Yukon Iron Ore Railway Feasibility Study
Lat 65°10' N to 65°20' N; Long 132°45' W to 133°15' W
J.L. Charles, Consultant Engineer C.N.R.
Aug. 1964 - Jan.1965

YUKON IRON ORE

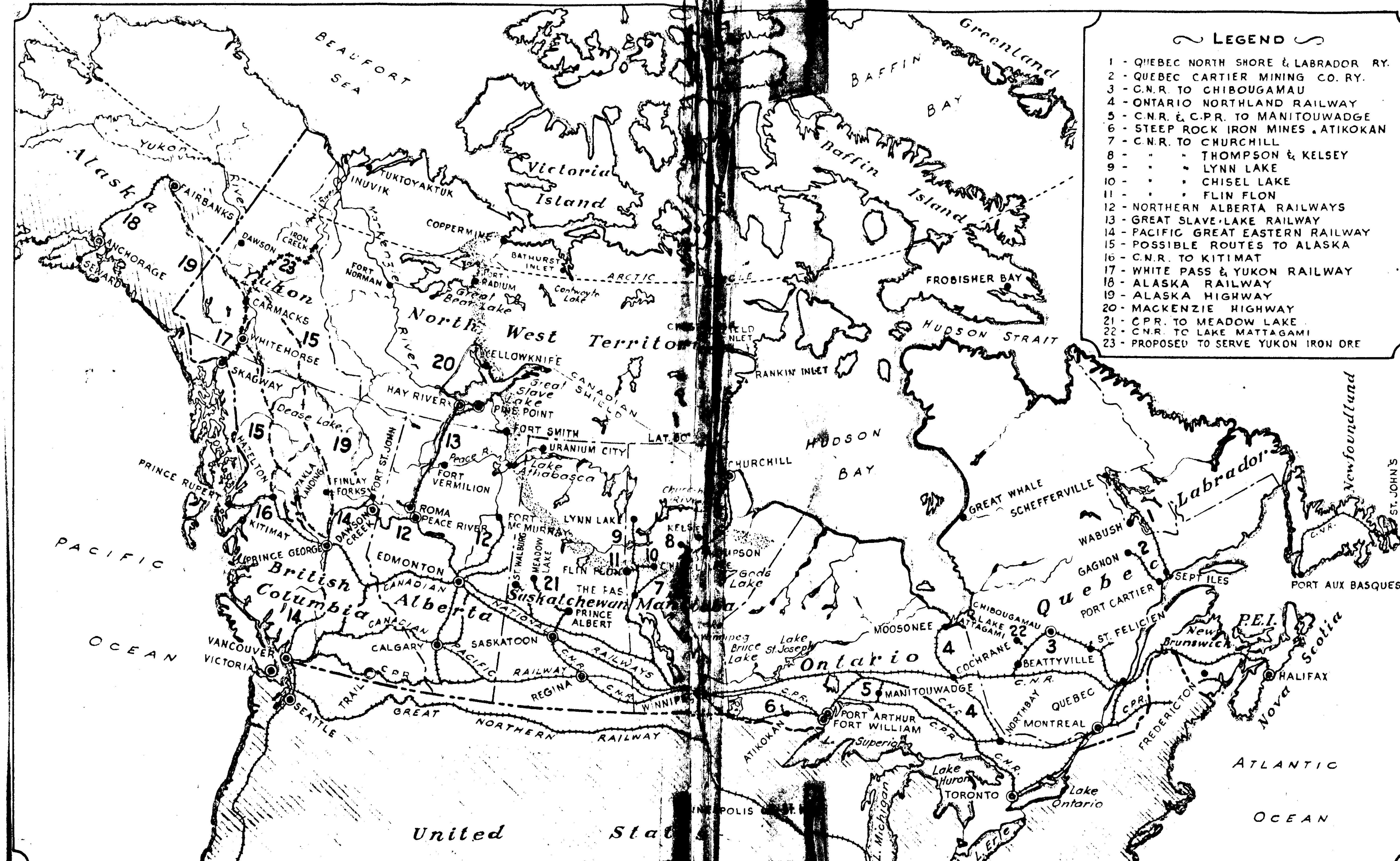
RAILWAY FEASIBILITY

prepared by
CANADIAN NATIONAL RAILWAYS
in co-operation with
CREST EXPLORATION COMPANY LIMITED
for
THE GOVERNMENT OF CANADA

THREE PORTFOLIOS ACCOMPANY THIS REPORT :-

1. Photographs , Nos 1 to 30
2. Maps, 1 general-1in. to 8 miles and 29 sectional sheets
3. Profiles, 2-scale 1" = 1.25 miles and 1-scale 1" = 1320'

J.L. CHARLES · Consulting Engineer
Canadian National Railways
Winnipeg, Manitoba
29 January 1965.



CANADA:~ RAILWAYS MARCH NORTHWARD

J.L. CHARLES, P. Eng. - CANADIAN NATIONAL RAILWAYS
Winnipeg, Manitoba Oct. 1960 - REVISED 17 JULY 1963, JAN. 1965
NOV. 1963

SCALE IN MILES

YUKON IRON ORE

Preliminary study of the feasibility to construct and operate a railway to transport iron ore from Iron Creek Mine to tide-water.

Prepared by the Canadian National Railways, in co-operation with Crest Exploration Limited

for

the Government of Canada

---

1. INTRODUCTION

During 1962, Crest Exploration Limited engaged Canadian Bechtel Limited to carry out a preliminary evaluation of an extensive jasper-hematite iron ore deposit, recently staked in a remote area, near the confluence of Iron Creek and Snake River and the Yukon-Northwest Territories' border, 80 miles south of the Arctic Circle and 320 air miles north-easterly of Whitehorse.

Canadian Bechtel Limited submitted its report to Crest Exploration Limited in January 1963.

One of the principal items to be studied, in relation to marketing this ore, is transportation. The class of commodity and volume of traffic indicate a railway.

2. EXISTING RAILWAY

During the period of the Klondike gold rush, the White Pass and Yukon Railway was constructed from the port of Skagway, Alaska, a distance of 110 miles, to Whitehorse, in the interior of Yukon Territory. This was accomplished within two years, 1898-1900. It is the only railway within Yukon Territory and has no physical connection with other railways.

At Whitehorse, passengers and freight were transferred to river steamers, operating on the Yukon River to Dawson City and other points accessible by water.

With the advent of highways and airways, river traffic could no longer compete. The grand old steamers are resting on the river bank at Whitehorse.

This railway from Skagway continues as a valuable asset, with relative truck services to points beyond Whitehorse, via the Alaska Highway and the highway through Carmacks to Dawson City, together with its branch to Mayo, Elsa and Keno Hill. The latter point is within 110 air miles of Iron Creek Mine.

However, the White Pass & Yukon Railway is a narrow gauge line, 36 inches, with steep gradients up to 3.9 per cent, and, sharp curves up to a rate of 20 degrees.

Studies have been made to assess whether it would be physically and economically practical to up-grade the W. P. & Y. Railway and convert it to standard gauge. Report by Swan, Wooster & Partners, Consultants of Vancouver, advises that it would be feasible to substantially reduce the curvature and relief could be made at some locations to reduce the rate of gradient.

However, it would not appear to be economically practicable to lessen the maximum rate, 3.9 per cent uncompensated, between Skagway and the summit of White Pass, and therefore, it would appear to be impracticable for the W. P. & Y. Railway, as presently constituted, to expand its operations to carry heavy shipments of iron ore.

3. PROPOSED RAILWAY

Preliminary aerial reconnaissance was carried out by the late Mr. M.P. Boyle of Bechtel and the writer, early in September 1962, to discover whether a feasible route could be established for construction of a railway, to high standards, between Iron Creek and the Pacific Coast.

Several possibilities were reconnoitred, in particular, routes to Haines and to Skagway.

Time available was very limited and observation was restricted to one trip over each area by Beaver aircraft. No helicopter was available.

3.1 Port Site - Dyea

Evaluation of the controlling features indicated that the most favourable site for development of a port, with facilities to tranship iron ore, and relative railway approach route, would be near Skagway - at Dyea, the head of Taiya Inlet.

From the open Pacific Ocean, the direct approach to Skagway and Dyea is through Chatham Strait, Chilkoot Inlet and Taiya Inlet - 250 miles. Photo 1.

Dyea is the site of one of the ports of entry used by the stampeders, who travelled over the Chilkoot Pass, to the Klondike during the gold rush of 1898.

This site has long since been abandoned. It is now a wide open tidal flat at the estuary of the Taiya River, although a part of the area is privately owned. There are 650 acres suitable for a railway yard, ore stockpiles and facilities close to deep water wharf sites on the westerly side of Taiya Inlet. Extreme range of tide is 25 feet. Photograph 2.

Skagway, Alaska, population about 800, is a port of entry to British Columbia and Yukon Territory via the White Pass and Yukon Railway. There is no access by highway to Skagway, however, inhabitants are advocating construction of a road to connect with the Alaska Highway.

A low standard road has been graded between Skagway and Dyea, 7 miles. This would not be difficult to improve to a paved highway.

Sand and gravel is available in the Taiya Valley for grading railway yards and roads, etc.

3.2 Bechtel's Report - basic factors

Conjectures of costs were made, to construct and operate a railway between Dyea and Iron Creek, designed to the highest standards, for delivery of up to 20,000,000 tons annually. Reference Bechtel's Report - Railroad Section. At the same time, it was recommended that consideration be given to alternative standards and also an alternative route, to reduce initial capital requirement.

4. SUBJECT OF THIS REPORT

In the Spring of 1964, Crest Exploration, with its parent, California Standard Oil Company, approached the Government of Canada to jointly undertake further reconnaissance in an endeavour to find a means to reduce the cost of railway construction. This was approved and the Canadian National Railways was commissioned by the Government to carry out this feasibility study, in co-operation with Crest Exploration Limited.

Field reconnaissance was made, with the aid of a light helicopter, during the period of 6 August to 1 September 1964, and, the following report is submitted with respect to a single track, standard gauge, railway, with passing tracks and terminal yards, only.

Facilities for loading ore at the Mine and unloading and transhipping at the port are not included. Reference Bechtel's Report, sections on "Mine Area Facilities" and "Port Facilities".

5. DESIGN CRITERIA

Product to be shipped would range from 3,500,000 to 5,000,000 long tons of iron ore pellets annually, during 340 days.

Ore car capacity 100 tons; 120 cars per train.

Maximum rates of gradients:-

(1) From the Mine against outward traffic loads - 1.00 per cent compensated to ascend the Snake River Valley and gain the Goz Pass, elevation 4,040, through the Bonnet Plume Range of the Selwyn Mountains, and 0.80 per cent compensated on balance of the line. Later revised to 1.00 per cent compensated overall, reference "Train Performance" and "Transportation Studies", Sections 15 and 16.

(2) From the port against inward traffic, empty ore cars, fuels and supplies - 1.90 per cent not compensated, to ascend the Taiya River Valley and through a long tunnel to pierce the Coast Range, to Mile 24 at the south end of Lindeman and Bennett Lakes, and, 1.50 per cent compensated on the balance of this line.

Maximum rate of curvature 8 degrees.

Rise and fall, see accompanying condensed profiles.

Passing tracks, 11 of 6,800 feet each, also, service sidings in relation to local conditions.

Speed - maximum 40 m.p.h., reduced where necessary in relation to grades, curvature and safety on sections where rock slides and snow slides may occur.

Right-of-way - 132 feet wide and increased where necessary.

Roadway - minimum dimensions - top of embankments 22' wide; base of excavations 30' wide; side slopes as required to meet local conditions which vary widely.

Culverts - corrugated iron pipes 24" to 60" diameter and where necessary structural steel pipes 72" to 120" diameter.

Bridges - for minor requirements, treated timber trestles; for major crossings, steel spans on concrete sub-structures.

Rock sheds and snow sheds - overhead reinforced concrete or structural steel plates where slides cannot be passed under bridges.

Ties - during construction loss and breakages are unavoidable and, in northern latitudes untreated ties have comparatively longer life than further south, also, they are more easily handled. Therefore, for this project, untreated ties are recommended - No. 1 and 2 for main track and No 3 for sidings (9"x7"x8', 8"x6"x8' and 7"x6"x8' respectively) - to be protected with tie plates. Replacements, when required, to be treated ties.

Rail - weight 115 lb. for main track, 85 lb. for sidings; anchored as necessary.

Turnouts - for main track No. 12; others No. 10.

Ballast - pit run 18" and minimum of 12" crushed and screened gravel under ties.

Communication and despatching - by radio direct to all stations and trains. C.T.C. not considered necessary for volume of traffic; could be installed if traffic increases sufficiently to justify the expenditure.


YUKON IRON ORE
RAILWAY FEASIBILITY
PROJECTED RAILWAY ROUTES
SCALE :- 1" = 35 MILES
WINNIPEG, MAN.
29 JANUARY 1965
ALASKA
YUKON TERRITORY
MACKENZIE DISTRICT
TERMINAL YARD MILE 577
JUNCTION - MILE 473 ROUTE "A"
= MILE 443 ROUTE "X"
ALTERNATIVE ROUTE "X"
ROUTE "A"
JUNCTION - MILE 170
ALTERNATIVE ROUTE "X"
PROJECTED RAILWAY
PROJECTION TOWARDS
RECONNAISSANCE
HAINES
DYEA
MILE 0
WHITEHORSE
PROJECTIONS FROM
PRINCE GEORGE AND HAZELTON
Arctic Circle
MACKENZIE MOUNTAINS
BACKBONE RANGES
CANYON RANGES
WERNECKE MOUNTAINS
HESS MOUNTAINS
PELLY MOUNTAINS
FAIRBANKS
GOZ PASS
ALASKA HIGHWAY
HIGHWAY

6. RAILWAY TERMINI

Review of harbours, on the Pacific Coast within range of Iron Creek ore deposit, confirms in our opinion that Dyea would be the most favourable site for railway approach and development of a port for transhipment, of the product to be marketed, from railway to ocean freighters. Therefore, Dyea is considered to be the southern terminus and Mile 0 for this proposed railway.

For the purpose of this report, the northern terminus is shown as Mile 577, at the confluence of Snake River and Iron Creek, where there is an area suitable for a marshalling yard, for outward trains, as close as practicable to the ore deposits.

However, the main track could be extended, as a spur, beyond the marshalling yard, up the valley of Iron Creek, North Fork, for seven miles, where car loading facilities might be placed; beyond this, the North Fork is confined in a narrow valley.

7. RAILWAY ROUTES

7.1 Reconnaissance was made of the general territory, then Route "A" and alternative Route "X" were projected, as shown on the accompanying map.

7.2 Route "A" commences at Dyea, Mile 0, thence via Bennett, Carcross, Whitehorse, Carmacks, Minto, Pelly Crossing, Stewart Crossing, Mayo, Elsa, Keno Hill, Kathleen Lake, Nadaleen Mountain, Goz Pass and Snake River to its confluence with Iron Creek, approximately 577 miles.

7.3 Route "X" branches off from Route "A" at Mile 170, thence via Mandanna Lake, Little Salmon, Kelly Creek Canyon, Moose Lake, Penape Lake to Nadaleen Valley and rejoins "A" by Nadaleen Mountain, then follows "A" to Iron Creek, approximately 547 miles.

However, Route "X" by-passes Carmacks, Minto, Mayo, Elsa and Keno Hill.

8. GENERAL DESCRIPTION

8.1 Territories

The southerly 15 miles of this line, Dyea to the summit of the Coast Range, would be in the State of Alaska, then 26 miles in the Province of British Columbia and the balance in Yukon Territory.

8.2 Topography

There are two prominent topographical features to be overcome:-

(a) The Coast Range, within a few miles of the Pacific Ocean. Near Skagway, mountains rise abruptly to 8,000 feet above sea level, then break off sharply to Lindeman Lake, elevation 2185, all within a distance of 24 miles.

Lindeman Lake is one source of the Yukon River.

(b) Selwyn Mountains and Mackenzie Mountains which divide the drainage areas flowing to the Yukon River, thence to the Bering Sea, from waters flowing to the Mackenzie River and on to Beaufort Sea.

Between these main mountain ranges, the Yukon River, together with its principal tributaries - Teslin, Takhini, Pelly and Stewart Rivers - flow through broad valleys, elevations 1500 to 2500, between hills and low mountain ranges up to 6,000 feet. This interior country is known as the Yukon Plateau.

9. SPECIAL FEATURES

9.1 Heavy rock work, on the mountain side of Taiya River, and tunnel 11 miles long, through the Coast Range, would be necessary to ascend from Dyea to the interior - "Yukon Plateau".

9.2 The White Pass and Yukon Railway, as constructed at the toe of the mountain slope along Bennett Lake, occupies the most practical location between Bennett and Carcross. Therefore, the proposed railway would be located adjacent to, or on, the W. P. & Y. Railway's right-of-way. Heavy rock work would be encountered and careful methods and scheduling would be essential to avoid obstructing the W. P. & Y. Railway's main track. This would increase all unit costs considerably, on this section.

Northerly from Carcross to MacRae, near Whitehorse, the country is more open but there are some tight topographical controls, where the White Pass and Yukon Railway is in the most favourable location. At these points it may be necessary for the proposed railway to encroach on the W. P. & Y. Railway's right-of-way.

Therefore, it would appear that agreement will have to be made with the White Pass and Yukon Railway. This is a major matter with respect to construction and also operation of the proposed railway.

9.3 Develop a location by Whitehorse, west of the airport, to avoid conflicting with business interests - Department of National Defence installations and residential subdivisions.

9.4 Bridge the Yukon River and its principal tributaries - Takhini, Pelly and Stewart Rivers, also their respective tributaries.

9.5 Locate up Goz Creek Valley to Goz Pass and descend into Snake River Valley, with minimum crossings of rock and snow slide paths and necessity for protective structures.

9.6 Bridge Snake River and tributary streams flowing from the Bonnet Plume Range.

10. COMMUNICATIONS AND SIGNALS

The Canadian National Telecommunications suggests the following system for operation of the proposed railway. The plan provides for:-

10.1 The construction of one pair of insulated, high strength aluminum wire with steel core between Mile 0 - Dyea - Whitehorse and the Northern Terminal.

The plan provides for a new pole line between Mile 0 - Dyea and Whitehorse, attachment to the CNT highway line between Whitehorse and Elsa and a new pole line between Elsa and the Northern Terminal.

10.2 Wayside-to-train radio communication, based on equipping 34 locomotives. The fixed (wayside) radio stations will be selected and operated by the despatcher by means of control tones. The radio base stations will be bridged to the way-station telephone circuit, paragraph 10.4.

The system proposed will function in the same manner as the despatcher-to-train system presently in use on the C.N.R. between Edmonton and Vancouver.

10.3 A despatching office - located at Whitehorse.

10.4 A way-station telephone circuit, linking the base stations for (10.2) with the despatching office (10.3).

10.5 An administrative telephone circuit between Mile 0 - Dyea, Whitehorse and the Northern Terminal.

10.6 25 - line telephone exchanges, each equipped with 12 telephone sets, at the three points in (10.5).

10.7 Provision for intermediate connection of the way-station telephone circuit (10.4) to 10 locations such as stations and sectionmen's houses.

10.8 The provision of two-way supervisory channels from the Whitehorse despatching office to four remote locations for the transmission of control signals to operate power switches and the receipt of indication signals.

10.9 Capital - estimated cost to construct

Radio	$ 591,000.
Construction of one pair #6 ACSR Wire and pole line	$ 874,000.
Telephone, Carrier equipment, Remote Control equipment for operating power switches	$ 120,000.
Drop circuits from highway to railway	$ 55,000.
	$ 1,640,000.

Signals

10.10 Centralized traffic control is not considered necessary in relation to the expected volume of traffic.

Simple battery operated signals will be required in relation with equilateral switches at each end of long passing tracks, required for operation of "Integrated Trains", reference section 16 paragraph 14.

Cost of signals, say $90,000.00.

10.11 Annual maintenance and operating expenditure

Radio	$ 17,000.
Power	$ 24,000.
Outside plant (Pair, pole line, etc.)	$ 15,000.
Other	$ 14,000.
	$ 70,000.

11. CLIMATE

At Skagway, average annual precipitation, total rain and snow, is recorded as 30 inches. Daily mean temperatures are - July 56 degrees, January 24 degrees. Although zero days are said to be rare, forty below has been recorded.

The valleys are well timbered but the trees would not be termed very large and the appearance of Skagway is not so wet as many coastal points north of Prince Rupert.

However, on the mountains near by, snowfall is extremely heavy, 50 to 60 feet per year.

