REPORT ON SURVEY
TRANS-CANADIAN ALASKA RAILWAY LOCATION

Syllabus

The district engineer reports completion of Trans-Canadian Alaska Railway location survey and incorporates condensed profiles, maps, and preliminary estimates in his report. Field and district office work is still under way on construction studies, evaluation of possible revisions and permanent records.

WAR DEPARTMENT
United States Engineer Office
Seattle, Washington

October 12, 1942.

Subject: Report on Survey of Trans-Canadian Alaska Railway Location.

To: The Division Engineer, North Pacific Division, Portland, Oregon.

1. Authority. - The following directive was issued' by the Commanding General, Services of Supply, Washington, D.C., March 25, 1942.

"MEMORANDUM FOR THE CHIEF OF ENGINEERS”

"1. It is directed that a field survey be undertaken at the earliest practicable date and pushed to completion for the construction of a rail route via the Rocky Mountain Trench from Prince George, British Columbia, to Fairbanks, Alaska, .The survey should be completed during the coming season. It is desired that an experienced railway locating engineer familiar with the northwest be placed in charge of the survey or attached to it in a superior "executive capacity.

"2. That the general specifications for this projected location be restricted to meet the requirements of a military railroad only.

"3. That the area northwest of Fairbanks, Alaska, be reconnoitered, both by air and ground, in order to have more knowledge on file as to the possibilities of that terrain in case of emergency.

BREHON SOMERVELL,
Lieutenant General, Commanding.

a. In compliance with paragraphs 1 and 2 of the above-quoted directive, the following report, with appendices A to I, inclusive, is submitted on the survey of a railroad location from Prince George, British Columbia, to a rail connection with the Alaska Railroad.

b. A reconnaissance of the area west of Fairbanks to tidewater, authorized in paragraph 3 of the directive, has been made the subject of a separate report, file 7559 (Trans-Canadian Alaska Ry.) l67, submitted June 15, 1942.

2. Conduct of Survey.

a. Establishment of field divisions; In order to facilitate field operations, the route was divided into three location divisions, namely, Alaska, Yukon Territory and British Columbia, each under the direct supervision of a Principal Locating Engineer with headquarters at Fairbanks, Alaska, Whitehorse, Yukon Territory, and Prince George, British Columbia, respectively.

b. District office activity: A section was established in the office of the District Engineer, Seattle, for the express purpose of conducting this survey. This section interviewed and selected the personnel for the locating parties and arranged transportation to the several division headquarters; issued instructions governing the survey; established uniform reporting procedure purchased and shipped all equipment and supplies; secured and issued to the field all maps and data available, and coordinated the transfer of parties and equipment between field divisions.

c. Aerial reconnaissance: An aerial reconnaissance of the route was made during the period. May 3 to May 12, inclusive. A report on this reconnaissance is included with this report as Appendix "A".

d. Methods and instructions: The route adopted is through relatively unexplored portions of Canada and Alaska and it was readily apparent that locating crews would be out of contact with their division engineers for considerable periods of time. In order to secure maximum uniformity in line development and presentation of data by the several locators under these conditions, written instructions governing the location were issued. A copy of these instructions is made a part of this report and listed as Appendix "B".

e. Personnel: Field surveys were started in Alaska in advance of the receipt of authority to initiate the surveyed in Canada. Upon receipt of such authority, crews were immediately sent into the field in Yukon Territory. Considerable delay developed in the British Columbia Division. This office selected as principal locator in British Columbia, a highly recommended locating engineer formerly in the employ of the Canadian National Railway and now serving with the Canadian Army. Request was immediately made through channels for the assignment of this officer to duty with the office of the District Engineer. However, this officer was not officially released by the Canadian Army until June 1, 1942. The original plan for conducting the survey contemplated using eighteen crews. However, as the nature of the problems in Yukon Territory became known, and the starting date in British Columbia was postponed, the number was increased until a total of 24 crews were in the field by the end of July. Men with known railroad locating experience were contacted first, who in turn recommended other qualified engineers. A number of men with railway survey experience were so obtained, but the majority were from the ranks of highway departments in the Northwest. Partymen, such as rodmen, chairmen, axemen, cooks, and flunkeys, were recruited from Washington, Idaho and Oregon, or in the vicinity of the work. Six parties made up of Canadians entirely were enyloyed in British Columbia. Peak employment was 556 persons on July 15. The actual number employed during the survey is shown in Appendix “C”.

f. Transportation and supply: Transportation and supply of field crews was one of the most difficult problems encountered.

(1) The key men of the first two crews were transported by commercial air lines and Army transport planes from Seattle April 21 to Big Delta, Alaska, at which point field work was started on April 23, 1942. The remainder of the crews in the Alaska Division traveled by steamer to Seward, by Alaska Railroad to Fairbanks, and thence by boat, air and tractor trail to the initial point on their assigned sections.

(2) Crews for Yukon Territory were sent by steamer to Skagway and by White Pass and Yukon Railroad to Whitehorse. From Whitehorse, crews in the northern and central sections of Yukon Territory traveled chiefly by riverboat to the site of their Work. The crews in southern Yukon Territory were flown in by chartered plane which was the only feasible means of transportation.

(3) Three crews assigned to work in northern British Columbia were sent from Seattle to Wrangell by steamer, thence to Telegraph Creek, British Columbia, by Stikine River boats and by highway from Telegraph Creek to Dease Lake, from which point they were flown by chartered plane to points near the site of their work. Crews for southern British Columbia traveled by rail from Seattle to Prince George, thence by plane and riverboat to their starting point.

(4) Initial subsistence supplies and crew equipment were purchased in Seattle prior to the crews' departure. It was found that adequate quantities of subsistence items were procurable at Prince George, British Columbia, at reasonable cost. Other sections of the survey continued to be supplied from Seattle. River transportation was utilized in Alaska and northern Yukon Territory, except in emergencies, for the subsequent supply of these crews. To supply the crews in Yukon Territory along the Frances and Pelly Rivers and in British Columbia north of Sifton Pass, the only practicable means was by chartered or rented airplanes. Crews in British Columbia south of Sifton Pass were generally supplied by riverboat except in emergencies, when a private plane was used.

(5) Transportation of the crews on the job was by boat wherever possible. This proved quite satisfactory for the crews on the Parsnip and Finlay Rivers, along the Frances River and Frances Lake section, along the Pelly River, and from Little Salmon Lake to the mouth of the White River. This method was

available to thirteen crews. The remaining eleven crews were forced to rely on pack horses, native back-packers and pack dogs. Pack stock in many cases had to travel from 100 to 200 miles to reach the site of their work. Due to heavy demands of other agencies operating in this locality and scarcity of pack stock, crews were forced to accept animals in poor condition, poorly equipped, and which ordinarily would not have been considered usable.

(6) Crews using boats or rafts along the rivers suffered some delay when, due to the low-water stage late in the summer, outboard motor equipment was damaged. One of the difficulties encountered by crews using pack trains was that along a large portion of the route, trails had to be built before the pack trains could move, and where old trails existed, an excessive amount of clearing and repairing was necessary before they were usable. Feed for pack animals had to be provided practically the entire summer due to the scarcity of forage along the route.

(7) The planes used under rental contiacts consisted of one Waco with a 285 H.P. motor, one Waco with 225 H.P., one Fairchild with a 145 H.P., and one small Taylorcraft, all on floats. These planes proved very practical for periodic contacts with the crews by the division engineers, and for emergency use in transporting sick and injured personnel from the field to medical facilities. However, the type of plane used, proved unsatisfactory for transporting any quantity of freight. Major freight or personnel movement's were made by Canadian Pacific Air Line's planes, Junkers type, which proved to have a freight capacity of approximately 1500 pounds. Rough flying weather necessitated numerous repairs to the ships.

(8) Communication between crews and field division offices was chiefly by plane contact. A few crews working along the Yukon River were equipped with field telephone sets, enabling them to cut in on the existing Dominion telegraph line west of Selkirk, Yukon Territory. An attempt was made early in June to secure portable field radios for crews in isolated sections, but these were not obtained prior to completion of the survey. In the few emergencies that arose, these crews managed to send messages to the nearest Hudson Bay post from which point the message was transmitted to the division headquarters.

g. Existing maps and records: Following receipt of the directive authorizing the survey, attempt was made to locate all available maps of the territory to be traversed. U.S. Geological Survey maps gave complete coverage In Alaska. These maps are on a scale of 1 to 250,000 with 200-foot contour intervals. Various proofs of aeronautical charts were obtained covering the entire route and were of help in showing the drainages. Elevations shown on these charts were only approximate. These were the best maps available for Yukon Territory. The Rocky Mountain Trench route through British Columbia had been previously mapped by the Department of Lands of British Columbia. Although the maps were not available at the start of the survey, they were received in

June. Various other maps, chiefly of a local nature, were obtained but were of little value because of incomplete or incorrect data.

h. Aerial photography: Due to lack of adequate maps in Yukon Territory and because two important summits were involved, it was deemed advisable to have aerial photographs made of the section from Lower Post to Little Salmon, This was done by the Aero Service Corporation early in May. Control points were tentatively selected from stereoscopic study of the contact prints and these points noted on a mosaic which had been made up from individual prints. Copies of the mosaic prints were furnished locating engineers and proved of considerable value in guiding the field location. Supplementing existing maps and aerial photography, the small chartered planes were used periodically to acquaint the several locators with the nature of the terrain ahead of their located line for distances varying from 5 to 20 miles. This procedure was found most effective and frequently enabled the locators to establish a satisfactory located line without the necessity of running a preliminary line.

i. Rate of progress: The rate of progress in the conduct of this survey is graphically shown in Part "A" of the final field progress report for the period ending September 30, 1942. A copy of this report is attached and marked Appendix "C”.

