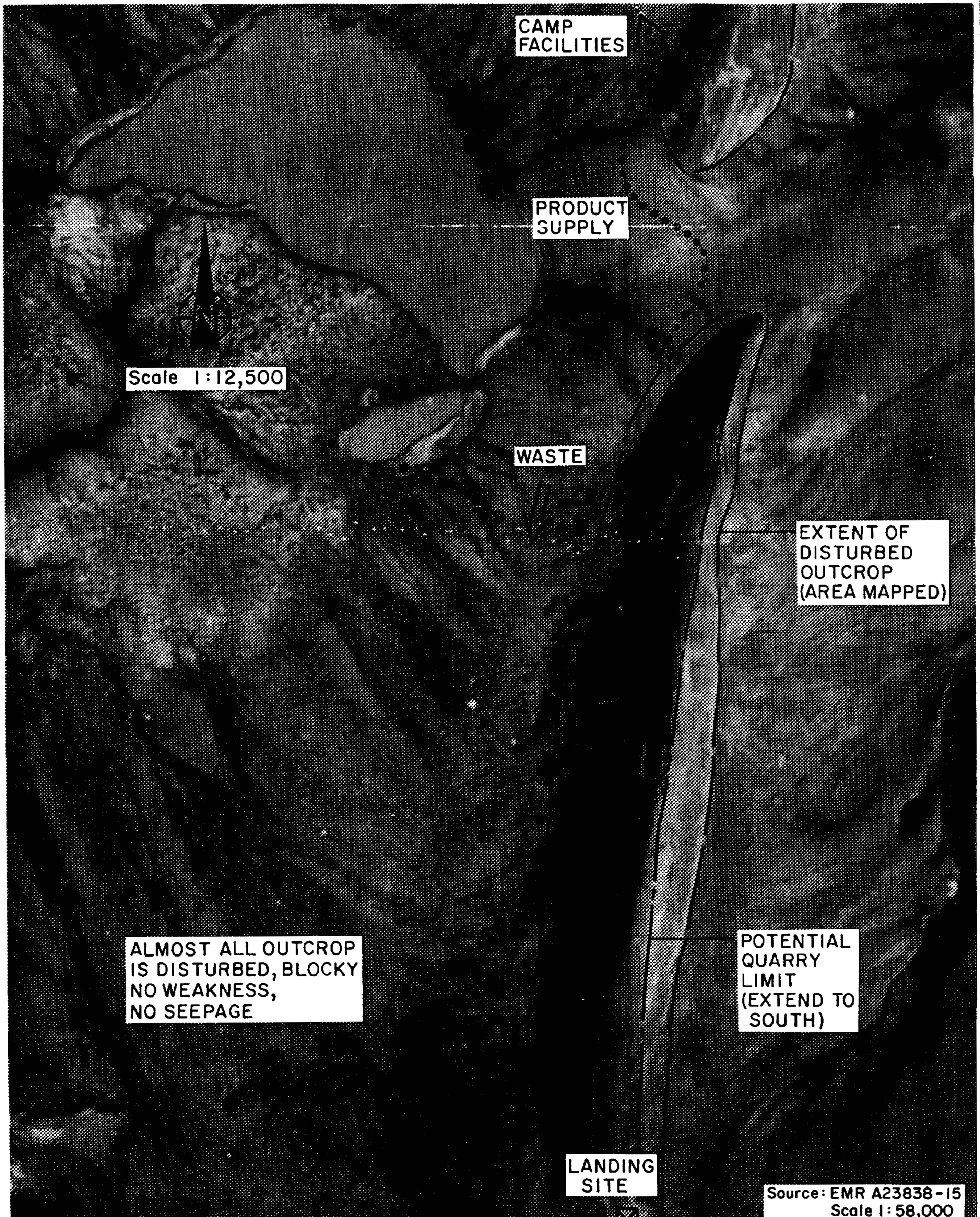
SITE 2 - MT. DAVIES GILBERT

Figure **2-2**



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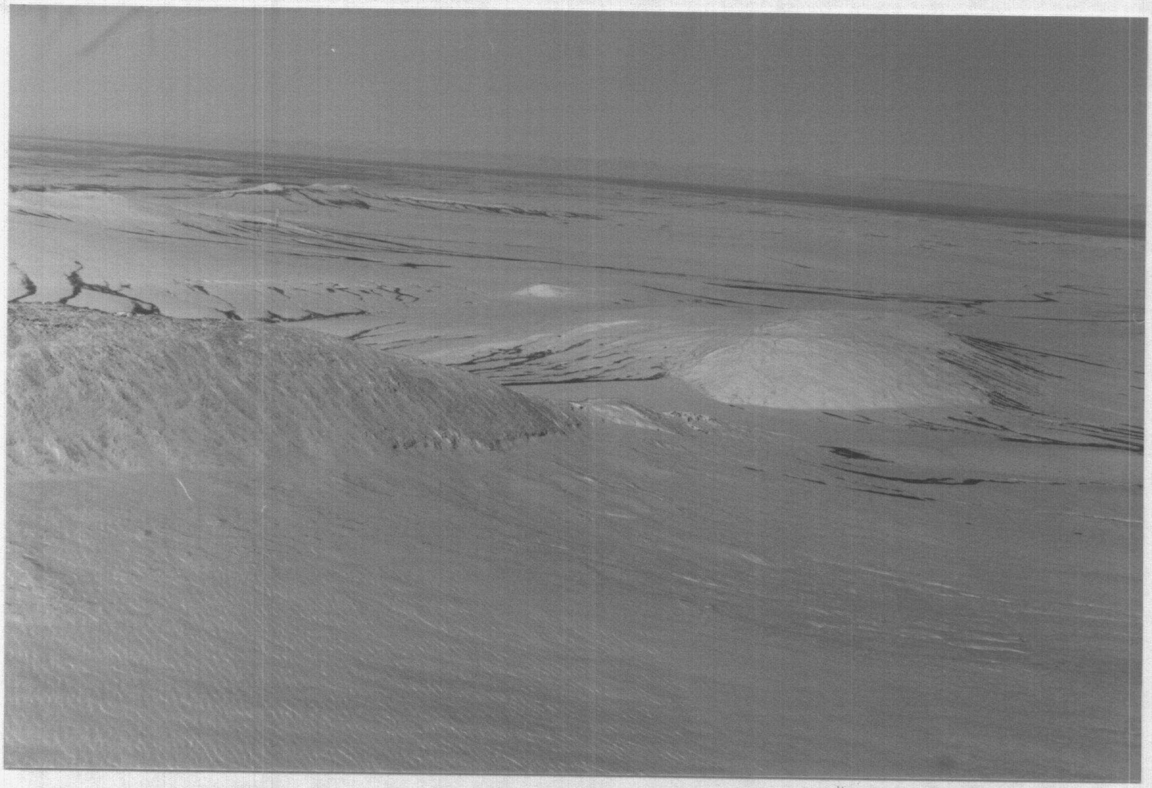


PHOTOGRAPH 3: AERIAL VIEW OF MT.DAVIES GILBERT LOOKING NW

PHOTOGRAPH 4: QUARTZITIC FELSENMEER ON WEST SLOPE OF MT. DAVIES GILBERT

6.1.3 Site 3, Mount Gifford

The northern spur from Mount Gifford comprises gently undulating terraces which drop away steeply to the east and the Mackenzie Delta. The lower flanks of the mountain range, closer to the deltaic plain, are gently sloping and poorly drained, probably permafrost bearing, outwash fans resulting from erosion of the sandstone/siltstone ridges, in combination with moraine deposits. The steep eastern face of the local range has good bedrock exposures while the flatter, western face is predominantly covered with colluvial debris and sparse vegetation. Local bedrock knobs, more erosion resistant, protrude through the thin mantle of recent deposits.

Two possible quarry sites were located about 1 km apart, with considerably different rock mass characteristics in terms of bedding and joint orientations. In both cases, the rock mass was made up of slabby rock pieces with a maximum block size of only 0.5 m x 0.3 m x 0.2 m. Interbeds of siltstone make the prospect unattractive since careful material segregation would be required to generate select rock grades.

The best source of quartz sandstone in the Mount Gifford area lies as an inaccessible stratum high up the east facing slopes of the mountain. Natural erosion has produced a large talus pile at the toe of the bluff, and the residents of Aklavik use this as a source of rip-rap for shore protection in their community. The material is segregated and transported along winter roads to Husky Channel and thence to Aklavik.

Quarry development involving haul roads through permafrost morainal country would be difficult, especially if screening from the east were a requirement.

As a limited source of riprap, such as currently exploited by the Aklavik residents, the Mount Gifford site is technically feasible. However, long-term durability has not been evaluated in the shore protection at Aklavik. The riprap inspected was of very mixed quality and size ranges; the stockpile contained a considerable fraction of undersize and fines which appeared to have been developed, in part, by mechanical break down of larger rock blocks. As a source of armour stone, this site is not believed to warrant further investigation.

DSS/QUARRIES/BEAUFORT 862-1806 ROCK MASS DESCRIPTION

FIELD CHECKLIST - ALL ENTRIES TO BE COMPLETED

MAPPED BY DFW/RSR

SITE NUMBER 2 Mt. Davies Gilbert

DATE 30-Sep-86

LOCATION N-S bedrock ridge to N of Mt. Davies Gilbert

- -

LOCALITY TYPE Bedrock Quartzite

felsenmeer yes colluvium no moraine no

SIZE 2000 metres X 500 metres horizontal

ELEVATION RANGE 275 metres to 520 metres

- -

IMAGE	Sketch	no	no. of photos	21 land, 6 air
	Air photos	yes	sequence	A23816/178-180 A23838/13-15
	Land photos	yes	sequence	0421-0425, 0518-0524, 0600, 0701-0708

- -

SAMPLE Location Crest of ridge

Size 17.5 kg

- -

ROCK MATERIAL	Colour	grey		
	Grain size	1 mm	recrystallized	
	Weathering	slight with limonite stained joints		
	Strength	very strong	field est.	brittle ringing sound on impact
	ROCK TYPE	QUARTZITE		

- -

ROCK MASS Fabric very blocky, angular - tabular

Block size - minimum	0.1 m X	0.1 m X	0.05 m
- maximum	<1 m X	1 m X	0.5 m
- average	0.3 m X	0.3 m X	0.2 m

Discontinuity - set 1	80/185	orient.	0.3 m.	spacing	Joint
- set 2	44/087	orient.	0.3 m.	spacing	Joint
- set 3	65/272	orient.	0.2 m.	spacing	Joint

Convention used Dip/Dip direction (true north)

Significant weakness None

Seepage None

- -

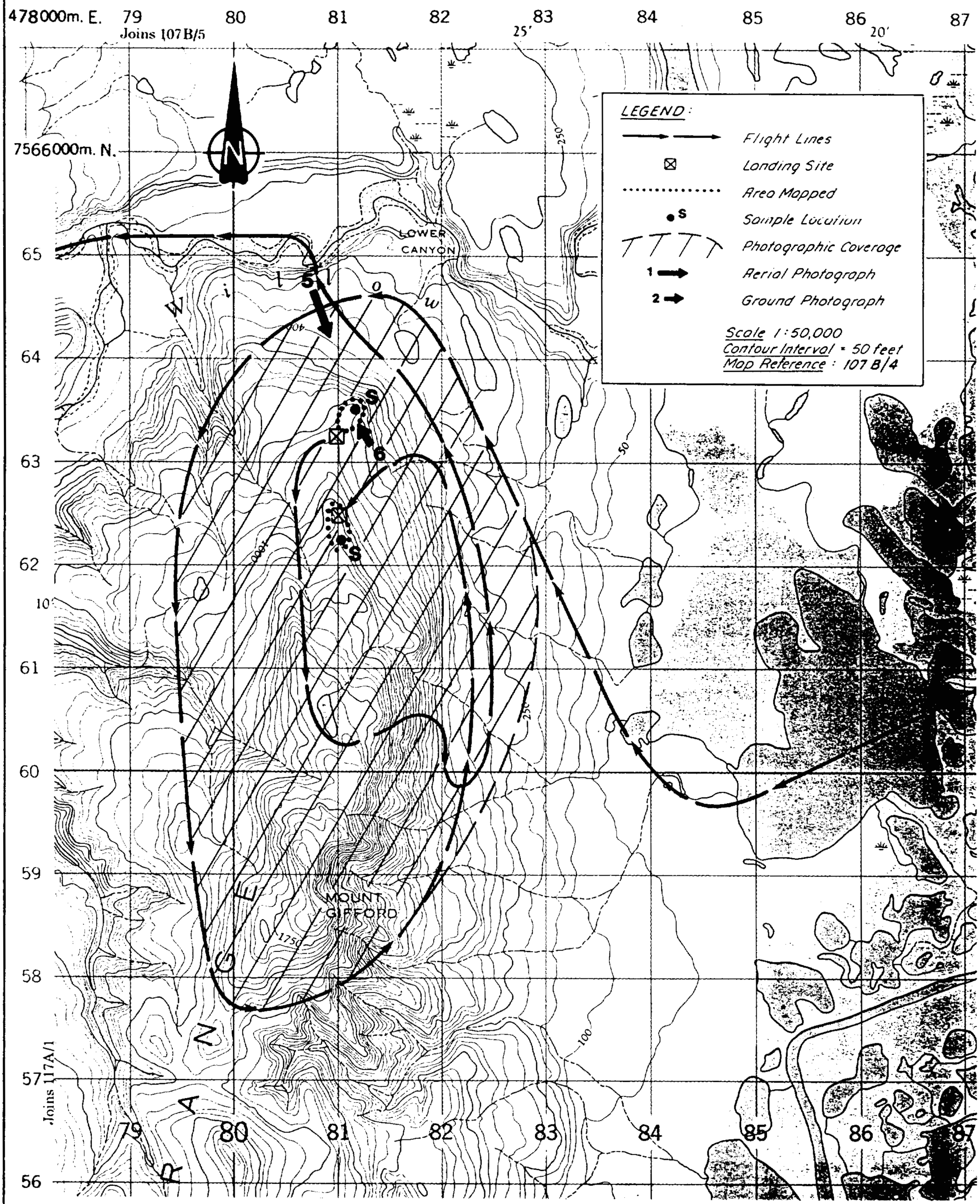
COMMENTS Very difficult to develop - hog back ridge (narrow)

MOUNT GIFFORD

SITE 3

SITE 3 - MOUNT GIFFORD

Figure **3-1**



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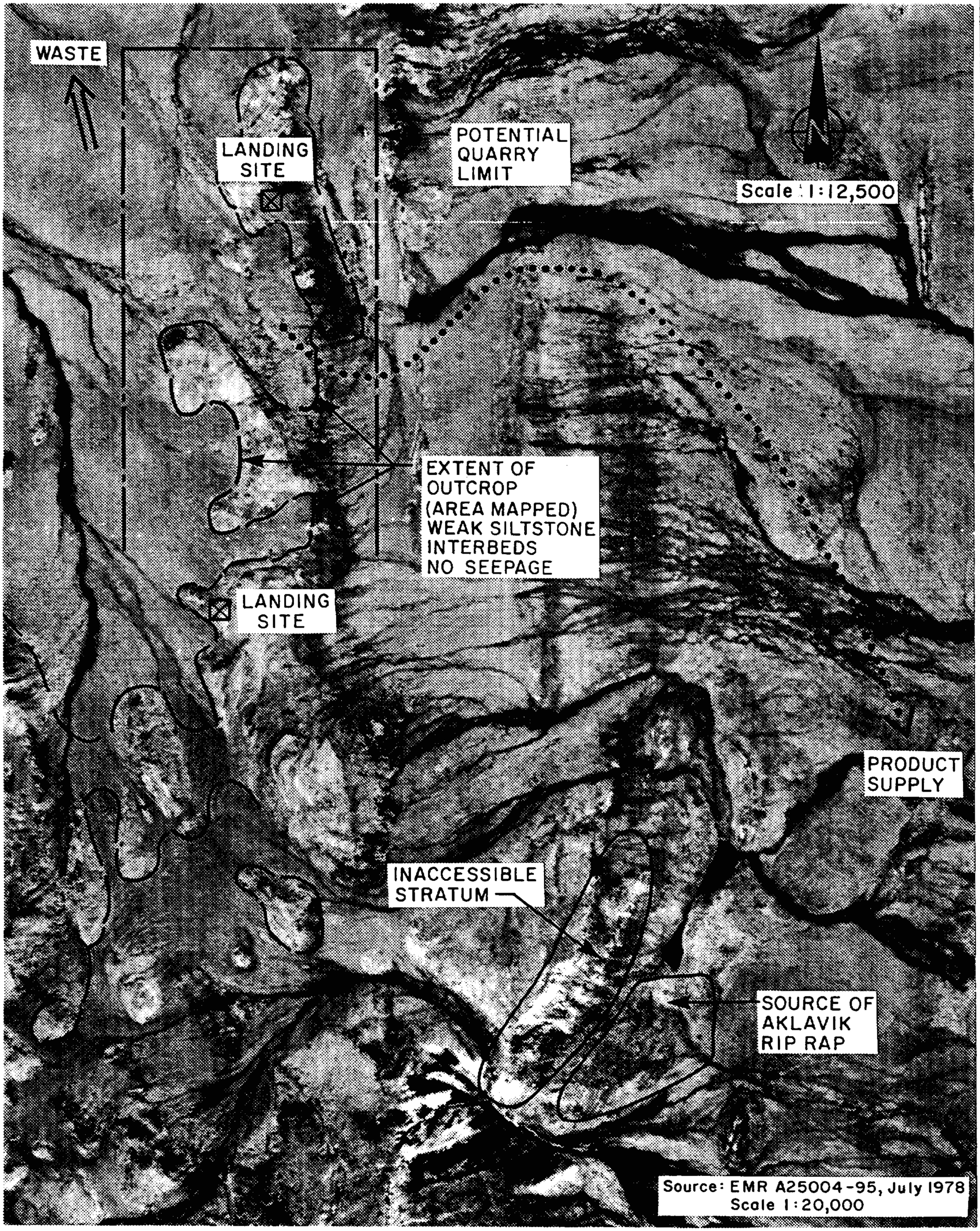
SITE 3 - MT. GIFFORD

Figure **3-2**



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PHOTOGRAPH 5: AERIAL VIEW OF MT. GIFFORD LOOKING SW

PHOTOGRAPH 6: SANDSTONE FELSENMEER ON EAST SLOPE OF MT.GIFFORD

DSS/QUARRIES/BEAUFORT 862-1806 ROCK MASS DESCRIPTION
FIELD CHECKLIST - ALL ENTRIES TO BE COMPLETED

MAPPED BY DFW/RSR

SITE NUMBER 3 Mt. Gifford, N.W.T. (site a + b)

DATE 01-Oct-86

LOCATION North spur of Mt. Gifford

- -

LOCALITY TYPE Bedrock Sandstone with interbeds of Siltstone
felsenmeer yes colluvium no moraine on access
SIZE 600 metres X 600 metres horizontal

ELEVATION RANGE 215 metres to 265 metres

- -

IMAGE	Sketch	no	no. of photos	34 land, 24 air
	Air photos	yes	sequence	A26752/60-63 A25004/91-110
	Land photos	yes	sequence	0607-0616, 0717-0724, 0901-0916

- -

SAMPLE Location Crest of spur
Size 52 kg

- -

ROCK MATERIAL	Colour	light pinkish brown
	Grain size	0.5 - 1 mm
	Weathering	moderate
	Strength	mod. str.-strong field est.
	ROCK TYPE	Quartzitic SANDSTONE with interbeds of SILTSTONE to < 1 m.

