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Report.

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THE SENATE OF CANADA

REPORT

OF THE

SPECIAL COMMITTEE APPOINTED TO REPORT ON THE
NAVIGABILITY AND FISHERY RESOURCES OF

HUDSON BAY AND STRAIT

PRINTED BY ORDER OF PARLIAMENT



OTTAWA
THOMAS MULVEY
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1920

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ORDER OF APPOINTMENT.

THURSDAY, April 22, 1920.

On motion of the Honourable Mr. Fowler, it was

Ordered, That a Special Committee of twelve of this House be appointed to take evidence and report at this session upon the navigability and fishery resources of Hudson Bay and Strait, and of the character of the ports of said Hudson Bay with regard to their fitness as railway terminals, and that such committee shall have power to call for persons and papers, and that the said committee do consist of the Honourable Messieurs Bostock, Casgrain, Dandurand, Daniel, DeVeber, Fowler, Loughheed (Sir James), Michener, Schaffner, Sharpe, Watson and Willoughby.

FINAL REPORT.

THE SENATE,

COMMITTEE ROOM No. 534,

FRIDAY, June 4, 1920.

The Special Committee of the Senate appointed to take evidence and report at this session upon the navigability and fishery resources of Hudson Bay and Strait, and of the character of the ports of said Hudson Bay with regard to their fitness as railway terminals, beg leave to make their Second Report, as follows:—

We have held some fifteen meetings and called and examined twenty-one witnesses drawn from all parts of the country. The Committee had in view acquiring information on the following points:—

(1) The length of the season during which the bay and strait were reasonably navigable, having in view the presence of ice, the occurrence and persistence of snow-storms, the advantages to be gained by aids to navigation such as wireless telegraphy, lighthouses, fog signals, and hydroplanes.

(2) The style and size of vessels to be used for the carrying trade.

(3) The relative merits of the two ports, Nelson and Churchill, and the relative cost of the development of each port.

(4) The fishing resources of the bay and strait and of the rivers emptying into the bay.

(5) The mineral resources of the country tributary to the bay.

(6) The utilization of the country for the production of meat and furs to be obtained from the reindeer and musk ox, which would subsist upon the extremely nutritious grasses grown there.

A large number of witnesses were called with respect to the length of the season during which the bay and strait can be safely navigated. There was some variation among the several witnesses regarding the length of the season of navigation, but all agreed that the minimum would under ordinary circumstances be at least four months while the maximum would not likely exceed five months. Voyages have been made through the strait as early as the fifth day of June, and as late as the first part of November with the ordinary type of vessel without meeting any difficulty, but these were admittedly rather exceptional cases. All were agreed, however, that modern navigating appliances such as lighthouses, wireless stations, hydroplanes and fog signals would greatly facilitate navigation in these waters and in a large measure

overcome the natural difficulties from ice and snow. In order that the route would be able to compete with the more southerly channels of communication between this country and Europe, it would be necessary to have a type of freighter capable of carrying from 5,000 to 10,000 tons of dead weight, and in the opinion of this Committee, from the evidence adduced before us, there would be no difficulty in handling so large a vessel on the route, provided it was properly strengthened and protected in the forward part. Of course, heretofore only vessels of smaller size have been used because ships of larger capacity have not been required.

The consensus of opinion is that Hudson Bay remains open all the year through and that the ice does not extend beyond thirty or forty miles from the shore. The strait is also open for the greater part of the year, and would probably be open all the time except for the ice which comes down late in the autumn from Fox Channel and obstructs navigation in the strait. It was generally conceded by the eight witnesses who gave evidence on this point that the aids to navigation which might be installed along the strait would greatly facilitate the passage and considerably extend the season of navigability.