3. Description of Route:

a. General: Preliminary map study and aerial reconnaissance revealed that the most favorable junction point with the Alaska Railroad would be at Kobe, Alaska, a rail station 85 miles south of Fairbanks. The selected route between Prince George, British Columbia, on the main line of the Canadian National Railway and Kobe, Alaska, on the Alaska Railroad is about 250 miles inland and practically parallel to the coast line of Alaska. The route follows two general courses, which may be described with sufficient accuracy for orientation on small scale maps, as follows: From Prince George, British Columbia, to Fort Frances, Yukon Territory, an air line distance of 570 miles on a true bearing of 332 degrees, thence 285 degrees true, an air line distance of 650 miles to Kobe, Alaska. The developed line does not diverge from these two general courses by more than 30 miles at any point in the entire total length of the line which is 1,417 miles.

b. Drainages and summits: The eastern portion of this route follows through the Rocky Mountain Trench from Prince George, British Columbia, to its northern terminus; near the 6Oth parallel of latitude. The trench is a relatively straight, narrow valley at the foot of the western slope of the Rocky Mountains. The floor of the trench has a mean elevation of 2500 feet above sea level. In this section, the located line rises to a minor summit about 30 miles north of Prince George, then descends along a northern-flowing drainage to the head of the Peace River about Milepost 170. The line then rises on a slight grade along the southern-flowing tributaries of the Peace River to the summit of Sifton Pass, the highest point reached on the route, 3,273 feet, at a distance of 350 miles from Prince George. From the summit of Sifton Pass the line drops to the crossing of the Liard River in the vicinity of Lower Post near the northern boundary of British Columbia. The line follows the same general course north of the Liard Crossing to Frances Lake, Yukon Territory, utilizing the valley of the Frances River, a southern-flowing tributary of the Liard River. From Frances Lake the line swings sharply to the west and continues to ascend to the summit of the Arctic-Bering Divide, approximately three miles west of Finlayson Lake and then descends along the Pelly Hiver valley for a distance of about 100 miles from the Arctic-Bering Divide at which point it leaves the Pelly drainage, crosses a minor summit and then descends the Magundy and Little Salmon drainage to its confluence with the Yukon River at the trading post of Little Salmon, Yukon Territory. The line follows the right limit of the Yukon River to Five Finger Rapids where pinnacles of rock in the river channel afford excellent bridge rests for a crossing. After crossing the Yukon, the line continues along the left limit of the Yukon River to the mouth of the White River, thence up the right limit of the White to a point immediately below the confluence of the Ladue River, an eastward-flowing tributary of the White, where the line crosses the White and then ascends the Ladue River to a summit between the Ladue and the Tanana Rivers. From this summit the line drops rapidly to the Tanana Valley floor, crosses immediately to the left limit of the Tanana River and follows along the foot of the northern slope of the Alaska Range to a junction with the Alaska Railroad at station Kobe, 273 rail miles north of Anchorage, and approximately 85 miles south of Fairbanks. The route of the projected railroad is shown on map marked Appendix "D" of this report.

(1) The entire route offers favorable location for a railway line. Summits may be reached by relatively easy grades and the conformation of the valleys permits satisfactory alignment for the service contemplated. Rockwork is negligible, very little soft ground is encountered and the use of an undulating grade line with a 2% maximum grade makes possible a very light line, capable of rapid construction.

4. Description of Located Line:

It is readily apparent from examination of the data gathered by the several locating engineers that instructions issued by the District Office were uniformly observed, resulting in a location survey which is consistent throughout the project. The uniformity thus obtained makes possible a brief description of the located line confined to topographical changes.

a. British Columbia Division.

(1) Physical characteristics:

(a) Junction -- Divide Section, (Mile 0 to Mile 27): The location leaves the Canadian National Junction immediately west of the yards at Prince George and crosses the Nechako River in the first mile. From the north bridge head of the Nechako, the line ascends on 1.5% compensated grade with considerable generated line in heavy work up McMillan Creek, a tributary of the Nechako, for about 6 miles. From this point to the summit of the Continental Divide at Mile 27, the location is in light to medium construction with an undulating grade and fair alignment. This portion of the location is through some improved land and is in close proximity to a gravel road from Prince George to Summit Lake.

(b) Divide — Finlay Forks, (Mile 27 to Mile 173): The drainage flows toward the north from Divide to Finlay Forks, The location follows the Crooked, Pack and Parsnip Rivers in the order named and drops 500 feet on a line distance of 146 miles. Some adverse grade is adopted to avoid bad ground adjacent to the rivers. Alignment is good and the work is classed as medium.

(c) Finlay Forks — Ware, (Mile 173 to Mile 301): Five miles north of the junction of the Parsnip and Finlay Rivers the line crosses to the left limit of the Finlay and closely follows the river to the end of this section. Mile 301, rising 540 feet in a distance of 128 miles. This portion of the line is largely side-hill development. The alignment is good and less than 10 percent can be classified as heavy work.

(d) Ware — Sifton Pass, (mile 301 to Mile 345): After crossing the Kwadacha River at Fort Ware and the Fox River at Mile 305, the line follows the west limit of the trench in good ground to Mile 318 . At this point, which is opposite Fox Pass, a prominent break in the range to the west, the location starts across the valley floor to the east side of the trench which is followed to the summit. The valley between Fort Ware and Fox Lake, Mile 336, is 2-1/2 miles wide but narrows, rapidly above the lake to a width of 1/4 mile at the summit. The gradient does not exceed 1.5 percent against north-bound traffic. Excavation is glacial material consisting of clay, gravel, and boulders, and is light work except for a 6-mile section immediately above Fort Ware, where heavy grading is encountered in a canyon section. The summit itself is scarcely distinguishable and while the low point in the saddle is elevation 3,273 feet, the line crosses at an elevation of 3,299 feet to avoid swampy sections in the valley bottom.

(e) Sifton Pass — Gataga Forks; (Mile 345 to Mile 401): The location north from the summit is in light grading, following the Kechika River and crossing it at several places to avoid difficult sidehill work. Some sidehill development to the top of a bench is resorted to at a point 11 miles above the confluence of the Kechika and Gataga Rivers in order to avoid a 4-mile canyon section on the Kechika. From the crossing of the Frog River at Mile 396, the line is in good ground along the western edge of a bench above river level. Very little hard rock is encountered in the section from Sifton Pass to Gataga Forks. Excavation will be chiefly glacial drift with some cemented conglomerate which will not require blasting.

(f) Gataga Forks — Chee House; (Mile 401 to mile 447): At Gataga Forks, the confluence of the Gataga and Kechika Rivers, the valley widens abruptly to 2-1/2 miles and increases in width to 4 miles at the confluence of the Turnagain River. The Kechika River holds generally to the east side of the trench and the west side is characterized by a series of river terraces. The location follows along one of these terraces on a fairly uniform grade except where incised side drainages are crossed. Grading is light and is entirely in glacial material. At Chee House, an abandoned trading post near the mouth of the Turnagain River, the Kechika turns eastward and the Rocky Mountains deteriorate to foothills.

(g) Chee House — Lower Post; (Mile 447 to Mile 518): Leaving the Kechika Valley 3 miles north of Chee House, the location continues to Lower Post across a region of typically broken glaciated topography marked by gravel ridges and intermediary small lakes and swamps. The line is essentially straight except for deviations necessary to avoid heavy grading and to secure suitable crossings of the several creeks. Large swamps were avoided successfully, and those that were crossed present no construction difficulties, A minor summit is crossed 26 miles south of Lower Post, which necessitates some 1.5 percent grade in the approach and some 2.0 percent grade in the descent to the Liard River, Mile 518. No ledge rock is encountered in this section.

(2) Revisions:

To avoid the steep climb out of Prince George with its objectionable heavy grading and line development, an alternate route starting from the Canadian National Railway at Willow Creek, 19 miles east of Prince George, and proceeding up the Salmon River Valley to a junction with the original line to Summit Lake, is being located. This route will reduce the length of new construction by 10 miles and offers better grade, alignment and lighter construction. It will necessitate a crossing of the Fraser River but will obviate crossings of the Nechako and Salmon Rivers. An excellent site for the crossing of the Fraser is developed. Although this junction is east of Prince George and may result in some back haul from Prince George Division yards, there is adequate room for sidings at the willow Greek Junction. With only minor revisions, several points of heavy earthwork elsewhere in the British Columbia Division may be avoided. These revisions may be projected from available topographic data.

(3) Vegetation:

Dense stands of timber with trees up to 24 inches in diameter cover most of the trench between Prince George and Fort Ware. North of Fort Ware, there is a fair forest covering, but stands are thinner and poorer in quality. The principal species are spruce and tamarack. Lodgepole pine, Douglas fir (mountain type), cottonwood, aspen and white birch are also present. Sufficient timber may be found adjacent to the line throughout its length in British Columbia to supply all construction requirements but imported timber for bridge stringers and truss members is recommended because of its superior structural qualities. Extensive forest fires have occurred in many places in the trench and these burned areas are in various stages of reforestation although the more recent burns are still barren or grass-covered. Other openings in the forest occur at swampy places which are covered with brush and moss. Swamps along the route are due to the immature drainage system or operations of beavers and firm ground is encountered at slight depth.