In the interior, the general appearance reflects the comparatively dry climate. At Whitehorse, snowfall is not heavy; average annual precipitation, rain and snow, only amounts to 10 inches with daily mean temperatures of 56 degrees during July, and, 5 degrees average for January. Lowest recorded temperature 62 degrees below zero.

At Carmacks there is a wider range of temperatures, with July daily mean 60 degrees above and January 26 degrees below zero, dropping at times to well under minus 60 degrees F.

There are no meteorological records for the territory about the Goz Pass, through the Bonnet Plume Range. However, the entirely bare mountain slopes do not indicate heavy precipitation. Temperatures drop, at times, to 60 or more degrees below zero.

The open grading season, free of serious freezing, is five months - mid-May to mid-October - however, during summer, daylight hours are long and favourable to working a minimum of two ten hour shifts daily.

12. ROUTE "A" - DESCRIPTION BY SECTIONS

12.1 Ascent from Dyea, in Taiya River Valley, Mile 0 to 13

Dyea railway yard site, adjacent to the port, would be on the tidal flats. Good materials, mostly granular, would be available for grading. Taiya River channel would have to be controlled towards the east side of the valley and rock facing would be necessary to protect embankments built of other materials.

The point of departure for northward trains to Iron Creek would be from the north end of Dyea Yard, Mile 1.5, elevation 40. Photograph 3.

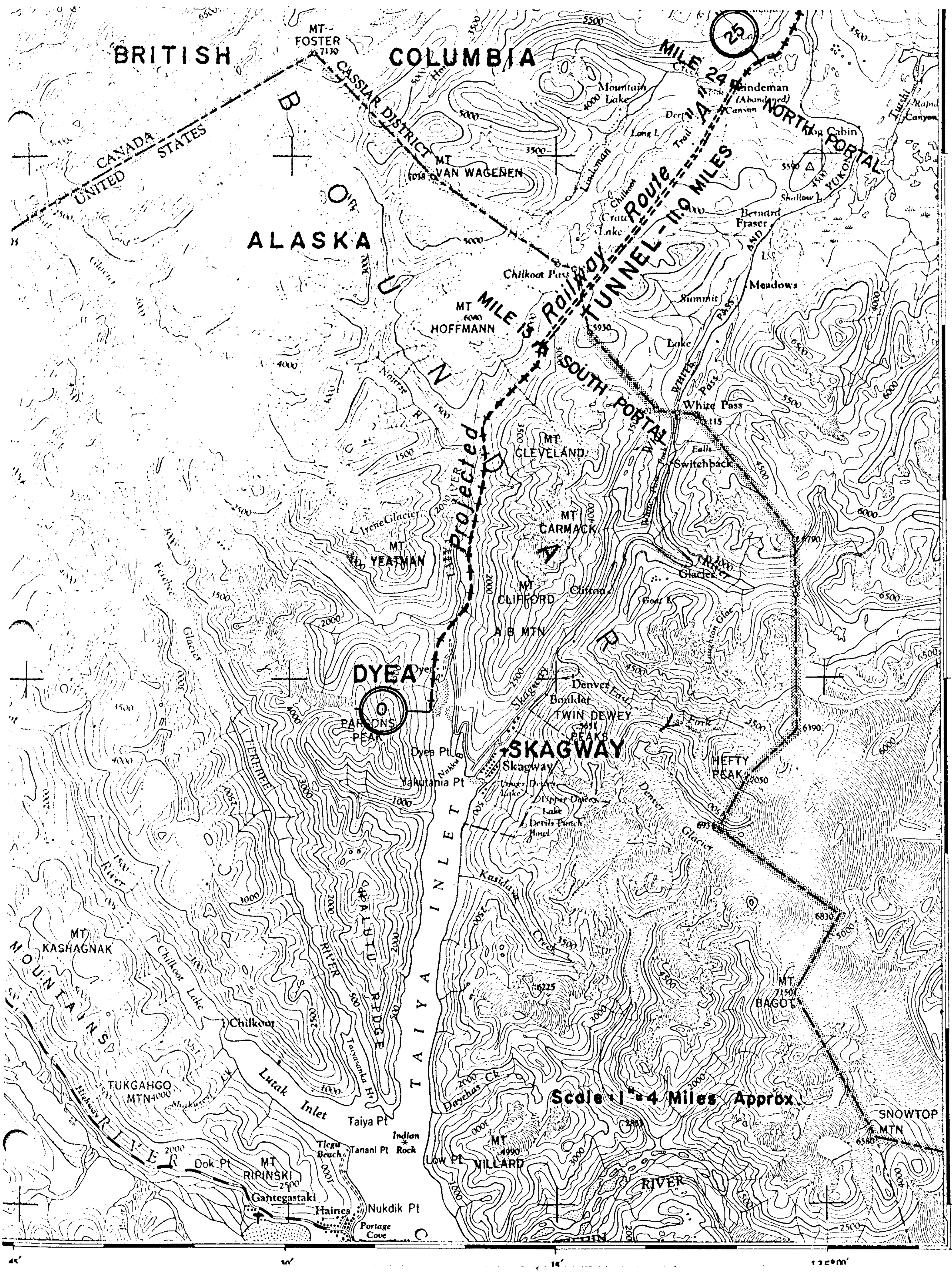
The floor of the valley is one half of one mile wide and well timbered with spruce, poplar and cottonwood for a distance of nine miles. The Chilkoot Trail of 1898 is in this valley approaching the Chilkoot Pass.

At Mile 2.5, immediately south of a large tributary flowing from extensive glaciers to the west, the line would cross the Taiya Valley, from west to east, over the river, on a bridge of deck plate girder spans, with overall length of 500 feet.

The line would then be developed up the steep mountain side, mostly solid rock, fairly well treed. There are fewer indications of rock slides and snow slides on this, the east, side of the valley than on the west side. Reference accompanying map.

To avoid an excessively sharp curve, a tunnel, of no great length, will probably be required through a rock bluff opposite the confluence of the Nourse River with the Taiya River. Photograph 4.

At Mile 13, the line would enter a long tunnel through the Coast Range. Photograph 5 shows possible site of the south portal.



BRITISH COLUMBIA
ALASKA
CANADA
UNITED STATES
BOUNDARY
CASSIAR DISTRICT
MT FOSTER 7130
MT VAN WAGENEN
Mountain Lake
Lindeman (Abandoned)
MILE 24 "A" NORTH PORTAL
Log Cabin
Crater Lake
Bernard
Fraser
Chilkoot Pass
MILE 13 "A" SOUTH PORTAL
TUNNEL-11.0 MILES
Protected Railway Route
Summit
Meadows
MT HOFFMANN
White Pass
Switchback
MT CLEVELAND
MT CARMACK
MT YEATMAN
Irene Glacier
MT CLIFFORD
A B MTN
DYEA
PARSONS PEAK
Denver
Boulder
TWIN DEWEY PEAKS
SKAGWAY
Skagway
HEFTY PEAK
Dyea Pt
Yakutania Pt
Lower Dewey Lake
Upper Dewey Lake
Devils Punch Bowl
TAIYA INLET
MT KASHAGNAK
MOUNTAINS
Chilkoot
Chilkoot Lake
TUKGAHGO MTN
Lutak Inlet
Taiya Pt
Indian Rock
Tanani Pt
Low Pt
MT WILLARD
MT BAGOT
SNOWTOP MTN
MT RIPINSKI
Dok Pt
Haines
Nukdik Pt
Portage Cove
RIVER
Scale 1"=4 Miles Approx.

12.2 <u>Tunnel through the Coast Range to Lindeman Lake, Mile 13 to 24</u>

A long tunnel, 11 miles, would be required to obtain a gradient for the safe operation of heavy ore trains to descend from the south end of Lindeman Lake to nearly sea level at Dyea.

Alignment through this tunnel will be tangent, or nearly so, with a gradient of 1.90 per cent from the north portal, elevation 2200, to the south portal, elevation 1096.

Surface elevation at the summit and glaciers above this tunnel location - one mile easterly of the Chilkoot Pass and Crater Lake - is shown to be nearly 6,000 feet. Photographs 6 and 7.

The south portal and 2 miles of tunnel would be within the State of Alaska and the northerly 9 miles in the Province of British Columbia.

To drive this tunnel, minimum section, would be 19.5 cubic yards per lineal foot and amount to 1,133,000 cubic yards.

Reinforced concrete lining, where necessary, would require 4.25 cubic yards per lineal foot. An alternative method would be with structural steel liner plates.

At the request of "Bechtel", Dr. Victor Dolmage, Consulting Geologist, made a report, 9 November 1962, on the "Geological Aspects of Several Possible Railway Tunnel Sites Crossing the Alaska-British Columbia Boundary near Skagway and Haines."

With respect to the above tunnel site between the Taiya Valley and Lindeman Lake area, Dr. Dolmage states:-

"It may be predicted therefore that any one of the proposed tunnels driven in this region will pass through granitic rocks such as quartz diorite and granodiorite for almost its entire length. Small bodies of older included rocks will be encountered but these will not differ materially in tunnelling characteristics from the granitic rocks. Generally speaking, these rocks offer as good tunnelling conditions as any, but are not without some difficulties."

"It is probable that much water will enter the tunnel through joint cracks and faults."

"The large glaciers of the area, unless they happen to rest on permafrost, will produce large amounts of water throughout the year."

"While the tunnel will no doubt be wet, it is unlikely that the amount of water will be greater than can be contained in drainage ditches. The most important expense due to the presence of water will be that of pumping it out of the upper half of the tunnel during construction."

"Icing of the portals. There will be no trouble at the south end. At the north end no water will flow out of the tunnel except that pumped out during construction."

"Costs - you may expect bids in the neighbourhood of $10.00 per cubic yard for unsupported excavation. Supports will be in the form of rock bolts or wood or steel arch sets with wood lagging, or gunite or concrete lining, or some combination of these."

"Concrete lining is the most expensive and may be roughly estimated at $90.00 to $100.00 per lineal foot in place for 15" thick concrete. It would appear to me that very little of this type of support would be required."

"Experience has shown that larger tunnels in this complex on the average require support over only 20 or 25 per cent of their total length."

Ventilation - Dr. Dolmage states, "Ventilation during construction need not be a serious problem, though it will be a significant item of cost. I have no useful opinion to offer regarding permanent ventilation which might be required assuming the use of diesel locomotives."

"I think the overall cost of these tunnels per lineal foot advanced will be less than $300.00."

Rate of progress - Dr. Dolmage advises, "It should be possible to drive these tunnels at an average rate of 1,000 feet and possibly 1,300 feet per month per heading. The average rate of the 11 mile Kenamo Tunnel was 823 feet per month. This was a 25 foot diameter horseshoe tunnel."

Comments

Based on Dr. Dolmage's advice, it would appear that from 2½ to 3 years would be required to drive this proposed tunnel, 11 miles long, through the Coast Range, near the Chilkoot Pass.

Permanent ventilation

In long tunnels on steep grades, heat from the leading diesel units tends to cause trailing units to overheat. Exhaust gas accumulation is also a problem.

The Great Northern Railway installed a ventilating system during 1955 to permit operation of diesel locomotives through its Cascade Tunnel - 7.79 miles long. "The largest railway tunnel in the Western Hemisphere, it is a straight, single track, concrete lined bore on a uniform grade of 1.57 per cent ascending from west to east."

This system is described in the American Railway Engineering Association's proceedings, Volume 59, page 1288 and Volume 61, page 693. "The results obtained with the ventilation system as related to the operation of diesel-powered trains through the Cascade Tunnel have been most satisfactory."

Cost of installation is given as $750,000.00.

Conjecture of the overall cost to construct the proposed Chilkoot Tunnel, together with ventilating system, say $21,300,000.00.

Additional lining may become advisable from time to time. Thirty years after construction, the Canadian National Railways commenced a progressive programme to line all tunnels on the main line between Jasper and Vancouver; this work is being carried on annually.

Endeavour has been made, without success, to discover a route to eliminate this costly tunnel.

12.3 Lindeman Lake to Bennett Lake, Mile 24 to 30

Northerly drainage from glaciers about Chilkoot Pass flows through Crater Lake, Deep Lake, Lindeman Lake, Bennett Lake, Tagish Lake and Marsh Lake into the Yukon River above Whitehorse.

From the north portal of the Chilkoot Tunnel, at the south end of Lindeman Lake, the route is along the east shore of the lake and by the east bank of Lindeman Creek to Bennett Lake and Bennett Station, elevation 2165.

There would be considerable curvature and fairly heavy solid rock excavation along Lindeman Lake, but along the creek and at the south end of Bennett Lake there is sand overburden. However, there are no high mountain slopes and no danger from slides close to this section.

12.4 Bennett Station to Carcross, Mile 30 to 57

This twenty-seven miles would be on or closely adjacent to the narrow gauge White Pass & Yukon Railway's right-of-way, which runs along the east shore of Bennett Lake and at the toe of steep mountain slopes, rising, in places, to 4,000 feet above the lake. Photograph 8.

The White Pass & Yukon Railway maintains a large station restaurant at Bennett in connection with tourist traffic.

This line was constructed with heavy curvature. There is one 20 degree curve three miles north of Bennett; to reduce this, a tunnel, 800 feet long, would be required and heavy rock work would be encountered on much of this section, although some other materials would be obtainable towards the north end of the lake.

The "Narrows" between Bennett Lake and Nares Lake is crossed, from south to north, just south of the village of Carcross. The White Pass & Yukon Railway crosses on Howe truss swing span with timber trestle approaches, total length approximately 425 feet; the swing span is not operative. A heavy duty railway would require 3-100' thru plate girder spans with 150' of pile trestle approaches at a higher grade line than the existing bridge. Photograph 9.

12.5 Carcross to MacRae, Mile 57 to 94

The White Pass & Yukon Railway maintains a station at Carcross (Caribou Crossing) and formerly operated a boat service on Tagish Lake.

This narrow gauge railway was located with much skill to obtain minimum amount of grading and time to construct; it was an outstanding achievement. Therefore, the proposed railway to Iron Creek would be close to and at some points on the White Pass & Yukon Railway's right-of-way.

Encroachment on some private property and crossing of the highway to Whitehorse would be unavoidable through Carcross Village. Although vehicular traffic crosses the railway bridge between the village and a settlement on the south side of the Narrows, there is no road between Carcross, Bennett and Skagway.

The line under study would ascend from grade elevation 2175, at the Carcross Narrows, through the broad valley of Watson River to the summit, elevation 2525, between Lewes Lake and Cowley Lake, then descend, across Wolf Creek, to MacRae, elevation 2430.

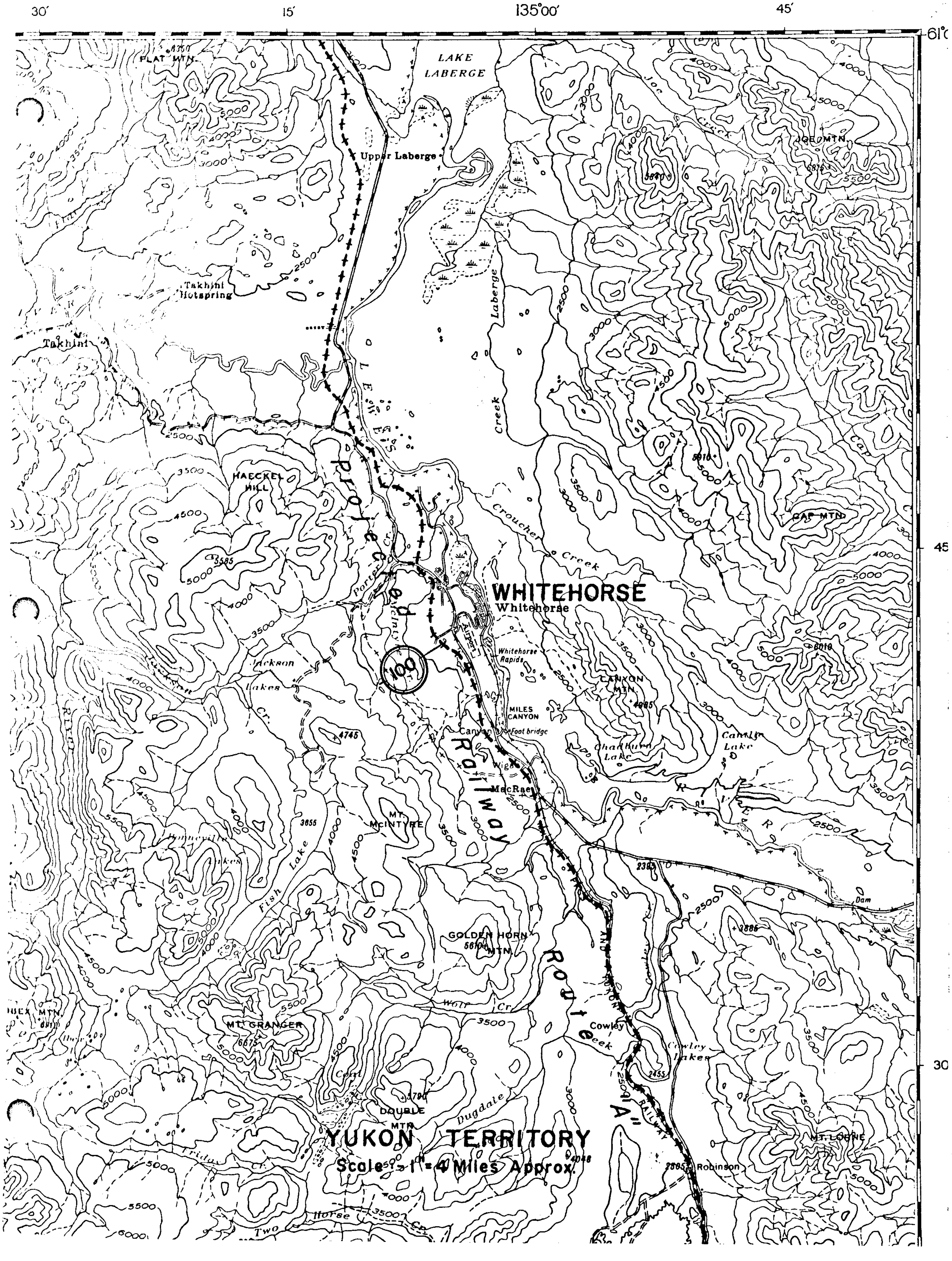
To obtain acceptable gradients and curvature, grading quantities on this section would be fairly heavy, but materials are favourable. Mostly sand and gravel, hills and some flats, as at Robinson, timbered with jackpine, spruce and poplar. Some small quantities of rock may be disclosed at a few locations. No major river crossings. Photograph 10.

At MacRae, the White Pass & Yukon Railway crosses the Alaska Highway and descends on steep gradients to the river flats at Whitehorse.

12.6 <u>MacRae, by Whitehorse, to Takhini River, Mile 94 to 111</u>

The new line would continue on the west side, at a general elevation 2400, and at points quite close to the Alaska Highway and north of Military Reserve and Whitehorse Airport, Mile 103. Thence it would cross to the east of the highway and descend on 0.80 per cent compensated gradient (maximum against southward loaded ore trains), on rugged side-hill formation - crossing two wide and deep creek valleys and the highway to Dawson City - to a crossing of the Takhini River, grade elevation 2170.

This is a difficult section. Grading quantities would be heavy, mostly



30′
15′
135°00′
45′
61°
45
30
LAKE LABERGE
FLAT MTN.
Upper Laberge
Takhini Hotspring
Takhini
Laberge Creek
JOE MTN.
Joe Creek
CAP MTN.
Croucher Creek
HAECKEL HILL
Projected Railway Route "A"
WHITEHORSE
Whitehorse
Airport
Whitehorse Rapids
MILES CANYON
Canyon
Foot bridge
Wigg
MacRae
CANYON MTN.
Chadburn Lake
Canyon Lake
Porter Cr.
Jackson Lakes
MT. McINTYRE
Fish Lake
GOLDEN HORN MTN.
Wolf Cr.
MT. GRANGER
Cowley
Cowley Lakes
DOUBLE MTN.
Dugdale
YUKON TERRITORY
Scale: 1" = 4 Miles Approx.
Robinson
MT. LORNE
Dam

sand, gravel, clay and boulders, also a substantial amount of solid rock. Two large pile and frame timber trestles and two highway grade separations and a major steel bridge would be necessary.

Whitehorse - the situation is complicated. The town, population about 5,000, entirely occupies the flats on the west side of the Yukon River below Whitehorse Rapids, now dammed for development of hydro-electric power. Photograph 11.