- -

ROCK MASS Fabric slabby

Block size - minimum	0.025 m X	0.025 m X	0.005 m
- maximum	0.5 m X	0.3 m X	0.2 m
- average	0.3 m X	0.1 m X	0.05 m

Discontinuity - set 1	56/032	orient.	0.2 m.	spacing	Joint
- set 2	54/276	orient.	0.5 m.	spacing	Joint
- set 3	58/126	orient.	0.1 m.	spacing	Bedding
- set 1	86/088	orient.	0.3 m.	spacing	Joint
- set 2	86/184	orient.	0.3 m.	spacing	Joint
- set 3	Horiz.	orient.	0.1 m.	spacing	Bedding

Convention used Dip/Dip direction (true north)

Significant weakness Bedding planes, siltstone interbeds

Seepage None visible

- -

COMMENTS Not a suitable prospect. Good rock inaccessible due to steep slopes and unstable rock mass. Accessible areas appear to provide inadequate rock for armour stone.

DSS/QUARRIES/BEAUFORT 862-1806 QUARRY DESIGN PARAMETERS

FIELD CHECKLIST - ALL ENTRIES TO BE COMPLETED

MAPPED BY DFW/RSR

SITE NUMBER 3 Mt. Gifford, N.W.T. (site a + b) DATE 01-Oct-86

LOCATION	Local topography	Gently sloping with steep bedrock ridge	>200 m2
	Deposit topography	Bedrock ridge, knob to south, scarp to east	200 m2
	Deposit orientation	N-S ridge	azimuth

ACCESS	Personnel/supplies	20 km dist.	East direction	Good rating	Aklavik
	Product/delivery	150 km dist.	North direction	Poor rating	to King Point
	Distance to tidewater (barge)	115 km dist.	North direction	Poor rating	to Shingle Poin
	Distance to barge	7 km dist.	SE direction	Good rating	Peel Channel

OVERBURDEN	Type(s)	Rock detritus, frost shattered felsemmer		
	Extent - depth	1 m est.		
	area	360,000 m2 est.	covers outcrop	
	Disposal area(s)	1,000,000 m2 est.	west terrace	location

QUARRY	Size	360,000 m2 est.		
	Depth	50 m est.		
	Working space	2,000,000 m2 est.	West	location
	Stockpile space	1,000,000 m2 est.	West	location
	Facilities	Aklavik and local		
	Camp	Aklavik		

HYDROLOGY	Surface water	Minor	vol. est.	east in gullies (drainage)	location
	Pit drainage	Minimal	vol. est.		location
	Water supply	No Limit	vol. est.	lakes to NE	location

PERMAFROST	Evidence	Local communications (D. Storr)	location
	Potential change	Possible problems with road building - winter access preferred	

CONSTRAINTS	Environmental	Possible Dahl's sheep	type
	Archeological	Unlikely	type
	Recreational	Unlikely	type
	Proximity to water	1.5 km est. North to Willow Creek	direction
	Wildlife observed	Ptarmigan, raven, likely bear	type
	Reclamation	East facing, visible from delta	
	Restoration	East facing, visible from delta	

REMARKS A+B = 2,000,000 m2

ROCHE MOUTONEE

SITE 3C

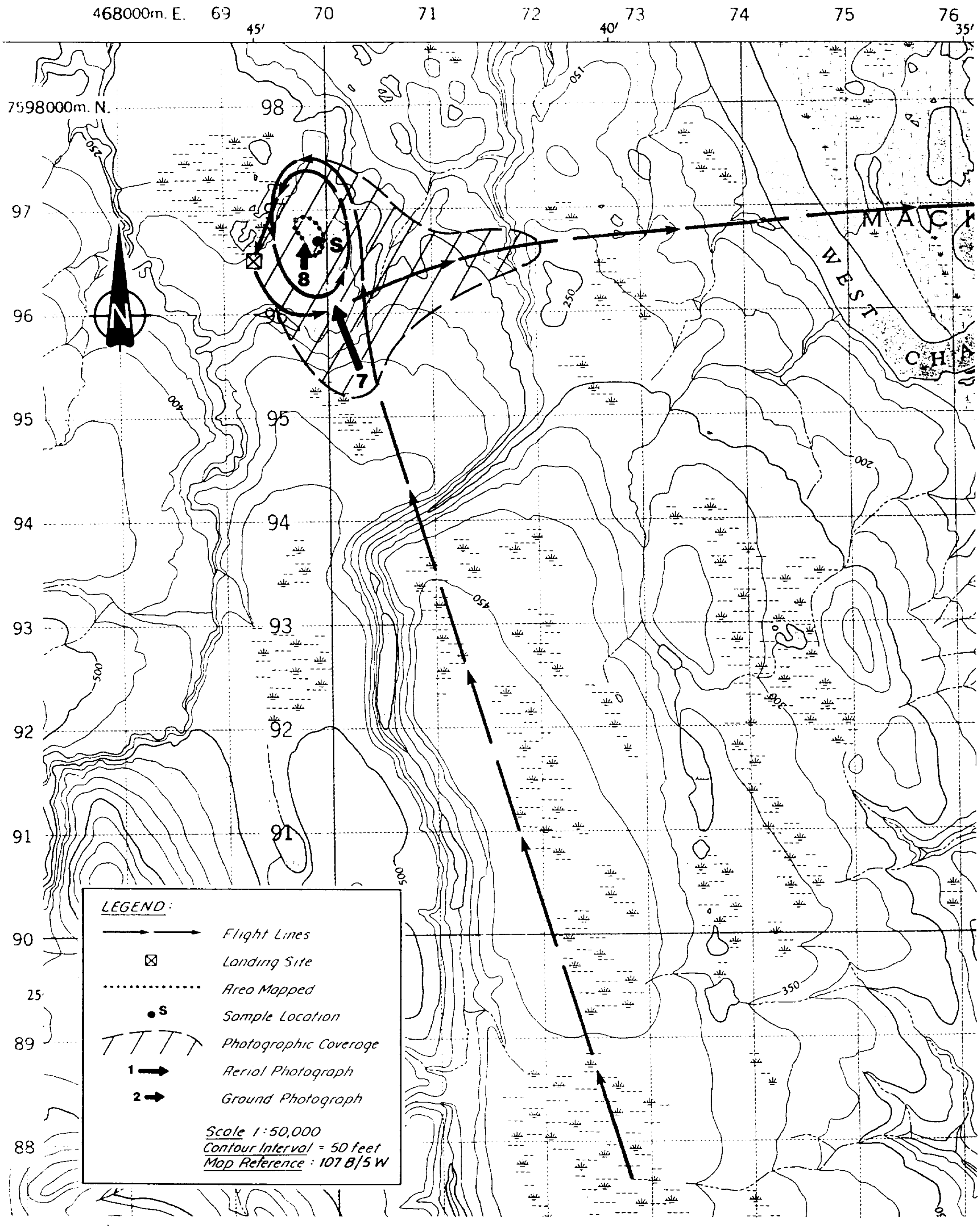
6.1.4 Site 3C, Roche Moutonee, West of Delta

The West Delta Roche Moutonee comprises a glacially eroded whaleback ridge of quartzitic sandstone with a lateral extent of some 250 m north/south and 50 m east/west. This isolated bedrock knob rises some 10 m above the surrounding peneplain. The erosion resistance of this rock material is clearly exhibited by its intact structure with loose rock blocks lying to the west of the outcrop. The massive nature of the rock, and the size of some naturally occurring blocks (to 4 cu. m in volume) led to a preliminary conclusion that this prospect would make an excellent, though limited, source of armour stone which could be won relatively easily.

This prospect is limited in size and exhibited unacceptably low durability in laboratory testing. It could provide an easily won source of low grade armour stone or rip rap which is close to the west channel of the MacKenzie for transhipment to barges. The total volume available is low, however, and the poorer quality relative to all other sources renders this a technically unsuitable prospect for all grades of rock in the current study.

SITE 3C - WEST DELTA ROCHE MOUTONEE

Figure **3C-1**



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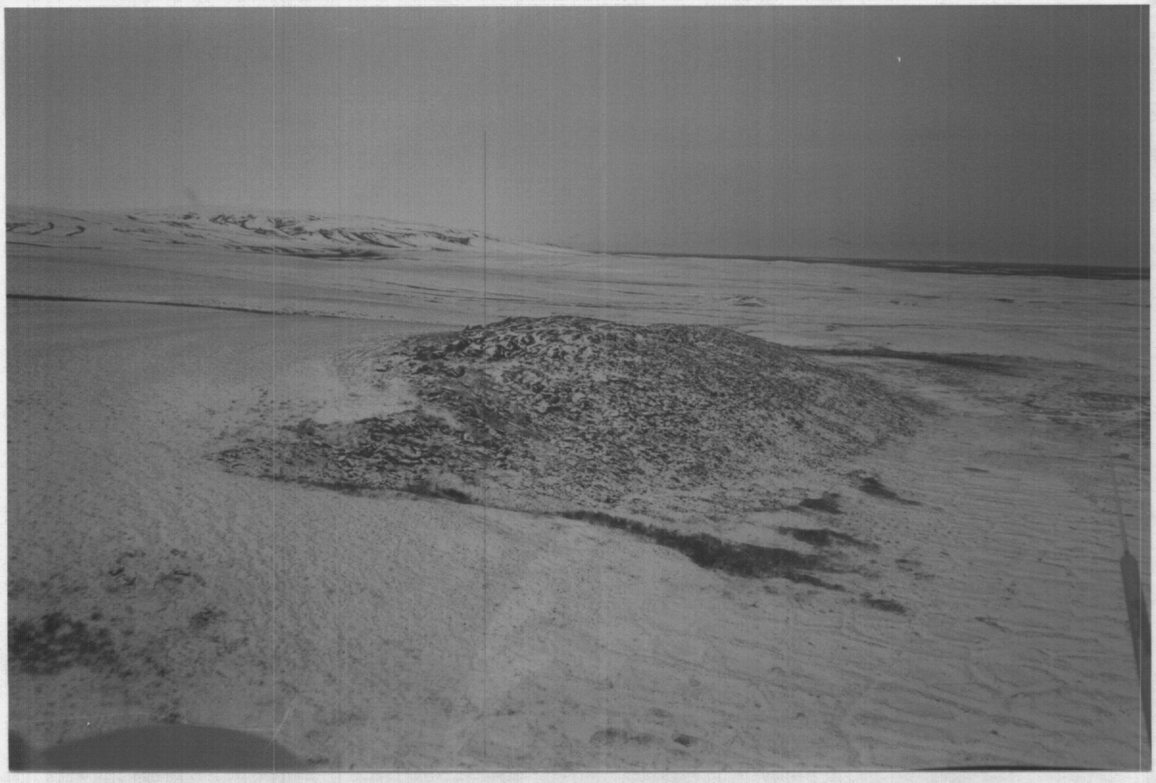


PHOTOGRAPH 7: AERIAL VIEW OF WEST DELTA ROCHE MOUTONEE LOOKING N

PHOTOGRAPH 8: SANDSTONE BLOCKS ON WEST SLOPE OF ROCHE MOUTONEE

DSS/QUARRIES/BEAUFORT 862-1806 ROCK MASS DESCRIPTION
FIELD CHECKLIST - ALL ENTRIES TO BE COMPLETED

MAPPED BY DFW/RSR

SITE NUMBER 3c Mt. Gifford, N.W.T.

DATE 01-Oct-86

LOCATION Whaleback hummock N of Beaver House Creek

- -

LOCALITY TYPE Bedrock Quartzitic Sandstone
felsenmeer yes colluvium no moraine no
SIZE 250 metres X 50 metres horizontal

ELEVATION RANGE 90 metres to 100 metres

- -

IMAGE	Sketch	no	no. of photos	18 land
	Air photos	yes	sequence	---
	Land photos	yes	sequence	0617-0623, 1103-1114

- -

SAMPLE Location Crest of hummock
Size 12.5 kg

- -

ROCK MATERIAL	Colour	light pinkish brown
	Grain size	0.5 mm
	Weathering	moderate 5mm of penetrative weathering with no strength loss
	Strength	very strong field est.
	ROCK TYPE	Quartzitic SANDSTONE

- -

ROCK MASS Fabric blocky

Block size - minimum	0.4 m X	0.3 m X	0.2 m
- maximum	2 m X	2 m X	1 m
- average	1 m X	1 m X	0.75 m

Discontinuity - set 1	84/077	orient.	2 m.	spacing	Joint
- set 2	68/192	orient.	0.3 m.	spacing	Joint
- set 3	90/347	orient.	1 m.	spacing	Joint

Convention used Dip/Dip direction (true north)

Significant weakness None

Seepage None visible

- -

COMMENTS Loose blocks on east side, massive whaleback west and center.
Glaciation 337
Other joints at 72/282, 90/157, bedding at 25/072.

DSS/QUARRIES/BEAUFORT 862-1806 QUARRY DESIGN PARAMETERS

FIELD CHECKLIST - ALL ENTRIES TO BE COMPLETED

MAPPED BY DFW/RSR

SITE NUMBER	3c Mt. Gifford, N.W.T.		DATE	01-Oct-86	
LOCATION	Local topography	Polygonal permafrost terrace		>200 m2	
	Deposit topography	Whaleback glacially eroded roche moutonee'		200 m2	
	Deposit orientation	N-S		azimuth	
ACCESS	Personnel/supplies	85 km dist.	E direction	Fair rating	Inuvik
	Product/delivery	145 km dist.	NW direction	Poor rating	King Point
	Distance to tidewater	110 km dist.	NW direction	Poor rating	Shingle Point
	Distance to barge	4 km dist.	E direction	Good rating	West Channel
OVERBURDEN	Type(s)	None			
	Extent - depth	--- m estimated			
	area	--- m2 est.			
	Disposal area(s)	--- m2 est.	---	location	
QUARRY	Size	12,500 m2 est. total rock mass			
	Depth	10 m est.			
	Working space	100,000 m2 est.	to West	location	
	Stockpile space	100,000 m2 est.	to West	location	
	Facilities	To SW			
	Camp	To SW			
HYDROLOGY	Surface water	125,000 m3 est.	lakes to East	location	
	Pit drainage	None vol. est.	---	location	
	Water supply	125,000 m3 est.	lakes to East (?)	location	
PERMAFROST	Evidence	Polygons to East		location	
	Potential change	Road building to barge site			
CONSTRAINTS	Environmental	East facing to delta, permafrost		type	
	Archeological	Unlikely		type	
	Recreational	Unlikely		type	
	Proximity to water	1000 m est.		NE direction	
	Wildlife observed	None		type	
	Reclamation	East facing			
	Restoration	East facing			
REMARKS	Rock quality may make site unsuitable. Difficult to maintain access all year - possible seasonal operation.				

GULL CREEK QUARTZITE

SITE 4

6.1.5 Site 4, Gull Creek Quartzite

The Gull Creek quartzite prospect lies within 2 km of the East Channel in an area of subdued outcrop rising some 75 m above the surrounding delta. The area has an irregular topography with isolated bedrock ridges, coarse felsenmeer and small lakes. The extent of undisturbed outcrop is limited to benched ridges around small hills, the majority of the area being covered either by blocky felsenmeer up to 24 cu. m in volume or organic material and stunted trees.

No areas were observed where intact bedrock gave evidence that this prospect could provide quantities of armour stone, although the site would be rated as an excellent riprap source. The block sizes encountered while traversing the area varied considerably from .006 cu. m to 24 cu. m in volume which attest to the variability of the quartzite material. Such variation would be highly undesirable in an armour stone quarry where uniformity is an advantage in generating large block sizes.