(4) Drainage:

The waters of the trench between the Continental Divide and Sifton Pass find their outlet through the Peace River and, north of the Pass, flow to the Liard River. Aside from these major water courses, the drainage is poorly defined due to the effects of glaciation as evidenced by the numerous small lakes and swamps. The major streams in lowering their beds have left terrace remnants which are a prominent feature of the valley, Cross drainages enter the main streams through deeply cut channels. Rapids in the rivers are generally due to accumulations of boulders rather than to projecting bedrock. Melting snows cause the heaviest run-off which occurs in the spring or early summer.

(5) Climatic conditions:

Authentic weather records for the portion of British Columbia traversed by the line are meager but information gathered indicates that precipitation is light, averaging about 20 inches per year, The greater portion of this falls during the summer season. Accumulated snow depths in winter seldom exceed two feet. Even in Sifton Pass, settlers in the vicinity report a maximum depth of five feet and this depth has been observed only a few times in the past 20 years. The wide range of temperatures characteristic of inland regions is observed throughout the trench route. Temperatures of 50 degrees below zero, Fahrenheit, are noted but it is reported that these extremely low temperatures are of short duration with intervening periods of relatively mild but freezing weather throughout the winter. The smaller rivers freeze early in October. River navigation opens about May 10, although there nay be some local delays due to high water in canyon sections.

(6) A condensed profile and plan of the route in the British Columbia Division is attached as Appendix "E".

b. Yukon Division.

(1) Physical characteristics:

(a) Watson Lake Section: (mile 518.8 to mile 570.5):

This section begins at the north bridge head of the Liard River, Mile 518.8, The crossing of the Liard River is about one and one half miles below the confluence of the Dease River. From the crossing, a gradual departure is made from the river level, ascending on maximum compensating grade with the curves up to 12 degrees in medium work through an area of densely wooded ridges and benches to Mile 529. The line continues in a northwesterly direction in light construction through rol1ing "wooded country with undulating grades and light curves to mile 570.5 where the line crosses from the left to the right limit of the Frances River. This crossing is approximately 475 feet wide between rock walls and 60 feet above water level. From Mile 523, the line is in close proximity to the existing road between Lower Post on the Liard River and the Watson Lake airport at Mile 544.

(b) Frances River Section: (Mile 570.5 to Mile 640.7):

From its source at Frances Lake to its confluence with the Liard River, the Frances River descends by rapids through box canyons with intervening reaches of sluggish channels in relatively broad, densely forested valleys. In this section the line follows the right limit of the Frances Valley but departs some distance from the river in several places to secure more favorable alignment and to avoid heavy rockwork along the box canyons, from mile 572.5 is to Mile 630 the line may be classified as light construction. At little 630 the line leaves the Frances River, swings to the west to skirt the western shore of Frances Lake, crossing drainages and intervening ridges in medium to heavy work.

(c) Frances Lake Section; (Mile 64.0.7 to Mile 695.5):

The line continues northerly along the west shore of Lake Frances through light to medium construction, light rolling grades, short tangents and moderate curves to Mile 665. Departing from the lake the line follows the west side of the Finlayson River and Finlayson Lake to the Arctic-Bering Divide at Mile 695.5. Occasional rock outcroppings are encountered in this portion of the line and many small structures are required.

(d) Pelly River Section, (Mile 695.5 to Mile 812.6):

Descending from the Arctic-Bering Divide, the line follows Campbell Creek to Pelly River, continuing along its left limit, crossing numerous northerly flowing tributaries of the Pelly River to Mile 800; thence across Magundy Summit to the Magundy Kiver, mile 812.6, the end of the section. The line follows through medium to heavy construction departing from the river in numerous places to avoid river cutbanks, to shorten distance and to reach more favorable ground on light grades, moderate length tangents and curves.

(e) Little Salmon Lake Section; (Mile 812,6 to Mie 890): The line continues westward through a park-like valley, one to three miles wide, along the Uagundy River, coming to Little Salmon Lake at Mile 837» The north shore of Little Salmon Lake is 19 developed with considerable curvature and flat grade for a distance of 24 miles, then departure is made from the lake to higher ground along the Little Salmon River Valley, coming to the course of the Little Salmon River at Mile 875, and folio-wing in close proximity thereto, to the Lewes River at the end of the section, Mile 890. The line involves light work except for short stretches and offers excellent alignment and grades. The valley formed by the Magundy River, Little Salmon Lake and Little Salmon River is between distant snow-covered peaks with dense forest covering of the adjacent slopes.

(f) Carmacks Section; (Mile 890 to Mile 924-1): From the mouth of the Little Salmon River the location follows the right limit of the Lewes River. Light work on long tangents and easy curves is encountered to Mile 896, continuing through heavy and light work intermittently to Mile 913. Between this point and Mile 919, the line traverses steep, sloughing slopes along high riverbank, entailing heavy work on a curved line with short tangents and broken grade to Five Finger Rapids bridge site at the end of the section, Mile 924.1, The formation traversed is composed of gravel, considerable ledge rock outcrops and large shale slides overgrown with spruce and cottonwood.

(g) Five Finger-Selkirk Section; (Mile 924.1 to Mile 977): A natural bridge site exists at Five Finger Rapids and is formed by three solid rock islets extending some 30 feet above the surface of the water. After crossing to the left limit of the Lewes River, the line encounters medium work on long curves and tangents and light, rolling grades to Mile 939. From this point, heavy rockwork is encountered intermittently with light work on moderate curvature and rolling grade to Mile 969. The location leaves the river for short distances in this section to avoid bad ground or exceptionally heavy work. The remainder of the line from Mile 969 to Selkirk is in light construction with long tangents, easy curves and undulating grade. The village of Selkirk, Mile 977, is located at the confluence of the Lewes and, Pelly Rivers -- which combine to form the Yukon River flowing westerly from this point.

(h) Yukon River Section; (Mile 977 to Mile 1070): Beginning at Selkirk, where an airport of sufficient size to accommodate the larger planes is situated, the line continues on the left limit of the Yukon River and in close proximity to it for the entire length of the section. The work varies from extremely light to sections of medium work where rock outcrops along the riverbank are encountered. Alignment varies from light curvature with long tangents to occasional sections of short tangents and easy curves to avoid heavy work. Forest covering of suitable timber for construction purposes is light in this section. However, the locator notes the existence of 1500 40-foot spruce trees suitable for piling and 1,000,000 board feet of timber suitable for lumber in a stand on Independence Creek approximately 8 miles south of Mile 1054.

(i) White River - Boundary Section; (mile 1070 to mile 1119): At the beginning of this section the line swings sharply toward the west following the right limit of the White River in light to medium work with excellent alignment and a rolling grade to Mile 1075. West of Mile 1075, somewhat heavier work in sidehill is taken to the crossing of the White River at Mile 1092.0. At this point the line crosses and then follows the left limit of the

White River to Mile 1097 where it leaves the White and continues westerly up the Ladue Valley to the Alaska boundary, Mile 1119. Light work with long tangents and moderate curvature predominates in this section. Forest covering varies from scattered spruce and birch to open hillsides with fair stands of tie timber along the watercourses.

(2) Revisions:

Owing to the difficult ground and heavy construction encountered in the Carmacks section and particularly between Mile 913 and 919 an alternate route has been investigated. A preliminary survey of a revision to eliminate this section has been made. The revision leaves the located line at Mile 885, near the western end of the Little Salmon Lake section, and traverses a shallow valley 5 miles north of the present location, returning to the river line at the Five Finger Rapids bridge site. Mile 924.1. The proposed revision is largely in gravel formation and will provide a light line with excellent grade and alignment and will shorten the distance 6.5 miles. The only objection to the revision is its distance away from transportation on the river. The route is shown on map. Appendix "F". Minor revisions of the line elsewhere in the division are under consideration

(3) Vegetation:

The forest covering is composed of spruce, pine, tamarack, hemlock, birch, poplar and aspen. Sufficient quantities of piling, tie and culvert timber are available along the route with relatively short haul. Spruce is predominant and reaches diameters of 24 inches. There is considerable variation in ground cover ranging from large areas of moss and peat to heavy grass and brush growth in both the open and timbered section. Grassy areas are common to south and west facing slopes in the lower altitudes, while the north and east slopes are usually well timbered. The timber line is generally at an elevation of 4,000 feet. Throughout this region, a multitude of ponds, lakes, swamps and tributary streams are encountered. The swamps are rarely of great extent and are so situated as to be entirely avoided or narrowly crossed by the line. The low ground usually has a firm base of gravel or small boulders about a foot below the surface and will present no unusual construction problem.

(4) Drainage:

The route traverses relatively broad valleys surrounded by gentle to medium slopes leading to distant mountains, some of which in the high altitudes, maintain perpetual snows. The drainages are generally in well-defined channels, classed as semi-arid, the region is subject to light snowfall and seasonal rains in early spring and late fall with periodic rains throughout the summer season. On the high side of excavations and embankments, small interceptor drain ditches are planned to lessen the occurrences of slides and reduce the number of small culverts required. A minimum size culvert of three-foot span and two-foot height is deemed advisable due to the presence of ice, snow, drifts and sediment. Using this dimension, as minimum,. culverts will readily permit easy maintenance and lessen the danger of obstruction during run-offs.