The business section and heavy industrial area served by spurs from the White Pass & Yukon Railway is at a general elevation of 2100. A steep slope, subject to landslides, rises abruptly to a wide bench occupied by the airport, elevation 2330. This is part of a large Military Reserve.

The Alaska Highway by-passes Whitehorse town; it, the highway, is immediately west of the airport. There are three residential subdivisions, an oil tank farm, communication towers and aerials on higher ground west of the highway.

Three miles northerly there is the Porter Creek Subdivision, and below it a large bench within a bend of the Yukon is occupied by a radio station with relative towers and aerials.

These man-made obstacles aggravate those presented by the natural ground formation.

A station, yard and industrial area could be established on the proposed railway near the oil tank farm· this is within 3 miles, by highway, of Whitehorse centre. However, direct rail service to the existing heavy industrial area, on the river flats, would have to continue via the present White Pass & Yukon Railway route.

Takhini River - the site for a railway bridge is one mile upstream from the confluence with the Yukon River and the bridge on the highway to Dawson City. These two rivers have eroded deep courses through broad valleys causing cut banks, in silty material, up to 200 feet high. Photograph 12.

Therefore, a crossing with grade approximately 100 feet above water level is indicated, with 3-200' deck truss spans. Seepage was observed flowing from the south bank, this might cause some foundation difficulty.

12.7 Takhini River to south end of Fox Lake - Mile 111 to 138

From the Takhini River there is a gradual ascent, elevation 2170 to 2610, to the south end of Fox Lake.

At Mile 113, there would be a grade crossing of the road to Takhini Hot Spring. Then the line would be on moderate side hill formation without exceptional grading quantities. Formation of sand, gravel, silt and clay, also some solid rock.

12.8 By Fox Lake and Little Fox Lakes - Mile 138 to 155

The Dawson City Highway was constructed, and recently improved, near the east shore of Fox Lakes; however, with revision of the highway at four points amounting to not over 3 miles, it would be practical to construct a railway between the highway and the lakeshore without extraordinary work. Formation - sandy loam, silt, gravel and boulders.

Right-of-way would have to be obtained through a few parcels of private property fronting on the lakeshore.

Two alternatives were examined to avoid encroaching on the highway:-

(1) by the west shore of Fox Lake it is definitely not favourable on account of landslides,

(2) by the west shore of Lake Laberge the formation is more rugged with considerable solid rock.

12.9 Little Fox Lakes to Braeburn Lake - Mile 155 to 170

From the summit, elevation 2715, there is a continuous descent on 0.80 per cent compensated gradient, through the very narrow crooked valley of the creek flowing northerly from Little Fox Lakes, for a distance of 12 miles, to elevation 2300.

Considerable curvature would be necessary, with recrossings of the creek several times; also, the Dawson Highway would be crossed twice to maintain the railway rate of gradient on the side hill.

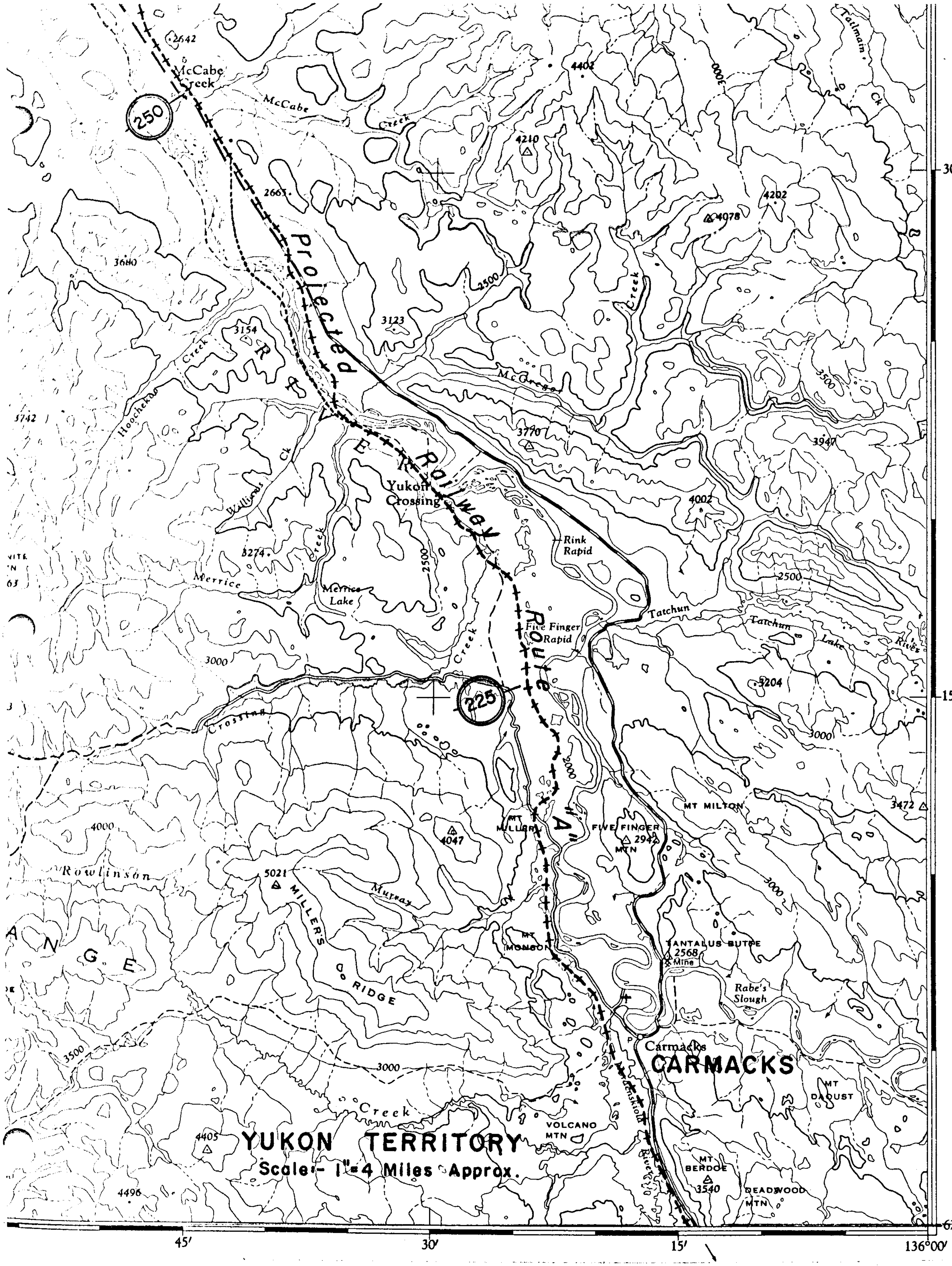
Grading would be very heavy, with cuts up to 100 feet deep and relatively high embankments. Materials appear to be sand, gravel, silt, clay and boulders, with solid rock exposures.

Mile 170, Route "A", is the turn-off point for the alternative Route "X", via Little Salmon.

12.10 By Nordenskiold River Valley to Carmacks - Mile 170 to 212

This is through the broad valley of Klusha Creek, between Twin Lakes, then by the Nordenskiold River. These water courses are meandering with light rate of gradient. Some channel diversions would be advisable to obtain the best railway alignment and avoid swampy areas.

Grading quantities would be comparatively moderate, without solid rock.



YUKON TERRITORY
Scale - 1"=4 Miles Approx.
Projected Railway Route "A"
250
225
CARMACKS
Carmacks
McCabe Creek
McCabe Creek
Yukon Crossing
Rink Rapid
Five Finger Rapid
Merrice Lake
Merrice
Tatchun
Tatchun Lake
McGregor
Hoochekoo Creek
Williams Ck
Crossing
Rowlinson
RANGE
MILLER'S RIDGE
Murray
MT MILLER
MT MONSON
FIVE FINGER MTN
2942
MT MILTON
TANTALUS BUTTE
2568
Mine
Rabe's Slough
MT DAOUST
VOLCANO MTN
MT BERDOE
3540
DEADWOOD MTN
Nordenskiold River
Tatlmain Ck
2642
4402
4210
2665
4202
4078
3680
3123
3154
3742
3770
3947
4002
3274
2500
3500
3000
3204
2000
3472
4000
4047
5021
3000
4405
4496
30′
15′
62°
45′
30′
15′
136°00′

The Nordenskiold River would be crossed at Mile 209, with thru plate girder spans, amounting to 200 feet.

Mile 190 would be a suitable area for a divisional yard.

12.11 Carmacks to near Minto - Mile 212 to 253

This section is in the broad valley of the Yukon River, with an undulating grade line ranging from elevation 1900 to 1600.

Northerly from Carmacks, on the west side of the river, for a distance of 20 miles, is very irregular with high local hills and deep pot holes, some of which are occupied by small lakes of very clear water. Grading quantities would be very heavy but favourable materials, mostly sand and gravel.

By the bend of the river at "Old Yukon Crossing", the line would be at the toe of a steep rock side hill close to the west bank of the river for about one mile. Then it would cross a wide jackpine bench, four miles, to a possible bridge site, Mile 238.5, to cross the Yukon River, from west to east.

Yukon River Crossing - the narrowest part of this river, downstream from Carmacks, is at Five Finger Rapids. Foundation conditions appear to be good, with islands for the base of piers. Conditions are somewhat similar five miles downstream at Rink Rapids, excepting there are no islands. However, the topography of the banks approaching both of these rapids cause either to be unsuitable for a bridge site for the railway under consideration. There are cut banks up to 300 feet high which would necessitate sharp curvature and heavy grading.

There are two alternative sites further downstream below "Old Yukon

Crossing" - (1) at railway projection Mile 238.5 near Williams Creek, and (2) Mile 244, near Hoochekoo Creek. The width of the river at both sites is approximately 900 feet. Approaches are favourable; in this respect the northerly one is somewhat better, however, there would be one and one-half miles of rock grading at the toe of the steep side hill close to the west bank of the river north of Williams Creek.

River current is steady but not particularly swift with no evidence of overflow of the banks in this vicinity. Photograph 13.

Detailed topographic survey, soundings and drilling would be necessary to establish which site should be adopted.

After crossing the Yukon River, from west to east, the line would be on favourable benches - mostly sand and gravel, well timbered with jackpine, spruce and aspen - to Mile 253.

Dawson City Highway would be crossed, at grade, near McCabe Creek, Mile 250.

12.12 Minto to Pelly River - Mile 253 to 280

This section surmounts the summit between Yukon and Pelly Rivers.

From Mile 253, grade 1590, there is an ascent by Von Wilczek Creek, along moderate side hill slopes, well timbered with jackpine, spruce and aspen, to the lakes at the summit, Mile 267, elevation 1915. Ground formation is favourable - mixture of clay, silt, sand and gravel with possibly some solid rock. Quantities would not be very heavy.

A very different situation is presented by the descent, (on 0.80 per cent compensated grade), to the Pelly River, Mile 280, grade 1610. Unfavourable topography about Mica Creek indicates considerable curvature and a large pile and frame trestle bridge, up to 100 feet high and overall length of 1,200 feet.

Mile 275 is close to a steep cut bank of silty material above a sharp bend of Pelly River; heavy rip-rap would be required, for a length of 3,000 feet, to protect the toe against erosion. Projection continues along the side hill to Mile 277, then over a wide bench for three miles to the river crossing.

Pelly River meanders through a wide valley, floor about 3 miles, on a characteristic course with high cut banks on the outside of many sharp bends.

The projected bridge site is 5 miles due east, upstream, from the existing highway bridge.

River width averages 700 feet. There are considerable variances between seasonal water levels. During high water, current is swift; large logs and trees float down from upper reaches. As the level drops, extensive bars of silt, sand, gravel and boulders are exposed.

Bridge design would probably consist of 3-200' thru truss spans, with 2-100' D.P.G. approaches, subject to results of drilling to ascertain foundation conditions.

12.13 Pelly River to Stewart River Valley - Mile 280 to 326

Immediately from the Pelly Crossing, elevation approximately 1610, grade would ascend, 1.50 per cent compensated, on moderate side hill slopes, then cross the Dawson City Highway to Willow Valley and continue on more moderate gradients to the summit Mile 301, elevation 2320. Much of this area has been burned over. Materials are favourable for grading and quantities required are not very heavy.

North of the summit it is difficult to descend, across Crooked Creek, to the flats of the Stewart River Valley, Mile 326, elevation 1620, on the maximum rate of gradient - 0.80 per cent compensated against southward traffic, loaded ore trains. Several alternative routes were reconnoitred and projected.

The most practical line appears to be through a burned over area along the west side hill slope to a crossing of Crooked Creek at Mile 317. This would not be possible without three major construction works:-

(1) Drain two small lakes, near the summit, and excavate a very large cut. To grade partly below the drained lake beds and at the outlet, there would be a rock cut up to 100 feet deep; overall length of this cut 6,000 feet. Materials excavated to be built into a heavy adjacent embankment.

(2) Bridge Crooked Creek, Mile 317, with a steel viaduct 2,000 feet long, up to 220 feet high, plus 400 feet of pile and frame timber trestle approaches.

(3) Grade separation, Mile 318, indicated underpass, to cross Dawson City Highway.

Northerly from the highway crossing, the descent is along a moderate side hill slope, well timbered with aspen and spruce, to the floor of Stewart River Valley, Mile 326.

12.14 <u>Stewart River Valley to Mayo - Mile 326 to 352</u>

Stewart River, in this area, has an average width of 1,000 feet, with considerable seasonal range in water levels and extensive bars of silt, sand, gravel and boulders are exposed during low water. It meanders through a valley floor 2 to 3 miles wide. There are many old "oxbow" channels and some muskeg areas.

Mile 326 northerly, to the proposed crossing of Stewart River, Mile 342, the line would have light gradients, ranging between 1600 and 1630, on the east side of the river, a burned over area with light second growth. Grading quantities would be moderate, sand, silt, clay and a little gravel.

<u>Stewart River</u> is crossed at a point where it is in a definite channel with banks of sufficient height to contain the flow at all stages. Width is approximately 800 feet. Steady current, without excessive velocity.

Indicated bridge design is 4-200 foot deck truss spans, plus 160 feet of pile and frame trestle approaches, subject to sub-surface investigations for foundations.

From the bridge, grade 1630, the projection ascends on 1.50 per cent compensated gradient to a bench, elevation 1780, to avoid a sliding bank at Mile 345.

Between Mile 350 and 352, topography is very irregular with local hills of sand and gravel with pot holes between. This area is well timbered with jackpine, aspen and spruce.

Grading quantities would not be heavy and materials favourable - sand, gravel, silt and clay.

Highway to Mayo, Elsa and Keno Hill would be crossed, from south to north, near Mile 352, 2½ miles westerly of Mayo Village.

12.15 Mayo to Elsa - Mile 352 to 383

This section overcomes the summit between Stewart River and McQuesten River. It ascends the westerly side of the Mayo River Valley, well clear of the Mayo Hydro Electric Power Plant (on the east bank) and at an elevation above the dam and reservoir, to cross Minto Creek and continues by the valley of Mud Creek to the summit, elevation 2330, near Halfway Lakes.

Opposite the power plant and reservoir, grading quantities would be heavy, mostly solid rock, but, would be moderate, without rock, by Mud Creek to Halfway Lakes. This area has been burned over but now has some second growth.

Descent would be moderate to the crossing of Christal Creek, Mile 383, opposite Elsa and Keno Hill.

Permafrost occurs in this area; it has been disclosed to a depth of 120 feet by mining people drilling in the valley. Care should be taken to avoid excavations, to the extent practicable, and disturbing the base on which embankments are to be built. Suitable borrow pits should be obtainable within reasonable hauling distances.

12.16 Elsa to Beaver River - Mile 383 to 424

This section is through the valley, one to three miles wide, between South McQuesten River and Beaver River; the summit is low, elevation 2300, and railway gradients would be light.

Mile 385 to 392, the route is by Hanson Lakes. Topography is very rough and irregular, with high local hills and deep pot holes. Considerable curvature would be necessary, even so, grading would be heavy but materials appear to be favourable, mostly sand and gravel.

Typical permafrost country was observed - where the route turns to the east - Mile 392 to 407, south of McQuesten Lake and the many smaller lakes and ponds about the summit of this valley. Much of the surface covering is organic material with scrub spruce. The grade should be kept to embankment to the extent practicable.

Drainage is of major importance. Culverts should be installed wherever necessary to permit direct flow through embankments to avoid conducting water along ditches on the upper side of embankments. Also culverts should be of ample diameter to facilitate cleaning them of ice and snow.

In many locations, it may be advisable to install double culverts, with the intake of one higher than the stream bed so that it will function if the lower one may be obstructed by glaciation. This is good precaution against washouts during Spring run-off.

The route then crosses to the north side of the valley by Clark Lakes, Scougale Lakes and Scougale Creek to its confluence with Beaver River, Mile 419. This section is comparatively well timbered with spruce, jack-pine and aspen, and, there are indications of some sand and gravel.

There is a short ascent along the west side of Beaver River to a crossing, Mile 423.5.

Beaver River - The projection crosses from west to east. The river flows southerly. The valley base is one half of one mile wide. The river bed is gravel and boulders. Banks are low with overflow channels on some reaches. Normal depth is shallow but marked rise and swift current during high water.

Bridge would be 3-100' deck plate girders or thru plate girders, if under clearance would not be sufficient for the former.

12.17 Beaver River to Rackla River - Mile 424 to 441

From Beaver River, grade elevation 2325, the route again turns east, through a valley with base one half mile wide, to a low summit, elevation 2500, then by the south shore of Kathleen Lakes to the Rackla River.

About the summit there are typical meandering creeks, small lakes, ponds and muskeg. Grading would not be very heavy, but, along the shore of Kathleen Lakes considerable solid rock would be encountered for a distance of six miles. Photograph 14.

Kathleen Lakes, together five miles long and one half mile wide, are very beautiful waters, well stocked with trout, between mountains rising to two thousand feet above lake level. The shores are fairly well timbered with spruce, and, a comfortable campsite is on the north shore. An alternative route by the north shore was considered; it would be longer without sufficient compensation.

Rackla River flows south-westerly to Beaver River which in turn flows south-easterly to Stewart River.

The crossing of Rackla River would be immediately downstream from its confluence with East Rackla River, where there is a good bridge site, between almost sheer rock walls 75 feet high at a width of 350 feet. Photograph 15.

Indicated bridge design, 3-105' D.P.G. spans. Grade elevation 2475.

12.18 East Rackla Valley to Bonnet Plume River - Mile 441 to 488.5

The lower reaches of East Rackla River are very meandering with old oxbows, beaver dams and ponds, within a swampy valley, base one half mile wide.

The railway route here is easterly; it ascends along the toe of the south slope to the summit, Mile 481, grade elevation 3405. No long sections of maximum gradient, 1.50 per cent compensated, are necessary.

Alignment at some points would be close to the river. One or more channel diversions may be advisable, also demolition of beaver dams.

Grading quantities would be fairly heavy cuts and fills. Exposures of solid rock were observed which it would not be practical to avoid; on the other hand, there are some eskers of sand and gravel available for borrow.

At Mile 473, the course turns from easterly to north-easterly and the valley bottom narrows one eighth of a mile. This is the junction point with alternative Route "X" at the base of Nadaleen Mountain.

At the summit there are sloughs and indications of permafrost, so summit cut should be kept to a minimum. Photograph 16.

This is the divide, on the proposed railway route, between drainage to Stewart River thence to Yukon River and waters flowing to Peel River and the Mackenzie.

From the summit, Mile 481, there is a descent, via a creek valley, of seven miles on 1.00 per cent compensated gradient to Bonnet Plume River. This gradient is the same maximum rate against southward traffic, loads, as necessary in the Snake River Valley and is relative to it with respect to train operation.

The summit area and through the creek valley approaching Bonnet Plume River, there are scattered spruce up to twenty feet high. Some indications of sand and gravel are near the Bonnet Plume.

Bonnet Plume River, Mile 488.5, flows northwesterly. It is fairly swift but excepting at high water is not deep. The bed is gravel and boulders. Banks, at bridge site, gravel, 10' high, immediately upstream from confluence with Goz Creek. Fair growth of spruce about. Photograph 17.

Grade elevation 3080, would be 40 feet above river bank, so deck plate girders could be used - say 3-90' spans, with 140 feet of pile and frame trestle approaches.

12.19 Goz Creek Valley, Mile 488.5 to 506

Goz Creek, flowing in this valley south-westerly from Goz Pass, is a typical braided mountain river with a steep gradient up to three per cent. The bed is gravel and boulders. Some patches of ice and snow, 4' deep, from the previous winter, were seen on the side of the creek bed, August 17, 1964. Photograph 18.