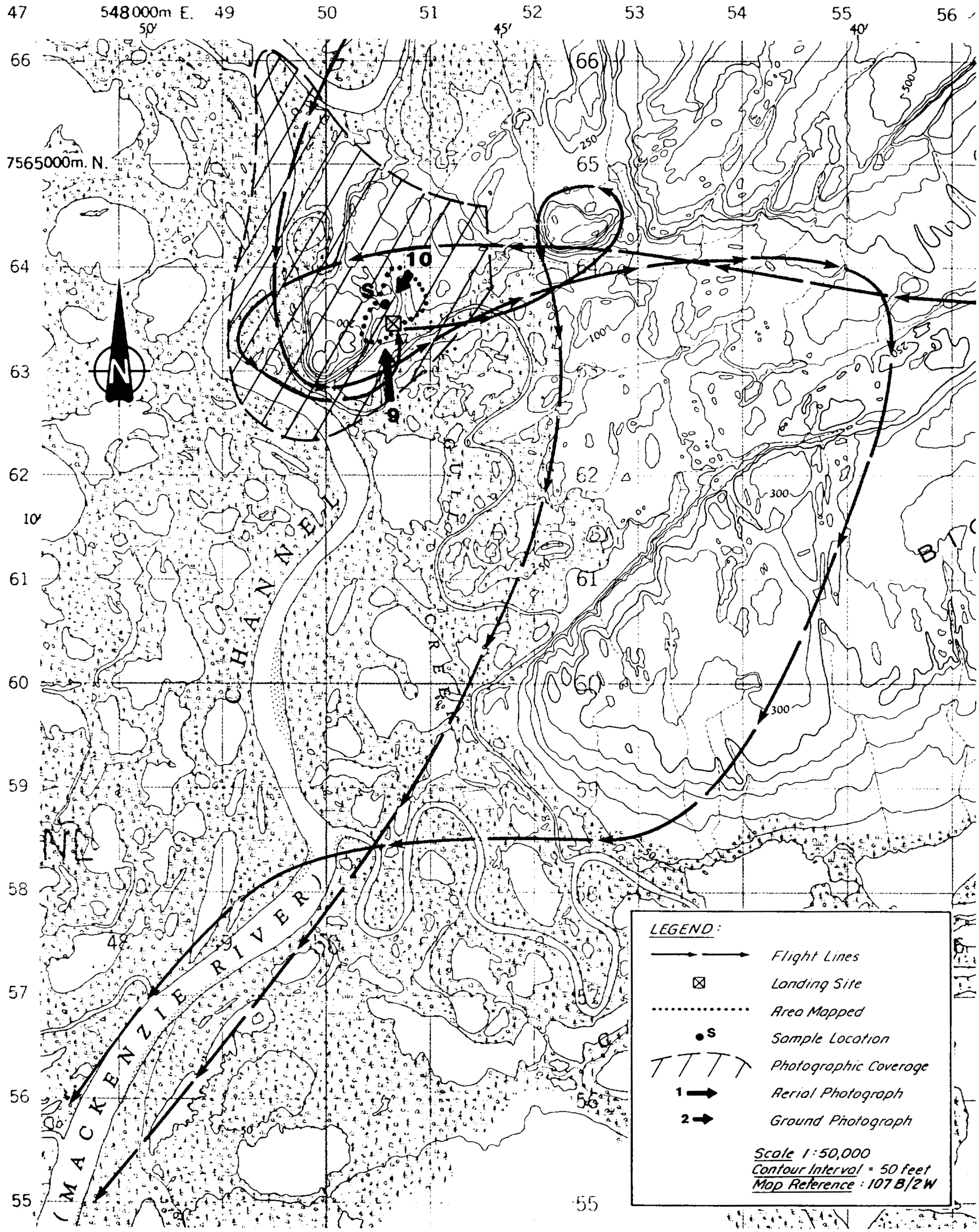
This site was given an overall rating by EBA (1983) as "Good" with a strong suggestion that good quality armour stone could be won for marine construction. It is noted, however, that this assessment was based on aerial reconnaissance only. EBA (1976) suggested that the quartzite was of inferior quality to the nearby dolomite based on cementation and jointing.

Although the quality of the rock material has proven itself in laboratory testing, block sizes found on the ground, and outcrop limitations lead to the conclusion that the deposit may not be able to provide armour stone in great quantities. The site would be technically feasible to develop for riprap, blast rock, general fill and aggregate. Barge and winter road access to Inuvik would be comparatively easy to establish and product delivery would be less expensive than other sites in the vicinity.

The major limitations to the Gull Creek quartzites lie in the slightly inferior quality of product, and the lower potential for supplying the better grades of rock compared with the nearby dolomites.

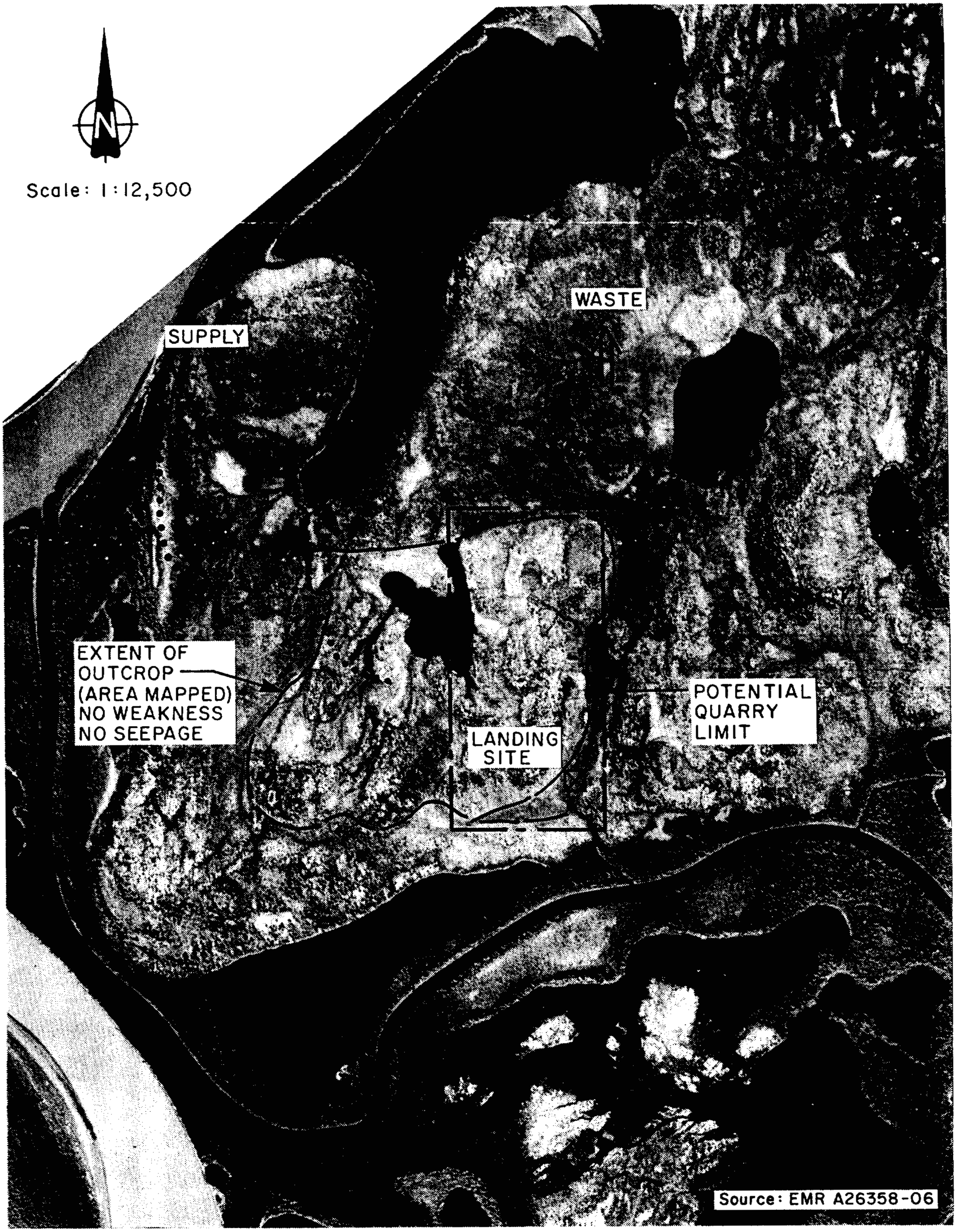
SITE 4 - GULL CREEK QUARTZITE

Figure 4-1



PROJECT NO. 862-1806 DRAWN G.H. REVIEWED DATE Mar. '87

SITE 4 - GULL CREEK QUARTZITE	Figure 4-2



PROJECT NO. 862-1806 DRAWN BAD REVIEWED .... DATE June '87

PHOTOGRAPH 9: AERIAL VIEW OF GULL CREEK QUARTZITE LOOKING NW

PHOTOGRAPH 10: LARGE BLOCKS ON EAST SLOPE OF GULL CREEK QUARTZITE

DSS/QUARRIES/BEAUFORT 862-1806 ROCK MASS DESCRIPTION
FIELD CHECKLIST - ALL ENTRIES TO BE COMPLETED

MAPPED BY DFW/RSR

SITE NUMBER 4 Gull Creek (quartzite), N.W.T.

DATE 02-Oct-86

LOCATION Immediately E of south end of V shaped lake

- -

LOCALITY TYPE Bedrock Quartzitic Sandstone
felsenmeer yes colluvium no moraine no
SIZE 300 metres X 600 metres horizontal

ELEVATION RANGE 15 metres to 45 metres

- -

IMAGE Sketch no no. of photos 13 land, 6 air
Air photos yes sequence A26723/117-119 A26723/142-144
Land photos yes sequence 0105-0109, 0201-0203, 0819-0822, 1207

- -

SAMPLE Location E facing ridge in low hills
Size 33 kg

- -

ROCK MATERIAL Colour light pinkish grey with local limonite spotting to 1 mm
Grain size <1 mm
Weathering slight in outcrop
Strength strong-v.strong field est.
ROCK TYPE Quartzitic SANDSTONE

- -

ROCK MASS Fabric blocky in outcrop, massive felsenmeer

Block size	- minimum	0.1 m X	0.2 m X	0.3 m
	- maximum	2 m X	3 m X	4 m
	- average	0.5 m X	0.7 m X	0.8 m

Discontinuity	- set 1	84/138	orient.	0.2 - 1 m.	spacing	Joint
	- set 2	84/243	orient.	1 - 4 m.	spacing	Joint
	- set 3	05/048	orient.	0.3 - 2 m.	spacing	Bedding

Convention used Dip/Dip direction (true north)

Significant weakness None apparent

Seepage None apparent

- -

COMMENTS Easily accessible from East Channel.

DSS/QUARRIES/BEAUFORT 862-1806 QUARRY DESIGN PARAMETERS

FIELD CHECKLIST - ALL ENTRIES TO BE COMPLETED

MAPPED BY DFW/RSR

SITE NUMBER 4 Gull Creek (Quartzite), N.W.T. DATE 02-Oct-86

LOCATION	Local topography	Fairly level-topped hill			>200 m2
	Deposit topography	Smooth hill, benched ridge			200 m2
	Deposit orientation	NE-SW			azimuth
ACCESS	Personnel/supplies	34 km dist.	S direction	Good rating	Inuvik
	Product/delivery	205 km dist.	N direction	Poor rating	Tuktoyaktuk
	Distance to tidewater	205 km dist.	N direction	Poor rating	Tuktoyaktuk
	Distance to barge	1.2 km dist.	W direction	Good rating	Inuvik
OVERBURDEN	Type(s)	Organic			
	Extent - depth	< 0.2 m est.			
	area	180,000 m2 est.			
	Disposal area(s)	300,000 m2 est.		NE location	
QUARRY	Size	180,000 m2 est.			
	Depth	30 m est.			
	Working space	250,000 m2 est.		E location	
	Stockpile space	300,000 m2 est.		E location	
	Facilities	To N or E			
	Camp	Unlikely - Inuvik			
HYDROLOGY	Surface water	300,000 m3 est.	lake to be drained	location	
	Pit drainage	Minimal vol. est.	---	location	
	Water supply	1,600,000 m3 est.	lake to S	location	
PERMAFROST	Evidence	Swampy lowland, stunted trees		location	
	Potential change	Access			
CONSTRAINTS	Environmental	Proposed GNWT park, Norris camp		type	
	Archeological	Possible		type	
	Recreational	Possible hunting park		type	
	Proximity to water	1.2 km est.		W direction	
	Wildlife observed	Falcon, swans		type	
	Reclamation	East facing, hidden by hills			
	Restoration	East facing, hidden by hills			

REMARKS Develop quarry from North. Drain V-shaped lake.
Access to East Channel over rock.

GULL CREEK DOLOMITE

SITE 5

6.1.6 Site 5, Gull Creek Dolomite

An isolated "butte"-like outcrop at the east end of the dolomite exposures north of Gull Creek shows evidence of being capable of supplying large quantities of all grades of rock. The butte, which rises over 100 m above the topography to the west and south, is approximately 2.5 km east of the East Channel of the Mackenzie River, and some 28 km south of Inuvik.

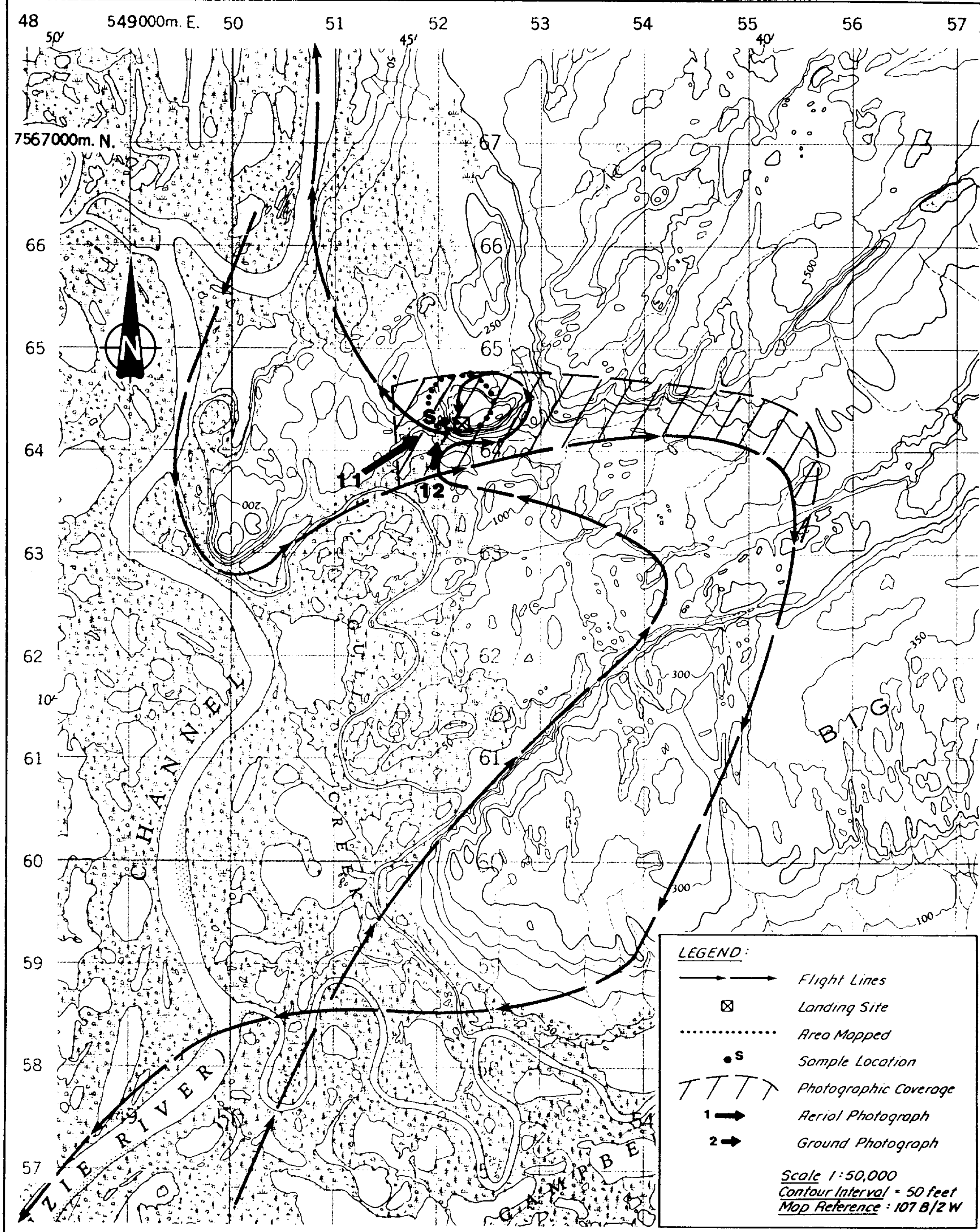
Cliffs up to approximately 50 m in height surround most of the butte, with talus slopes below. The outcrop is approximately 700 m east-west by 400 m north-south. Blocks in the colluvium at the toe of the cliffs were estimated to reach 4 m x 4 m x 3 m in size which attests well to the intact strength and low degree of jointing to be found in the crystalline dolomite, in addition to the long term durability and weathering resistance.

The site could be developed with benching operations being carried out from the flat upper surface of the outcrop. There would be a short haul to the east channel of the MacKenzie for trans-shipment to small barges or winter haul trucks. This site is one of the more favourable for potential development as it appears that all grades could be produced from one quarry, aesthetic screening could be achieved, water supply is close at hand without drainage being a problem, and an all-weather road could be developed to the barge site without major permafrost impact. Further, easy assess could be achieved from Inuvik, thereby negating the need for a camp at the site. The length of the shallow barge haul, however, would need to be considered further, as would the required rehandling to ocean-going vessels at Tuktoyaktuk.

The Gull Creek area was assessed by Imperial Oil in 1976 to evaluate potential riprap quarry sites in the Campbell Lake area. An aerial overview in the present study led to the conclusion that the site selected by Imperial Oil as a potential riprap source would not be able to provide large volumes of armour stone and an alternative source location was investigated by Golder. The outcrop descriptions in Imperial Oil's report for the dolomite rock mass indicated that their proposed sites would be less suitable than the one suggested here for producing the full range of rock grades required.