(5) Climatic conditions:

While few official records of the climate exist, the conclusion is drawn from information gathered from observation, native Indians and whites, that the climate is not unlike that of the northwestern states of Dakota, Montana, and Washington, east of the mountains, with proportionately colder and longer winters as the distance increases toward the north. Local variations, due to elevation and protection, are similar to the states referred to above. The route traverses a region of low precipitation and varying, but not high winds, as indicated by the absence of wind erosion and unbalanced tree growth. The depth of snow in the low broad valleys rarely exceeds 18 inches, increasing with the altitude to a maximum depth of 4 feet on the Arctic-Bering Divide and Magundy Summit. Freeze-up occurs generally in October accompanied by light snows which increase until February, diminishing about the middle of March. By the middle of April, the route is generally free of snow, and plant growth has begun although the large rivers and lakes may contain ice until the middle of May.

(6) A condensed profile and plan of the route in the Yukon Division is attached as Appendix "F".

c. Alaska Division:

(1) Physical characteristics:

(a) Boundary to Tanacross; (Mile 1119 to Mile 1207): From the Alaska-Canada boundary the line continues in light construction ascending through the mile-wide valley of the Ladue River. A line requiring numerous channel changes of the Ladue River is developed on light grades, long tangents and easy curvatures to Mile 1169 from which point the line continues up the west fork of the Ladue with increased gradients and curvatures to the summit at Mile 1173. From the Ladue Summit the line descends through heavy construction to a crossing of the Tanana River at Mile 1186. This descent is sidehill development with almost continuous curvature, although less than the maximum gradient is used. The line as staked includes three short tunnels and a high structure over a dry gulch. Examination of the alignment, grade and topographic data reveals the need for revisions which can be accomplished, eliminating the high bridge and tunnels. Several other revisions on this 13-mile descent are now obvious and desirable to reduce costs and expedite construction. These revisions can be projected with the data now available. After crossing the Tanana River, Mile 1186.0, the line continues down the left limit of the Tanana Valley on a direct route to Tanacross at which point the river approaches the located line. This portion of the line involves light construction on long tangents and essentially level grades.

(b) Tanana to Big Delta; (Mile 1207 to Mile 1306): From Tanacross to the Johnson River, Mile 1263.7, the line follows closely the left limit of the Tanana River but again departs from the river immediately west of the confluence of the Johnson with the Tanana and skirts the foothills of the Alaska Range, thus avoiding swamp and overflow land adjacent to the Tanana. The line crosses the Richardson Highway at Mile 1305 and the Big Delta River at Mile 1305.2. Light construction is encountered throughout the entire section except for three and one-half miles in the vicinity of the Robertson River crossing, mile 1230.6, and a four-mile section at the crossing of the Johnson River, Mile 1263.7. The alignment is excellent with tangents exceeding 10 miles in length and light curvature. Gradients are well below the maximum allowed.

(c) Big Delta — Kobe Section: (Mile 1306 to Mile 1416): The line continues in a westerly direction, crossing the many northern-flowing tributaries of the Tanana River to the junction point with the Alaska Railroad, at station Kobe. The entire section is in light construction, alignment consists of long tangents connected with easy curves and the grade is undulating but below the allowable maximums.

(2) Vegetation:

The timber along the route in the Alaska Division is much more limited both in quantity and size than in either the British Columbia or Yukon Divisions. The species to be found are spruce, hemlock, birch and poplar. It is believed that sufficient timber for ties and piling can be secured along the route but line transportation up to 50 miles will be required in certain sections. The ground generally is carpeted with moss ranging in depth from 3 to 18 inches over gravel or firm ground with isolated patches of bunch grass. A considerable portion of the Tanana lowlands, formerly timbered, has been burned over in recent years and these burned areas are now covered with a dense growth of alder and willow brush.

(3) Drainage:

From the Alaska boundary to the Ladue Summit, there are no cross drainages of any consequence. The tributaries of the Ladue are not glacier-fed and there is no indication of flood stages in the Ladue. However, after crossing the Tanana River, practically all the streams entering the Tanana from the Alaska Range discharge from melting glaciers. There is a marked variation in flow of these streams with maximum discharge during the summer. These streams carry a great amount of gravel as they emerge from their canyon sections and deposit this load as the gradient is reduced after entering the Tanana Valley. The channels are threaded and the bank to bank width of the river is much greater than is required for the volume of flow. It is considered inadvisable to constrict these channels and long crossings of pile trestle design are advocated. As these streams head above timberline, there is relatively little floating drift and there is no ice floe since channel ice melts before the high water stages of the summer.

(4) Climatic conditions:

Accurate records of the temperatures in the Tanana Valley are available only for Fairbanks and the immediate vicinity. There are no records of temperatures in the upper reaches of the Tanana drainage. At Fairbanks the mean July temperature is 60.7 degrees and the January mean is minus 15.3 degrees. The extreme range, officially recorded, is from minus 65 degrees to plus 99 degrees. There is an average of 238 days annually with minimum temperatures below freezing. The Tanana River freezes up each year between October 9 and November 13 and the spring break-up is between April 29 and May 11, the average being May 5. The river is open less than 170 days during the year. Fairbanks is the only precipitation recording station maintained in the Tanana Valley but records of this station are available since 1906 and these reveal mean annual total of 11.62 inches.

(6) A condensed profile and plan of the location in Alaska will be found in Appendix “G” to this report.

5. Bridges:

The location crosses six rivers sufficiently large to be classed as navigable waterways although only three have been so used in recent years. These larger streams are the Nechako, Finlay and Liard Rivers in British Columbia, the Yukon (Lewes) and White Rivers in Yukon Territory and the Tanana in Alaska. The Nechako River flows into the Fraser River at Prince George and was used as a navigable waterway during the construction of the Canadian National Railway and prior thereto. The railroad bridge of the Canadian National across the Fraser at the mouth of the Nechako was designed to permit navigation. However the bascule has been converted to a fixed span and the highway crossing of the Nechako adjacent to the site of the proposed Trans-Canadian Alaska Railway crossing is on fixed spans at an elevation only slightly above maximum high water, The Finlay and Liard Rivers are used by small shallow-draft power boats and barges. Fixed spans with vertical and horizontal clearances required for a safe structure will provide adequate clearances for any possible navigation on these streams. The Yukon River is an important inland waterway, navigated by river steamers. A vertical clearance of 72 feet was authorized for fixed spans over the navigable channel. The horizontal clearance is fixed by the position of the rock pinnacles in the river which provide the bridge rests for this structure. The White and Tanana Rivers, like the Finlay and Liard, are used by small boats and barges only occasionally.
The crossing of all these streams with the exception of the Yukon will be effected with multiple-span bridges of Howe or Towne truss design on pile abutments and piers with rock-filled log cribs and pile trestle approaches as required. Studies now under way indicate that steel spans will be required for the crossing

of the Yukon. Estimates contained in this report are of a preliminary nature and are intentionally high. It is expected that a reduction can be made in the costs of bridging as the result of further study and investigation. The type of bridge presently planned for each crossing is shown on the profiles, Appendices "E", "F" and "G".

6. Terminal Facilities at Junctions:

a. Prince George, British Columbia: The railway yard at Prince George, a division point on the Canadian National Railway occupies about 300 acres and is situated between the town and the Nechako River. There are three sidings about a mile in length along the main line, with four other house tracks and short spur tracks in the yard. Rail weights used vary from 60 to 80 pound. There is adequate area for expansion with only a slight amount of grading. Engine service facilities include a 12-stall roundhouse with a 90-foot turntable. The machine shop is equipped to handle all the usual repairs. Miscellaneous facilities consist of fuel oil storage tank, pump house, water crane, ice house and coal station, the latter not in use at present. There is also a concrete culvert casting yard which utilizes bank run gravel from the adjacent Nechako River. Train crews are housed in the town or in outfit cars set out in the yard. The existing engine and train service facilities at Prince George are believed to be no greater than are required for main line service on the Canadian National. Relatively little yard expansion is deemed necessary but complete facilities for an engine terminal with housing for operating personnel should be included in the construction program.

b. Kobe, Alaska: At present there are no terminal facilities at Kobe. Sufficient area is available and the terrain is favorable for installation of the terminal development required. Locomotive and car shops are not contemplated as these facilities are available at Nenana, 25 miles north of Kobe on the Alaska Railroad. The yard at Kobe should include make-up yards for both north and southbound traffic on the Alaska Railroad, as well as east-bound on the Trans-Canadian system.

7. Tributary Area:

Pursuant to request made by this office, the National Resources Planning Board through its Portland, Oregon field office prepared and submitted a description of the area traversed by the Trans-Canadian Alaska Railway route and districts tributary thereto. This description is a thorough presentation of all available data and is included in its entirety as Appendix “I”, thus obviating the necessity for treatment of this subject in the body of this report. In addition thereto, the National Resources Planning Board has furnished this office a treatise dealing with the economic justification of the proposed construction. The directive issued by the Commanding General, Services of Supply, indicates that this project should be considered as a military necessity, therefore economic justification is not properly within the scope of this report. Consequently, these findings of the National Resources Planning Board are not reproduced but have been placed on file in the office of the District Engineer for future reference or transmittal to higher authority if so directed. It should be noted that the development of a line from Prince George, British Columbia, to Kobe, Alaska, under economic standards would differ in some respects from the present location which has been layed down without regard to the creation of rail tonnage enroute.