Some of the longest sections of maximum gradient, 1.50 per cent compensated against northward traffic - fuels, supplies and empty ore cars - are required to ascend this valley, elevation 3065 to 4030.

From crossing Bonnet Plume River, the line is projected across a favourable flat for two miles then develops near the toe of the east or south mountain side. The valley bottom is from 300 feet to 1,500 feet wide; mountains rise on both sides up to elevation 7000.

Slopes near the toe are not excessively steep.

The upper part of this valley is bare of trees. Grading quantities would be heavy, predominately solid rock and loose rock.

Duo Creek would be crossed at Mile 495.5 and three other large creeks, Mile 502, 504.6 and 505.8, which would require steel bridges - 3-100' and 2-80' D.P.Gs; 4-100' D.P.Gs; 3-90' D.P.Gs and 4-60' D.P.Gs respectively.

Large diameter structural steel pipe culverts should be provided at several locations to accommodate quick runoff from steep bare rock slopes.

There were no indications of serious rock and snow slides. However, some precautions would be necessary with respect to winter maintenance and operation.

12.20 Goz Pass, Mile 506 to 509

Bonnet Plume Range consists of very rugged and bare mountains of sedimentary formations rising to 7,000 feet above sea level, between the valleys of Bonnet Plume River and Snake River.

Goz Pass is the most direct access route between the upper reaches of these two rivers. It is an open valley, 400 feet to 1000 feet wide - entirely bare of trees, even very few shrubs - partly occupied by two small lakes, together, a little over one mile long and up to 800 feet wide, draining to Goz Creek.

The summit, elevation 4030, is 1,600 feet north-east of the easterly end of the lakes.

The better side of the lakes for a railway location is on the south or east, near the toe of slope between the lake shore and mountains. Photograph 19.

The roadbed should be of embankment to the extent practicable to minimize the possibility of snow drifts.

Creek flowing from the summit northerly, falls rapidly through a narrow gorge to the Snake River, nearly 500 feet in 3 miles. Photograph 20.

Railway projection crosses above the gorge to the west side of the creek valley and west of Snake River.

In order not to exceed a 1.00 per cent compensated gradient from Goz Summit down the Snake Valley, (maximum against southward ore trains), grade elevation is required to be, on the mountain slope, 370 feet above river level, where the line emerges from Goz Pass into the Snake Valley.

12.21 <u>Snake River Valley - Mile 509 to 569</u>

The Snake is a typical braided type river with many channels and wide range of seasonal water levels. These waters flow north-westerly between Bonnet Plume Range and Backbone Range of the Mackenzie Mountains, to Peel River and Mackenzie River to the Arctic Sea. Photographs 21 and 22.

Opposite Goz Pass, the bottom of Snake Valley is 1,500 feet wide, this increases to 2,500 feet at the confluence with Iron Creek.

Slopes, where the proposed railway is projected, vary from 2:1 to 10:1 but are much steeper, 1:1, higher up the mountain sides entirely bare of trees or shrubs. Paths of rock and snow slides are clearly defined through gorges or "chutes" in the higher levels to emerge in typical "fan" formations as the slopes flatten towards the bottom of the valley. Photograph 23.

Protection against slides may be overhead sheds of reinforced concrete and/or structural steel plates, or, bridges with sufficient underclearance to permit rocks, snow and debris to pass under. There are five slide paths, between Mile 511 and 514, just north of Goz Pass, where either overhead or under protection would appear to be necessary.

Protective works would also be required further north, between Mile 553 and 557. At this location, the toe of the mountain slope, $1\frac{1}{4}$:1, runs right down to the river bank where the railway grade would be constructed. Photograph 24.

Continuous 1.00 per cent compensated grade is necessary from the summit of Goz Pass to develop a descent along the bare mountain slopes, on the west side of Snake River, for 17 miles towards the floor of the valley.

Grading quantities of solid rock and talus would be very heavy along the mountain side and continuous one per cent gradient Mile 509 to 526.

Steel viaduct up to 2,040' long with height to 130' would be required to cross tributary creek at Mile 517, and, as mentioned before, six structures would be required for drainage and protection against rock and snow slides, also, a number of large diameter structural steel plate culverts.

This area of the Snake Valley, near the north entry to Goz Pass, where very heavy construction would be encountered, has been given particular study.

Mr. W. C. Cook of Crest Exploration plotted an alternative projection. This turns southerly from Goz Pass, up the Snake Valley, for approximately five miles then turns around a horseshoe curve to resume the northerly direction towards Iron Creek, and, crosses the creek, flowing from Goz Pass, close to its confluence with Snake River and is on a low bench, just above river level, instead of the direct route which is 370 feet above the river.

Although this alternative projection has some merit, it would add nine miles to the construction, maintenance and operation length of this proposed railway and it appears no overall economy would be effected.

However, if location survey is proceeded with, it would be advisable to give further consideration to this alternative.

Duo Pass was also reconnoitred. A route through it would be longer and have no compensating features in comparison with Goz Pass.

From Mile 526 to 553 the location would be on more favourable formation - the lower slopes and benches. Grading quantities would be fairly heavy but materials including sand and gravel may be obtained close by.

Minor steel bridges should be provided at Miles 528, 530, 531, 540, 546, 547 and 552, also, a number of large diameter culverts.

There would be four miles of very heavy construction, mostly solid rock and loose rock, Mile 553 to 557, at the toe of steep mountain slope, running into the river. Diversion of some back channels would be advisable, also protective works against rock and snow slides and against erosion of embankments by the Snake River. Photograph 24.

Northerly to the crossing of Snake River, from west to east, at Mile 569, the line would be on favourable benches, however, some rock excavation should be expected. Three minor steel bridges would be required.

<u>The Snake</u>, Mile 569, is a braided type mountain river, but, at the proposed bridge site, to cross from west to east, it is confined to one definite channel, approximately 200 feet wide, with banks of gravel and boulders 10 feet high. Current is swift with marked seasonal ranges of water levels, but no evidence of overflow at this site, on a bench, well treed with small spruce and cottonwood.

Indicated bridge design is 1-200' thru truss span and 2-80' deck plate girder approach spans. Grade elevation approximately 2045.

12.22 East bank of Snake River - Mile 569 to 576

Northerly from the river crossing, the projection is along side hill slopes, 3:1, treed with spruce, general elevation of grade 2000, from 50' to 100' above river level. Grading quantities would be fairly heavy, including some solid rock.

12.23 Iron Creek Marshalling Yard - Mile 576 to 578

Crest Exploration has constructed an air strip on the east bank of Iron Creek, just upstream from its confluence with Snake River, photograph 25, and has graded a road in Iron Creek Valley, for 9 miles, to a camp site by the North Fork.

Subject to further advice with respect to mine development plans, it is recommended that a railway terminal, or marshalling yard, be located on the bench, 150' above river level, within the "fork" between Snake River and Iron Creek, one mile south of their confluence, approximate elevation 2000. Photograph 26.

There is ample area for yard, shops and facilities as may become necessary. Grading quantities would be relative to the yard design, etc. Although permafrost occurs, frost-free borrow is obtainable.

12.24 Iron Creek Valley - Mile 578 to 584

It would be practical to continue the proposed railway in a south-easterly direction by the west bank of Iron Creek, then a crossing near Mile 583 to an open area, east of the creek, to Mile 584, elevation 2500. Photograph 27.

Beyond this, the north branch of Iron Creek has an average gradient of 2 per cent and is confined to a comparatively narrow valley.

ALTERNATIVE ROUTE "X" - DESCRIPTION BY SECTIONS

13. The objective is to reduce the overall length of this proposed railway by approximately 30 miles.

This could be achieved by turning off from Route "A", Mile 170, near Braeburn Lake, thence in a north-easterly direction via the base of a triangle, rather than around the other two sides, to rejoin "A" at Mile 473, near the headwaters of East Rackla River, by Nadaleen Mountains.

Carmacks, Minto, Mayo, Elsa and Keno Hill would be by-passed.

13.1 Braeburn Lake to the Yukon - Mile 170 to 210.5

From the turnoff, elevation 2280, the route is over a low summit, 2410, to the head of Mandanna Creek, thence along the west side of this creek and Mandanna Lake to the Yukon River Valley and to a crossing of Yukon River, just below its confluence with Little Salmon, elevation 1860.

Three sections of 0.80 per cent compensated maximum gradient, against southward traffic, would be necessary.

Approaching the summit and the area about the headwaters of Mandanna Creek has been burned over. The topography is irregular with local hills and pot holes. Materials appear favourable for grading.

Mandanna Creek flows northerly, to Yukon River, through a fairly open valley, bottom width from one half to one mile wide. It is occupied by Mandanna Lake and a number of smaller lakes. Projection is along the west slope of this valley; topography is moderate to rough. Low mountains rise to 1,000 feet above the lakes. The area about these lakes is fairly well timbered with spruce and aspen.

Grading would be fairly heavy - sand, gravel, clay and silt, also at at least two points there would be solid rock.

Two miles north of Mandanna Lake the valley merges into the Yukon River Valley. The descent to the river is along a moderate side hill slope and over a broad bench. This area has been severely burned over. Materials appear favourable for grading.

An alternative was reconnoitred to turn-off from Route "A", Mile 118, near the south end of Lake Laberge, thence via the west shore of Lake Laberge, through Ogilvie Valley and over a summit, 2600, to Coghlan Lake and Frank Lake, photograph 28, then over a low divide to Chain Lakes and by the east side of Mandanna Lake to Little Salmon.

Along the west shore of Lake Laberge a number of solid rock outcrops were observed and the topography is much rougher than along Fox Lake.

Northerly by Coghlan Lake, Frank Lake and Chain Lakes, topography is very rough in comparison with by Mandanna Creek. Although there are extensive deposits of sand, gravel and some eskers, about Frank Lake, the irregular local hills are high and relative pot holes deep. Grading quantities would be very heavy, even on a location with considerable curvature.

The route by Mandanna Creek is better by far than via Frank Lake.

The Yukon River, Mile 210.5, proposed bridge site is one quarter mile below the confluence with Little Salmon. The course of the Yukon is fairly straight and in one definite channel. Width approximately 750', with banks 25' high. Photograph 29.

River current is moderate but water levels and velocity are subject to seasonal variances. There was no opportunity to sound the depth or foundation conditions but no unusual surface features were observed. South bank has been burned over. North bank is treed with second growth aspen.

Indicated bridge design - 4-200' thru truss spans, with 300' pile and frame trestle for approaches.

13.2 By Frenchman Lake to Tatchun River - Mile 210.5 to 228

After crossing Yukon River, the route crosses a bench to the east side of the valley, which runs north-westerly for some fifteen miles, up to one mile wide, but almost entirely occupied by Frenchman Lake.

Topography is very jumbled up, with local hills, mostly sand and gravel, and pot holes; fairly well treed with aspen, jackpine and spruce but the mountain slopes do not crowd in close to the lake. Although materials appear to be favourable for grading, quantities would be heavy, even with introduction of considerable curvature.

There is an old wagon trail along the east side of Frenchman Lake.

Drainage from this lake is north-westerly to Yukon River below Five Fingers Rapids.

The Tatchun, Mile 228, is a minor river flowing from the area of low mountains, east of Frenchman Lake. If closer examination does not show too much debris of logs and trees being carried down, a timber trestle bridge 200' long may be sufficient to accommodate the flow of this river.

13.3 Tatchun River to Pelly River - Mile 228 to 279

The route ascends through a very crooked, narrow valley, including a narrow and deep canyon, by Kelly Lake and Ess Lake, to the summit, elevation 2450. A long section of 1.50 per cent compensated, against northward trains of fuels, supplies and empty ore trains, would be required within this creek valley.

Two or more timber trestle bridges may be required to cross and recross the creek to obtain reasonably good railway alignment.

Kelly Creek Canyon is a very narrow natural cut through the range situated between Yukon River and Pelly River. Photograph 30.

Much care would be necessary to locate, construct and maintain a railway through this gorge - 2 miles long, up to 450' deep, minimum bottom width 100' and walls subject to rock slides. There is evidence of a heavy flow from Kelly Lake during Spring run-off through this gorge.

Heavy rock work on very steep slope, with some sections of retaining walls or alternative of tunnelling, would be encountered to obtain a 1.50 per cent compensated gradient between Tatchun River and Kelly Lake.

However, it presents a "way through" shorter than to ascend the Little Salmon Valley and Bearfeed Creek Valley and then over the higher summit to Needlerock Creek.

After passing through the canyon, the line would be by the east side of Kelly Lake and continue to the head of the creek. There are steep rock faces and another "gut" - not as long or as deep as the canyon - by an "S" turn in the creek; this would require a heavy rock cut or a tunnel, opposite Tadru Lake.

Projection would then pass to the south and east of Ess Lake, over the summit, then across Needlerock Creek to the plateau about Ragged Lake.

This summit area, between Frenchman Lake and Pelly River, is a jumbled formation of local hills, which appear to be mostly sand and gravel, treed with second growth aspen; rock knolls were also observed. Grading would not be very heavy.

The route continues northerly, on the east side of the creek draining Ragged Lake, to Pelly River Valley, then descends along favourable benches to a crossing, elevation 1870, just below the confluence with Tummel River.

Three sections of 0.80 per cent compensated gradient would be required between the summit and Pelly River,

The Pelly River, Mile 279, has a meandering main course, also many high water channels, and old oxbows, flowing through a wide valley. Bed is of silt, gravel and boulders. Current fairly swift, with wide seasonal ranges in water level, velocity and width. Much debris, logs and trees, are carried down during high water periods.

The proposed bridge is on a comparatively straight reach, one definite channel, immediately downstream from the confluence with Tummel River. Grade elevation 1870.

Indicated bridge design - 3-200' thru truss spans and approaches 2-100' D.P.Gs.

13.4 Pelly River to Macmillan River - Mile 279 to Mile 305

From Pelly River crossing the route would be somewhat east of north over a low summit, 2085, for a distance of ten miles to the Macmillan River

Valley, just west of Lone Mountain. However, 1.50 per cent compensated gradient would be necessary from the Pelly River northerly, by a narrow crooked creek valley, to the summit.

Between the summit and Lone Mountain, topography is irregular with some local hills. There are some rock exposures, otherwise grading materials appear good. Covering is light spruce, jackpine and aspen.

The projection is to the north of Lone Mountain, between it and the river, then north-easterly along moderate side hill slopes, a burned over area, for sixteen miles, to Macmillan River crossing. Grading quantities would be moderate.

<u>The Macmillan River</u>, Mile 305, although it is a tributary to Pelly River is also a major river. It too has a characteristic meandering course through a wide valley between low mountain, or foothill, ranges.

The proposed bridge site is a few miles upstream from the confluence with Moose River. The approach from the south is favourable, but, not from the north where there are high cut banks - sand, gravel and silty clay. Photograph 31.

The river is in a well defined channel; width, depth and velocity vary with seasons. Bed is gravel and boulders. Banks are timbered with spruce and cottonwood.

Indicated bridge design - 1-200' thru truss span and 4-100' D.P.Gs. Grade elevation 1900.

13.5 <u>Macmillan River to Stewart River - Mile 305 to 361</u>

To avoid a high crossing of the Macmillan River, sharp curvature and 1.50

per cent compensated maximum gradient would be necessary for three miles, to gain Moose River Valley.

Thence, the projected route is by the south side of Moose River to a crossing two miles south-west of the outflow from Moose Lake. There are no unusual features in this valley.

Moose River could be crossed, from south to north, with a pile trestle up to 400' long.

By Moose Lake, for eight miles, the line would be close to the north shore at the toe of a fairly steep mountain slope, rising to 2,500 feet above the lake. These slopes are well treed with spruce and poplar. Grading would be fairly heavy, including solid rock. Photograph 32.

An alternative, by the south shore of Moose Lake, would be clear of steep slopes but muskeg areas would have to be crossed and the line would be longer.

From the north end of Moose Lake the line would ascend by a creek valley and over the summit, 2400, to the headwaters of Canoe Creek. This summit is an area of small lakes, ponds and swampy, but would not present any serious difficulty.

Canoe Creek is crossed about Mile 341, then the route is by the west side of the Creek to where it flows into the big bend of Hess River.

The country around Canoe Creek is very pleasing. Treed with spruce, jack-pine and poplar, with some open meadows.

Hess River, west bank, is followed for fifteen miles, through the canyon, to its confluence with Stewart River, then a further two miles downstream to a crossing of Stewart River.

From the Big Bend of Hess River, the projection descends north-easterly along moderate side hill slopes, fairly well timbered, to the Canyon, then there would be sharp curvature to the southwest and some heavy solid rock grading to enter Stewart Valley and descend to a suitable elevation for bridging.

Sections of 0.80 per cent gradient would be necessary to develop in the Canoe Creek Valley and at the approach to Stewart River.

The Stewart River, Mile 361, two miles downstream from the confluence with Hess River, almost entirely occupies the valley floor. Although side slopes rise to 3,000 feet above river level, they are not steep.

The river channel is well defined, up to 1,000 feet wide at high water. The bed is of silt, sand and gravel. There is marked evidence of heavy movement of ice and logs during Spring run-off.

Grade, elevation 1860, may provide sufficient under clearance to permit bridge design of 3-200' deck truss spans, with 2-100' D.P.Gs and 300' pile and frame trestle approaches.

13.6 Stewart River to Beaver River, Mile 361 to 399

From the north bank of Stewart River the line would be developed, on 1.50 per cent gradient, up a very narrow crooked valley, by a group of small lakes to the summit, elevation 2400, near the south end of Penape Lake. Curvature and grading through this valley would be heavy, including some solid rock and swampy areas towards the summit. The north and east shores of Penape Lake are low and swampy.

Projection continues in a north-easterly direction by the west side of Penape Lake to re-enter Stewart River Valley after by-passing the big loop and Seven Mile Canyon, near Lansing.

Stewart River Valley is wide and its course is north-westerly from Penape Lake, for twelve miles, to Barren Plateau Creek and Keno Ladue River, then the course turns north-easterly in conformity with the general direction of this proposed railway route.

This area is fairly well treed with small spruce.

Grading quantities would be moderate by Penape Lake on the side hill to Keno Ladue River, although some have a fairly heavy surface cover of organic materials which might have to be stripped before commencing to build embankments, that is, if these organic materials are not protecting permafrost. If so, they, organic covering, should certainly not be disturbed, in order to preserve the permafrost condition of the materials below.

Between Keno Ladue River and confluence of the Stewart with Beaver River, the valley narrows and the banks of Stewart River are high with indications of slides, at least at one point. Therefore the projection would be above this, until necessary to descend to cross the Beaver River at a point two miles upstream from its confluence with the Stewart.

This is a difficult area, the Stewart and Beaver form a horseshoe which would be impracticable to go around without excessive curvature. To overcome this, a very heavy cut or tunnel, 2,600 feet long, would be necessary through the throat.

The Beaver River, Mile 399, is tributary to Stewart River. To cross the Beaver is a major undertaking, at this location, below the entry of Rackla River, in comparison with crossing the Beaver on Route "A".

Banks are comparatively high. River bed is sand, gravel and boulders. Current is swift with wide seasonal range of water level, width and velocity.

Bridge design may be 3-105' deck plate girders, 2-40' beam spans and 300' pile and frame trestle for approaches. Grade elevation approximately 2050.

13.7 Beaver River to Nadaleen River - Mile 399 to 408

The direction of this section is nearly east, on the north, or west, side of Stewart River, to the confluence with Nadaleen River.

The Stewart River has eroded its course, causing high cut banks, mostly clay, on alternate sides of the river and from bend to bend, and some slides occur. A railway gradient would ascend, after crossing Beaver River, to be above cut banks on the Stewart River. Grading quantities would be heavy.

At the confluence of the Stewart and Nadaleen, these two rivers form a horseshoe, somewhat more pronounced than the horseshoe at the confluence with Beaver River.

A tunnel, some 2,000 feet long, would be necessary through the throat by the Nadaleen confluence.

13.8 By Nadaleen Valley to East Rackla River - Mile 408 to 443

The direction of Nadaleen Valley, north-easterly, for twenty miles is favourable but beyond this it is necessary to turn north-westerly by a tributary creek to cross the summit to enter East Rackla Valley to connect, at Mile 443 "X" Route, with Route "A" Mile 473, opposite Nadaleen Mountain.

The Nadaleen is a swift mountain river flowing through a narrow valley with fairly steep side slopes, rising to 2,000 feet above river level.