Your Committee took a large amount of evidence regarding the relative merits of the two western ports, Churchill and Nelson, and there was a considerable divergence of opinion among the different witnesses as to which of the two should have been selected, having in view the shorter railway haul in the one case and the cheaper construction of the port itself in the other. Churchill was shown to be an absolutely land locked harbour entirely protected from every wind no matter from which quarter it should blow, where a few ships could at all times ride at anchor in perfect security. Nelson, on the other hand, has no natural protection from the sea except such as it receives by reason of its remoteness from the body of the sea, there being a twenty mile stretch of shallows between it and deep water. A narrow channel bordered by wide shallows connects the proposed harbour of Nelson with the open bay. A very large amount of money has already been expended upon the harbour improvements of Nelson but a much larger sum is still required before the present plans can be carried out. There seems to be considerable doubt whether or not, even when the proposed plans are completed, the harbour at Nelson will be an entirely safe one against an easterly gale. To utilize Churchill it would be necessary to build about eighty miles of road across a country which has been described by one witness as very difficult, it having a stretch of thirty miles of morass almost impossible to cross owing to the difficulty of getting a firm foundation for the roadbed. This is, however, denied by the testimony of two witnesses, of each of whom the Committee was greatly impressed. Both J. B. and J. W. Tyrell testified that there was a perfectly good and comparatively short route from the present route deflecting at a point some fifty-six miles from Nelson and going north and east to Churchill. The present harbour of Churchill is rather small, but, according to the evidence of the Messrs. Tyrell, uncontradicted, could easily be enlarged enough to accommodate all the trade likely to offer for many years to come. Beyond the present deep water harbour there is a large basin of shallow water, the bottom of which is composed of hard clay mixed with boulders, which could be easily dredged and the resultant harbour would be of its size one of the finest in the continent. The Tyrell brothers are very familiar with the country around Hudson Bay, having spent several years each in research and in examination of these regions. Mr. J. W. Tyrell spent one winter at a station in Hudson Strait taking observations for the Canadian Government and also looked over the country from the Pas to Churchill on behalf of a company who had some intention of building a railway in that part of the country—a scheme which was afterward abandoned. He had no hesitation in saying that no difficulty whatever would be found in extending the railway to Churchill. It is the opinion of this Committee that the Government would be well advised if before expending any more money on the harbour works at Nelson they were to appoint a committee of expert engineers

and railway builders to examine the route to Churchill and ascertain whether or not it is really possible, as the Messrs. Tyrell say, and what would be the cost and advantage of making Churchill the port and terminus of the Hudson Bay road rather than Nelson.

In the meantime, the laying* of the rails could be completed to Nelson, and that port could be used for the present in its present state.

While no one was able to speak with certainty as to whether the cod fish were plentiful in the bay or not, there is no doubt as to the strait. All the rivers flowing into the bay teem with fish, and walrus and seal are also found in large numbers in the strait. No doubt as soon as the Hudson Bay route is established a very large and lucrative fishing industry will be established there. Recent discoveries have shown that the country surrounding Hudson Bay is strongly and richly mineralized, particularly in gold and copper.

Mr. Stefansson, the distinguished Polar explorer, gave evidence before your Committee. He is a devout believer in the possibility of utilizing what have always been known as the barren lands of the north, and the islands within the Arctic Circle, in the cultivation of the reindeer, caribou and musk ox for the production of meat. He gave evidence as to the splendid quality of the flesh of these animals as food for the people, and as to the cheapness with which it might be produced. He said that the wild lands of the north which have always been looked upon as worthless could carry at least fifty million head of reindeer and ten million head of musk ox, and that the cost of handling these huge numbers would be trifling in comparison with the profit to be made. The effect of this upon the world's food supply would be tremendous, and your Committee would strongly recommend that the matter be energetically taken up by the Government.