SITE 5 - GULL CREEK DOLOMITE

Figure **5-1**



PROJECT NO. 862-1806 DRAWN G.R. REVIEWED DATE Mar. '87

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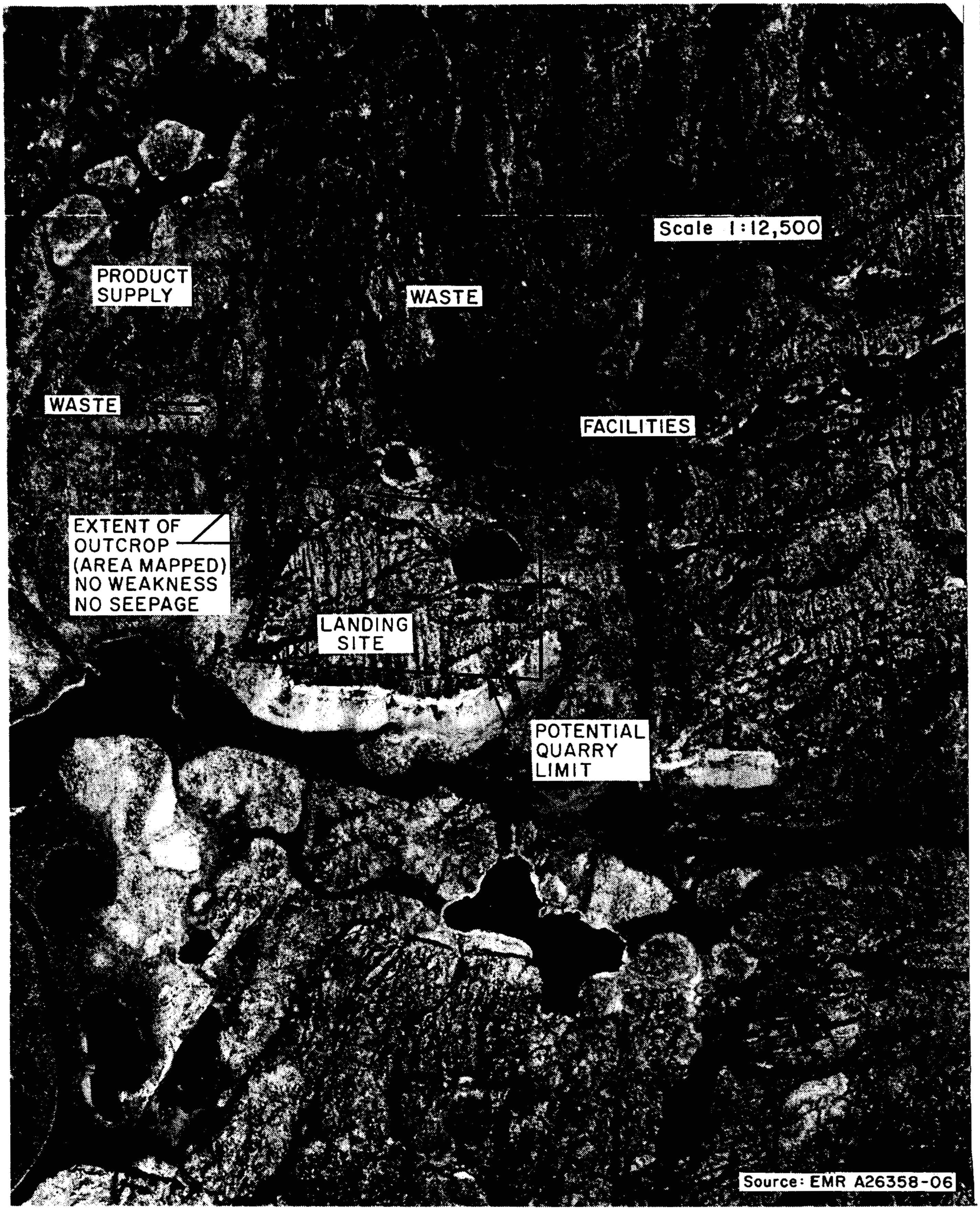
SITE 5 - GULL CREEK DOLOMITE

Figure **5-2**



PROJECT NO. 862-1806 DRAWN BAD REVIEWED ...... DATE June '87

PHOTOGRAPH 11: AERIAL VIEW OF GULL CREEK DOLOMITE LOOKING N

PHOTOGRAPH 12: BLOCKS IN TALUS BELOW GULL CREEK DOLOMITE CLIFFS

DSS/QUARRIES/BEAUFORT 862-1806 ROCK MASS DESCRIPTION
FIELD CHECKLIST - ALL ENTRIES TO BE COMPLETED

MAPPED BY DFW/RSR

SITE NUMBER 5 Gull Creek (dolomite), N.W.T

DATE 29-Sep-86

LOCATION W facing bluff NE of Gull Creek, talus at base

LOCALITY TYPE	Bedrock Dolomite with calcite xenocrysts				
	felsenmeer no	colluvium yes	to 4 m3	moraine no	
SIZE		200 metres X	50 metres	outcrop vertical surface	
		0 metres to	50 metres	talus	
ELEVATION RANGE		50 metres to	100 metres	bluff	

IMAGE	Sketch	no	no. of photos	40 land, 6 air
	Air photos	yes	sequence	A26723/117-119 A26723/142-144
	Land photos	yes	sequence	0110-0116, 0124, 0204-0205, 0220-0225, 0301 0400-0407, 0818, 1209-1222

SAMPLE
Location Base of talus slope near lake
Size 36 kg

ROCK MATERIAL	Colour	light pinkish grey
	Grain size	0 - 2 mm
	Weathering	slight at surface (0.5 mm)
	Strength	strong-v.strong field est.
	ROCK TYPE	DOLOMITE with calcite xenocrysts

ROCK MASS
Fabric massive to blocky

Block size - minimum	0.1 m X	0.1 m X	0.1 m
- maximum	4 m X	4 m X	3 m
- average	0.75 m X	0.75 m X	0.75 m

Discontinuity - set 1	85/293	orient.	4 - 10 m. spacing	Joint
- set 2	79/218	orient.	"	Joint
- set 3	74/340	orient.	"	Joint
- set 4	09/136	orient.	"	Bedding

Convention used Dip/Dip direction (true north)

Significant weakness None

Seepage None

COMMENTS
Develop from North, screened by other outcrop to west.
From air photos, strong lineation at --/253.
Second lineation at --/329.

DSS/QUARRIES/BEAUFORT 862-1806 QUARRY DESIGN PARAMETERS
FIELD CHECKLIST - ALL ENTRIES TO BE COMPLETED

MAPPED BY DFW/RSR

SITE NUMBER 5 Gull Creek (Dolomite), N.W.T. DATE 29-Sep-86

LOCATION	Local topography	Bluff to 100m, low hills to 50m		>200 m2	
	Deposit topography	Bluff to 100m with talus below		200 m2	
	Deposit orientation	80/260		azimuth	
ACCESS	Personnel/supplies	28 km dist.	N direction	Good rating	Inuvik
	Product/delivery	200 km dist.	N direction	Poor rating	Tuktoyaktuk
	Distance to tidewater	200 km dist.	N direction	Poor rating	Tuktoyaktuk
	Distance to barge	2.5 km dist.	NW direction	Good rating	East Channel
OVERBURDEN	Type(s)	Talus or none			
	Extent - depth	5 m est.			
	area	30,000 m2 est.			
	Disposal area(s)	250,000 m2 est.		SW location	
QUARRY	Size	40,000 m2 est.			
	Depth	100 m est.			
	Working space	200,000 m2 est.		West location	
	Stockpile space	200,000 m2 est.		West location	
	Facilities	To west if needed			
	Camp	To west if needed			
HYDROLOGY	Surface water	None vol. est.	---	location	
	Pit drainage	None vol. est.	free drain to lake	location	
	Water supply	No limit vol. est.	lake or Gull Creek	location	
PERMAFROST	Evidence	Stunted trees, insulated ground cover		location	
	Potential change	None			
CONSTRAINTS	Environmental	IBP zone		type	
	Archeological	Possible		type	
	Recreational	Possible		type	
	Proximity to water	150 m est.	towards SW	direction	
	Wildlife observed	Raven, woodpecker, grey jay, geese, rabbits		type	
	Reclamation	As current bluffs, benches, talus			
	Restoration	As current bluffs, benches, talus			

REMARKS Screened by natural bluffs and talus. Access across rock.

DELTA OUTLIERS

SITE 6

6.1.7 Site 6, The Delta Outliers

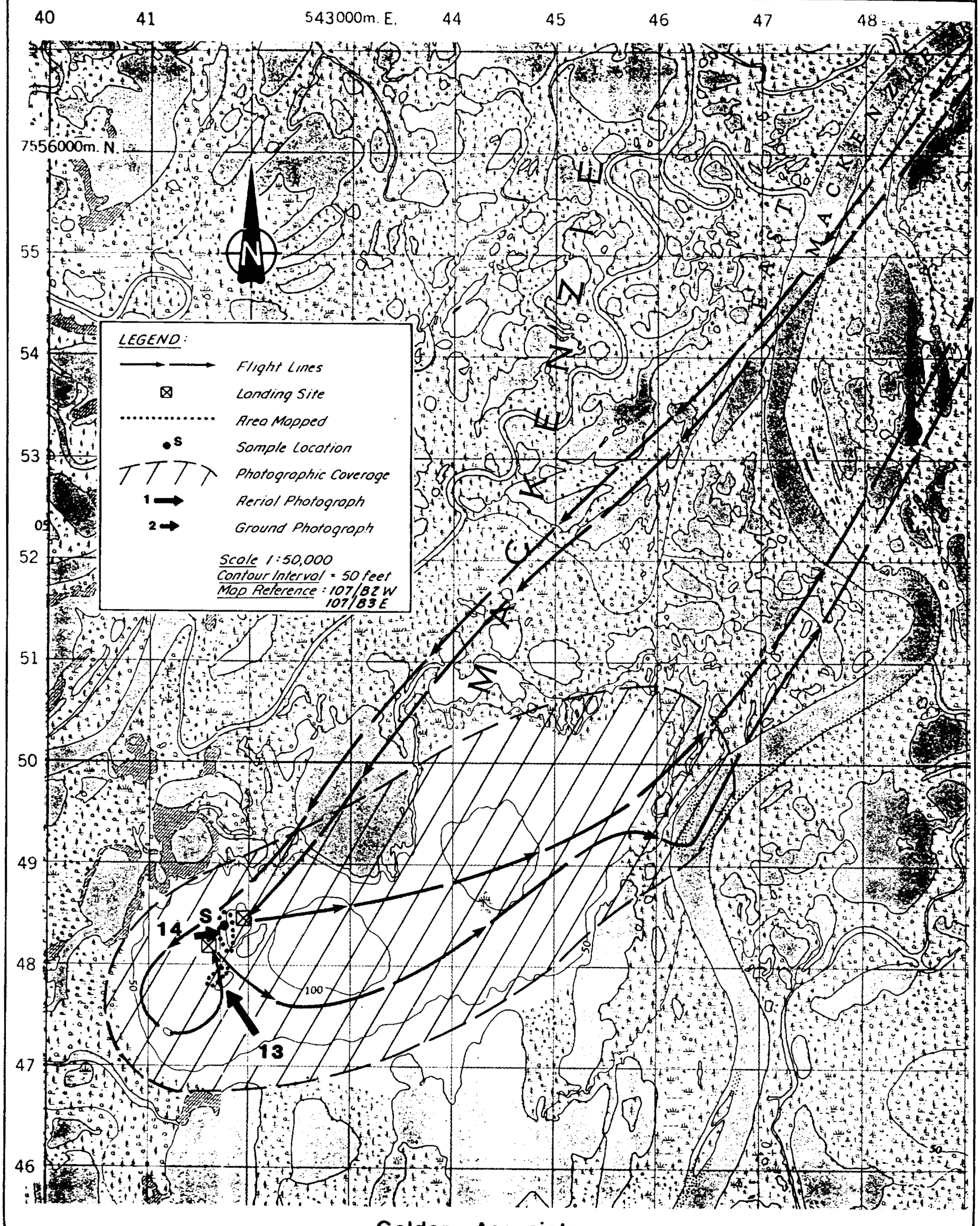
Some 15 km southwest of the Gull Creek area are a few isolated bedrock outliers within the Mackenzie Delta. These were appraised by Imperial Oil and EBA in 1976, although it is not believed that the largest outlier was visited in either study. The outcrop referred to as Site 6 has up to 30 m of subdued relief above the surrounding delta adjoining three small lakes and interlying swamp. Drainage and dewatering would be required for any large-scale quarrying operation on the outlier.

The rock mass is of questionable quality with interbeds of argillaceous material in some outcrops and thin bedding in other locations. The micritic limestone of the outliers would not lend itself to quarry development to acquire the grades of rock required for the current study. Low relief means that ground water issues become very important, including pre-development drainage, quarry inflow, and possible flooding in extreme cases. The rock material did not perform well in laboratory testing, and one sample arrived in Vancouver as broken detritus from a large block selected in the field. This was shipped by air freight so handling and transport disturbance is likely to have been minimal.

The site appears to have been selected as an alternative to the Gull Creek sites since the outliers are located outside the proposed GNWT park and the proposed IBP site. This site does not appear to represent a feasible or suitable prospect at this time.

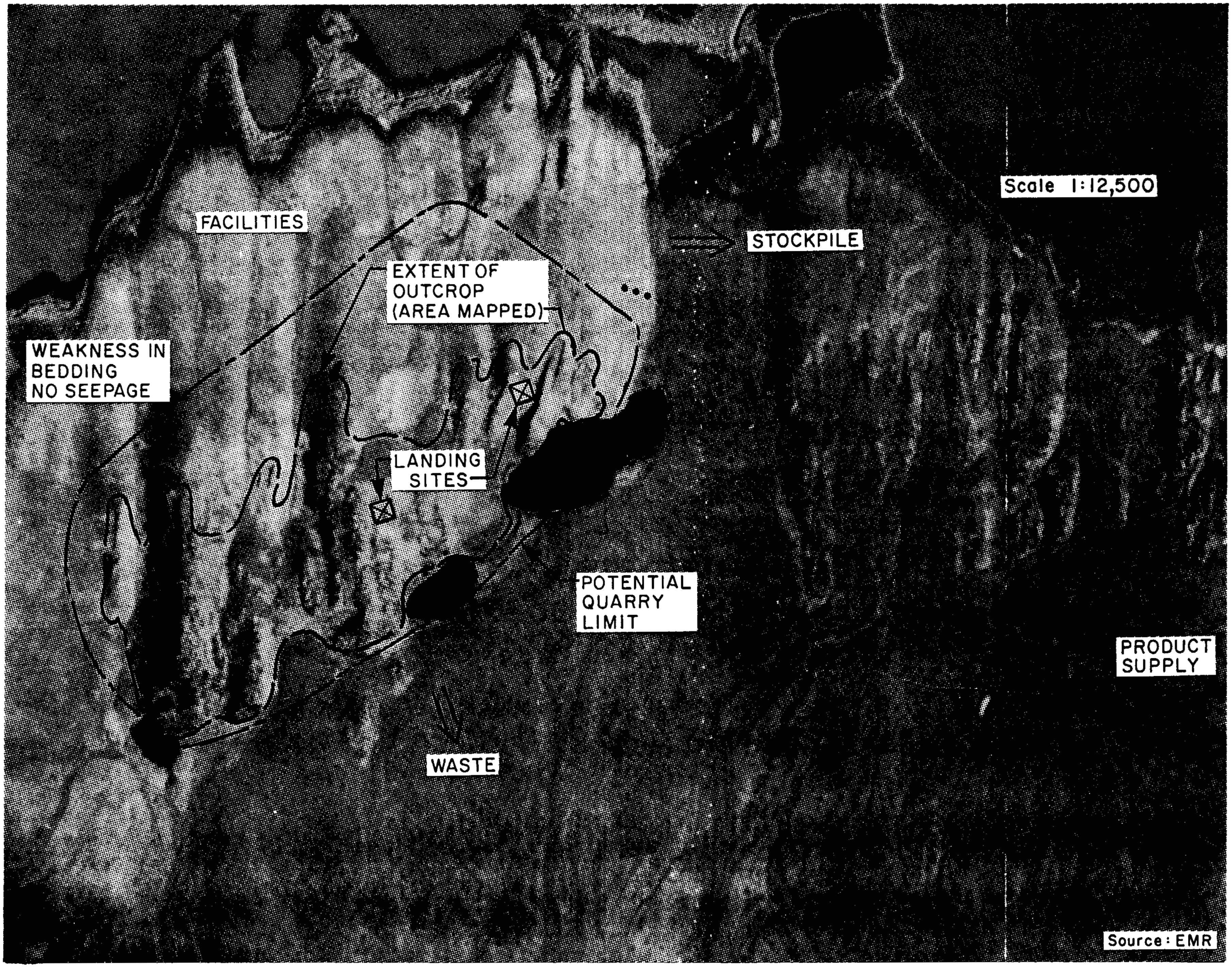
SITE 6 - DELTA OUTLIERS

Figure **6-1**



PROJECT NO. 862-1806 DRAWN G.A. REVIEWED .... DATE Mar. '87

PROJECT NO. 862-1806 DRAWN BAD REVIEWED .... DATE June '87



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SITE 6 – DELTA OUTLIERS

Figure 6-2

PHOTOGRAPH 13: AERIAL VIEW OF DELTA OUTLIERS LOOKING NE

PHOTOGRAPH 14: BEDDED LIMESTONE OUTCROP OF DELTA OUTLIERS

DSS/QUARRIES/BEAUFORT 862-1806 ROCK MASS DESCRIPTION
FIELD CHECKLIST - ALL ENTRIES TO BE COMPLETED

MAPPED BY DFW/RSR

SITE NUMBER 6 Delta Outliers, N.W.T.

DATE 01-Oct-86

LOCATION N trending ridge near NE lake on outlier

LOCALITY TYPE	Bedrock	Shelly Limestone				
	felsenmeer no		colluvium minor		moraine no	
SIZE			300 metres X	10 metres	vertical	
ELEVATION RANGE			15 metres to	30 metres		

IMAGE	Sketch	no	no. of photos	17 air, 18 land
	Air photos	yes	sequence	A23016/10-13,113-116 A26723/33-36,57-61
	Land photos	yes	sequence	0117-0123, 0206-0216

SAMPLE Location Rock Face
Size 36 Kg

ROCK MATERIAL	Colour	light grey		
	Grain size	very fine		
	Weathering	slight		
	Strength	mod. strong	field est.	in outcrop
	ROCK TYPE	LIMESTONE/shelly LIMESTONE		

ROCK MASS Fabric massive to blocky, few blocks developed on colluvium

Block size - minimum	0.3 m X	0.2 m X	0.1 m
- maximum	2 m X	1 m X	1 m
- average	0.7 m X	0.7 m X	0.4 m

Discontinuity - set 1	79/001	orient.	2 - 10 m.	spacing	Joint
- set 2	89/274	orient.	1 m.	spacing	Joint
- set 3	09/204	orient.	0.1 - 2 m.	spacing	Bedding

Convention used Dip/Dip direction (true north)

Significant weakness Weak bedding

Seepage None observed

COMMENTS Hydrogen sulphide smell when broken. Shell fragments noticeable in rock.
Some calcite healed joints in J1.