The projection ascends along the slopes on the west, or north, side of Nadaleen River. The lower reaches are well timbered with spruce and some aspen, but, the upper reaches have been burned over. Grading would be heavy, including areas of solid rock.

Where the line turns from the Nadaleen, to a north-westerly direction, sharp curvature and maximum rate of gradient, 1.50 per cent compensated, would be necessary to surmount the summit, elevation approximately 3000, between the Nadaleen and East Rackla Valleys.

Elevation of the connection of Route "X" with Route "A", as projected, is approximately 2980, on the east side of East Rackla River and west slope of Nadaleen Mountain.

An alternative to avoid this adverse north-westerly course would be to proceed three miles further up Nadaleen Valley, then turn-off, by a creek, north-easterly, through a pass east of Nadaleen Mountain, to the headwaters of East Rackla River. However, the summit is higher and to gain it without exceeding 1.00 per cent compensated gradient, as in the Snake River Valley, would necessitate a loop up the Bonnet Plume Valley, above the confluence of Goz Creek. This would effect no savings in distance and costs.

14. ROADWAY AND TRACK - ROUTES "A" AND "X"

A portfolio of maps and also one of relative profiles accompany this report. The proposed railway location is projected on the Department of Mines and Technical Resources' maps, scale 1:50,000, showing contours 50' V.I., covering the route between Dyea and the crossing of Beaver River, a few miles north of Elsa, railway Route "A", Mile 0 to 420.

Northerly from Beaver River crossing, no Departmental maps are available at scale greater than 1 inch to 4 miles, showing contours 500' V.I.

Therefore, Crest Exploration Limited had map sheets plotted from general R.C.A.F. aerial photographs to a scale of 1 inch to 1,320 feet, with contours 25' or 50' V.I., of a strip, average one half mile wide, along Route "A", from Beaver River crossing, through Goz Pass, to the confluence of Snake River and Iron Creek, Mile 420 to 577.

Alternative Route "X", railway Mile 170 to 443 - equation with Route "A" Mile 473 - maps, scale 1 inch to 4 miles, showing contours 500' V.I., only are available of the territory beyond Frenchman Lake, north of Little Salmon.

With only such general type maps available to plot an initial projected location on, it is impracticable to establish other than general route and relative profile showing the major "Rise and Fall"; therefore, <u>the following should not be taken as more than a "conjecture of costs to construct roadway and track"</u>.

14.1 Route "A" via Whitehorse, Carmacks, Mayo and Elsa

Main Line, 578 miles plus 11 passing tracks 6,800 feet each and loops at terminals - total 600 miles - 115 lb. rail.

Terminal Yards at port and mine, 69,000 feet and service sidings at 10 mile intervals, also requirements during construction - total 40 miles - 85 lb. rail.

Item	Unit	Quantity	Range of Prices	Amount
Clearing and Grubbing				
Coastal area	Acres	200	$1,000.	$ 200,000.
Interior	"	8,800	185.	1,600,000.
Grading				$ 1,800,000.
Solid rock	Cu.Yds.	9,600,000	$2.75 to $3.50	$30,900,000.
Other materials	"	47,900,000	.50 to .80	29,500,000.
O.M. Permafrost	"	6,500,000	2.00 to 2.20	13,700,000.
Highway diversions by Fox Lakes	Sum			300,000.
				$74,400,000.
Tunnels				
Coast Range 11 miles	Cu.Yds.	1,133,000	10.	$11,330,000.
Concrete lining 50%	Lin.Ft.	29,000	300.	8,700,000.
Ventilating plant	Sum			1,270,000.
				$21,300,000.
Short tunnels	Lin.Ft.	2,700	260.	700,000.
				$22,000,000.
Bridges, culverts and protection against slides				
Timber bridges	Lin.Ft.	8,300	253.	$ 2,100,000.
Steel bridges	"	17,400	1,350.	23,500,000.
Rock & Snow Sheds	"	1,600	1,200.	1,900,000.
Retaining walls	"	1,500	800.	1,200,000.
Culverts	"	240,000	29.	6,900,000.
Rip-rap	Cu.Yds.	100,000	4.	400,000.
				$36,000,000.
Track				
Cross Ties #1 Untr.	No.	1,950,000	5.30	$10,335,000.
Cross Ties #2 Untr.	No.	115,000	4.90	564,000.
Switch Ties 170 sets	M.F.B.M.	850	130.	111,000.
Rails 115# & 85#	N.T.	128,000	159.	20,352,000.
Fastenings	Sum			3,477,000.
Tie plates	N.T.	27,100	169.	4,580,000.
Anchors	No.	2,000,000	.55	1,100,000.
Turnouts	No.	182	Sum	471,000.
Track Materials				$40,990,000.
Lay Track	Miles	640	7,500.	$ 4,800,000.
Install turnouts	No.	170	470.	80,000.
Sub-ballast pit run	Cu.Yds.	4,200,000	1.50	6,300,000.
Surface-crushed & screened	"	2,200,000	3.50	7,700,000.
Lay track, ballast and surface				$18,880,000.
Total of above 5 items				$194,070,000.

14.2 Route "X" by-passing Carmacks, Mayo and Elsa

Main Line, 548 miles plus 11 passing tracks 6,800 feet each and loops at terminals - total 570 miles - 115 lb. rail.

Terminal Yards at port and mine, 69,000 feet and service tracks at 10 mile intervals, also requirements during construction - total 38 miles - 85 lb. rail.

Item	Amount
Clearing and grubbing	$ 1,800,000.
Grading	78,200,000.
Tunnels	22,600,000.
Bridges, culverts and protection against slides	34,200,000.
Track	56,910,000.
	$193,710,000.

14.3 Unit prices applied are 1964 quotations.

Grading, tunnels, bridges, culverts and protection against rock and snow slide quantities and respective unit prices are items most subject to considerable variations. With such large quantities, small changes in unit prices could cause large differences in costs of the respective items.

Recent tenders for grading have been highly competitive.

Advice received of prices for grading highway relocation, in the Whitehorse-Carmacks-Mayo areas, range from 40¢ to 48¢ per cubic yard for common excavation, and, near Watson Lake 29¢, with 30¢ per cubic yard mile for haul over 1,000 feet; rock excavation $3.50.

On a small highway job near Skagway, Alaska, price for rock was $3.20 per cubic yard.

On the Great Slave Lake Railway, Hay River to Pine Point section, N.W.T., common excavation, including overhaul, came to 71.4¢ per cubic yard, built into embankments, during 1964. Much of this was favourable granular material.

For comparison of costs for major steel bridges on concrete sub-structures, the following are costs for highway bridges, constructed 1958-1960:-
Yukon River at Carmacks: Thru trusses 2 x 98' and 2 x 260', overall 727'. Total cost $822,000.00, say $1,130.00 per lineal foot.

Pelly River: 2 x 97' D.P.Gs and 3 x 220' thru trusses, overall 865 feet. Total cost $945,000.00, say $1,100.00 per lineal foot.

Stewart River: 2 D.P.Gs and 1 thru truss, overall 692 feet. Total cost $748,000.00, say $1,080.00 per lineal foot.

Sales tax and freight cause high prices for track materials f.o.b. Whitehorse.

Cross ties No. 1, untreated, near Prince George, B. C., $2.10, sales tax 24¢, strap and load 15¢, freight via Prince Rupert to Skagway $2.25 and 56¢ to Whitehorse - $5.30 per tie.

Rails, 115 lb., at Mill, Sydney, Nova Scotia, $113.50 N.T., tax $12.49, end hardening $1.34, controlled cooling $1.50, freight by ship to Skagway $20.00, handling and rail to Whitehorse $10.00 - $159.00 N.T.

14.4

ROUTES "A" AND "X"
COMPARISON BETWEEN CONSTRUCTION OF ROADWAY AND TRACK

Route "X" turns-off from Route "A" at Mile 170 and rejoins it at "A" Mile 473 = "X" Mile 443.

The comparative distances between Dyea and Iron Creek are - Route "A" 577 miles and Route "X" 547 miles. However, the writer believes this difference of 30 miles is the maximum which might be obtained through more detailed surveys, also, this difference might prove to be somewhat less.

GRADING: Observation of the topography of the respective routes, from a light helicopter and landing at some of the principal controlling features, indicated that the quantities would be heavier and that there would be a larger percentage of solid rock per mile on Route "X".

On Route "X" there are several difficult areas, in particular:-
Kelly Creek Canyon - deep and very narrow, also the rock does not appear to be too competent.

Canyon on the Hess River, above the confluence of Hess River and Stewart River, also, the nearby crossing of Stewart River.

Confluence of the Stewart and Beaver Rivers.

Nadaleen River Valley.

On the other hand, Route "A" has two difficult areas between the junctions of these two routes:-

Crossing the Pelly River Valley and to descend northerly, from the summit between Pelly and Stewart Rivers, to a crossing of Crooked Creek.

However, introduction of 1.00 per cent maximum gradient against southward traffic, reference Section 15, will be of considerable assistance in locating the proposed railway to cross the valleys of Pelly River and Crooked Creek.

BRIDGES AND CULVERTS: Although there is one additional major river - the Macmillan - to be bridged on Route "X", the overall cost for bridge and culvert requirements appear to be slightly less, in favour of "X".

ACCESS: Route "A" is fairly close to the existing, gravel surface, highway from Whitehorse, through Carmacks and Stewart River Crossing, to Dawson City and the branch highway to Mayo and Elsa.

This would permit clearing, grading and bridging to be opened up and to be carried on at several points simultaneously.

Tenders for contracts could be called for in comparatively short sections - say 30 or 40 miles long. This practice would permit some reliable "smaller" contractors to bid in competition with "larger" firms, having relatively higher overhead expenditures, and probably result in minimum unit prices.

Whereas, there is no existing access road through the territory of Route "X".

To gain access to Route "X", it would be necessary to construct a road from the turn-off point, Mile 170, for some forty miles northerly to the crossing of the Yukon River, and also, construct a road from the highway north of the Yukon River bridge, at Carmacks, some 25 miles easterly to railway Route "X", north of the Yukon River, at Little Salmon.

From Little Salmon, an access road would be necessary for nearly 250 miles to the junction to rejoin Route "A". This would involve temporary bridges, or ferries, to cross four major rivers - Pelly, Macmillan, Stewart and Beaver. Temporary bridges would not stand through the Spring break-up and the alternative - ferries - would not be operative during both freeze-up and break-up periods.

This matter of access would cause higher actual unit prices on Route "X", and, indirectly increase overall costs, as it would be necessary to award the work in one contract, or two, for which only major firms would be in a position to finance.

<u>TRACKLAYING AND BALLASTING</u>: Costs per mile on "X" would be similar to "A", so there would be a definite reduction for these two items on "X".

<u>COMMUNICATIONS</u>: On Route "A", railway requirements could be incorporated with the existing C.N. Telecommunications between Whitehorse, via Carmacks and Mayo, to Elsa, so the shorter distance via Route "X" would be of no benefit.

<u>CONCLUSION</u>: The overall costs for construction of roadway, track and communications via Routes "A" and "X" would appear to be so closely similar for these items that there would be no savings by adopting Route "X".

Other items which would be affected - maintenance-of-way and train operation are discussed in Sections 15, 16 and 21.

15. TRAIN PERFORMANCE STUDY

This study is to determine the expected performance of trains on the proposed track by means of its Train Performance Calculator (TPC) program on a 7074 IBM computer. By feeding into the computer the track, train and motive power characteristics, this program (TPC) is able to simulate the expected behaviour of trains with different car and locomotive consists and to give indication as to their speeds and running times over a given line. The computer simulation thus provides a means to evaluate the merits of alternative routes and the effect of different types of power and train consists on total running times and maximum speeds.

15.1 Input Data: The track distances, elevations, location of sidings and speed restrictions used in this study correspond to the data shown on the accompanying condensed profiles - scales, horizontal 1" to 8 miles, vertical 1" to 500 feet. Proposed track structure to support axle weights up to 65,000 lbs.

15.2 Routes: Two routes have been tested: Line "A" extends from the proposed Port Terminal at Dyea, Alaska, Mile 0.00, northward through Whitehorse to the proposed Mine Terminal at Mile 577.

The alternative "X" route between Mile 170 and Mile 473 on Route "A" has a length 30 miles shorter, its Mile 443 being equal with Mile 473 of Route "A".

15.3 Locomotives: Two types of diesel units were tested in the simulation, both with 2500 nominal horsepower; units with 390,000 lbs. weight on six driven axles, and units with 260,000 lbs. weight on four driven axles.

15.4 Cars: Two types of cars were examined, both with 100-ton load capacity: six-axle hopper type cars with a total loaded weight of 135 GT, and four-axle gondola type cars, total loaded weight 126 GT. The performance of any type of car suitable for heavy ore service is likely to be similar to these.

15.5 Resistances: The calculation of locomotive rolling and air resistance follows the conventional Davis Formula; that of the cars is based on the C.N. modified formula ($R = 0.6 + 20/W + 0.01V + 0.0007AV^2/Wn$ in lbs./tons, where V = speed in mph, W = axle weight, tons, n = number of axles and A = cross section of carbody in square feet) which was found more suitable for equipment with roller bearings than the Davis Formula. The grade resistance is calculated as 20 lbs./tons per % of grade, and the curves are expressed in equivalent elevations.

Considering the grades on the proposed lines, it can be expected that the grade resistance rather than rolling and air resistance will be the dominant factor in determining train performance. The difference therefore in the performance of trains with different types of cars will be due primarily to the overall difference in weight and not to the difference in specific (lbs./ton) resistances. To verify this assumption, the loaded trains were processed containing 135 ton and 126 ton cars, using different specific resistance data for each type.

As the specific resistance in lbs./ton of the empty car of 35 tons on six axles is very near to that of the 26 ton car on four axles, the resistance of the empties has been considered as an average of the above, and uniformly 30 ton average car weight was used for all empty trains. The actual running times of any particular type of empty train can be easily determined from the accompanying Minimum Running Time Charts, Exhibits 1 and 2.

15.6 <u>Tractive Effort and Adhesion</u>: The tractive effort of both types of locomotives is calculated according to the equation for any constant horsepower unit: TE = 375 HP x E/V; the efficiency factor "E" was taken as having a uniform average value of 0.865.

Tractive effort is limited in the low speed range by the available adhesion, taken as 25% of the locomotive weight at starting, and as 19% at the lowest continuous speed. The tractive effort curve on the adhesion line is considered as varying on a straight line between these limits. On this basis, the six-axle unit has 97,500 lbs. tractive effort at start, and 74,100 lbs. continuous tractive effort at about 11 mph; the four axle unit has 65,000 lbs. starting, and 49,400 lbs. continuous tractive effort at about 16.5 mph.

15.7 <u>Trains Processed</u>: The loaded trains selected consist of 120 cars, using gross car weights of 135 GT and 126 GT respectively. These trains were powered in turn by 5, 6 and 8 six-axle diesel units, and by 6, 8 and 10 four-axle diesel units. The trains with 5 six-axle units were assigned one, and the trains with 6 four-axle units were assigned two auxiliary or helper units of the same type between Mileages 577-481. Altogether, 12 loaded trains were processed, both on Route "A" and Route "X". On Route "X", the trains have been run from Mile 481 only, to avoid duplication of runs. Hence, between the Mine Terminal and the junction point at Mile 477 the running times of Route "A" apply also to Route "X".

The empty trains contain either 120 or 144 cars, the latter consist having been used to satisfy the proposal to make up 5 empty trains from 6 loaded ones. Both consists were processed with 4 and 5 six-axle units, and 5, 6 and 8 four-axle units. Altogether, 10 trains of empty cars were run, both on Route "A" and Route "X", all through.

The trains used are listed in Exhibit 3, showing the type and number of units and cars, the average car weights and the code symbols used in the program and on the charts to identify the trains. ("F" stands for 6-axle units, "D" for 4-axle units, "L" for loads and "E" for empties.) Also are shown the weight-to-power ratios for every train. The weight-to-power ratio is the quotient of the total train weight in tons, including locomotive, and the total nominal horsepower.

This ratio is significant in train performance, the running times generally being proportional to the weight-to-power ratios unless the speed of the train is limited by low speed restrictions.

All runs were made with start from a standing position, and stops at the intermediate division yards and at the final terminal only. No time allowance is included for the standing time at stops or for delays such as meets.

15.8 Output and analysis

The output sheets show, for each train, the accumulated running time at every station or siding, and the minimum speeds reached under full power between stations, and, the accumulated time and train speed at every mile. Train speed at every mile has been plotted against distance in a graphical form.

15.9 Minimum running times: All the running times given by the computer and shown on the exhibits represent minimum running times, that is, the shortest time possible for a train with a specified weight-to-power ratio to complete the run over the section. The simulation program assumes that the train always uses the full power available unless travelling at speed limit or during braking.

The total running time of each train, together with the partial times between main points, are tabulated in Exhibits 4 and 5 for a quick reference to compare the performance of differently powered trains, and the alternative routes.

15.10 Minimum running time charts: **If the total running times are plotted against** the weight-to-power ratios, they fall in a smooth curve. These are shown in Exhibits 1 for Route "A" and in Exhibit 2 for Route "X", both for the loaded and for the empty trains.

From these curves the running time for any combination of weight and power, or the weight-to-power ratio necessary to meet a required running time, may be determined, provided the average car weight is similar to those processed. (126-135 tons/car for loads, and 26-35 tons/car for empties.) The type of power, however, may be limited by adhesion considerations as discussed in Section 15.6.

The running times are distributed between the main points (stations) on the right hand side of the charts.

15.11 Type of cars: About 15-40 minutes can be gained, depending on the power used, when using the lighter type gondola cars of 126 tons each. Otherwise, the performance of the trains with 126-ton cars and with 135-ton cars is quite similar.

15.12 Comparison of routes: Although the distance via Route "X" is 30 miles shorter, the running times are about 30 minutes longer than via Route "A", due mostly to the great number of slow orders on Route "X". Unless the speed limits are raised or the overall height to be overcome by loaded trains turns out to be much less on Route "X" than on Route "A", Route "X" has no advantage over Route "A" from a traction and running time standpoint.

15.13 Minimum number of diesel units: Calculations based on the adhesion data outlined in paragraph 15.6 show that the minimum number of units which can move the loaded train of 120 cars under average weather and rail conditions on the 1% grades between miles 577-481 is:

6 six-axle units, or 8 four-axle units; and on the 0.8% grades over the rest of the line.

5 six-axle units, or 7 four-axle units.

These requirements were verified by the computer runs; the trains powered by only 6 four-axle units went under the safe 16.5 m.p.h. speed with 135-ton cars, and was just over the limit with 126-ton cars, on the 0.8% grades.

It may happen that trains must be stopped and restarted on the ruling grades. Calculations show that on the 1% grades:

7 six-axle units, or 10 four-axle units; and on the 0.8% grade,

6 six-axle units, or 9 four-axle units are needed to start the loaded trains.

Similarly, to haul a train of 144 empties on the 1.9% grade will need at least:

3 six-axle units or 4 four-axle units; and to start the trains on this grade needs a minimum of:

4 six-axle units, or 5 four-axle units in the locomotive consist.

15.14 Recommended number of units: In view of the foregoing, it is felt that the operation requires the use of 7 diesel units with 390,000 lbs. weight on six driven axles for the loaded trains and 4 units for the empties. Additional units beyond these minima would decrease running times and provide a measure of protection against mechanical failure in one or more diesel units in the total locomotive consist.

The use of 7 diesels for the loaded haul and 4 units for the empty haul would obviate the need for helper service over the ruling grades.

This study has assumed the use of 2500 H.P. diesel units. Consideration could also be given to use of 1750 H.P. or 1800 H.P. units if added running time can be tolerated. Conversely, use of 2750 H.P. units or higher would decrease running time.

The maximum draw bar pull of 7 units may exceed 700,000 lbs. at starting which is more than permissible for standard draw bars. The locomotive therefore must be distributed through the train. This distribution can be accomplished by one of the following methods:

a) Use of cars equipped with locomotive M-J connections

b) Use of radio remote control

c) Use of strain gauge remote control

If diesel units are operated at the rear of the train, these could provide accommodation for the tail end crew if such is required.

To brake the loaded trains on the 1.9% grade will need around 7000 lbs./ car braking force at the wheels which may be over the expected adhesion limit during the return empty movement. A special braking system self-adjusting to load should be considered.