8. Proposed Standards:

The standards governing the location surrey and subsequent design are based on the requirements for a military railway. Speed of construction was given first consideration in selection of the route with cost of operation and maintenance of secondary importance.

a. Clearing and grubbing: The width of right-of-way for purposes of estimating quantities has been taken as 200 feet. Trees within the right-of-way and dangerous trees adjacent thereto will be removed and debris burned under favorable or controlled conditions to reduce future fire hazard. Experience on the Alaska Railroad in areas of permanently frozen ground has shown that a usable roadbed may be obtained more quickly by maintaining the frozen condition than by attempting to thaw it. The native moss and other vegetative matter on the surface will be preserved as much as possible to serve as an insulating layer under the embankment. Decay of organic matter under conditions existing along the route will cause only minor disturbance of the roadbed. Trees will be cut at ground line in light fill sections -where the ground line is less than two feet below subgrade, and where greater, not to exceed the diameter. Material cleared from the right-of-way will be utilised as much as possible for corduroy mats, ties, piling and culvert timber. Borrow pits for ballast or embankment materials will be cleared and stripped of unsuitable material prior to excavation.

b. Grading: Width of roadway has been taken as 16 feet in cuts and 14 feet for fills. Side slopes of 1:1 in common excavation, ¼:1 in rock excavation, and 1 1/2:1 in embankment are considered satisfactory for the materials encountered. Throughout the line, grades in light earthwork sections are carried 2 to 3 feet above ground level to minimize and facilitate snow removal. Through cuts are avoided where possible and sidehill cuts are "daylighted".

c. Bridges, trestles, culverts: Local timber is available in sufficient quantity to meet most of the structural requirements, thus avoiding use of critical metals and reducing the materials that must be procured from commercial markets. With only a few exceptions, multiple span bridges may be used at the major river crossings. Foundation conditions, and required height of piers are such that span lengths may be varied at will to fit standard truss lengths. Wooden trusses, with a maximum span of 150 feet, will fit these conditions in practically all cases. Steel trusses are required for the crossing of the Lewes River at Five Finger Rapids where spacing of the islands requires one span of 300 feet and one span of 270 feet. Further studies are being made to determine the advisability of utilizing steel trusses at canyon crossings where extreme height makes false work supports impractical and the cantilever method of construction necessary. Timber trusses in several standard lengths may be prefabricated at points of suitable structural timber supply for rapid assembly at the construction site. Rock-filled cribs and piling will provide satisfactory abutments and piers for timber structures. Where navigation, ice, drift, or flood conditions do not require clear openings, crossings will be made on pile trestle, following A.R.E.A,, 4 pile bent design. Materials for piling, caps, and bracing are obtainable in the vicinity of the route. Stringer material may not be available in the vicinity of the point of use, but may be obtained at Prince George and other points without drawing on the commercial market for high grade structural timber. Local timber will be adequate for construction of culverts. Rock suitable for riprap protection of bridge and culvert foundations will be available in the vicinity of the work, with only short hauls.

d. Ties, rail, and track-laying: Second grade ties, 6" x 7" x 8", are considered satisfactory for the service proposed for this railway. Although tie material along the route is not of the best decay-resistant type, it is considered that strength and durability are sufficient for the use contemplated. Tie materials to these standards will be obtainable from timber along the line, and haul distance to any point should not exceed 50 miles. Lightweight rail of 60-pound and not to exceed 70 pounds per yard will prove satisfactory and is desirable for the service intended. Advantages gained from the use of light rail are reduction in tonnage of materials to be transported to the job, a considerable saving in amount of steel required, and ease of placing. Light rail will permit bending in the field to the required curvature, as it is laid whereas heavier sections would require pre-curving which could not be properly coordinated for rapid track-laying under existing transportation conditions. The saving in steel between 60 and 80-pound rail would amount to approximately 50,000 gross tons. Inasmuch as rail and rail accessories constitute the largest item of construction material that must be brought in, this represents a substantial reduction of the transportation problem.

e. Ballasting and surfacing: Suitable ballast materials may be found along the entire route. Haul distances will be short, in no case exceeding 20 miles. A ballast section providing 6-inch depth under the ties which will require 2,000 cubic yards per mile has been adopted.

f. Yards and sidings: For military use, the train movements will generally be through to destination. It is not considered likely that trains will need to be broken up at intermediate points. Yards at division points will therefore consist only of a few house tracks, and a wye track for turning. Yard and transfer facilities will be needed at Watson Lake, at which point the Alcan Highway is crossed, and possibly at Little Salmon, if Yukon River transportation is to be utilized. No. 7 turnouts will be satisfactory in yards. Sidings one-half mile in length will be placed at approximate 10-mile intervals. To aid in starting trains in cold weather, a grade of 0.25 percent will be built into the sidings where possible. No. 9 turnouts will be used from the main line.

g. Stations and buildings: It is believed that motorized section cars will permit the adoption of 10-mile section lengths. The use of double section houses and tool sheds at 20-mile intervals is recommended. Water tanks should be installed at alternate section houses or at approximately 40-mile intervals on steam operated sections of the line. Fuel stations will be located at division points only, which will average 120 miles apart. In view of the fact that there is an adequate supply of merchantable grade timber along the route in British Columbia and southern Yukon Territory, it is proposed to establish semiportable sawmills in the accessible stands along the right-of-way to supply trestle and culvert timber. These mills can also produce suitable rough lumber or slabbed timbers for the construction of all permanent buildings in these portions of the line. In western Yukon Territory and Alaska where tile timber is less suitable for building purposes, and transportation is less difficult, the use of prefabricated, winterized T/0 type buildings is contemplated as a temporary measure pending completion of the rail line at which time a more permanent type of structure can be erected by maintenance forces with train-hauled materials.

h. Engine service installations: The design of shops, engine sheds, fuel and water stations, and the nature of shop equipment will depend on the type of motive power adopted. The use of steam locomotives in Alaska seems preferable for the following reasons: 1. Fuel can be obtained from operating mines at Healy on the Alaska Railroad, 25 miles south of Kobe junction; 2. Water supply is satisfactory and should require no treatment plants; 3, The Alaska Railroad maintains shops at Fairbanks, Nenana and Anchorage, thus necessitating minimum shop equipment at engine terminals; 4. This portion of the line will undoubtedly continue to operate in the future as a branch line of the Alaska Railroad which is a steam line.

(1) An advantage of steam is long engine life and superior performance at higher speeds but these factors do not, appear to be applicable to the line through Canada which is considered as a temporary military requirement only. Under these conditions, the advantages of diesel power assume greater importance. The thermal efficiency of a diesel-electric locomotive is approximately 26% whereas a modern steam locomotive rates about 6%. Diesel stand-by losses are negligible. This is particularly important where fuel must be delivered over long haul. Engine servicing facilities are

materially simplified. Fuel delivery and stations, water supply, treatment plants and tanks; fire protection engine sheds and shops are items on which substantial first cost savings can be effected and permit earlier operation of the line. The chief objection to diesel is the sharp reduction in tractive effort as road speeds are increased but since the maximum speed for which this line is designed is 35 miles per hour, this characteristic is not significant, and under relatively low speed operation, diesel power increases the ratio of tonnage hauled to total train weight.

(2) If diesel power is adopted, multiple stall engine sheds of native timber, shed-roofed and of the simplest construction will be adequate. Since diesel locomotives are equipped with built-in heaters in the engine cooling system to provide for line lay-overs, there is no need for heating plants in the sheds. A division shop, 4O' wide and 80' long, with two stub-tracks is considered sufficiently large for this service. A boiler house is not required. The principal equipment would consist of an overhead crane for the removal and replacement of power units and a wheel press. The remainder of the equipment would differ but little from the average well-equipped garage or small machine shop.

(3) No turntables are contemplated. Yard wyes will serve all requirements either for steam or diesel operation.

(4) Ash pits and ash disposal equipment are not required where diesel power is used.

(5) Intermediate fuel stations are unnecessary with diesel-electric locomotives which are capable of operating 18 to 20 hours at full load on their tanks. Tank cars set out in division yards will serve this requirement and obviate the need for permanent tanks.

(6) In general, the water along the route and particularly in British Columbia and Yukon Territory is extremely hard and usually carries considerable vegetable matter in suspension. In order to prevent foaming and scale, treatment plants will be necessary for a steam operated line. This item can be disregarded for diesel service.

(7) Sand houses of conventional design will be required at engine terminals.

(8) Oil houses will also be located at engine terminals, These buildings will be merely storage sheds with racks for barrels of lubricants. The installation of fixed tanks is not recommended.

i. Train service installations:

(1) Way station buildings — The addition of a small telegraph office and platform to the double section houses located at alternate sidings, 20 miles apart, will provide adequate train control. Freight sheds at way stations are not indicated for the service contemplated.

(2) Division stations — These station buildings should be designed to provide in addition to waiting room, baggage room and

agents' office, all necessary office space for the division superintendent dispatcher, engineer M. of W., master mechanic, roadmaster, yardmaster, chief of T. and T. and division storekeeper. A two-story frame building, 30 feet by 60 feet in size with platform 30 feet wide and 80 feet along the main line will satisfy these requirements.

(3) Freight sheds — It is not expected that any appreciable volume of way freight will be handled over this system, A freight shed, 30' x 120' with 8' platform, should be constructed at car floor level on a siding opposite the division station office. A 40-foot section of this shed should be insulated for warm storage. It is anticipated that this building will serve primarily as the division warehouse.