Your Committee makes the following findings upon the evidence adduced before them:—

- (1) That the Hudson Bay route is feasible and will probably in time be profitable.
- (2) That the season of navigation under present conditions is at least four months in length and may by reason of improvements in aids to navigation be considerably increased.
- (3) That in the opinion of this Committee sufficient care was not taken in the selection of Nelson as the terminus of the railway, and that the Government should not make further important expenditures upon this port without first making a new and thorough examination into the relative merits of Churchill and Nelson as a terminus for the railroad.
- (4) That the waters of the strait and rivers tributary to the bay teem with fish and valuable marine animals, and we believe that the bay is equally well stocked but there has not yet been sufficient data collected as to the extent of the fisheries of the bay to enable an authoritative statement to be made as to their value.
- (5) That the mines already discovered in the Hudson Bay district are of sufficient number and richness to indicate the existence of great potential mineral wealth.
- (6) Your Committee feel that they cannot too strongly endorse the valuable suggestion of Mr. Stefansson as to the cultivation of the reindeer and musk ox, and would urge upon the Government that the Department of the Interior be empowered to take hold of this matter, earnestly taking advantage of what has been done in this regard by the United States Government.
- (7) Your Committee, although it is somewhat outside the scope of their mandate, cannot close this report without making some reference to the national value of the explorations of Vihljalmar Stefansson. He has completely revolutionized our ideas of the region within the Polar Circle. He has demonstrated that it is possible for white men to live and thrive in that northern region though drawing from no other

resources than those afforded by the country itself, and he has proven that those lands which were looked upon as barren and utterly worthless will eventually be a valuable asset to Canada. The Committee ventures the hope that the Canadian Government will not be unmindful of the great services performed by Mr. Stefansson, whose reward so far has not been commensurate with the national importance of the work he has accomplished.

(8) Your Committee expresses its thanks to the gentlemen who have voluntarily come forward and given valuable evidence upon the important matters under consideration.

(9) Your Committee submit herewith an extract in narrative form of the evidence given before the Committee, and beg to recommend that 1,000 copies of this report and the extract of the evidence be printed in pamphlet form for general distribution.

All which is respectfully submitted.

GEO. W. FOWLER,
Chairman.

EXTRACT FROM THE EVIDENCE OF SERGEANT E. H. L. THOMPSON, R.N.W.M.P.

I am stationed at Port Nelson, having been there almost three years, and I know the country, including a certain portion of that inland from Fort Churchill, south to Port Nelson and east as far as Cape Tatnam. I am stationed at Port Nelson on the north bank of the Nelson river. The Hayes lies south and east of my post. I have travelled north from Port Nelson as far as Fort Churchill, southwest from Nelson as far as the Pas.

I know the country between Nelson and Churchill as well as the average white man knows it from travelling through it. I know the country from Cape Tatnam to Fort Churchill. It is practically barren.

After we reached Broad river we found some timber or pulpwood—pretty scrubby. Port Nelson is exposed to all the northerly winds.

The deep hole is situated in the channel, about ten miles up the river from the artificial island.

Captain Mack brought the Hudson Bay Company's steamer *Nascopie* in there in 1917 and anchored in the deep hole. I think the *Nascopie* draws from 20 to 25 feet. Captain Mack said that at low water there was a foot of water under the steamer—that is ten miles out toward the bay (referring to Churchill).

I know of occasions when hope was abandoned in the bay; that is to say, a steamboat was in the bay and all hope of saving their lives was practically abandoned, and they entered Churchill harbour in this gale, and when they entered the harbour after passing the harbour entrance, they were in absolutely calm water.

I think the entrance is rather more than 1,500 feet wide.

I never saw the harbour in any state of unrest—practically calm, so that a ship can safely ride at anchor. From my knowledge I would say it is landlocked.

I do not think a dozen of ships of 2,000 tons each could anchor there. I have seen the *Nascopie*, the *Fort York*, and the *Kathleen*, all there at once, and there seemed to be ample room. I have never heard of any difficulty in getting into or out of Churchill harbour. One may say, perhaps, the ice breaks in the Nelson river before it does in the Churchill river; but we have slush-ice running in the Nelson river after we have it in the Churchill river, generally speaking.

After the Churchill river is clear. That is due to the trend of the current, which washes the ice down—it catches and jams in the southwest corner of the bay, off Marsh point, and on the incoming and outgoing tide, the ice is running in and out

of the estuary. Once it goes out, it is out, but at Nelson it is in and out all the time. From my observation I think Churchill in certain ways would be freer of ice for a longer season than Nelson. I should think for the purposes of navigation it would be freer, but my knowledge is too limited to make a definite statement, but I would say this from my knowledge and observation.