YUKON IRON ORE STUDY

RAILWAY FEASIBILITY
PRELIMINARY PROJECTION ROUTE "A"

FROM DYEA, ALASKA, UNDER COAST RANGE NEAR CHILKOOT PASS - VIA LINDEMAN LAKE AND WHITEHORSE TO IRON CREEK MINE, YUKON TERRITORY

ESTIMATED DISTANCE 577 MILES

DIAGRAM OF PRINCIPAL "RISE AND FALL"

Datum Mean Sea Level

SCALES:- HORZ. " = 8 MILES
VERT. " = 500 FEET

Prepared by Canadian National Railways
in co-operation with Crest Exploration Company Limited
for
The Government of Canada

WINNIPEG, MAN., 29 JANUARY 1965

CONSULTING ENGINEER
Canadian National Railways

NOTE MAXIMUN RATES OF GRADIENTS :-

Against northward traffic 1.50% compensated excepting between Dyea and Lindeman, 1.90% not compensated.

Against southward traffic 0.80% compensated between Dyea and Keno Hill, Mile 0 to 390, and 1.00% compensated Keno Hill to Iron Creek, Mile 390 to 577.

YUKON IRON ORE STUDY

RAILWAY FEASIBILITY
PRELIMINARY PROJECTION

FROM DYEA, ALASKA, UNDER COAST RANGE NEAR CHILKOOT PASS - VIA LINDEMAN LAKE AND WHITEHORSE TO IRON CREEK MINE, YUKON TERRITORY

ALTERNATIVE ROUTE "X"

From near Braeburn Lake Route "A", Mile 170, via Little Salmon and Nadaleen River Valley to rejoin with Route "A" at Mile 473, near the headwaters of East Rackla River

ROUTE "X" MILE 443 = ROUTE "A" MILE 473

DIAGRAM OF PRINCIPAL "RISE AND FALL"

Datum Mean Sea Level

SCALES:- HORZ 1" = 8 MILES
VERT 1" = 500 FEET

Prepared by Canadian National Railways
in co-operation with Crest Exploration Company Limited
for
The Government of Canada

WINNIPEG, MAN., 29 JANUARY 1965

CONSULTING ENGINEER
Canadian National Railways

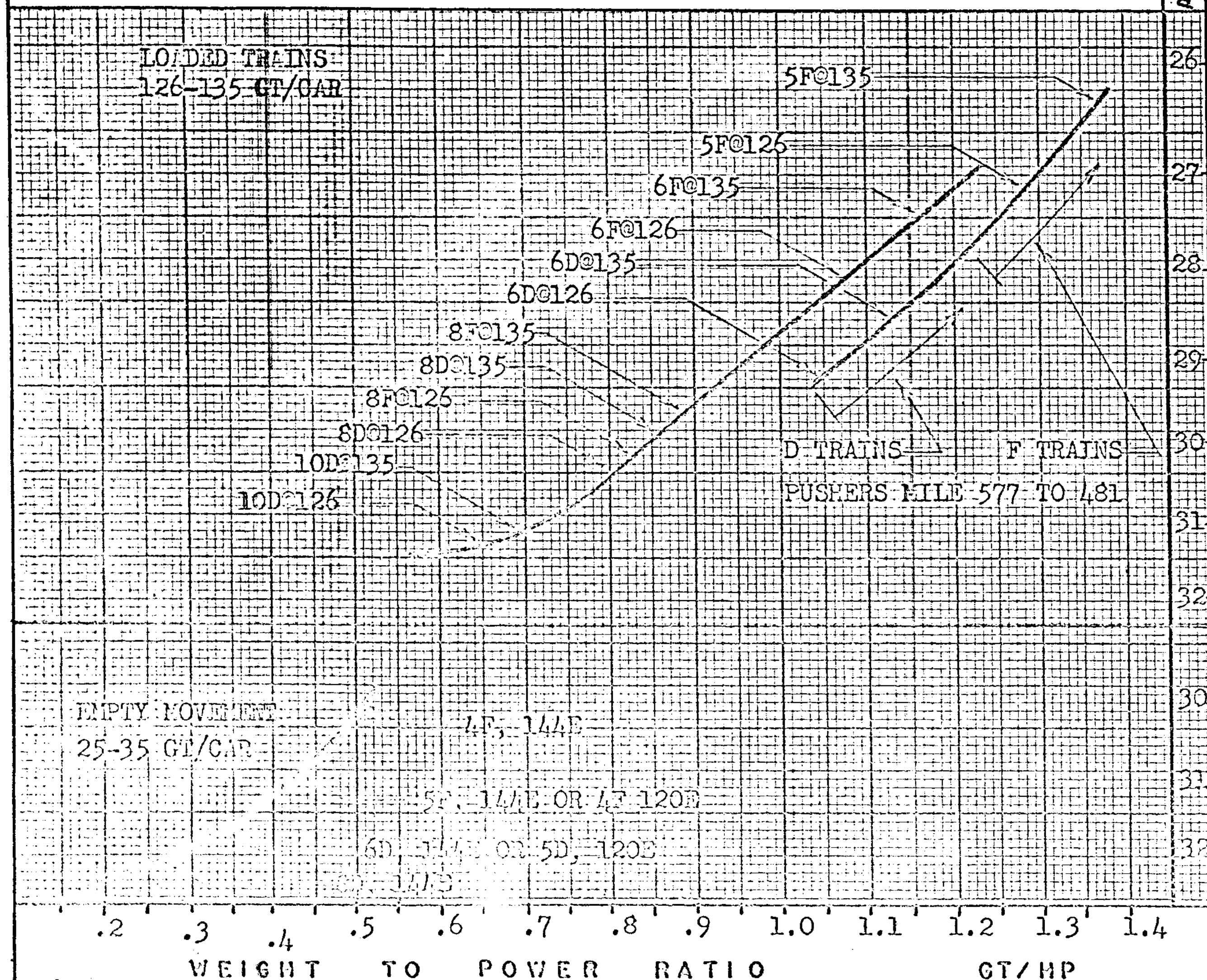
MINIMUM RUNNING TIME

Exhbt. 1

CLASS OF SERVICE: through freight **DIRECTION:** South and North **SUBDIVISION:** YUKON RAILWAY

RUN Route "A"
DISTANCE 577 miles
SIDING CAPACITY

DATE Dec. 1964



READ LEFT TO RIGHT

TOTAL TIME IN HRS-MINS.	M 577 Mine Tml. – M 526 Siding	M 526 Siding – M 481 Siding	M 481 Siding – M 473 Jct "X"	M 473 Jct "X" – M 390 Div. Yd.	M 390 Div. Yd. – M 326 Siding	M 326 Siding – M 252 Siding	M 252 Siding – M 190 Div. Yd.	M 190 Div. Yd. – M 170 Jct "X"	M 170 Jct "X" – M 100 Whitehorse	M 100 Whitehorse – M 57 Siding	M 57 Siding – M 0 Dyea
22hrs	2 19	2 40	13	2 17	2 [illegible]	3 15	1 55	0 42	2 52	1 21	2 19
40"											
20"											
21hrs	2 10	2 32	13	2 16	2 02	3 02	1 50	0 37	2 41	1 19	2 18
40"											
20"											
20hrs	2 00	2 21	13	2 15	1 58	2 48	1 46	0 34	2 31	1 17	2 17
40"											
20"											
19hrs	1 50	2 12	12	2 14	1 54	2 29	1 43	0 32	2 22	1 15	2 17
40"											
20"											
18hrs	1 40	2 02	12	2 13	1 50	2 11	1 39	0 30	2 14	1 13	2 16

READ RIGHT TO LEFT

TOTAL TIME IN HRS-MINS.	M 577 Mine Tml. – M 526 Siding	M 526 Siding – M 481 Siding	M 481 Siding – M 473 Jct "X"	M 473 Jct "X" – M 390 Div. Yd.	M 390 Div. Yd. – M 326 Siding	M 326 Siding – M 252 Siding	M 252 Siding – M 190 Div. Yd.	M 190 Div. Yd. – M 170 Jct "X"	M 170 Jct "X" – M 100 Whitehorse	M 100 Whitehorse – M 57 Siding	M 57 Siding – M 0 Dyea
30"	1 39	1 59	22	2 19	1 54	2 35	1 41	0 30	2 19	1 17	2 55
19hrs	1 39	1 57	19	2 17	1 50	2 31	1 40	0 30	2 17	1 15	2 45
30"	1 39	1 55	16	2 15	1 46	2 27	1 40	0 30	2 16	1 14	2 32
18hrs	1 39	1 53	12	2 13	1 42	2 25	1 39	0 30	2 13	1 14	2 15

Both Directions Include Stops at Terminals and Division Yards

STATION TO STATION TIMES MINS

EXHIBIT 1.

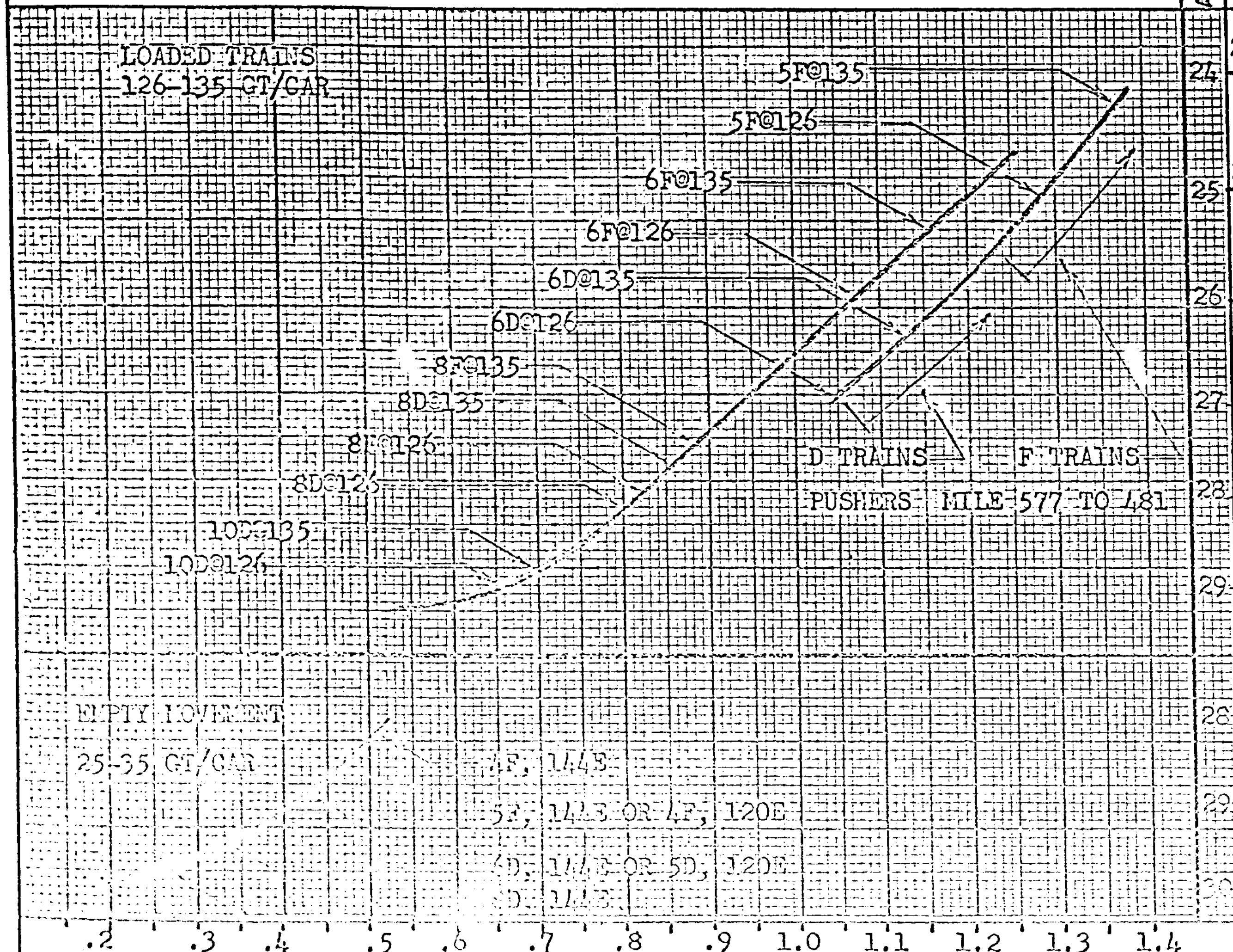
	Exhbt. 2

MINIMUM RUNNING TIME

CLASS OF SERVICE: Through Freight **DIRECTION:** South and North **SUBDIVISION:** YUKON RAILWAY

RUN Route "X"
DISTANCE 547 miles
SIDING CAPACITY

DATE Dec. 1964



WEIGHT TO POWER RATIO GT/HP

READ LEFT TO RIGHT

TOTAL TIME IN HRS.-MINS.	M 577 Mine Tml – M 526 Siding	M 526 Siding – M 481 Siding	M 481 Siding – M473) M443) Jct "A"	– M 379 Div. Yd.	M 379 Div. Yd. – M 300 Siding	M 300 Siding – M 230 Siding	M 230 Siding – M 180 Div. Yd.	M 180 Div. Yd. – M 170 Jct "A"	M 170 Jct "A" – M 100 Whitehorse	M 100 Whitehorse – M 57 Siding	M 57 Siding – M 0 Dyea
23hrs.	2 16	2 43	14	2 34	3 06	3 02	2 13	18	2 55	1 20	2 19
40"											
20"											
22hrs.	2 15	2 42	13	2 28	2 55	2 50	2 02	17	2 42	1 18	2 18
40"											
20"											
21hrs.	2 00	2 24	13	2 24	2 50	2 44	1 56	17	2 36	1 18	2 18
40"											
20"											
20hrs.	1 55	2 18	13	2 20	2 39	2 34	1 45	17	2 26	1 16	2 17
40"											
20"											
19hrs.	1 47	2 04	12	2 17	2 30	2 27	1 37	16	2 19	1 15	2 16
30"	1 40	1 53	12	2 15	2 26	2 25	1 35	16	2 17	1 15	2 16

READ RIGHT TO LEFT

TOTAL TIME IN HRS.-MINS.	M 577 Mine Tml – M 526 Siding	M 526 Siding – M 481 Siding	M 481 Siding – M473) M443) Jct "A"	– M 379 Div. Yd.	M 379 Div. Yd. – M 300 Siding	M 300 Siding – M 230 Siding	M 230 Siding – M 180 Div. Yd.	M 180 Div. Yd. – M 170 Jct "A"	M 170 Jct "A" – M 100 Whitehorse	M 100 Whitehorse – M 57 Siding	M 57 Siding – M 0 Dyea
30"	1 40	1 59	20	2 17	2 26	2 29	1 36	16	2 19	1 16	2 52
19hrs.	1 39	1 54	18	2 16	2 25	2 27	1 35	16	2 16	1 15	2 39
30"	1 39	1 52	16	2 15	2 23	2 25	1 34	15	2 14	1 13	2 24
18hrs.	1 37	1 52	12	2 15	2 23	2 25	1 34	15	2 12	1 13	2 02

Both Directions Include Stops at Terminals and Division Yards

STATION TO STATION TIMES MINS

EXHIBIT 2

EXHIBIT 3

LIST OF TRAINS PROCESSED

CODE	2500 HP Diesels No. of Units	2500 HP Diesels Type	Cars No. of Cars	Cars Average Wt. Ton	Weight to Power Ratio	Remarks
Loaded Trains:						
1. 5FL @ 135	5	6 axles	120	135	1.375	With 1 helper (M.577-481)
2. 6FL @ 135	6	"	"	"	1.158	
3. 8FL @ 135	8	"	"	"	.888	
4. 6DL @ 135	6	4 axles	"	"	1.132	With 2 helpers (M.577-481)
5. 8DL @ 135	8	"	"	"	.862	
6. 10DL @ 135	10	"	"	"	.700	
7. 5FL @ 126	5	6 axles	"	126	1.288	With 1 helper (M.577-481)
8. 6FL @ 126	6	"	"	"	1.086	
9. 8FL @ 126	8	"	"	"	.834	
10. 6DL @ 126	6	4 axles	"	"	1.060	With 2 helpers (M.577-481)
11. 8DL @ 126	8	"	"	"	.808	
12. 10DL @ 126	10	"	"	"	.657	
Empties						
1. 4F 120E	4	6 axles	120	30	.438	
2. 5F 120E	5	"	"	"	.366	
3. 5D 120E	5	4 axles	"	"	.340	
4. 6D 120E	6	"	"	"	.292	
5. 8D 120E	8	"	"	"	.232	
6. 4F 144E	4	6 axles	144	"	.510	
7. 5F 144E	5	"	"	"	.423	
8. 5D 144E	5	4 axles	"	"	.395	
9. 6D 144E	6	"	"	"	.338	
10. 8D 144E	8	"	"	"	.267	

Note: F = 6 axle units D = 4 axle units L = loaded trains E = empty trains

ROUTE "A"

EXHIBIT 4

RUNNING TIMES - LOADED TRAINS

Station	Mile Post	* 5FL@135	6FL@135	8FL@135	** 6DL@135	8DL@135	10DL@135	* 5FL@126	6FL@126	8FL@126	** 6DL@126	8DL@126	10DL@126
Train:	W/P Ratio:	1.375	1.158	0.888	1.132	0.862	0.700	1.288	1.086	0.834	1.060	0.808	0.657
Mine Terml.	577												
		4-56	4-56	4-14	4-10	4-10	3-50	4-41	4-41	4-05	4-02	4-02	3-44
Pushers Off	481.4												
		0-14	0-14	0-13	0-14	0-14	0-13	0-14	0-14	0-13	0-13	0-13	0-13
Jct. "X"	473												
		2-17	2-17	2-14	2-15	2-13	2-13	2-17	2-15	2-14	2-15	2-14	2-13
Div. Yard II	390												
		7-15	6-47	6-15	6-46	6-13	5-58	7-00	6-36	6-09	6-33	6-06	5-56
Div. Yard I	190												
		0-41	0-37	0-32	0-36	0-32	0-31	0-39	0-35	0-32	0-34	0-32	0-31
Jct. "X"	170												
		6-31	6-15	5-58	6-14	5-57	5-50	6-22	6-09	5-55	6-08	5-54	5-50
Ocean Terml.	0												
T O T A L:-		21-54	21-04	19-26	20-15	19-19	18-35	21-13	20-30	19-08	19-45	19-01	18-27

ROUTE "X"

Station	Mile Post	* 5FL@135	6FL@135	8FL@135	** 6DL@135	8DL@135	10DL@135	* 5FL@126	6FL@126	8FL@126	** 6DL@126	8DL@126	10DL@126
Mine Terml.	577												
		4-46	4-56	4-14	4-10	4-10	3-50	4-41	4-41	4-05	4-02	4-02	3-44
Pushers Off	481.4												
		0-14	0-14	0-13	0-14	0-14	0-13	0-14	0-14	0-13	0-13	0-13	0-13
Jct. "A" 473=	443												
		2-30	2-24	2-20	2-24	2-18	2-17	2-27	2-22	2-18	2-22	2-18	2-16
Div. Yard II	379												
		8-07	7-33	6-54	7-30	6-52	6-34	7-50	7-20	6-47	7-16	6-44	6-32
Div. Yard I	180												
		0-18	0-17	0-17	0-17	0-17	0-16	0-17	0-17	0-16	0-17	0-17	0-16
Jct. "A"	170												
		6-29	6-14	5-57	6-14	5-57	5-50	6-22	6-09	5-54	6-06	5-53	5-49
Ocean Terml.	0												
T O T A L:-		22-34	21-38	19-55	20-49	19-48	19-00	21-51	21-03	19-33	20-16	19-27	18-50

* - 1 Pusher Mile 577 to 481.4

** - 2 Pushers Mile 577 to 481.4

ROUTE "A" | EXHIBIT 5

RUNNING TIMES - EMPTY TRAINS

Station	Train: / Mile Post	4F 120E	5F 120E	5D 120E	6D 120E	8D 120E	4F 144E	5F 144E	5D 144E	6D 144E	8D 144E
	W/P Ratio:	0.438	0.366	0.340	0.292	0.232	0.510	0.423	0.395	0.338	0.267
Station	Mile Post										
Ocean Terminal	0										
		6-08	5-54	5-50	5-43	5-38	6-23	6-06	6-01	5-51	5-42
Jct. "X"	170										
		0-30	0-30	0-30	0-30	0-30	0-30	0-30	0-30	0-30	0-30
Division Yard I	190										
		5-57	5-30	5-49	5-47	5-45	6-06	5-56	5-53	5-50	5-46
Division Yard II	390										
		2-15	2-14	2-13	2-12	2-13	2-17	2-15	2-15	2-13	2-13
Jct. "X"	473										
		3-51	3-46	3-45	3-44	3-43	3-57	3-50	3-48	3-46	3-44
Mine Terminal	577										
T O T A L:		18-41	18-14	18-07	17-56	17-49	19-13	18-37	18-27	18-10	17-55

ROUTE "X"

Station	Mile Post	4F 120E	5F 120E	5D 120E	6D 120E	8D 120E	4F 144E	5F 144E	5D 144E	6D 144E	8D 144E
Ocean Terminal	0										
		6-08	5-54	5-50	5-43	5-38	6-23	6-06	6-01	5-51	5-42
Jct. "A"	170										
		0-16	0-15	0-15	0-15	0-15	0-16	0-16	0-16	0-15	0-15
Division Yard I	180										
		6-25	6-23	6-23	6-23	6-23	6-30	6-26	6-26	6-25	6-24
Division Yard II	379										
		2-17	2-15	2-15	2-15	2-15	2-17	2-16	2-15	2-15	2-15
Jct. "A" 473 =	443										
		3-51	3-48	3-47	3-45	3-44	3-58	3-51	3-50	3-48	3-46
Mine Terminal	577										
T O T A L:		18-57	18-35	18-30	18-21	18-15	19-24	18-55	18-48	18-34	18-22

16. TRANSPORTATION STUDY

This study is to compare alternative modes of train operation.