(4) Personnel quarters — Winterized T/0 type buildings for the housing of train crews and other personnel on duty in division offices, yards and shops must be provided. A suitable cantonment would consist of one barracks for division officers, six barracks for train crews and shopmen, one 250-man mess hall, two recreation rooms, one infirmary and a post exchange.

(5) Utilities — The nature and size of water supply, sewage disposal and electric power plants for cantonment buildings, offices and shops at the division points, will vary with the locations, but it is not expected that these installations will prove either difficult or expensive.

(6) Blacksmith and car shops — These facilities will be located at division points only and in connection with the locomotive shops or as close thereto as the yard layout will permit. Both shops may be housed in a frame building, 40' x 100', with two stub-tracks extending 60 feet therein for car repair. The remainder of the building will provide sufficient space for the blacksmith shop and car truck repair. The use of portable welders and compressors is contemplated in all division shops rather than fixed installations.

(7) Carpenter and paint shops — Carpentry and painting of roadway structures will either be performed during the initial construction or by maintenance of way forces as required. The need for these shops is not indicated for train service.

(8) Track scales are not required.

(9) Ice houses — Instead of the usual type of ice house located in the yards for servicing refrigerator cars, it is recommended that ice be kept in cut and cover type storage of log and sod construction near the lake from which the ice is harvested. Delivery can be made as required by truck and the cars serviced from an elevated platform. The capacity of ice storage vaults should be 200 tons.

j. Miscellaneous roadway construction: The erection of fences, cattle guards, rail racks, mileposts, and all signal boards can be performed by maintenance of way forces and are not included in the initial construction program.

k. Telephone and telegraph: A four-wire system is considered adequate for the operation of this railway. In order to facilitate construction of the road, it is proposed to erect this line immediately following the clearing of right-of-way. The use of tripods rather than poles has been found preferable on the Alaska Railroad, both from a standpoint of economy and speed of erection. It has also been found that in localities where perpetual frost is encountered, poles will freeze out of the ground.

9. Plan of Construction:

a. The location of existing access routes indicates the desirability of subdividing the project for construction purposes into four grand divisions, as follows:
(1) Southern Division — 345 miles; From Prince George to the summit of Sifton Pass.
(2) Central Division — 351 miles; Summit of Sifton Pass to Arctic-Bering Divide.
(3) Northern Division — 423 miles; Arctic-Bering Divide to Alaska boundary.
(4) Alaska Division — 298 miles; Alaska boundary to Kobe junction.
b. The various access routes are shown on map accompanying this report, Appendix "D".

(1) In the Southern Division, there are existing roads from Prince George along the projected route to Summit Lake for 30 miles and from Vanderhoof, a rail station on the Canadian National Railroad, 70 miles west of Prince George, to Manson River, It is proposed to construct a 4.0-mile extension of the Vanderhoof-Manson River road to connect this road system with Finlay Forks, Mile 170 on the line, from which point the line may be served between Milepost 100 and Milepost 300 by water route during the navigation season and by tractor train in winter. This leaves 70 miles on the south end and 50 miles on the north end of the division where the construction of a low standard tractor road along the right of way is necessary to facilitate construction.
(2) All access routes to the Central Division converge on the line in the vicinity of Watson Lake near the center of the division and do not provide line coverage. These routes are as follows:
a. The Stikine River route from Wrangell, Alaska, consisting of 165 miles of river navigation from Wrangell, Alaska, to Telegraph Creek, British Columbia; thence by highway 72 miles to Dease Lake, and again by water route on the Dease River, approximately 140 miles, to its confluence with the Liard River at Lower Post.
b. White Pass and Yukon Railway from Skagway to Carcross; thence by Alcan Highway from Carcross to Watson Lake.
c. The Alcan Highway from Fort St. John to Watson Lake. Although the Frances and Kechika Rivers can be navigated by very shallow-draft boats and barges, it is believed that a tractor trail along the right-of-way should be constructed from Lower Post south to

the summit of Sifton Pass and north from Watson Lake to the Arctic-Bering Divide.

(3) The Northern Division will be served by the White Pass and Yukon Railroad from Skagway, Alaska. This route includes 110 miles of railroad from Skagway to Whitehorse, Yukon Territory, from which point transportation may be either by riverboats and barges to the project at Little Salmon or by road from Whitehorse to the project in the vicinity of Five Finger Rapids. Transportation from these points may be effected by river route, either barge haul in summer or tractor train in winter, westward as far as the mouth of the Ladue River. A tractor road will be required from the mouth of the Ladue to the Alaska boundary, a distance of approximately 20 miles. The project east of Little Salmon must be served by tractor trail to the Arctic-Bering Divide, although heavy tonnage can be barged up the Pelly River from Selkirk to the mouth of Ross River during the summer navigation season.

(4) There are three principal points of access to the project in the Alaska Division. These are Kobe, the junction point with the Alaska Railroad} Big Delta, at the crossing of the rail line with the Richardson Highway; and Tanacross on the Tanana River. These points are approximately 100 miles apart on the project and construction can be pushed both ways from each of these bases. Kobe is served directly by rail over the Alaska Railroad. The Big Delta base can be supplied either from Valdez, Alaska, direct over the Richardson Highway or from Fairbanks, Tanacross will be supplied by river route from Big Delta or by road now under construction direct from the Richardson Highway. A tractor trail from Tanacross to the Alaska boundary may be required but end construction from the three base points would appear to be satisfactory in this division.

(5) The total construction road to provide access to the project throughout is as follows:

	Truck Road	**Tractor Road**
Southern Division	40	120
Central Division	0	355
Northern Division	0	240
Alaska Division	0	80
Total	**40**	**795**

c. Subdivision of the grand divisions into construction sections will be made on the basis of engine stages, approximately 120 miles long, It is believed that this procedure will result in greater uniformity of the constructed project within an operating stage and will afford closer control over construction.

10. Factors Effecting Construction:

a. Climatic conditions: Although this line is projected through country where winter temperatures of 30 degrees below zero Fahrenheit are normal and may reach minus 60 for short periods of time, there is relatively little precipitation. Snowfall is light and will not seriously hamper winter construction or operation of the line. Winter construction can be successfully prosecuted in all clearing, rockwork, heavy cutting and hauled fills. Span erection can be more readily performed in winter than in summer in view of the ease with which false work can be foundationed on ice. The erection of pile trestle bridges over cross-drainages will progress more rapidly during the winter months due to the fact that skid drivers can be readily moved on the ice of the rivers paralleling the line and in advance of grading operations. Scratchwork grading cannot be performed in winter unless the material is well-drained. It is believed that a considerable portion of the light line on this route is sufficiently well-drained to permit winter operations but, in general, scratchwork grading, frame trestle erection, permanent buildings, shops, fuel stations and water supply should be programmed for summer construction. During construction of the Alaska Railroad, there was a marked reduction in the effectiveness of labor in severely cold periods, but this can be largely offset by the increased use of mechanical equipment now available. To further compensate for a lowered efficiency of workmen, the transportation of materials and supplies is rendered less difficult. It is generally recognized in the north that winter transportation by tractor trains is the cheapest and most effective method of supplying remote, undeveloped districts. This procedure was followed in the construction of the Alaska Railroad, and is also used by the Alaska Road Commission and mining interests in both Alaska and Yukon Territory. Winter construction camps of rough log and pole design, chinked with native moss, and with pole and paper roofing are favored for the more permanent camps, but canvas is not impractical for camps in the Southern Division in winter. For small, rapidly moving crews, such as clearing forces and bridge gangs, the use of skid-mounted wannagans similar to railroad outfit cars have proved satisfactory on similar work.

b. Labor; This line has been located with a view to rapid construction. Clearing will be reduced in width to the minimum that will provide protection from blow-down. Ground cutting of trees is favored and grubbing will be quite limited. Erection of telephone lines will be on tripod construction. Grading methods will closely approximate highway practice and the ratio of manpower to yardage will compare favorably with road grading. Production of ties, piling and lumber along the route is included in the labor estimate. Track-laying, surfacing and ballasting are estimated on the basis of 60-pound rail and 6-inch ballast, The manpower required for bridges and culverts is for field erection only and contemplates delivery of sized stringers and framed truss members to the job site. The labor expended on transportation and supply includes the construction of access and haul roads. The erection of camps and buildings are grouped together as the camp construction will be retained insofar as possible as part of the roadway buildings.

(1) An estimate of man days labor required for the project is as follows:

	lOOO-Man Day Units				
	South.	**Cent.**	**North.**	**AK**	**Total**
Clearing and grubbing	138	154	164	90	546
Telephone and telegraph	17	20	24	15	76
Grading	966	1,078	1,175	600	3,819
Ties, timbers, etc.	155	175	235	165	730
Track laying	52	58	70	45	225
Surface and ballast	55	60	75	50	240
Bridges and culverts	50	55	75	60	240
Transportation and Supply	91	110	88	41	330
Camps, buildings, misc,	125	154	185	105	569
Totals	**1,649**	**1,864**	**2,091**	**1,171**	**6,775**
Men, Assuming 400 days for Completion: x 2.5:					
	4,122	**4,660**	**5,228**	**2,927**	**16,937**

c. Materials: Aside from rail, track fittings and bridge steel, there is relatively little demand on the materials market for the construction of this roadway. Motive power, rolling stock and other operating equipment are outside the scope of this report except insofar as the nature of the equipment influences the design of roadway. Bridge stringers and all timbers for Howe trusses should be Douglas fir and are included in the estimates of imported materials. However, these designs may be modified for the utilization of local spruce, if found necessary. Local timber will be used for ties, culverts, piling, posts, caps, braces, false work, buildings and floating plant. This procedure will also materially reduce transportation requirements but will increase the labor, camp and subsistence factors. There is very little rockwork on the line and the amount of explosives required is surprisingly small.