DSS/QUARRIES/BEAUFORT 862-1806 QUARRY DESIGN PARAMETERS

FIELD CHECKLIST - ALL ENTRIES TO BE COMPLETED

MAPPED BY DFW/RSR

SITE NUMBER	6a Delta Outliers, N.W.T.		DATE	29-Sep-86		
LOCATION	Local topography	Low hills, low ridges 10 - 20 m			>200 m2	
	Deposit topography	Steep bluff to lake, low hill above <10m			200 m2	
	Deposit orientation	Bluff faces SE on NW of lake			azimuth	
ACCESS	Personnel/supplies	54	km dist.	N direction	Fair rating	Inuvik
	Product/delivery	225	km dist.	N direction	Poor rating	Tuktoyaktuk
	Distance to tidewater	225	km dist.	N direction	Poor rating	Tuktoyaktuk
	Distance to barge	5	km dist.	E direction	Fair rating	East Channel
OVERBURDEN	Type(s)	Local organic soil cover, trees to 0.2 m dia. x 10 m				
	Extent - depth	0.4 m meas.	<1 m estimated			
	area	1,000,000 m2 meas. covers dpposit to NW				
	Disposal area(s)	No limit m2 est. to NE or SW of lake			location	
QUARRY	Size	1,000,000 m2 est.				
	Depth	10 to 15 m est.				
	Working space	4,000,000 m2 est.		To East	location	
	Stockpile space	4,000,000 m2 est.		To East	location	
	Facilities	Inuvik or to East				
	Camp	Possibly to East				
HYDROLOGY	Surface water	None vol. est.			location	
	Pit drainage	Pumping vol. est.	local lake		location	
	Water supply	No limit vol. est.	East Channel		location	
PERMAFROST	Evidence	Stunted trees, soft ground cover, well insulated				
	Potential change	No major change				
CONSTRAINTS	Environmental	Low topography, access			type	
	Archeological	Unlikely			type	
	Recreational	Unlikely			type	
	Proximity to water	3 km est.		East	direction	
	Wildlife observed	Swans			type	
	Reclamation	Highly visible from air				
	Restoration	Highly visible from air				
REMARKS	Typical of three lake slopes. Rock constrictions in river channel.					

DSS/QUARRIES/BEAUFORT 862-1806 QUARRY DESIGN PARAMETERS
FIELD CHECKLIST - ALL ENTRIES TO BE COMPLETED

MAPPED BY DFW/RSR

SITE NUMBER 6b Delta Outliers, N.W.T. DATE 01-Oct-86

LOCATION	Local topography	Rounded hills			>200 m2	
	Deposit topography	Small ridge			200 m2	
	Deposit orientation	N-S			azimuth	
ACCESS	Personnel/supplies	54 km dist.	N direction	Fair rating	Inuvik	
	Product/delivery	225 km dist.	N direction	Poor rating	Tuktoyaktuk	
	Distance to tidewater	225 km dist.	N direction	Poor rating	Tuktoyaktuk	
	Distance to barge	5 km dist.	E direction	Fair rating	East Channel	
OVERBURDEN	Type(s)	Colluvium, organics				
	Extent - depth	<0.5 m est.				
	area	90,000 m2 est.				
	Disposal area(s)	15,000 m2 est.		West location		
QUARRY	Size	90,000 m2 est.				
	Depth	10 m est.				
	Working space	20,000 m2 est.		East location		
	Stockpile space	40,000 m2 est.		East location		
	Facilities	NW				
	Camp	Unlikely - Inuvik				
HYDROLOGY	Surface water	100,000 m3 vol. est.	East adjoining lake	location		
	Pit drainage	Pumping vol. est.	seepage	location		
	Water supply	100,000 m3 vol. est.	East adjoining lake	location		
PERMAFROST	Evidence	Stunted trees				
	Potential change	Access				
CONSTRAINTS	Environmental	Unlikely			type	
	Archeological	Unlikely			type	
	Recreational	Unlikely			type	
	Proximity to water	3 km est.	East		direction	
	Wildlife observed	Swans, ducks			type	
	Reclamation	No problem				
	Restoration	No problem				
REMARKS	Typical of outliers					

DPW QUARRY

SITE X1

6.1.8 Site X1, Existing DPW Quarry

This quarry is located just east of a small ridge which runs northeast/southwest parallel to the eastern shoreline of Campbell Lake. It is the quarry which was referred to in the EBA (1976) report as Mile 948.5.

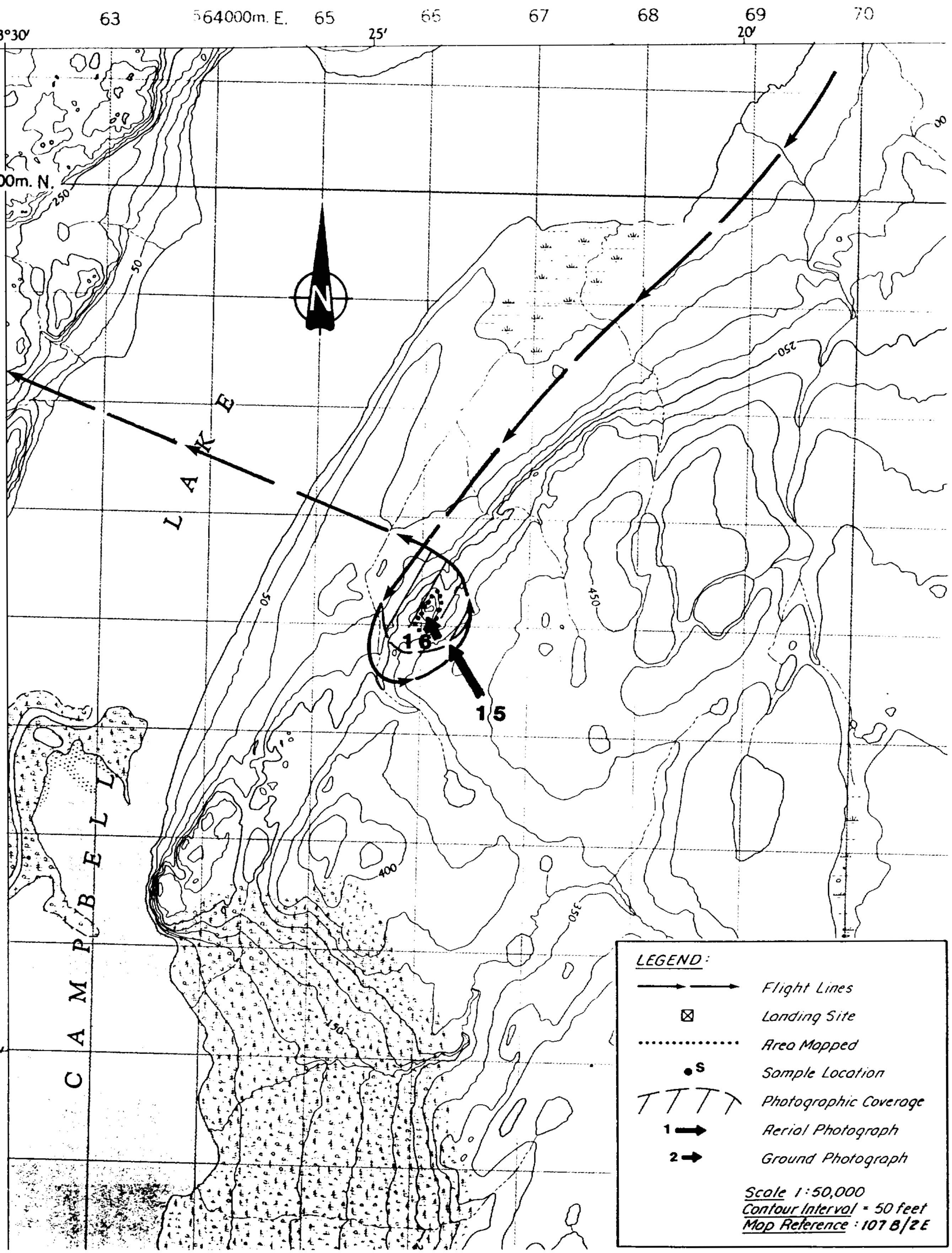
The rock mass is blocky with an average volume of about 0.3 cu. m, to a maximum of about 12 cu. m. It appears that overblasting led to the shattering of some rock, as shown by cracked blast hole traces and broken rock, and it is inferred that product requirements were for general fill and road stone. The limestone is believed to be formationally related to the delta outliers although in appearance, it is massive and dolomitic rather than friable and micritic in the outliers.

The local topography comprises rounded hills with outcrop of limestone near to their summits. Other potential quarry locations in these hills were reviewed by EBA (1976) when the DPW proposal was under review. It was suggested that the quarry could be extended "almost indefinitely" along the ridge. It is clear that this prospect was considered by EBA as a source of crushed rock only, although their rationale is not clear.

The existing pit has been benched into the ridge leaving a screening buffer to the west of the pit. This means that the only visible evidence of quarrying from the Dempster Highway is the small access road currently in existence. Further laboratory testing has been proposed to evaluate this site more fully.

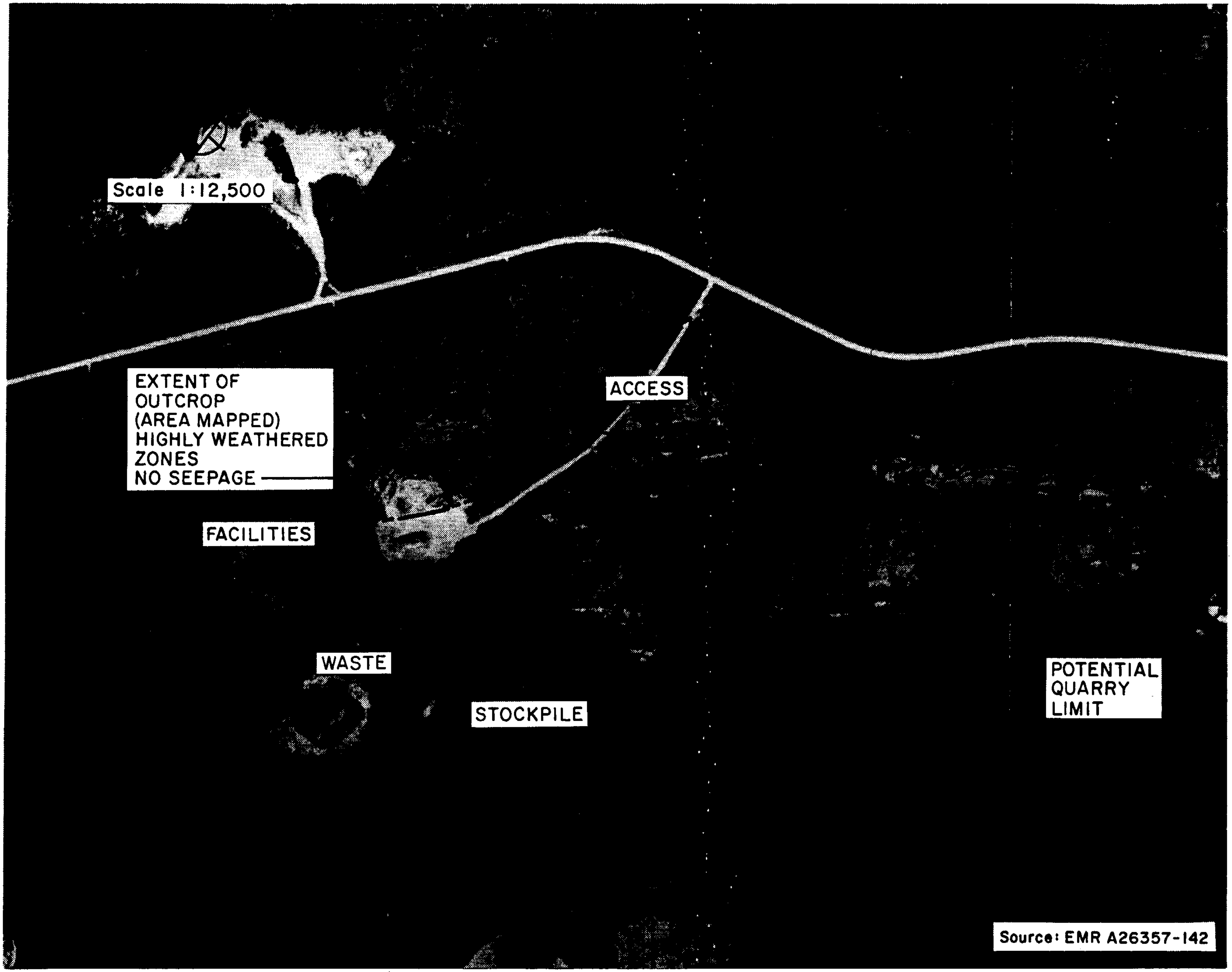
SITE X1 - EXISTING DPW QUARRY

Figure **X1-1**



PROJECT NO. 862-1806 DRAWN G.A. REVIEWED .... DATE Mar. '87

PROJECT NO. 867-1806 DRAWN BAD REVIEWED .... DATE June '87



SITE X1 – EXISTING DPW QUARRY

Figure X1-2

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PHOTOGRAPH 15: AERIAL VIEW OF EXISTING DPW QUARRY LOOKING W

PHOTOGRAPH 16: GROUND VIEW OF DPW QUARRY LOOKING W

DSS/QUARRIES/BEAUFORT 862-1806 ROCK MASS DESCRIPTION
FIELD CHECKLIST - ALL ENTRIES TO BE COMPLETED

MAPPED BY DFW/RSR

SITE NUMBER X1 Existing DPW Site, N.W.T.

DATE 03-Oct-86

LOCATION E of Campbell Lake

- -

LOCALITY TYPE Bedrock Limestone
felsenmeer no colluvium no moraine no
SIZE 250 metres X 30 metres vertical

ELEVATION RANGE 76 metres to 120 metres

- -

IMAGE	Sketch	yes	no. of photos	11 land
	Air photos	yes	sequence	---
	Land photos	yes	sequence	0807-0810, 1002-1005, 1202-1204

- -

SAMPLE Location None
Size ---

- -

ROCK MATERIAL	Colour	dark grey
	Grain size	very fine
	Weathering	faint with local highly weathered zones
	Strength	v. strong field est.
	ROCK TYPE	LIMESTONE

- -

ROCK MASS Fabric blocky

Block size - minimum	0.1 m X	0.2 m X	0.3 m
- maximum	2 m X	2 m X	3 m
- average	0.5 m X	0.75 m X	0.75 m

Discontinuity - set 1	82/249	orient.	2 - 3 m. spacing	Joint
- set 2	78/342	orient.	1.5 m. spacing	Joint
- set 3	09/087	orient.	0.1 - 2 m. spacing	Joint

Convention used Dip/Dip direction (true north)

Significant weakness Highly weathered zones

Seepage None apparent

- -

COMMENTS Good potential for expansion to ten times present size.

DSS/QUARRIES/BEAUFORT 862-1806 QUARRY DESIGN PARAMETERS

FIELD CHECKLIST - ALL ENTRIES TO BE COMPLETED

MAPPED BY DFW/RSR

SITE NUMBER X1 Existing DPW Site, N.W.T. DATE 03-Oct-86

LOCATION	Local topography	Rounded hills			>200 m2
	Deposit topography	Rounded hills			200 m2
	Deposit orientation	Quarry faces 128			azimuth
ACCESS	Personnel/supplies	39 km dist.	NW direction	Good rating	Inuvik
	Product/delivery	209 km dist.	N direction	Poor rating	Tuktoyaktuk
	Distance to tidewater	170 km dist.	N direction	Poor rating	Tuktoyaktuk
	Distance to barge	39 km dist.	NW direction	Good rating	Inuvik
OVERBURDEN	Type(s)	Stripped			
	Extent - depth	--- m est.			
	area	--- m2 est.			
	Disposal area(s)	100,000 m2 est.			SE location
QUARRY	Size	5,000 m2 est.			
	Depth	30 m est.			
	Working space	100,000 m2 est.			SE location
	Stockpile space	2,500 m2 est.			SE location
	Facilities	SE			
	Camp	None - Inuvik			
HYDROLOGY	Surface water	None vol. est.			location
	Pit drainage	None vol. est.			location
	Water supply	No limit vol. est.	West - Campbell Lake		location
PERMAFROST	Evidence	On Dempster Highway			location
	Potential change	None			
CONSTRAINTS	Environmental	Screening to highway			type
	Archeological	Unlikely			type
	Recreational	Unlikely			type
	Proximity to water	1 km est.			NW direction
	Wildlife observed	None			type
	Reclamation	None if not fully developed			
	Restoration	None if not fully developed			
REMARKS	Existing stockpiles of finer material on site				