16.1 The recommended procedure and equipment, outlined in the following, is based partly on the preceding "Train Performance Study" and extending the maximum rate of southward gradient 1.00 per cent compensated, necessary to ascend from the Snake River to Goz Pass, to the overall operation, Mine to Port.

Maximum speed of 40 m.p.h. with permanent slow orders of 20 to 30 m.p.h. in relation to local conditions - curvature and possible occurrences of rock and snow slides.

16.2 Yearly volume:

Iron, pellets or granular concentrate:	5,000,000 tons
Miscellaneous supplies (no details are given):	85 trains @ 57 cars
Working days yearly:	340 days

16.3 Mode of operation:

Integral train operation, with the engine crew remaining on the train during its round trip, is proposed to be introduced. The proposal has no Canadian precedent as yet, it is felt, however, that the new railway being a captive line with no connection to other tracks, is not bound by any conventional practice. This mode of operation was found to be superior to any current procedure both in efficiency and in economy. All trains to operate according to pre-set schedule, by train orders received on radio, directed and supervised by one despatcher at all times.

16.4 Type of rolling stock:

(a) Locomotive:

One type for every service: 2500 HP diesel electric units, 390,000 lbs. weight on six driven axles, swivel couplers, extended range dynamic braking, oversize fuel tanks, cab equipped with radio, toilet, cooking and resting facilities.

(b) Ore Cars:

Open gondola type, 100 tons load capacity, tare weight 26 tons on four axles, (or up to 35 tons on six axles), swivel couplers, drawbar to withstand pull and push stresses up to 500,000 lbs., brakes self-adjusting to load.

(c) Supply Cars:

Standard tank, box and flat cars, with brakes and drawbar as above 16.4 (b).

16.5 Train operation:

(a) Ore trains:

Integrated trains of 120 cars powered by 7 diesel units, 4 at the head end and 3 at the rear end, handled by one train crew throughout the whole cycle of the train. The units and crew remain on the train during loading and unloading at the terminals and also do the necessary switching. Trains are leaving in every 15 or 16 hours from both terminals.

(b) Supply trains:

Either trains up to 120 cars with mixed consist, powered by 7 diesel units as the above ore trains, once a week; or two trains of 60 cars a week, one fuel train powered by 4 diesels at the head end, and a wayfreight with 3 diesels at the head end. One train crew will operate during the whole cycle. The units and crew remain on train and do the necessary switching at the terminals and intermediate stations by transferring the cars to the loading and unloading points. The moving of the cars during loading and unloading is supposed to be done by other means.

16.6 Number of trains yearly:

Ore trains: 5,000,000 tons/120 x 100 tons:	418 trains
Supply trains with up to 120 cars once weekly:	52 trains
Total Yearly	470 trains
Or, supply trains with 60 cars:	85 trains
Total Yearly	503 trains

16.7 Cycles and train frequency:

(a) Ore trains, minimum cycle

	Complete Train	Locomotive only
Loading 20 cars/hour	6 hrs.	- hrs.
Cushion time for make up train, brake test, inspection, wait for opposing train.	3 hrs.	1 hr.
Servicing locomotive	* - hrs.	2 hrs.
Terminal Time at Mine:	9 hrs.	3 hrs.
Running time southbound	20 hrs.	20 hrs.
Meets	1 hr.	1 hr.
On the road south:	21 hrs.	21 hrs.
Unloading, 20 cars/hour	6 hrs.	- hrs.
Cushion time as above	3 hrs.	1 hr.
Servicing locomotive	* - hrs.	2 hrs.
Terminal time at Port:	9 hrs.	3 hrs.

* NOTE: The units can be serviced during the loading and unloading in turns, since 3 units are sufficient to handle train on level track in the terminals.

(a) Ore trains, minimum cycle: (Continued)

	Complete Train	Locomotive only
Running time northbound	19 hours	19 hours
Meets	2 hours	2 hours
On the road north:	21 hours	21 hours
TOTAL CYCLE:	60 hours	48 hours

(b) Supply trains, minimum cycle:

Is taken as the same as for the ore trains.

16.8 Minimum train frequency:

Based on 340 working days yearly, the minimum frequency of trains, i.e. time elapsed between train departures:

Ore trains:	340 day x 24 hrs/418 trains:	19.5 hours
All trains:	340 day x 24 hrs/470 trains:	17.4 hours
or, all trains:	340 day x 24 hrs/503 trains:	16.2 hours

16.9 Train frequency of 15 hours:

In case of continuous operation the train cycle must be a multiple of the train frequency; and the frequency must be less than, or equal to, the minimum frequencies shown in the previous section. Therefore, the best frequency which meets these criteria is 15 hours, that is, trains are leaving at both terminals in every 15 hours, 4 trains during a 60 hour cycle.

This could allow a maximum of 544 trains yearly, more than enough for all ore and supply trains. Four sets of locomotive and 4 sets of ore cars are needed.

16.25 serves 5 trains

When using 15 hour train frequency the schedules can be arranged on weekly basis, with 8 ore trains and one long (or two short) supply trains every week, representing 468 trains yearly, still sufficient for the yearly demand. This type of scheduling would provide a good cycle for the crew as shown in paragraph 16.19.

16.10 <u>Train frequency of 16 hours</u>:

An adequate continuous operation could be arranged with the same number of equipment as above, and providing sufficient trains yearly, on a 64 hour train cycle basis, trains leaving every 16 hours. This has the advantage that the train departure times would be the same every other day, and that the change over to 10,000,000 yearly volume would result in an optimum utilization of equipment as shown in the next section. The terminal times, however, will increase by 2 hours and herewith the "away from home" time of the train crew by 4 hours, as compared with the operation on 15 hour train frequency.

16.11 <u>Optimum cycle - frequency relation</u>:

The optimum utilization of equipment would be obtained if the locomotives and cars were operated on independent minimum cycles. In this case locomotives of arriving trains, after having been serviced, would pick up another ready-to-depart train which was handled by extra switcher during loading. This type of operation can be arranged only if the train frequency plus the locomotive terminal time is about equal to the terminal time of the cars; and further, if both the locomotive and car cycles are multiples of the train frequency.

No such an operation can be arranged for a 5,000,000 tons yearly volume. Should the operation, however, be based on a 10,000,000 tons yearly volume, increasing hereby the train frequency to 8 hours by doubling the number of trains during the 64 hour cycle, the above criteria are satisfied. In this case the necessary 8 sets of cars can be handled by only 6 sets of locomotive, as compared with 8 locomotives necessary when simply doubling the equipment of the operation described in paragraph 16.9. Extra sets of switchers will be needed, though, at both terminals.

Therefore, if it is likely that the yearly volume will be increased to 10,000,000 tons in the near future, consideration should be given to base the operation on a 64 hour train cycle rather than on 60 hours, which is more economical for the 5,000,000 tons volume. Since the location of the long sidings for meets is determined by the train frequency (and by the running time which will not change), decision in this matter should be reached before the detailed design of the line commences.

16.12 Rolling stock:

Diesel units, as 16.4(a), 4 locomotives @ 7 units:		28 units
Diesel units, for work trains:		3 units
Provision for maintenance:		3 units
	Total	34 units
Ore cars, as 16.4(b), 4 sets @ 120 cars:		480 cars
Provision for maintenance:		30 cars
	Total	510 cars
Miscellaneous supply cars, 2 sets @ 120 cars:		240 cars
Provision for maintenance:		20 cars
	Total	260 cars

As no details are given as to the mine supplies to be transferred, no exact distribution of the supply cars can be made. From the Bechtel Report, it can be presumed that half of the supply cars be tank cars of 20,000 gallon capacity, and box and flat cars as well as 2 passenger cars should be included.

No cabooses are needed for the recommended operation.

16.13 Passing track requirements:

The continuous operation outlined, paragraphs 16.7 to 16.11, will involve only three meets for every train, necessitating 3 long passing tracks. Counting on possible train delays, adjacent to these sidings in about 20-20 miles distance on both sides, other sidings are advisable. Further, to avoid siding spacings more than 100 miles, two more sidings are necessary, altogether 11 long passing tracks.

The tentative location of these passing tracks, in case of a 15 hour train frequency, will be at about the mileages: 40, 60, 80, 169, 267, 285, 305, 390, 481, 507, 534; and in case of a 16 hour train frequency, at the mileages: 35, 50, 72, 155, 267, 292, 305, 410, 507, 526, 552. The underlined ones are the locations designated for regular meets.

All passing tracks should have adequate length to accommodate 120 cars and 7 units, about 6,800 feet. It is proposed to use #12 equilateral turnouts with spring switches on both ends of the sidings. These sidings can be considered as short sections of double track which can be passed without speed reduction. At meets the necessity to throw switches by the train crew will be avoided.

At the terminals, one passing track of full length, and either a loop track or a long pull-back track is needed whichever is easier to build. In case of the latter, the trains will not be turned around, but will proceed in the opposite direction, the tail unit becoming the leading one.

16.14 Signalling:

Battery operated two position signal lights, showing whether the switch points are properly closed in the right direction; located ahead of both ends of every siding. No other signals are necessary.

16.15 Communications:

Radio network throughout the line, with train to point, train to train, and head end to tail end facilities. Reference Section 10.

16.16 Fuelling Facilities:

Based on computer calculations, the fuel consumption is estimated from the energy output necessary for a round trip.

Loaded trains, 150,000 HP hours @ 0.07 gallons:	10,500 gallons
Empty trains, 70,000 HP hours @ 0.07 gallons:	4,900 gallons
Terminal switching, 2 x 9 hours for 7 units @ 20 gallons:	2,600 gallons
Consumption of one train (whole cycle):	18,000 gallons
Then the yearly consumption for 470 trains:	8,500,000 gallons

Accordingly, fuelling facilities are to be provided at both terminals, the tanks should hold a minimum of one weeks supply, about (10 tank cars) 200,000 gallons. Fuel standards should enable the simultaneous fuelling of 4 units. At the same place facilities to service the units with lubricants and sand, and crew supplies should be provided.

16.17 Ruling grades and pusher service:

In the original proposal 0.8% ruling grades were contemplated for southbound loaded trains, with exception between mileages 580-480 where 1.0% compensated grades and auxiliary pusher service was proposed.

The pusher service is not recommended for the following reason. On .8% compensated grade still 6 units are necessary for a safe operation, thus the locomotive requirements can be reduced only by 3 units; i.e. one less for each of the 4 locomotives plus one for the pusher service. It is apparent, however, that extra 2 member crews are needed to operate the pushers. The additional crew costs, on mileage basis, for 470 trains yearly on 200 mile distance, that is for 94,000 train-miles @ 2 x $.25, will amount to $47,000 yearly, which is more than the yearly depreciation of 3 units; 3 x 290,000 x .05 = $43,500. Even counting some savings in fuel costs and in diesel maintenance not much can be gained. On the other hand, the running times will be somewhat increased on the rest of the run and the operation will unnecessarily be complicated.

<u>It is recommended, therefore, that all the units should remain on the train throughout the entire distance. Accordingly, the ruling grades can be raised for southbound trains from 0.8% to 1.0% compensated grade wherever they would reduce the costs of construction</u>. This may result in somewhat longer running time than those determined by the computer, it is expected, however, that the time loss will be compensated by the reduced distance.

16.18 <u>Location of railway headquarters</u>:

The railway administration centre for general management, operation, maintenance, etc., together with the shops, stores, and main staff housing, would be more suitably centralized at the Port Area, hereby eliminating the necessity of hauling all supplies and parts 577 miles further; and besides, it may provide a somewhat less austere climate to live in for the personnel.

However, as the proposed port site is at Dyea, in Alaska, it may not be advisable to establish railway headquarters there. Alternatives appear to be Whitehorse and Iron Creek.

16.19 Train crew:

Four qualified enginemen, two at the front end and two at the rear end, all capable to operate diesels and to attend to small repairs en route, will accompany the trains during a whole cycle, including the loading, unloading and switching movements at the terminals. One on the front unit and one on the rear unit will be on duty in turns at all times. The other can be resting using the accommodation provided. No other train crew is needed.

Apart from the costs of equipping all the cars with train lines, or of installing TMU or other automatic remote control devices, it is felt that the units at the rear end cannot be kept unattended for 20-22 hour trips.

The enginemen are expected to make one round trip once a week on ore trains with one additional trip monthly on supply trains. Thus, the time on duty monthly will be: in case of 15 hour train frequency 320 hours, and in case of 16 hour frequency 341 hours, half of this time spent at rest.

A top salary of around $12,000. yearly would appear to be attractive enough to be able to hire highly competent people and to expect complex work and full responsibility in return.

Altogether , 8 crews of 4 men are needed with 3 in reserve - 35 enginemen.

16.20 Dispatching:

One Chief of Transportation acting also as Chief Dispatcher, 4 dispatchers on duty in turns around the clock, and 6 member clerical staff are needed.

16.21 Yard Staff:

In order to handle the 120 cars of supplies and to move cars to and from Maintenance Shops, one yard crew of 3 men will be required to work at Dyea to make up the supply train(s). The yard crew will work under the jurisdiction of the dispatcher.

16.22 Capital Investment:

Rolling stock:

Diesel units as 16.4(a) - 34 @ $ 290,000:	$ 9,860,000.
Ore cars as 16.4(b) -510 @ $ 18,500:	9,435,000.
Tank cars -130 @ $ 22,000:	2,860,000.
Miscellaneous cars -130 @ $ 13,000:	1,690,000.
Spare parts and stores stock, etc.:	1,555,000.
Rolling stock total:	$ 25,400,000.

(Excluding boarding cars, plows, wrecking cranes and other O.C.S. equipment.)

16.23 Operating costs:

Yearly, excluding maintenance of equipment.

Train supplies:

Diesel fuel oil, 8,500,000 gals/year @ $.15:	$ 1,275,000.
Lube oil, 10% of fuel:	128,000.
Sand, 5% of fuel:	63,000.
Miscellaneous supplies:	234,000.
Train supplies yearly:	$ 1,700,000.

Salaries and wages:

Chief of Transportation - 1 @ $14,000:	$ 14,000.
Enginemen - 35 @ $12,000:	420,000.
Dispatchers - 4 @ $10,000:	40,000.
Clerical staff - 6 @ $ 7,000:	42,000.
Yardmen - 3 @ $ 6,000:	18,000.
Salaries & wages yearly:	$ 534,000.
Employee benefit 20% :	$ 107,000.
Total cost for transportation	$ 641,000.

16.24 Comparative economy of the proposal

In order to show the economical aspects of the proposed mode of operation, it is compared with the current general procedure on Canadian Railways.

The conventional way of operation would be to handle trains at the terminals by extra switching units, and the locomotives of the arriving trains, after having been serviced, would pick up the ready-to-depart trains. The train crew of 4, that is enginemen, conductor, and brakemen at front and rear, would change at every 200 miles, and would be paid on train mile basis.

There will be no difference in train supplies but the capital investment as well as the train crew costs will be higher than that of the proposed integral train operation, as shown below.

16.25 Rolling stock:

Three sets of locomotives can handle the trains, but a locomotive consisting of 2 switchers and 2 boosters at both terminals will be needed. As shown in paragraph 16.9, 5 sets of ore cars will be necessary as well as 5 cabooses.

Road diesels 34 - 7	= 27 @ $290,000:	$ 7,830,000.
Switchers 4 + 2 spare	= 6 @ $120,000:	720,000.
Boosters	= 4 @ $ 50,000:	200,000.
Ore cars 5 x 120 + 40 spare	= 640 @ $ 18,500:	11,840,000.
Supply cars, as per 16.22	:	4,550,000.
Cabooses	5 @ $ 30,000:	150,000.
Spare parts and stores stock	:	1,610,000.
Rolling stock as per current practice	:	$ 27,900,000.
Rolling stock as per proposed operations	:	$ 25,400,000.
Capital cost reduced by proposed operations by	:	$ 1,500,000.

In addition to the above, bunkhouses for the layover crew at two points on the line are to be constructed, maintained, heated and supervised, and further, in order to handle all the units from the front unit, either all cars should be equipped with train line and multiple recepticles, or at least 8 units with TMU automatic remote control devices. All these will increase the difference in the capital investment well over $1,600,000.

16.26 Operation costs:

There will be no difference in the train supplies, the train crew costs, however, calculated in train-mile basis, will be higher than for the integral trains.

470 trains yearly, each covering 1,200 miles, represent 514,000 train-miles, then the crew costs yearly :

4 men train crew 514,000 x 4 x $.25	:	$	564,000.
Yard crew for switchers, 3 at both terminals, 6 @ $7,000	:		42,000.
Train crew as per current practice	:	$	606,000.
Train crew as per integral train	:	$	420,000.
Yearly difference	:	$	186,000.
Employee benefits 20%	:	$	37,200.
Operation cost reduced in proposal by	:	$	213,200.

In addition to this, 2 caretakers are to be permanently employed at the intermediate bunkhouses, and cost of operating the bunkhouses must be met. All these will increase the difference in costs, to well over $250,000.00 yearly. A further item will be an increase in the car maintenance costs because of the greater number of cars.

16.27 Conclusions:

The integral train operation as proposed in present study proved to be superior to the current general mode of operation, by providing a saving in the range of $1,600,000.00 in rolling stock investment, and a yearly saving of about $250,000.00 in operating costs.

17. EQUIPMENT REQUIREMENTS

Reference "Train Performance" and "Transportation Studies", Sections 15 and 16, undertaken by the C.N. Transportation Department at Headquarters, Montreal, which indicated economy of operating integrated trains to transport iron ore pellets to the sea-board.

17.1 Rolling Stock: would be required as follows:-

*Diesel locomotives, 2500 HP,	34 @ $290,000.	$ 9,850,000.
Ore cars, capacity 100 N.T.,	510 @ 18,500.	9,450,000.
Tank cars	130 @ 22,000.	2,900,000.
Miscellaneous cars	130 @ 13,000.	1,700,000.
Spare parts and stores stock		1,500,000.
		$ 25,400,000.
Transportation and handling		1,600,000.
		$ 27,000,000.

*Includes 3 units for work trains, etc.; an alternative would be 4 or 5 lighter units to be available for construction.

17.2 On-track Equipment for Construction and Maintenance-of-Way:

Diesel locomotives, 1750 HP,	4 @ $250,000.	$ 1,000,000.
Wrecking cranes, 160 tons,	1 @ 350,000.	350,000.
Auxiliary outfits - cars and equipment (including 1-D8 bulldozer)	2 @ 150,000.	300,000.
Snow Plows - wedge type	2 @ 45,000.	90,000.
Flangers	2 @ 10,200.	20,400.
Jordan spreader with ditching equipment	1 @ 75,000.	75,000.
Industrial crane with pile-driver hammer and clamshell	1 @ 131,000.	131,000.
Cars - air dump	20 @ 12,000.	240,000.
Cars - ballast	180 @ 11,000.	1,980,000.
Cars - flat	20 @ 11,700.	234,000.
Cars - boarding	40 @ 16,500.	660,000.
		$ 5,080,400.
Transportation and handling		319,600.
		$ 5,400,000.

As this proposed railway has no direct connection with the general railway system of this continent, rental of on-track equipment would appear to be impracticable, considering the high cost of transportation which would be chargeable - in and out.