(1) The quantities of materials to be imported over access routes for the construction are estimated as follows:

	South.	**Cent.**	**North.**	**Alaska**	**Total**
In tons (2000 lbs.)					
Rail, 60#	37,340	41,488	51,536	32,672	163,036
Track fittings	3,240	3,600	4,500	2,835	14,175
Bridge steel	679	1,616	1,200	316	3,811
Bridge castings	483	253	360	0	1,096
Tel. and tel.	144	160	200	126	630
Explosives	90	310	785	473	1,658
Douglas fir timber	5,927	3,945	3,150	4,850	17,872
Subsistence and camp	8,245	9,320	10,455	5,855	33,875
Fuel, lub, and misc.	6,000	5,500	7,000	3,500	22,000
totals	62,148	66,192	79,186	50,627	258,153

d. Plant: The construction plant best adapted to this project will consist of diesel or gasoline powered equipment. Caterpillar mounted shovels and draglines from 3/4 c.y. to 1-1/4 c.y. capacities are deemed sufficiently large for the initial construction, although railroad shovels may be used at a later date for ballast loading and in sections where "shoo flys" are resorted to in the initial construction. Bulldozers will be the most effective tool on the job. Compressors should be skid-mounted. Pile drivers will be drop-hammer type skid rigs, powered by gasoline engines. It is desirable to keep track-laying close behind the grading at as many points as possible. The use of light industrial type locomotives and two-axle cars will not only facilitate track-laying, light ballasting and the transportation of materials and supplies from base supply dumps but this equipment can also be most effectively used for long-haul fills where skeleton track is laid on crossways. The use of 10-ton locomotives and 6-yard dump cars will perform better in this service than carry-alls or trucks. The weight of this equipment will not surface kink 60-pound rail in skeleton track.

(1) The major items of construction plant required in each division are estimated as follows:

Type of Plant	**Number of Units**				
	South.	Cent.	North.	AK	Total
Tractors w/dozers	36	40	60	30	166
Draglines, 3/4 c.y.	12	6	15	12	45
Shovels, 1-1/4 c.y.	9	9	12	10	40
Compressors, 210’	8	6	10	10	34
Pile Drivers	6	6	9	6	27
Locomotives, 10 T.	3	2	4	0	9
Dump cars, trucks 6 c.y.	36	24	48	0	108
Flat cars, trucks 8 T.	9	6	12	0	27
Trucks, dump 5 c.y.	12	12	36	63	123
Carry-alls, 10 c.y.	12	6	18	4	40
Sawmills, 30" x 40'	3	3	4	3	13
Small Tools					
Est. wt. - Tons	**1,500**	**1,390**	**2,300**	**1,450**	**6,640**

e. Transportation: The capacity of existing and proposed access routes is limited and improvement beyond absolute requirements is to be avoided wherever possible. Although construction plant, camp equipment and some construction materials must be made immediately available, a large percentage of the total tonnage may be on a uniform delivery rate throughout the construction period or in accordance with best conditions. In the following tabulation, the total tonnage by divisions is broken down to show the volume of tonnage required during the first 30 days and the balance for subsequent delivery over the term of the project, herein assumed to be 400 days. Operating equipment and the materials required for engine and train service installations are not included in the estimates of tonnages to be transported over access routes, as these materials can be more readily transported and erected after track has been laid. It should be noted that part of the construction plant may be considered self-propelled over those portions of the access routes that must be developed as a construction feature:

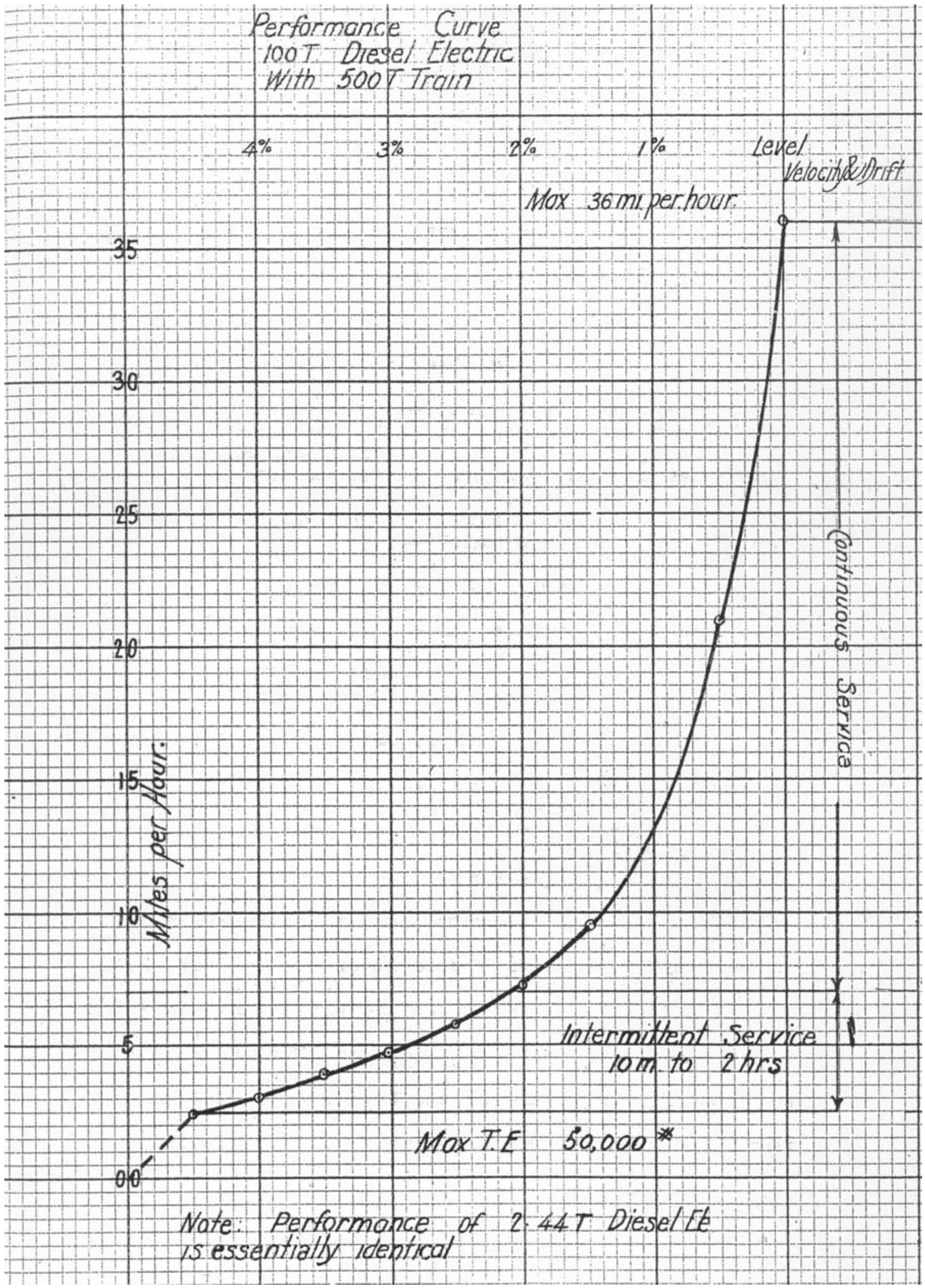
	In Tons (2000#)				
	South.	**Cent.**	**North.**	**AK**	**Total**
From c. Materials	62,148	66,192	79,186	50,627	258,153
From d. Plant	1,500	1,390	2,300	1,450	6,640
Total	63,643	67,582	81,486	52,077	264,793
Required lst 30 days	6,030	6,340	8,000	4,950	25,320
Subsequent	57,618	61,242	73,486	47,127	239,473
Total	63,648	67,582	81,436	52,077	264,793

The transfer of this tonnage from common carriers to the division supply dumps is in itself a large task. The labor required for this effort is included in the estimate given in sub-paragraph c above, but the plant required differs from construction equipment and is in addition thereto. Estimated requirements are as follows:

Type of Plant	**Units Required**				
	South.	**Cent.**	**North.**	**AK**	**Total**
Tractors w/o dozers	17	35	25	20	97
Tractor wagons 20 T.	34	70	50	10	164
Sleds - #4 s/m	34	20	20	10	84
Trucks - Cargo 10 T.	2	20	20	3	45
Barges - 20 T. s/m	20	0	20	2	42
Boats - power	10	0	30	2	22
Power barges - 100 T.	0	0	6	0	6
Planes 4-place	1	1	1	1	4
Planes, freight 1500#	2	3	4	0	9