CAMPBELL PIT

SITE X2

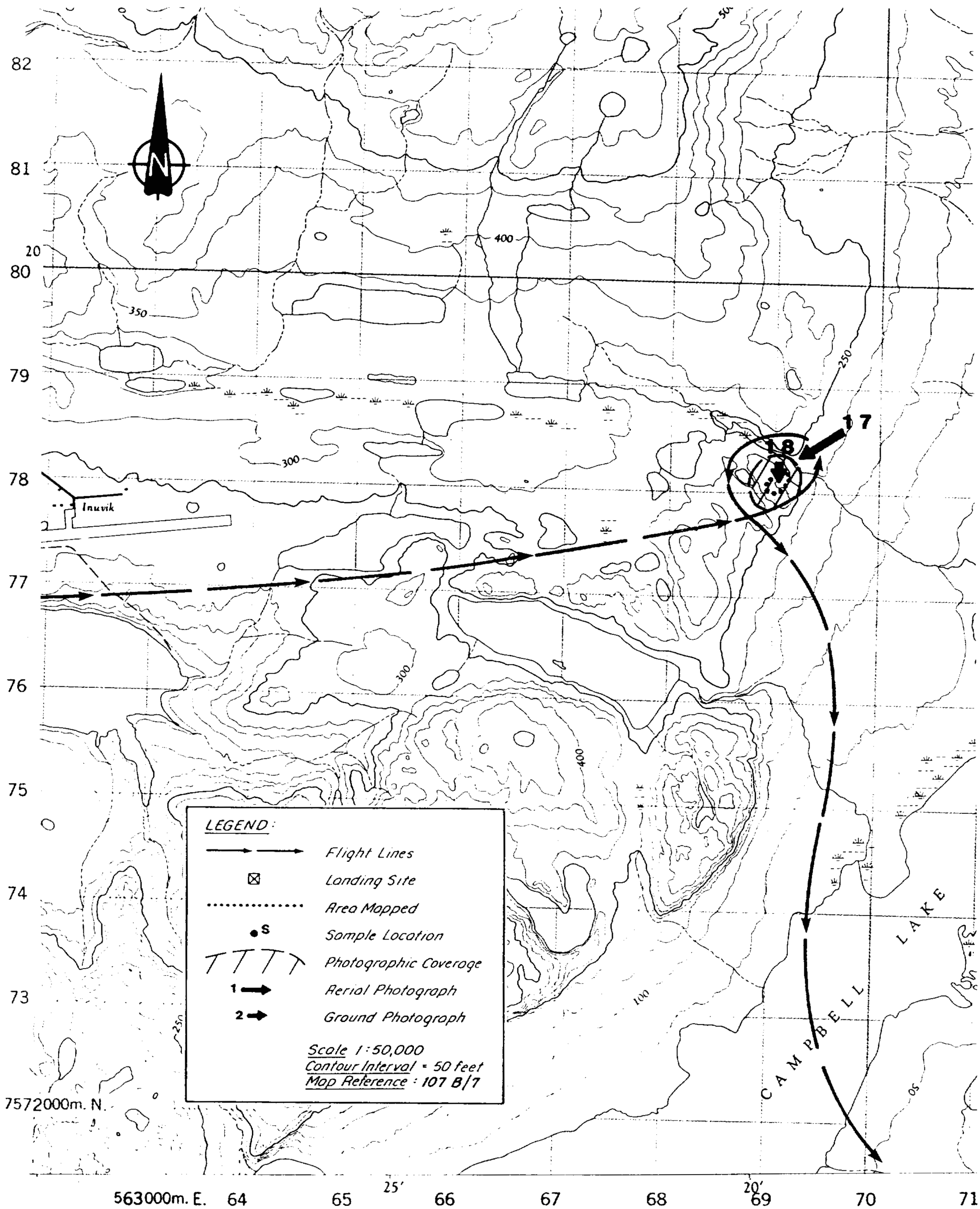
6.1.9 Site X2, Existing Campbell Pit

Located at the extreme northeast end of the Campbell Hills is the limestone quarry currently in operation by North Star Service and Constructon (Inuvik) Ltd. This quarry has been excavated into the dolomitic limestone of the Ogilvie Formation (EBA 1976) to generate blast rock which is crushed in pit for road stone. The bedding spacing varies from about 0.5 to 2 m which results in blasted block sizes ranging to 12 cu. m in size. The rock product appears to be durable and fairly resistant to weathering, although this has not been evaluated through laboratory testing. The quarry was in operation at the time of the field inspection and an examination was made from the quarry walls to avoid entering restricted areas.

The current quarry operations occupy some 20,000 m^2 with walls to 50 m high. Thus about 1 million cu.m. of rock is believed to have been excavated to this point, and it is estimated that less than 10 per cent of recoverable reserves have been exploited in the quarry thus far. Further reserves may be considered by deepening the quarry and using a ramped access. This quarry was also evaluated in the EBA (1976) study as "the Town Quarry" and it was recommended that approval be given for its expansion as a crushed rock source. The "bone pile" of oversize rock generated by blasting for crushed rock indicates that rip-rap and armour stone could be produced if blasting were redesigned. It has been proposed that consideration be given to further evaluation of this site as a potential for expansion either on its own or in combination with the DPW quarry.

SITE X2 - EXISTING CAMPBELL QUARRY

Figure **X2-1**



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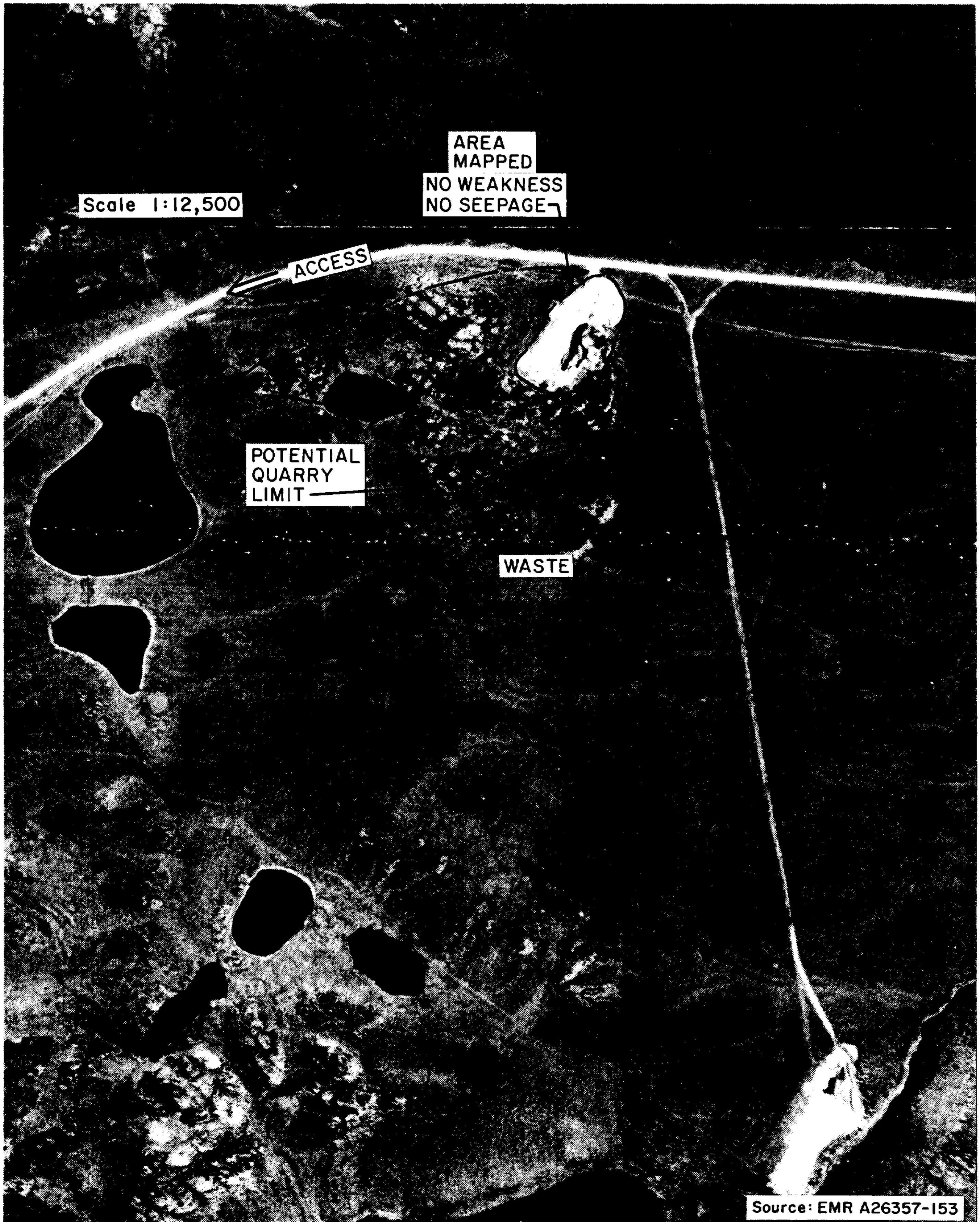
SITE X2 - EXISTING CAMPBELL PIT

Figure X2-2



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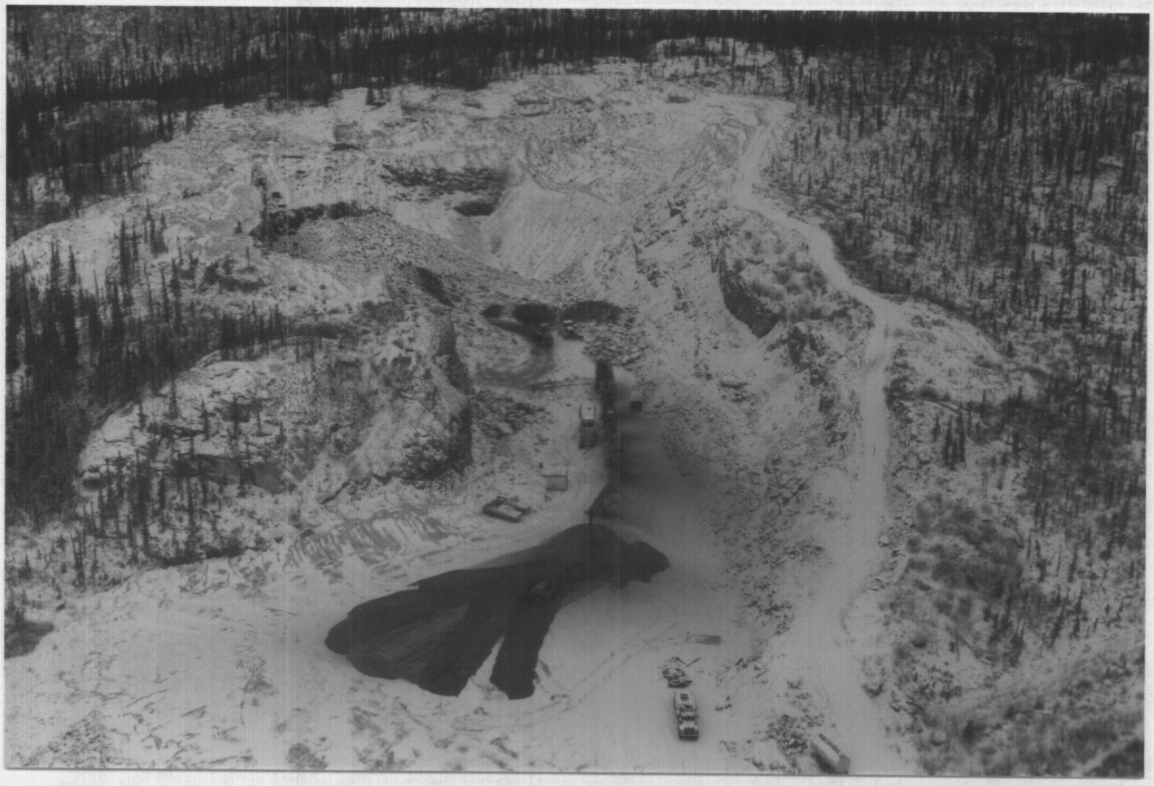

PHOTOGRAPH 17: AERIAL VIEW OF EXISTING CAMPBELL QUARRY LOOKING SW

PHOTOGRAPH 18: GROUND VIEW OF EXISTING CAMPBELL QUARRY LOOKING S

DSS/QUARRIES/BEAUFORT 862-1806 ROCK MASS DESCRIPTION
FIELD CHECKLIST - ALL ENTRIES TO BE COMPLETED

MAPPED BY DFW/RSR

SITE NUMBER X2 Existing Campbell Quarry, N W.T.

DATE 03-Oct-86

LOCATION NW end of Campbell Hills

- -

LOCALITY TYPE Bedrock Limestone
felsenmeer no colluvium no moraine no
SIZE 100 metres X 50 metres horizontal

ELEVATION RANGE 75 metres to 120 metres

- -

IMAGE	Sketch	yes	no. of photos	13 land
	Air photos	yes	sequence	---
	Land photos	yes	sequence	0803-0806, 1006-1011, 1123-1201

- -

SAMPLE Location None
Size ---

- -

ROCK MATERIAL	Colour	dark grey	
	Grain size	very fine	
	Weathering	slight - faint	
	Strength	v. strong	field est.
	ROCK TYPE	LIMESTONE	

- -

ROCK MASS Fabric blocky

Block size - minimum	0.1 m X	0.1 m X	0.1 m
- maximum	2 m X	2 m X	3 m
- average	0.7 m X	0.7 m X	1 m

Discontinuity - set 1	80/267 orient.	1 - 2 m. spacing	Joint
- set 2	90/176 orient.	1 - 2 m. spacing	Joint
- set 3	03/162 orient.	0.5 - 2 m. spacing	Joint

Convention used Dip/Dip direction (true north)

Significant weakness None apparent

Seepage None apparent

- -

COMMENTS Operating quarry.

DSS/QUARRIES/BEAUFORT 862-1806 QUARRY DESIGN PARAMETERS
FIELD CHECKLIST - ALL ENTRIES TO BE COMPLETED

MAPPED BY DFW/RSR

SITE NUMBER	X2 Existing Campbell Quarry, N.W.T.		DATE	03-Oct-86	
LOCATION	Local topography	Rounded hills		>200 m2	
	Deposit topography	Rounded hills		200 m2	
	Deposit orientation	Quarry faces 083		azimuth	
ACCESS	Personnel/supplies	23 km dist.	W direction	Good rating	Inuvik
	Product/delivery	193 km dist.	N direction	Poor rating	Tuktoyaktuk
	Distance to tidewater	170 km dist.	N direction	Poor rating	Tuktoyaktuk
	Distance to barge	23 km dist.	W direction	Good rating	Inuvik
OVERBURDEN	Type(s)	Stripped			
	Extent - depth	--- m est.			
	area	--- m2 est.			
	Disposal area(s)	40,000 m2 est.		E location	
QUARRY	Size	20,000 m2 est.			
	Depth	50 m est.			
	Working space	20,000 m2 est.		E location	
	Stockpile space	10,000 m2 est.		E location	
	Facilities	To East			
	Camp	Not necessary - Inuvik			
HYDROLOGY	Surface water	None vol. est.	---	location	
	Pit drainage	None vol. est.	---	location	
	Water supply	None vol. est.	---	location	
PERMAFROST	Evidence	No impact on site		location	
	Potential change	None			
CONSTRAINTS	Environmental	Restricted spring blasting - falcon's nest		type	
	Archeological	Unlikely		type	
	Recreational	Possible		type	
	Proximity to water	0.8 km est.		W direction	
	Wildlife observed	Falcon		type	
	Reclamation	Visible from airport			
	Restoration	Visible from airport			
REMARKS	Constraints refer to expansion of existing quarry				

6.2 Overall Comparative Rating

In order to arrive at an overall comparative rating of the sites in this study, consideration was given to the main objectives of the statement of work. The prime function was to technically evaluate the site conditions, deposit characteristics and rock properties in order to determine which potential sources could provide which rock grades. The visual assessments carried out in the field program were used to appraise rock fabric and block size, of particular concern for the larger grades of rock. Laboratory test results were consulted to verify that the rock materials could meet the required specifications for durability, strength and so on.

The qualitative evaluations shown in Tables 12 and 13, which are essentially summaries of the field sheets discussed in Section 3.2, were reviewed and refined using laboratory test results to produce Table 14, the overall rating. For example, during the field investigation, Mount Fitton was thought to be able to provide all grades of rock given in the proposal. As the other sites were visited, it became clear that, from a purely technical viewpoint, the Mount Fitton site showed more promise than any other in providing all grades of rock, with an estimated quarry size of 25 million cubic metres. Laboratory testing confirmed the quality of the material sampled, and the overall rating shown in the first parts of Table 12 is the result. By comparison, the west Delta roche moutonee appeared to be able to provide the stone grades required but was of questionable extent (some 125,000 cu. m). Further, laboratory testing gave unacceptable values of durability, and the overall ranking for this site is low.

TABLE 14

OVERALL COMPARATIVE RATING

SITE NUMBER	LOCALITY	ABILITY TO PROVIDE PRODUCT: ARMOUR STONE •	RIP-RIP	BLAST ROCK	GENERAL FILL	CONCRETE AGGREGATE	MATERIAL QUALITY: MATERIAL STRENGTH	DURAB'TY	BLAST'B'TY	CONSTRAINTS: POTEN'L QUANTITY	ACCESS	HYDROLOGY	WILDLIFE CONCERNS	OVERALL RANKING OF SITES
1	Mt. Fitton	4/4	4	4	4	3	3	4	4	4	2	4	2	1
2	Mt. Davies Gilbert	2/3	4	4	4	3	4	3	3	4	2	3	2	4
3	Mt. Gifford	3/2	3	4	4	3	3	2	3	3	2	3	2	5
3C	West Delta Roche Moutonee	3/1	3	4	4	3	3	1	3	1	3	2	3	6
4	Gull Creek Quartzite	4/3	4	4	4	3	4	4	3	2	3	3	2	3
5	Gull Creek Dolomite	4/4	4	4	4	3	3	4	4	4	3	3	2	2
6	Delta Outlier	1/1	2	3	4	3	3	1	3	3	3	1	3	7
X1	DPW Quarry	3/3	4	4	4	3	3**	3**	3	2	4	4	3	**
X2	Campbell Pit	3/3	4	4	4	3	3**	3**	3	2	4	4	3	**

NOTE: Significance Codes
1 = Unacceptable
2 = Poor
3 = Good
4 = Excellent

Comparative rating of prospects

• Significant code for armour stone also includes potential quantity, e.g. 3/1. Good prospect but unacceptable quantity of product.

** These sites have been evaluated semi-quantitatively pending laboratory testing.

The "ability to provide product" is based mainly on the rock mass description with some input from quarry design parameters, "material quality" has been assessed by combining the results of different laboratory tests, with blastability added from a subjective appraisal of the rock mass and laboratory test results. Potential quantity is addressed in 6.2.1 below.