17.3 <u>Machines and Tools for Track - Construction and Maintenance-of-way:</u>

Crane, 30 ton (1 for material yard) (1 for tracklaying)	2 @	$100,000.	$ 200,000.
Spike driver, heavy duty	1 @	29,500.	29,500.
Spike driver, regular	8 @	4,700.	37,600.
Bolters	8 @	2,900.	23,200.
Spike pullers	8 @	3,100.	24,800.
Rails saws	8 @	820.	6,560.
Rail drills	8 @	840.	6,720.
Cross grinders	4 @	830.	3,320.
Stock rail grinders	2 @	1,800.	3,600.
Ballast tampers, regular	4 @	37,300.	149,200.
Ballast tamper, heavy duty	1 @	79,900.	79,900.
Track liners	4 @	20,900.	83,600.
Ballast regulators	4 @	17,000.	68,000.
Ballast sleds	2 @	5,000.	10,000.
Bulldozers	4 @	35,000.	140,000.
Air compressors, diesel	4 @	18,000.	72,000.
Hand operated hoists	3 @	1,000.	3,000.
Electric tools for B & B, with generators, sets	3 @	800.	2,400.
Portable generators	20 @	500.	10,000.
Pumps, gas operated, 3"	6 @	1,500.	9,000.
Radios	40 @	900.	36,000.
Power jacks	4 @	5,000.	20,000.
Shovels, diesel 1½ cubic yards	2 @	70,000.	140,000.
Draglines	2 @	50,000.	100,000.
Truck, general purpose	6 @	7,000.	42,000.
Track motor cars - extra gang	4 @	2,700.	10,800.
Track motor cars - sections & B&B	60 @	1,030.	61,800.
Track motor cars - supervisors	10 @	1,300.	13,000.
Push cars	60 @	400.	24,000.
Hand tools		sum	40,000.
			$ 1,450,000.
Transportation and handling			150,000.
			$ 1,600,000.

18. SHOPS, ENGINE AND CAR FACILITIES

Canadian National built an engine and car shop at Saskatoon, during 1964. A similar plan should meet the requirements for the proposed railway; cost

in the Yukon is estimated, approximately	$ 1,800,000.
Shop machinery, drop table and tools	820,000.
Fuelling and sand facilities at shop	150,000.
Fuelling and sanding facilities, including oil storage tanks at the port	280,000.
Fuelling facilities on line, for emergencies	150,000.
	$ 3,200,000.

18.1 One combined locomotive and car repair shop is considered necessary to meet the requirements. It should preferably be located at one end of the line. Since the southern terminus is in Alaska, and it does not appear to be advisable to locate this facility there, the alternative site is Iron Creek.

The maintenance shop for the mine equipment might be combined with this shop, thus effecting some saving in first cost. Also the skills required for maintenance of mine machinery are similar to those needed for maintenance of railway rolling stock, so some flexibility in staffing might be achieved with overall facilities at Iron Creek.

19. MAINTENANCE OF EQUIPMENT

The number of personnel and the annual maintenance cost are based on maintaining the equipment throughout its normal expected life.

19.1 Staff at port terminal, in Alaska:

1 Supervisor	@	$12,000.	$ 12,000.
8 Mechanics	@	9,600.	76,800.
4 Labourers	@	7,200.	28,800.

Maintenance shop in Yukon Territory:

1 General Foreman	@	$15,000.	$ 15,000.
1 Locomotive Foreman	@	12,000.	12,000.
1 Car Foreman	@	12,000.	12,000.
8 Assistant Foremen	@	10,000.	80,000.
110 Mechanics	@	7,200.	792,000.
40 Labourers	@	5,300.	212,000.
174		Included in 19.2	$1,240,600.

19.2 Annual Maintenance and Servicing Cost:

Locomotives	- 4 million unit miles @ 23¢	$ 920,000.
Cars	- 64 million unit miles @ 1.7¢	1,088,000.
Shop machinery		80,000.
Miscellaneous equipment		120,000.
Supervision		140,000.
Other expenses		52,000.
		$2,400,000.

20. STATION AND ROADWAY BUILDING

One railway administration office, at Whitehorse, and three supervisors' offices on line, to be permanent type buildings. Maintenance-of-way forces to be accommodated in portable buildings, of dimensions suitable for movement on railway flat cars or highway trailers.

20.1	Administration office		$ 115,000.
	Offices on line	3 @ $31,000.	93,000.
	Foreman accommodation	35 @ 15,000.	525,000.
	Personnel accommodation	35 @ 8,000.	280,000.
	Tool and wash trailers	35 @ 6,000.	210,000.
	Repair garage for off-track equipment		177,000.
			$ 1,400,000.

Extra gangs and B&B gangs to be accommodated in on-track boarding cars, Section 17.2.

It is assumed that supervisory staff and train crews would make their own arrangements for dwellings, but, in the event of emergencies, at the port or mine, these employees could be accommodated in the general bunk and boarding houses.

21. MAINTENANCE-OF-WAY AND STRUCTURES

There are several procedures to carry out maintenance of track, bridges and other structures.

Until recent times, the general practice was to establish section gangs, on line, in permanent type housing, at intervals of about 10 miles.

With development of power machines and tools, the tendency is to increase the length of sections and for their duties to be little more than patrols. Renewal of ties and rails and surfacing to be undertaken with specialized, fully mechanized gangs, during the open season.

In mountain territory, the two major Canadian Railways have not as yet made an extensive change of practice from section gangs at intervals of about 10 miles, supplemented with extra gangs for "out of face" ballasting and rail renewals.

For this proposed railway, Dyea to Iron Creek, both modes of maintenance appear to be applicable:-

(a) Sections of 10 mile intervals:

Dyea to near Carcross - 50 miles - and from near Elsa to Iron Creek - 180 miles - in the confined mountain valleys, where it is advisable to have reliable maintenance gangs living on the property, not too far apart.

(b) Longer sections, virtually patrols, and fully mechanized gangs:

Between Carcross and Elsa - 350 miles - in the more open territory, where there is a gravel surface highway not far from the projected railway route.

(c) Bridge and Building Gangs:

3 with full compliment of power equipment and tools.

(d) Extra gangs:

4 for general track work and 1 rock gang for scaling slopes and tunnels - during open working season.

It is suggested that such an organization would result in the minimum overall cost for maintenance-of-way, bridges and other structures.

Regular Staff:

12 months		7 months	
Bridge & Building Master	1	Extra Gang Foremen	4
Roadmasters	4	Assistant Foremen	8
Master Mechanic	1	Machine Operators and Labourers	164
B&B Foremen	3	Shovel and Dragline Operators	4
Section Foremen	35	Rock Gang	10
Carpenters, Bridgemen and Painters	28		
Sectionmen	140		
Bulldozer Operators	4		
Mechanics & Electricians	14		
	230		190

White Pass and Yukon Railway Wage Schedule 1965:-

Section Foreman, on line, $406.10 per month
Sectionman , on line, $1.80 per hour
Plus board allowance $1.25 per day

Estimate of wages	$ 2,450,000.
Holidays 6.5%, pensions 7%, Workmen's Compensation 2%, Unemployment Insurance 1%, Health & Welfare 1.75%	447,000.
Loss on board, extra gangs, 40,000 man days	100,000.
Gang fuels and supplies	170,000.
Communications	70,000.
*Work trains, including snow plow	263,000.
Maintenance-of-way and Structures - wages, fuels and supplies	$ 3,500,000.

*Removal of ice and snow will be mostly done with bulldozers. Extra dozers, draglines and shovels to be rented locally as required.

22. CAPITAL REQUIREMENT

ROUTE "A" - Dyea to Iron Creek, approximately 577 miles

Engineering and Supervision:		$ 13,000,000.
Right-of-Way:		
Private properties & damages	$ 230,000.	
Relocate pipe line	170,000.	
Special agreements	6,000,000.	
Legal surveys	200,000.	6,600,000.
Clearing and Grading, reference Section 14.1:		76,200,000.
Tunnels:		
Coast Range, 11 miles	$21,300,000.	
Others	700,000.	22,000,000.
Bridges, Culverts and Protection Against Slides:		36,000,000.
Track:		
Materials	$40,990,000.	
Lay and ballast	18,880,000.	
Crossings, fences & signs	130,000.	60,000,000.
Communications and signals, reference Section 10:		1,700,000.
Shops:		
Engine and car facilities	$ 3,200,000.	
Stations & roadway buildings	1,400,000.	4,600,000.
(Reference Sections 18 & 20)		
Equipment:		
Transportation	$27,000,000.	
Maintenance	7,000,000.	34,000,000.
		$ 254,100,000.
Contingencies - approximately 10%		24,900,000.
		$ 279,000,000.

23. Assuming this railway would be operated as a division of the overall mining project and that, general administration, accounting, legal and medical services would be integrated with the overall operation, the following staff should be sufficient for the specific superintendence of the railway:-

1 Superintendent, 1 Assistant, 1 Engineer, 2 Instrumentmen, 8 Helpers, 1 Draftsman and 6 Timekeeper-clerks - total 20.

24. **ANNUAL EXPENDITURES**

General administration and engineering:			$ 320,000.	
Maintenance-of-way and structures:			3,430,000.	
Communications:			70,000.	$8,570,000
Transportation:			2,350,000.	
Maintenance of equipment:			2,400,000.	
Depreciation of roadway and structures:				
Tunnel lining	1.7%	$ 147,900.		
Bridges & culverts	1.7%	612,000.		
**Ties, untreated	8.0%	882,400.		
Rails & other track material	2.5%	749,500.		
Ballast	4.0%	560,000.		
Shops & buildings	3.0%	132,000.		
Communications	4.0%	68,000.		
Contingencies	1.0%	218,200.	3,370,000.	
Depreciation of equipment:				
Locomotives	5.0%	$ 545,000.		
Ore and other cars	3.0%	468,000.		4,930,000
Work units	5.0%	295,000.		
Machines & tools	10.0%	160,000.		
Tunnel ventilation	5.0%	62,000.		
Contingencies		30,000.	1,560,000.	
			$ 13,500,000.	
Interest:				
Non-depreciable property - $129,000,000 @ 5.5%				
Depreciable items - $150,000,000 - 60% @ 5.5%			$ 12,000,000.	
			$ 25,500,000.	
Contingencies - 10%			2,500,000.	
			$ 28,000,000.	

Interest during construction - Bechtel's Report shows this item with respect to the entire mine project, therefore it is excluded from the above.

As railway statistics are generally quoted with respect to tons of 2,000 pounds, this practice has been followed. The above annual expenditure is for 5,000,000 short tons.

**Untreated ties for construction to be replaced when necessary with treated ties. Reference Section 5.

25. CONCLUSION

This railway feasibility study has been made to indicate the cost to transport beneficiated iron ore concentrates from a proposed railway terminal yard, at the confluence of Iron Creek and Snake River, to a proposed port site at Dyea, near Skagway - distance approximately 577 miles, with marshalling yards at termini and necessary intermediate passing tracks and service sidings.

Facilities for loading at the mine and unloading at the port, which are dealt with separately in Bechtel's Report of January 1963, are excluded from this report.

Location of the ore loading facilities and procedure for delivering ore from the mine to the plant are as yet indefinite. Therefore it appeared advisable to limit this study to railway construction, maintenance and operation, to between the two above mentioned terminals.

However, it has been ascertained that, it would be practicable to extend railway trackage, from Iron Creek yard site, as a mine spur, up the valley of North Iron Creek for a distance of 7 miles, at a cost per mile similar to that of the main line. This would be additional to costs given in this report.

There are three principal factors to be considered.

25.1 Comparison of possible routes between Dyea and Iron Creek, reference the attached general maps and condensed profiles; also, three accompanying portfolios - route maps, projected profiles and photographs.

The "Trunk Route" is marked "A". It commences at Dyea, Mile 0, and runs through Bennett, Carcross, Whitehorse, Carmacks, Mayo and Elsa to Iron Creek terminal yard, Mile 577.

Several local deviations were considered, in particular, one marked Route "X". This turns-off from Route "A", Mile 170 - by-passing Carmacks, Mayo and Elsa - for a distance of approximately 273 miles, to "X" Mile 443, where it rejoins "A", Mile 473.

These two routes are described in Sections 12 and 13.

Adoption of Route "X", by-pass, would reduce the distance between terminals by up to 30 miles; however, this is the maximum which might result from actual location surveys, it might be somewhat less.

As "X" is through more difficult country, with one additional major river to be bridged, and it is entirely away from existing access roads, construction of an access road, some 290 miles - with temporary bridges or ferries to cross four major rivers - would be necessary.

Where there are heavy movements of ice and debris, during Spring break-up period, temporary bridges are not entirely satisfactory, and, alternative ferries are not operative during freeze-up and break-up.

Therefore, the cost to construct the shorter distance via "X" would not be less - if not a little more - than to build the longer line "A".

Train performance studies indicate that, by reason of more "Rise and Fall", there would be no savings in train operation.

Maintenance-of-way would be lower but not in direct proportion to comparative distances. There are difficult conditions at some points on "X", and, there is an intangible advantage to "A", being close to the existing highway between Carmacks and Elsa, this would facilitate servicing maintenance-of-way forces and the communication system.

After personal observations of the respective general geography, topography and character of soils, the writer is of the opinion that no overall economy would result from adoption of Route "X".

Further, although this study is to evaluate the feasibility to transport one primary product - ore from Iron Creek - Route "A" is in a preferable location to serve local traffic, and also, a part - 140 miles - could be intergrated into a future railway from British Columbia to Alaska, if such a line advances, beyond the several studies and surveys, to reality.

Therefore, the following costs are relative to Route "A" throughout.

25.2 Capital Costs:

This railway is a great distance from and would have no direct connection with other standard gauge railway systems. All costs would be comparatively high, particularly delivery of materials and equipment.

In addition to rail freight, either to Vancouver or to Prince Rupert, and barge costs to Skagway, much would have to be hauled over the narrow gauge White Pass and Yukon Railway to Carcross and/or to Whitehorse, thence by highway to sites along the line as far as Elsa.

Beyond Elsa, it would be necessary to open up an access road - 200 miles to Iron Creek - either in advance of, or, as construction proceeded.

Winter climate is severe; however, it has some compensations, such as to facilitate temporary transportation over muskegs and placing bases for embankments across swamps.

The long summer hours of daylight encourage "making hay while the sunshines".

Cost to Construct (Section 22) is $242,000,000.00. This includes two extraordinary items - tunnels $22,000,000. and special agreement $6,000,000. For the normal part of the line, 566 miles, average cost per mile is $376,000.

During 1952-54, Canadian National Railways constructed 40 miles, through rugged mountain country, from Terrace to Kitimat, British Columbia. Access was comparatively good - rail at the north end and the sea at the south. Average cost was $300,000.00 per mile - with 80 lb. second hand rails at low book value and no charges for freight on bridge, culvert and track materials, also, no rentals for "on-track" equipment.

Cost of equipment - locomotives, cars, work equipment, machines and tools - amounts to $37,000,000.00.

Total capital, 1964 prices and conditions, $279,000,000.00. Reduction of $54,000,000.00, 16 per cent, from Bechtel's Report.

This is brought about by:-

Increase maximum rate of gradient to 0.80 per cent compensated against southward traffic, between East Rackla summit and Dyea, as previously recommended.

Slight increase in gradient to 1.90 per cent, uncompensated, to descend from Lindeman Lake through the Coast Range tunnel to Dyea. This permits projecting a location along the east side of Taiya River Valley, where the topography is much more favourable and danger from rock and snow slides is considerably less.

Length of projected line Dyea to Iron Creek terminal site is reduced by 14 miles.

Classification of grading materials with higher percentage of common excavation.

Lower unit prices for grading, bridges and culverts, on account of competitive situation.

Less provision for protection against rock and snow slides, in the valleys of both Taiya River and Snake River.

Reduction in number of ore cars.

Elimination of intermediate division yards and relative buildings.

Elimination of automatic block signals.

25.3 Annual expenditures to transport from terminal to terminal, five million short tons of beneficiated ore, amount to $28,000,000.00.

The reasons for this large reduction from amount given in Bechtel's Report are:-

Reduction in capital costs.

Depreciation is calculated for the full normal life of the respective items.

Suggestion that the railway would be a division of the overall mine operation to reduce superintendence to a minimum.

Eliminate divisional staffs.

Integrated train operation - through movement between mine and port, crews remain on trains throughout the round trip, reference Section 16.

This has no precedent in Canada; however, as this railway would have no connection with the general railway system, it may be possible to introduce such an operation.

25.4 The writer emphasizes that this report is based on reconnaissance only, and that the quantities and costs given are relatively conjectural, to give a preliminary evaluation and magnitude of the project. He is of the opinion that the amounts are not too high.

This is for transportation of the product from Iron Creek to Dyea only.

If a situation develops to indicate that it would be advisable to provide services as a "Common Carrier", then some additional sidings, facilities and train miles would be required. Revenues would be expected to meet costs of such an operation, or it should be subsidized, so that no loss would be incurred.

25.5 Location is the foundation of a railway. Adequate advance engineering is essential to overall economy of construction, maintenance and operation.

If an analysis of reports indicates this project may be proceeded with in the foreseeable future, the next phase would be to undertake a preliminary location survey.

Such a survey would be carried out with aid of aerial photographs and photogrammetric mapping. The following steps would be necessary:-

Delineate a strip, and respective flight lines, to be photographed. This would be done on available maps, scale 1:250,000.

Study photographs in stereo pairs and delineate strip, average one half mile wide, to be mapped, scale 1 inch to 400 feet, showing contours 10' vertical intervals as practicable.

Set ground controls, horizontal and vertical, as required for photogrammetry.

Project the proposed railway centre line and relative profile.

Review aerial photographs and check ground conditions to classify grading materials.

Preliminary study of foundations for major bridges.

Scale approximate quantities and apply respective unit prices.

A reasonably close estimate would then be obtainable for a more refined evaluation of the project.

Also, maps would be on hand to direct staking a location on the ground in advance of construction.

Such a preliminary survey, by projection on photogrammetric maps and preparation of an estimate of costs to construct, Route "A", could be carried out at a cost of say $290,000.00.

Flight lines could be plotted, from information at hand, in readiness for photography this coming season.

26. <u>Acknowledgments:</u>

The writer wishes to express his appreciation of the co-operation and direct assistance by Crest Exploration Limited, in particular, the arrangements made by Mr. W. C. Cook, to set out fuel caches for helicopter operation

and his generous practical and technical assistance throughout our reconnaissance together.

White Pass and Yukon Railway - suggestions by Mr. Charles Brown, Geologist, with respect to Route "X", and making available a report by Swan, Wooster and Partners, Consultants of Vancouver.

Canadian National Railways' Transportation and Maintenance Department - undertook studies and made recommendations on train performance, transportation, maintenance-of-way and maintenance of equipment.

Canadian National Telecommunications operates throughout the Yukon and Northwest Territories and kindly suggested an organization for communications.

The suggestion, by the C.N. Transportation Department, Section 16, to adopt a maximum rate of gradient of 1.00 per cent compensated against southward traffic is concurred with. This would be of particular assistance to ascend from (1) Stewart River Valley, across Crooked River, to the summit; (2) Pelly River bridge site, across Mica Creek, to the summit; (3) Braeburn Lakes to Fox Lakes and (4) Takhini River to Whitehorse.

If required, the writer would be pleased to undertake further surveys, both in the field and office, with respect to location and construction of this proposed railway.

In the meantime, during the next month, Mr. Cook, of Crest, and the writer are going together, to examine snow conditions at points where they may be particularly heavy - Taiya River Valley, along Bennett Lake, Goz Creek Valley, Goz Pass and Snake River Valley.

J L Charles

J. L. Charles, P.Eng.,
Consulting Engineer,
Canadian National Railways.

Winnipeg, Manitoba,
29 January 1965.

I N D E X

	Pages
Introduction	1 - 7
General description and special features	8 - 9
Communications and signals	10 - 11
Climate	12
Route "A" - description by sections	13 - 37
Route "X" - description by sections	38 - 48
Comparison Routes "A" and "X"	49 - 55
Train performance study	56 - 67
Transportation study	68 - 80
Equipment requirements	81 - 82
Shops, engine and car facilities	83
Maintenance of equipment	84
Stations and roadway buildings	85
Maintenance-of-way and structures	86 - 87
Capital requirement	88
Annual expenditures	89
Conclusions	90 - 97

M A P S

Frontispiece - Railway Map of Canada

General Route Map, scale 1 inch to 35 miles

Sectional maps - Skagway, Whitehorse and Yukon Crossing

Condensed Profiles - Route "A" and "X"