11. Operations Structures and Motive Power:

The features of construction required for operation as described in paragraph 8, sub-paragraphs g to i inclusive, are scheduled for construction after the roadway has been completed. The extent of this construction is determined by the type of motive power and the length of engine stages. It is recommended for economic reasons stated in paragraph 8 that diesel-electric locomotives be used and in this connection, attention is invited to the apparent mechanical advantages of the 44-ton, 380 H.P., diesel-electric locomotive described in specifications. Railway 24,147-A, General Electric Company, September 1940. For road service, this locomotive may be used in multiples as dictated by the haul requirements. Outstanding features of this equipment are the use of Caterpillar diesel engines as power units and the design of cab, frame and running gear which are fabricated from standard steel shapes and plates. Personnel and equipment for maintenance, repair or replacement of such equipment should be more readily available than for steam locomotives. Maintenance of roadway will be simplified as the extent of frost heaving in winter seems to increase with the weight of locomotives used. Axle loading is such that light bridge designs may be adopted which, in turn, increase the speed of construction. Consideration should also be given to the fact that this line traverses timbered areas of considerable value to Canada and the fire risk with diesel-operated locomotives is negligible. The length of engine stages and location of engine terminal points have been selected in accordance with the attached performance curve.



a. Within the limits imposed by the foregoing performance curve, engine terminals have been selected where terrain and grade conditions are favorable. The desirability of combining these installations with necessary yard developments at points of substantial freight transfer has also influenced the selection of sites, as follows:

(1) Diesel-electric section:

Milepost 0 — Prince George Junction.
*Milepost 85 — Fort McLeod - Pine Pass Outlet.
*Milepost 193 —
Milepost 302 — Fort Ware -- Head of navigation, Finlay River.
Milepost 423 — Gataga Forks.
Milepost 532 — Watson Lake Area - Alcan Highway and airfield.
Milepost 64.3 — Frances Lake.
Milepost 755 — Ketzah River.
Milepost 885— Little Salmon Post – Yukon navigation.
Milepost 1008 — Selwyn.
Milepost 1119 — Boundary.

(2) Steam-operated section:

Milepost 1207 — Tanacross - Airfield, Alcan Highway.
Milepost 1306 — Big Delta - Airfield, Richardson Highway.
Milepost 1416 — Kobe Junction.

* Terminal at Finlay Forks, present Milepost 170 may be substituted for terminals at Milepost 85 and Milepost 193 if the Willow Creek revision is adopted.

12. Estimated Quantities:

a. The average mile of the located line from Prince George, British Columbia, to Kobe, Alaska, as now staked may be described as follows: Alignment consists of 4,100 feet of tangent and 1,180 feet of 5-degree curve. Grading can be accomplished with 23,140 cubic yards of common and 3,490 cubic yards of rock excavation. Fifty-seven feet of this mile is on bridge or trestle structure and there are 4 culverts.

b. The estimate of roadway buildings and service installations stated in the tabulation which follows is based on the operation of the line as a diesel-electric system from Prince George to the Alaska boundary and a steam line from the Alaska boundary to Kobe. Grading quantities are approximate, as final adjustment of grade lines has not been completed. However, the estimate is liberal and indicates that a light line has been developed. Revisions now under consideration are expected to further reduce the quantities and shorten the line approximately 16.5 miles.

Clearing	30,456 acres
Tel. and Tel.	1,416 miles
Grubbing	5,600 acres
Grading	
Common	32,769,000 cubic yards

Rock	4,938,000 cubic yards
Bridges	
Steel	2-400'
"	1-300'
"	1-270'
"	2-200'
Wood	20-150'
"	29-120'
"	3-100'
"	4-90'
"	2-80'
"	8-56'
Trestles	
Pile and frame	73,220 lineal feet
Culverts (log)	5,700
Ties	4,560,000
Rail and fittings	
(60# rail)	177,211 tons
Track-laying	
Main line	1,416 miles
Yards, sidings	104 miles
Surfacing, ballasting	1,520 miles
Buildings & service structures	
Double section houses	72
Tool sheds	144
T/O - O.Q.	14
" E.M. barracks	84
" 250-man mess	14
" Day rooms	28
" Canteens	14
Mob. type - Infirmaries	12
Station buildings	14
Freight sheds	14
Engine sheds (diesel)	11
Engine sheds (steam)	4
Locomotive shops (diesel)	11
Locomotive shops (steam)	1
Water tanks	8
Coaling plants	4
Sand houses	14
Oil houses	14
Car shops	14
Ice houses	14

13. Estimate of Cost:

The field survey of this route was completed September 28, 1942. Detail profiles and sections at bridge sites have not been prepared from the field notes as these data have as yet only been worked to the extent necessary for a descriptive report of this location. Although a better estimate can be prepared when these studies have been completed, it is believed that an accurate estimate of cost under existing labor and materials supply conditions cannot be determined. The procurement of rail involves intangible factors at this time, such as the location of Supply and weight of section which in turn effect the cost of transportation, both on commercial carriers and over the access routes.

In arriving at the estimate which follows, unit costs have been based on recent construction in the more remote sections of Alaska, modified by transportation costs and last quoted base prices of the various materials in Seattle, The construction of access roads as well as boats and barges necessary to augment existing transportation facilities are treated as a separate item of cost. The operation of transportation equipment, however, is included in the unit costs of materials in place. Extensions are made to the nearest $1,000.

a. Clearing:

Heavy, 12,182 acres @ $100	$1,218,000	
Light, 18,274 acres @ $75	$1,371,000	
Total:		$2,589,000

b. Telephone and Telegraph:

Tripods, 40/M 1,416 @ $400	$566,400	
4-Wire System 1,416 @ $350	$495,600	
Station Equipment 14@ $6,000	$84,000	
Total:		$1,146,000

c. Grubbing and Ground Cutting:

5,600 acres ® $200	$1,120,000

d. Grading:

Common, 32,769,000 c.y. @ $.80	$26,215,000	
Rock, 4,938,000 c.y. @ $2.00	$9,876,000	
Total		$36,091,000

e. Bridges (includes foundations):

Steel:	
2 spans, 400'@ $210,000	$420,000
1 span, 300' @ $150,000	$150,000
1 span, 270' @ $142,000	$142,000
2 spans, 200'@ $105,000	$105,000
Wood:	
20 spans, 150'@ $35,000	$700,000
29 spans, 120'@ $27,000	$783,000
3 spans, 100' @ $22,000	$66,000
4 spans, 90' @ $19,000	$76,000

2 spans, 80' @ $16,000	$32,000
8 spans, 56' @ $10,000	$80,000
Total	$2,659,000

f. Trestles:

73,220 l.f. @ $35.00	$2,563,000

g. Log Culverts:

5,700 each @ $120	$684,000

h. Cross Ties - #2:

4,560,000 @ $1.00	$4,560,000

i. Rail and Fittings - (60#):

163,036 tons @ $113	$18,423,000
34,175 tons @ $138	$1,956,000
Total:	$20,379,000

j. Track-laying:

1,520 miles @ $1,500	$2,280,000

k. Surfacing and Ballasting:

1,520 miles @ $2,800	$4,256,000

l. Buildings and Service Structures:

Section houses 72 @ $7,000	$504,000
Tool sheds, 144 @ $250	$36,000
G.Q. - T/0, 14 @ $6,000	$84,000
Barracks - T/0, 84 @ $6,500	$546,000
Mess, 250-man 14 @ $20,000	$280,000
Day rooms - T/0 28 @ $4,500	$126,000
Post Exch. - T/0 14 @ $5,500	$77,000
Infirmaries 14 @ $9,500	$133,000
Station offices 14@ $15,000	$210,000
Freight sheds 14 @ 6,000	$84,000
Engine sheds	
Diesel 11 @ $10,000	$110,000
Steam 4 @ 25,000	$100,000
Locomotive shops	
Diesel 11@ $20,000	$220,000
Steam 1 @ 50,000	$50,000
Water tanks 8 @ $6,000	$48,000
Fuel stations 4@ $12,000	$48,000
Sand houses 14@ $1,500	$21,000
Oil houses 14@ $1,500	$21,000

Car shops 14@ $12,000	$168,000	
Ice houses 14@ $3,000	$42,000	
Total		$2,908,000

m. Access Routes:

Truck roads 40 m. @ $12,000	$480,000	
Tractor roads 795 m. @ @ $5,000	$3,975,000	
Power barges, 100 T. 6@ $60,000	$360,000	
Barges, 20 T. 42 @ $3,000	$126,000	
Power boats, 100hp 22 @ $10,000	$220,000	
Total		$5,161,000

n. Land Acquisitions:

1,700 acres @ $40 — $68,000

o. Land Ties - (Contract):

1,119 miles @ $100 — $112,000

p. Engineering and Supervision:

5% of $86,576,000 — $4,329,000

q. Contingencies:

15% of $90,905,000 — $13,636,000

r. District and Division Overheads:

7% of $104,541,000 — $7,318,000

Total estimated cost: $111,859,000

The foregoing estimate has been prepared on the basis of 400 days active construction time. It is recognized that this is a very optimistic schedule and dictated by military necessity. In order to conform to this schedule or even closely approach it, far better transportation facilities and supply channels must be made available than have been applicable to previous construction in Alaska and Canada. Unless equipment, labor and materials, particularly rail, are delivered to the ports or railheads serving the access routes, in requisite amounts and on schedule to meet construction requirements, this time limit cannot be met.

14. Acknowledgements:

The District Engineer wishes to acknowledge the cooperation extended by Mr. F. C. Green, Surveyor General of British Columbia, and the National Resources Planning Board. The

assistance furnished by these offices has aided materially in the conduct of the survey and preparation of this report.

Peter P. Goerz,
Colonel, Corps of Engineers,
District Engineer