From a technical viewpoint, a rock quarry could feasibly be developed at any one of the six sites included in the current program (Sites 1-6), the roche moutonee on the west Delta (Site 3C), the existing quarries on the Dempster Highway; the DPW quarry (Site X1) and the Campbell Pit (Site X2) to provide some of the range of rock grades required. However, it can be seen that Mount Fitton and the Gull Creek dolomite are the only sites which Golder believes can supply a large quantity of excellent quality armour stone.

Of prime importance in the evaluation of these sites is their ability to provide stone at the grades required by industry. At this time an exact specification in terms of volume required for each grade of rock is not available, see below. For this reason, the first section in Table 12 shows the relative ability of each site to produce the product. If a site can be exploited for the larger grades of rock, then the smaller fractions will also be available, and the potential quantity of lower grades of quarry stone are unlikely to present a major concern in the development. Although all prospects are physically able to supply blast rock, general fill and concrete aggregate grades of material, laboratory testing has ruled out two sites by reason of unacceptable results.

Material quality is appraised in the second section of Table 12 from which it may be seen that durability, in its broadest sense, is the only sensitive criterion with Sites 3C and 6 being unacceptable and Mount Gifford poor. All other sites present good or excellent evaluations of strength, durability and blastability.

The results of the laboratory testing showed that both Site 3C and Site 6 failed to produce specimens of rock which could successfully pass the full suite of tests carried out. Site 3C was unacceptable in Los Angeles abrasion and sodium sulphate soundness in addition to having a low unit weight and poor petrographic assemblage. Site 6 was also unacceptably high in weight loss under L.A. abrasion and performed poorly in petrographic analysis. Mount Davies Gilbert and the Gull Creek Quartzite (Sites 2 and 4) appear unable, at this stage of evaluation, to supply rock of a sufficient block size to produce armour stone, although in its unweathered condition away from the surface the rock mass may indeed be more massive.

Within the evaluation of constraints, access to the market, potential quantity, and to some extent hydrology concerns are permanent and are likely to have a strong impact on the development of the resource. Mount Fitton (Site 1) and the Gull Creek Dolomites (Site 5) are the two most likely sources from a technical point of view; Mount Fitton would require an extensive camp, an estimated 75 km haul to the coast and seasonal constraints to operation during caribou migration. By contrast, the Gull Creek Dolomite would have relatively easy product delivery to small barges on the East Channel of the Mackenzie which could be replaced by heavier haul trucks on an ice road during the winter season.

The two existing quarries, were mapped and evaluated using the same criteria as for the other sites, but were not evaluated from laboratory testing. They have produced rip-rap and armour stone sizes of blast rock, often unintentionally when blasting for smaller block sizes. The Dempster Highway is in existence close to both quarries and access to Tuktoyaktuk has already been established through Inuvik. Further evaluation of access routes to barge loading points is outside the scope of this study. The experience gathered by operation of these two quarries would assist in designing an expansion program for one or both quarries, and further drilling to test out reserves would be reasonably straightforward. It is not clear from reading previous reports exactly why this site was not considered as a source of rip-rap and armour stone, since both appear to be developable.

Laboratory work has been proposed for both of the existing quarries and the results of the additional study will be included as an addendum to this report.

6.2.1 Potential Quantity

In the Statement of Work, Task 4b, Golder was required to estimate total recoverable volumes of the various grades of material available at each source investigated in the field program. It became apparent that different sources could theoretically be quarried to recover almost limitless supplies of material, and input from industry would be required to determine a realistic cut-off to the maximum resource volume being considered. The task of investigating product demand in the future was not included in the scope of the present study; however, DIAND has provided Golder with some 1987 estimates. The design of further exploration studies, including drilling and test blasting, should only be carried out after a thorough evaluation of product requirements.

DIAND has suggested that preliminary estimates of a potential maximum armour rock requirement of up to 1.5 million cubic metres be considered. Further, they estimated that 20 per cent of a competent granitic rock mass and 10 per cent of a limestone or sandstone rock mass would provide armour rock. It is anticipated that most other grades of rock would be obtained from undersize waste in armour rock development and DIAND estimates a combined riprap/blast rock requirement of 1 million cubic metres and about 1.25 million cubic metres of general rockfill.

A large surface area will be required at any proposed source for stockpiling each of these grades of rock, for sorting and grading the blasted material and possibly for secondary treatment to acquire a particular grade of rock. The quarry sizes referred to in the field assessment sheets are based on a visual appraisal of the land form at each site, and at sites X1 and X2 the sizes reflect the current operation only. The following Table 15 has been drawn up from field sheets and topographic plans as being the best estimate of potential quarry size in the light of DIAND information. Estimates of percentage recovery of each rock grade cannot be made with any degree of confidence until a full-scale test blast has been carried out at a particular source.

TABLE 15

PRELIMINARY TOTAL AND RECOVERABLE VOLUMES
(in thousands of cubic metres)

Site	Name	Total	Armour Rock	Riprap	Blast Rock	General Fill	Concrete Aggregate
1	Mt. Fitton	25,000	5,000	5,000	5,000	5,000	5,000
2	Mt. Davies Gilbert	25,000	500	1,000	10,000	7,000	6,500
3	Mt. Gifford	18,000	400	800	5,000	6,000	5,000
3C	Roche Moutonee	125	40	30	25	30	-
4	Gull Creek Quartzite	5,400	500	1,000	1,500	2,000	400
5	Gull Creek Dolomite	28,000	5,600	5,600	5,600	5,600	5,600
6	Delta Outlier	15,000	600	500	5,000	5,000	4,350
X1	DPW Quarry	3,500	450	800	1,500	400	350
X2	Campbell Pit	5,000	500	1,000	2,000	1,000	500

These estimates have been used in the comparative ratings shown on Table 14.

7.0 CONCEPTUAL QUARRY DEVELOPMENT PLANS

Conceptual quarry plans have been established for the Mt. Fitton and Gull Creek Dolomite prospects as the most likely of the six original study sites to provide rock in all categories on the west and east sides, respectively of the Mackenzie delta. Further work on the DPW Quarry and the Campbell Pit is outside the scope of the current study, although they should be recognized as established sources of general fill and concrete aggregate.

The quarry designs in this study are intended to indicate general layouts only, and to form the basis for recommendations for more detailed studies as outlined in Section 8 below. The lack of detailed topographic plans, in particular, means that large scale pit designs and access routings cannot be established. In consequence, the plans have be formulated to show the general feasibility of operations, rather than forming designs upon which detailed cost estimates could be established.

7.1 Mt. Fitton Prospect

A granite intrusion outcrops across the crest of Mt. Fitton, which rises to an elevation of approximately 630 m. on the west side of the Blow River in the Yukon Territory, some 70 km. inland from Shingle Point on the coast of the Beaufort Sea. Outcrop of the granite is limited to tors on the crest of the rounded mountain. However, all available data suggests that the granite underlies colluvium over the top of the mountain, but is in faulted contact with Palaeozoic and Cretaceous sediments on the eastern flank, see Figure 3.

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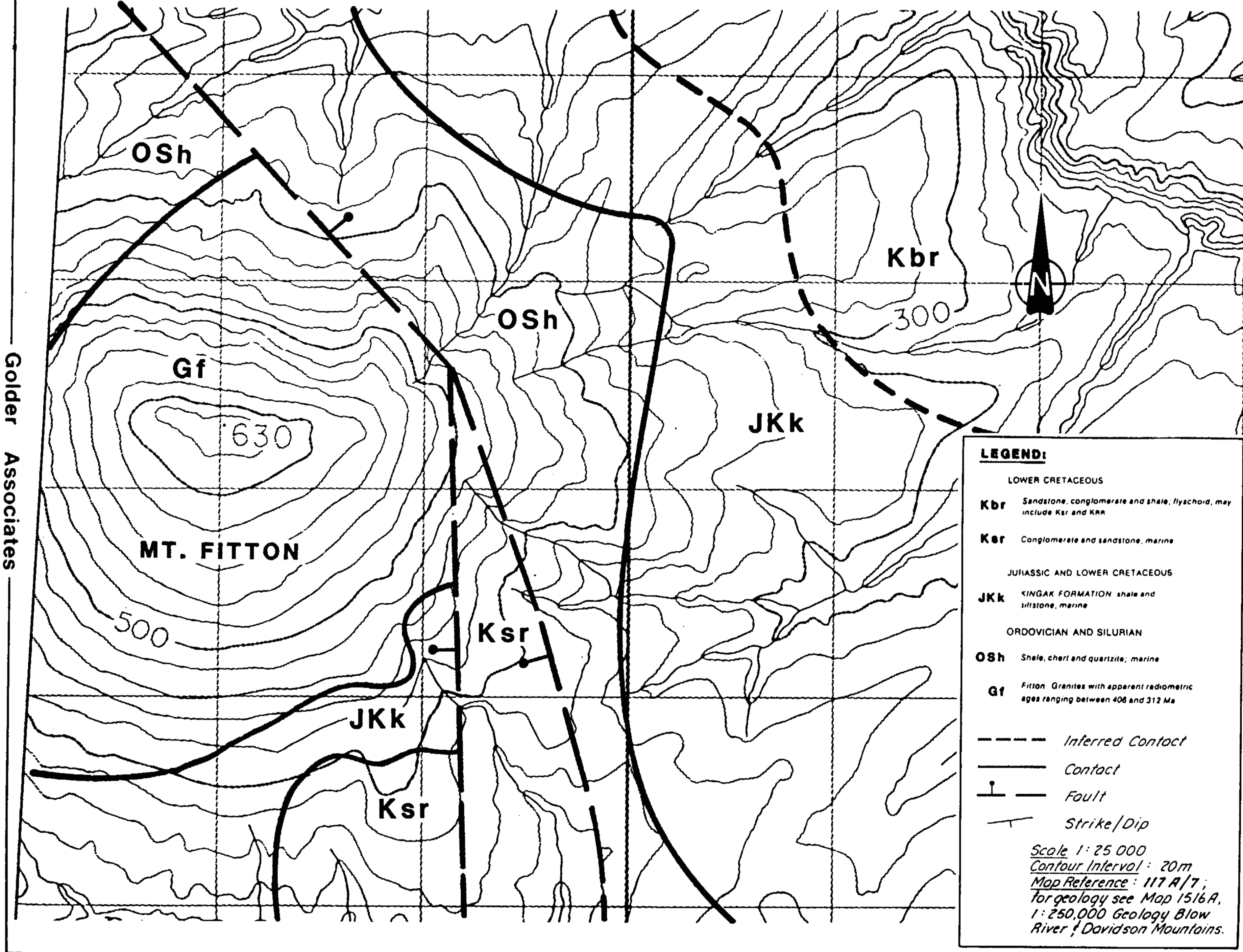

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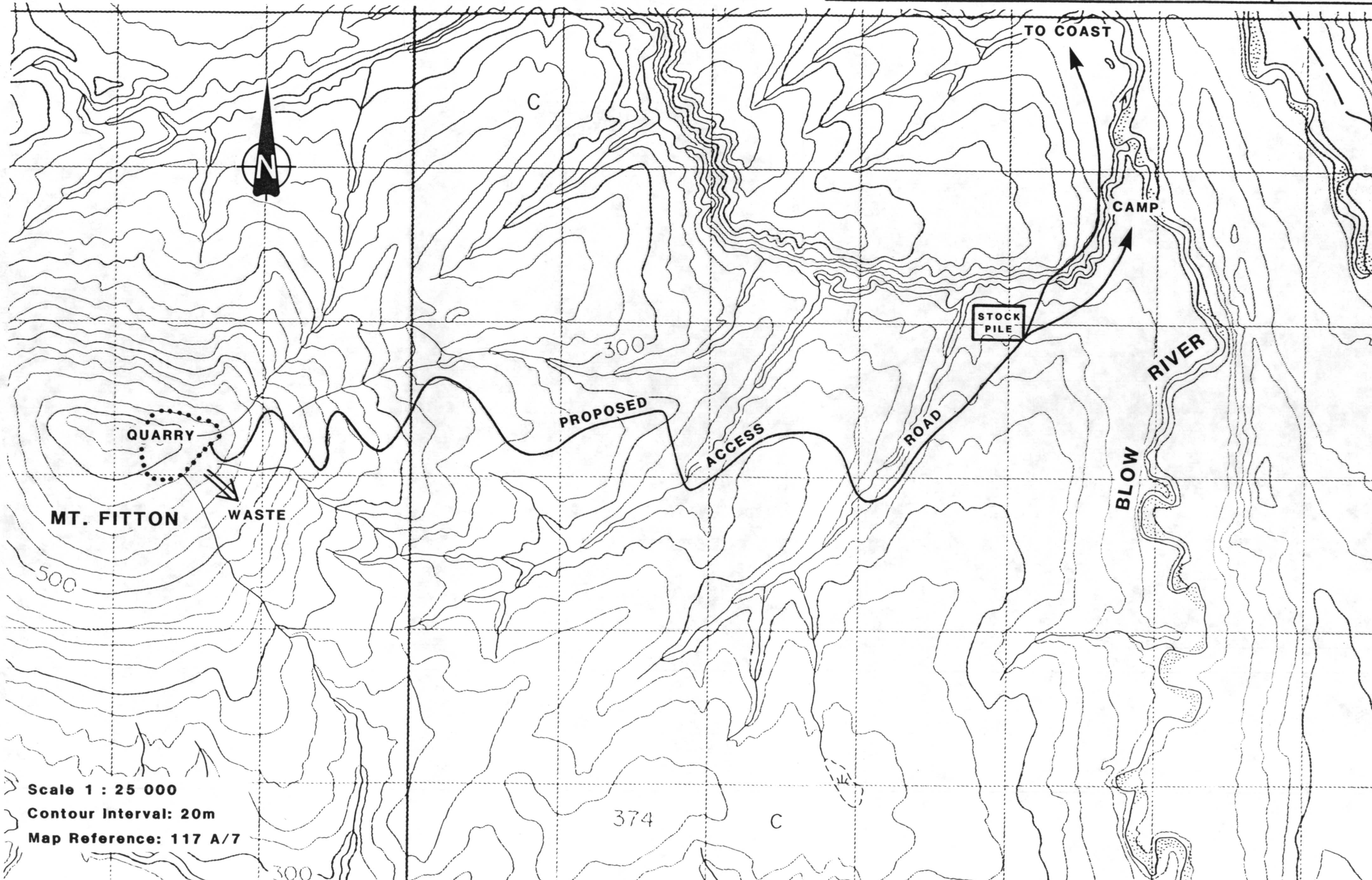
MOUNT FITTON – GEOLOGY

Figure 3

MOUNT FITTON CONCEPTUAL DESIGN

Figure 4



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The north face of the mountain has low bluffs along the crest, and then slopes down evenly, but quite steeply, to an east-flowing tributary of the Blow River. To the south, the mountain slopes gently down into the valley of Boulder Creek. Local topographic relief on both sides of the mountain is approximately 350 m.

To the east, the flank of the mountain is incised by east-flowing ephemeral streams which turn northwards on the lower slopes and join the Blow River tributary. Between the gullies formed by the streams on the upper slopes is a series of east-west trending spurs.

The whole Mt. Fitton area is above the tree line and very exposed. It would therefore appear to be appropriate to place all facilities associated with the quarrying activities at lower elevations in the valleys. A possible site for the camp facilities would be at the confluence of the Blow River and its tributary, approximately 6 km east of the mountain. This should assure adequate water supply in the summer, although the rivers are reported to freeze completely in the winter. If this is the case, wells would have to be sunk into the river gravels in order to supply a camp in winter.

The most appropriate quarry location appears to be the east end of the granite bluffs on the top of the mountain. An access road would have to be established up one of the spurs from the east, see Figure 4. This would permit development of an east-facing quarry at the end of the bluffs, and disposal of any waste rock in the upper part of the gully(s) to the south of the proposed road.

It is envisaged that the quarry would take the form of a series of low, wide benches, the faces of which would trend north-south. In this way the faces would approximately parallel one of the mapped joint sets (66°/078°), and would be exposed to the south.

Available data suggests that extensive reserves of granite are available in the mountain, and hence the quarry could be developed westwards across the mountain top as required. Overburden cover appears to be minimal, so stockpiling areas will probably not be required for stripped material.

Because of the exposed location of the quarry, it is suggested that any product stockpile area be established immediately above the tributary valley floor at the bottom of the access road. One possible site is indicated on Figure 4.

The most logical access route from a potential quarry to the coast would be along the north bank of the Blow River to Shingle Point. Alternatively, the road could turn northwards to King Point along the southern edge of the coastal lowlands. Either routing would involve at least 70 km. of road construction, some of it across terrain which is thought to contain sensitive permafrost.

Seasonal quarrying and haulage to the coast would likely be required to prevent disruption of the Porcupine Caribou herd which is reported to use the Blow River area as a major staging ground for bulls in late May and June as the herd migrates westward to its Alaskan summer range. Further restrictions may be necessary in September and October as winter migration takes place.

7.2 Gull Creek Dolomite

An isolated "butte"-like outcrop at the east end of the dolomite exposures north of Gull Creek shows all evidence of being capable of supplying large quantities of all grades of rock. The butte, which rises over 100 m. above the topography to the west and south, is approximately 2.5 km. east of the East Channel of the Mackenzie River, and some 28 km. south of Inuvik.

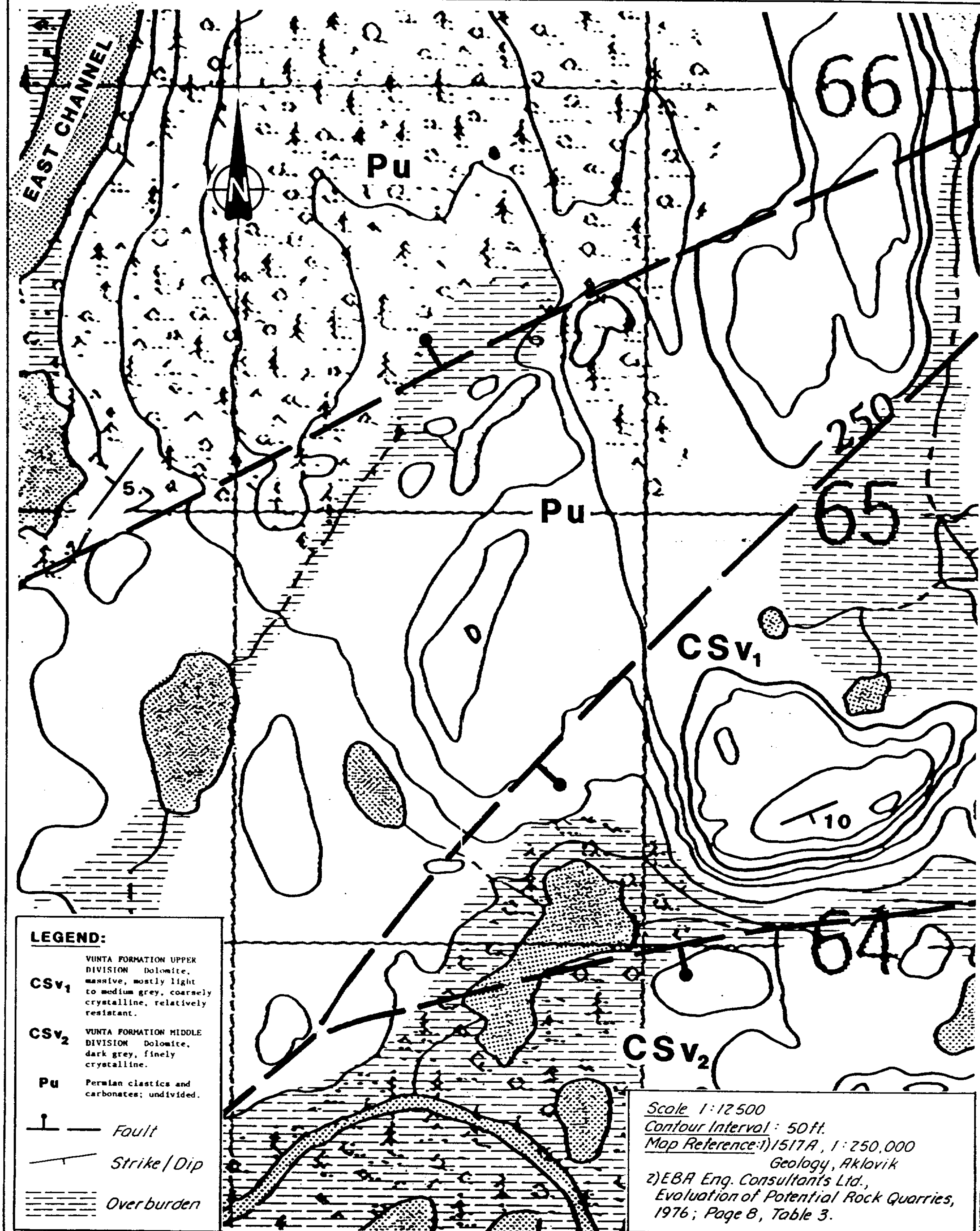
Cliffs up to approximately 50 m in height surround most of the butte, with talus slopes below. The outcrop is approximately 700 m. east-west by 400 m. north-south. The west and south faces are straight and steep, apparently reflecting structural control. On the northeast side the face is concave towards a basin containing a small lake, which drains to the north and east; the bluffs are lower and less rugged on this side of the outcrop.

The available geological data indicate that the dolomite in the butte is massive, coarse-grained and resistant with shallow, south-dipping bedding, and two approximately orthogonal joint sets which divides the rock into near-rectangular blocks, see Figure 5. These fracture sets also control the general shape of the butte.

Access to the site could be achieved by a cut and fill road which could be constructed northeastwards along the grain of the topography to the Dempster Highway close to Inuvik airport, see Figure 6. This road could be used to transport the workers from Inuvik on a daily basis, thereby removing the need for a camp.

GULL CREEK DOLOMITE - GEOLOGY

Figure **5**



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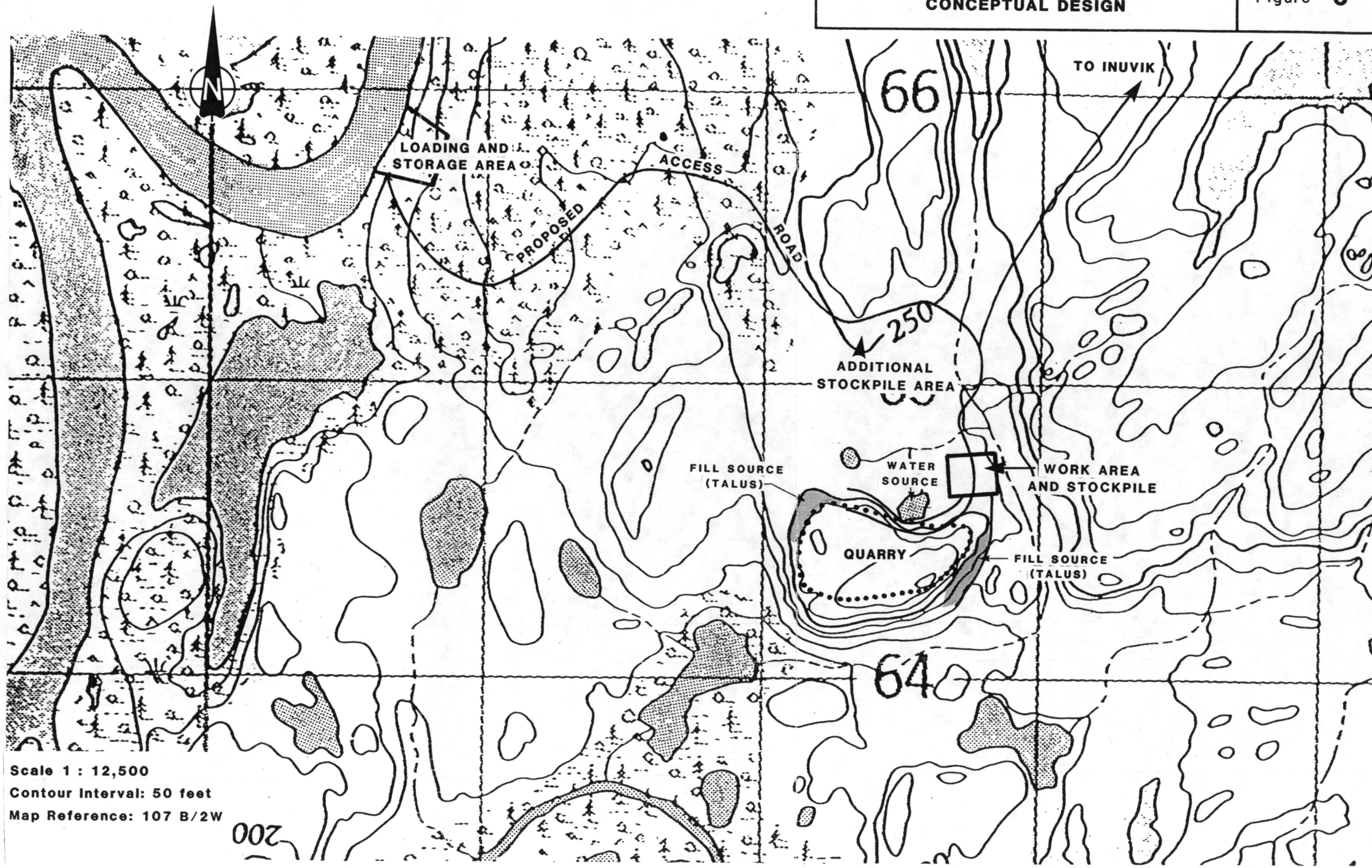
GULL CREEK DOLOMITE
CONCEPTUAL DESIGN

Figure **6**



Scale 1 : 12,500
Contour Interval: 50 feet
Map Reference: 107 B/2W

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The only viable route for accessing the top of the butte would appear to be from the east up the north face of the outcrop above the lake. This would permit the establishment of the initial quarry on the northern tip of the outcrop with north-facing benches, the face orientation of which would be controlled by the east-west trending vertical joint set.

Roads around the toe of the north and east faces of the outcrop would provide good quality talus fill for constructing the pads to accommodate facilities and stockpiling areas, as well as the haul road to the river. Some product up to armour stone size could also be selectively recovered from the talus.

There is no significant overburden on top of the butte. Hence the initial quarry benches could be developed towards the south, and further benches could then be excavated below, with access being achieved from the road on the north face of the butte.

Measurements based on the available, small scale topographic plans indicate that a 50 m. deep quarry covering the top of the butte would contain in excess of 10 million cubic metres of rock. Further material could be obtained by deepening the quarry on the west and south sides, and from the talus around the base of the cliffs.

A low ridge above the marsh immediately east of the small lake on the north side of the outcrop would provide a suitable work area, and some stockpile capacity. Further capacity could be established on the north side of the marsh along the road to the barge loading area, see Figure 6.

The product haul road could be constructed by cut and fill across the low ridges to the outcrop along the east bank of the East Channel. A dock in this location is likely to remain free of sediment as it is on the outside of a bend in the river at a point where the banks are formed by rock outcrop, and there is ample space for a further stockpiling area to be established behind the dock.

The proposed quarry site would be shielded from view from all current habitation, although it would be visible at a distance from the East Channel. However, at that range the benches would be not unlike the present cliffs.

8.0 FUTURE WORK PROGRAMS

Additional work will be required at each of the sites showing the greatest potential; Mt. Fitton on the west (Yukon Territory) side of the Delta, and the Gull Creek Dolomite prospect on the east (N.W.T.) side before the most appropriate source(s) of the various select stone grades can be established. The studies should initially be aimed at bringing some or all of these prospects to a level where the general nature and extent of the resources have been established, and sufficient basic engineering has been performed to support-overall feasibility studies, including cost estimates. This information would then form the basis for the selection of the appropriate site(s) of operations when stone requirements become apparent.

Golder has presented a proposal for sampling and laboratory testing of the DPW Quarry and Campbell Pit materials, followed by data analysis to provide evaluations that would be comparable with those provided for the original six sites in this report. It is proposed that these evaluations will comprise an addendum to this report.

The following discussions are intended to indicate the further work programs considered necessary to establish the required data bases to support feasibility-level studies on the four recommended prospects.

8.1 Mt. Fitton (Site 1)

A detailed investigation program would be required to support a feasibility-level study on the Mt. Fitton prospect. Exposure of outcrop at the site is limited, and in consequence, a drilling program would be required to establish the full extent of the granite stock, and to confirm that suitable quantities of the larger stone grades could be successfully quarried. At least four coreholes, each up to 50 m in length, would be required. The suggested locations for the proposed coreholes are presented on Figures 1-2, in Section 6. Ideally, these holes should be drilled at N-size or greater. However, in view of the isolated location, a small, helicopter-borne hydraulic drill may have to be used, drilling at A- or B-size.

The drill core logging data would be supplemented by more detailed mapping of any other available exposure identified during summer months, and laboratory testing of samples from depth.

A test blast should be attempted, but again, because of the location, it may have to be restricted in size, since it could be difficult to justify the transportation of heavy drilling or excavating equipment to the site unless a critical industry need is identified.

A detailed investigation of the haul route to the coast will be essential in order to find the most suitable alignment, particularly in the sensitive permafrost areas of the coastal lowlands. Several major creek/river crossings would be required, particularly if the product is to be taken to King Point. Because of the distance to the coast, the study would probably involve a detailed helicopter survey, with extensive "ground-truthing". This would probably take several crew-weeks, but would be justified, since the haul road construction and transportation are likely to be major cost items if stone is to be quarried at this site.

8.2 Gull Creek Dolomite (Site 5)

With almost total exposure on all four sides and the top of the Gull Creek Dolomite outcrop, it is not considered necessary to drill to provide the data required to support a feasibility-level study. Rather, detailed mapping of the butte in summer should be sufficient to

indicate any areas of structural disturbance, where the large stone sizes might not be obtained, and/or less durable rock might occur. This would be required for detailed quarry designs.

The structural mapping should also be used to confirm the joint orientations and spacing throughout the prospect. In this way, the approximate proportions of the respective product sizes could be estimated, and subsequently compared with actual results obtained in a test blast.

A test blast is recommended to confirm that suitable stone sizes can be obtained, particularly if there is a requirement for armour stone. This test should involve a sufficiently large volume of rock that the relative proportions of the various stone grades can be established.

Walk-over surveys will be required to establish actual alignments for the access road, and the road to the barge loading site. However, since there are no large streams or rivers along either routing, and the topography is relatively gentle, more detailed investigations are not envisaged.

At a feasibility level, investigations for the barge loading dock are likely to be relatively straightforward, since at the proposed site rock outcrop extends along the river bank for several kilometers. It should therefore be possible to establish a suitable location by field inspection, supported by depth soundings in the East Channel.

8.3 DPW Quarry (Site X1)

A conceptual plan for the expansion of the current DPW Quarry (Mile 948.5) was included in the September, 1976 EBA report. The initial phase of the expansion was to involve extension of the current operations northwestwards into the hill, but additional potential resources were also identified on the east side of the ridge to the northeast. All of these operations would be shielded from the Mackenzie (Dempster) Highway.

Further work at this prospect should initially involve confirmation of the resource around the current quarry through surface mapping, core drilling (estimated two holes), and test blasting for select product sizes.

If insufficient reserves are indicated around the present quarry, similar programs could be conducted along the ridge, where the EBA report suggests that approximately 3 million cubic metres of additional material might be quarried.

More detailed assessments of future work at the two existing quarries will be presented in an addendum to this report, after laboratory testing is carried out.

8.4 Campbell Pit Site X2

An outline for the development of the Campbell Pit ("Town Quarry Area") was also presented in the EBA report dated September, 1976. This conceptual proposal involved the extension of the existing operation to the northwest on the opposite side of the ridge from the Mackenzie Highway. A two-phased approach was indicated, giving a total of approximately 2 million cubic metres of material.

Assuming that the proposed laboratory tests confirm the strength and durability of the stone from the present quarry, the next stage would involve an exploration program to confirm the extent of similar material to the northwest. This investigation should involve mapping of available exposures on the ridge, and the drilling of at least four core holes to confirm the nature of the material at depth. These holes should be extended at least to elevation 65 m, which approximately corresponds to the proposed quarry floor elevation;

A test blast should also be performed in the current quarry to confirm that the required stone sizes can be obtained on a production basis, and the proportions of the various grades developed.

Depending upon the quantity of stone required, studies might also eventually involve the upgrading of the available highway and barge loading facilities to obviate the need to run haul trucks through Inuvik.

9.0 REFERENCES

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APPENDIX I

FIELD MAPPING CRITERIA

DSS/QUARRIES/ BEAUFORT — FIELD MAPPING CRITERIA — 862-1806

The criteria used in carrying out field mapping follows the guidelines outlined in the following documentation. Where applicable on the field mapping sheets, the dip/dip direction corrected to True North has been used. Major joint sets and bedding plane discontinuities have been identified as set 1, 2, 3, etc. for each site. For sites with varying rock conditions, more than one rock description sheet have been completed.

Rock description

The tables given below and overleaf are taken from the format proposed for mining and civil engineering purposes by the Geological Society of London Engineering Group in their Quarterly Journal of Engineering Geology Vol. 10 no. 4 1977 to which reference should be made for the full details of the recommended method.

Descriptive indices for rock material are: Colour, grain size, weathering and alteration, rock type and strength.

Rock colour

1	2	3
Light	Pinkish	Pink
Dark	Reddish	Red
	Yellowish	Yellow
	Brownish	Brown
	Olive	Olive
	Greenish	Green
	Bluish	Blue
		White
	Greyish	Grey
		Black

Grain size

Term	Particle size	Retained on BS Sieve No. (approx)	Equivalent Soil Grade
Very coarse-grained	>60 mm	2 in	Boulders + Cobbles
Coarse-grained	2–60 mm	8	Gravel
Medium-grained	60 microns-2 mm	200	Sand
Fine-grained	2–60 microns		Silt
Very fine-grained	<2 microns		Clay

Note: grains >60 microns diameter are visible to the naked eye

Very Soft < 0.5 Kg/cm²
Soft 0.5 – 1.0 Kg/cm²
Firm 1 – 1.5 Kg/cm²
Stiff 1.5 – 3.0 Kg/cm²
V. stiff 3.0 – 6.0 Kg/cm²
Hard 6.0 – 12.5 Kg/cm²

Rock description (continued)

Weathering/alteration grades

Term	Description	Grade
Fresh	No visible sign of rock material weathering.	IA
Faintly weathered	Discoloration on major discontinuity surfaces.	IB
Slightly weathered	Discoloration indicates weathering of rock material and discontinuity surfaces. All the material may be discoloured by weathering and may be somewhat weaker than in its fresh condition.	II
Moderately weathered	Less than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discoloured rock is present either as a discontinuous framework or corestones.	III
Highly weathered	More than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discoloured rock is present either as a discontinuous framework or corestones.	IV
Completely weathered	All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact.	V
Residual soil	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.	VI

Rock material strength

Term	Unconfined Compressive Strength MN/m^2 (MPa)	Field estimation of hardness
Very strong	>100	Very hard rock–more than one blow of geological hammer required to break specimen.
Strong	50–100	Hard rock–hand held specimen can be broken with a single blow of geological hammer.
Moderately strong	12·5–50	Soft rock–5 mm indentations with sharp end of pick.
Moderately weak	5·0–12·5	Too hard to cut by hand into a triaxial specimen.
Weak	1·25–5·0	Very soft rock–material crumbles under firm blows with the sharp end of a geological pick.
Very weak rock or hard soil	0·60–1·25	Brittle or tough, may be broken in the hand with difficulty.
Very stiff	0·30–0·60*	Soil can be indented by the fingernail.
Stiff	0·15–0·30	Soil cannot be moulded in fingers.
Firm	0·08–0·15	Soil can be moulded only by strong pressure of fingers.
Soft	0·04–0·08	Soil easily moulded with fingers.
Very soft	0·04	Soil exudes between fingers when squeezed in hand.

* The compressive strengths for soils given above are double the unconfined shear strengths.