The bay freezes out some distance, but I do not know what the approximate or average distance is.

We put a packet across from Nelson to York on the 16th day of November, 1917—two natives in a canoe. They crossed the river at low tide when the slush-ice was out.

The greatest tide we had at Nelson was in the September gale, I think of 1916. It was about a 21-foot tide on that occasion at the time of the equinoctial gale. Last year I left Port Nelson about the middle of June, travelling inland. The shore-ice was not broken then but it broke two days after I left.

We generally look for northerly winds as the prevailing wind across Hudson bay. I think in August, 1917, we saw ice from the barracks, driven in by the easterly winds, but that was rather exceptional. It was out towards the mouth of the estuary, quite visible to the naked eye, and about six or seven miles out at Nelson.

We generally expect to travel in that country by dogs over the snow by the middle of November and we abandon the dogs in May or towards the end of April.

There is very little fog. I have never heard any complaint by navigators of fog in the straits. We have remarkably little fog in that country.

We caught a halibut in the bay last spring. There is no sea-fishing going on. The natives fish in the rivers. The Nelson natives get all the fish they want around the terminals camp, within a mile or so, a species of herring—not the true herring of the Atlantic—a small fish about eight inches long and full of bones. Sometimes we have had an occasional sturgeon out of the Nelson, but in the Churchill we have magnificent rock salmon, we catch them in nets, from six to ten pounds. Then we have the rock sturgeon too, from forty to fifty pounds in weight. We also get white fish in the Churchill. We get rock salmon and salmon trout.

There is great excitement in all that territory north of the Pas over the mineral finds, copper, gold and nickel.

Not very much timber, some small timber. I travelled up the Hayes and branched on to the Shamattawa and then swung across the Sturgeon river to the Hudson Bay Company's port on South lake. All the territory through there has been seriously burned. I do not suppose I saw more than half a dozen trees of commercial value, and I was travelling about seven weeks—I mean real timber, twelve to eighteen inches on the butt. The other was quite small, not more than two or three inches on the butt.

Caribou are quite plentiful, occasionally the Chippewyans have made a tremendous killing at the Crossing, five days west of Churchill.

In my district there are approximately thirteen hundred Indians.

At mile 137 I think there is some clearing that they are endeavouring to cultivate, but along the railway line they have gardens at places; they grow potatoes, vegetables, etc., at different points on the line.

We generally expect the supply ship about the middle of August. I think that in 1916, one of the Government ships left in October, but I could not give you the date. The Hudson Bay Company ship came one year to Nelson, but it was not found satisfactory. The Hudson Bay ships now go to Churchill, then load in Churchill harbour and then they freight with their schooner and by whale boat down to York Factory. They simply steam into Churchill barbour and drop their anchor. They do not go aground at Churchill but at Nelson the ships rest on the mud. There is deep water in Churchill at low tide. At Nelson the terminals have three or four small docks and the lighters come in at high tide and then they rest on the bottom at low tide.

At York Factory the Hudson Bay Company have a little dock. York Factory is between twenty and twenty-five miles from Nelson by canoe, but by dog train between twelve and fourteen miles.

EXTRACT FROM THE EVIDENCE OF MAJOR G. A. BELL, DEPUTY
MINISTER OF RAILWAYS AND CANALS.

The total cost of the Hudson Bay railway, which includes the total expenditure of every kind, and covers the Nelson terminals to the 31st of March, 1919, was \$20,851,816.53. Of that amount \$14,526,560.43 is applicable to the railway, \$6,325,256.10 is applicable to the terminals at Port Nelson. The original estimate for the terminals at Port Nelson was approximately \$25,000,000. Up to date I find no report that that amount will be exceeded. If the work had continued, without interruption, and had been completed, it would not have exceeded that estimate. Of course, as traffic grows at Port Nelson it will necessitate extension to the harbour. The original estimate of the work would not have been exceeded, but owing to the closing down of the work it will increase the cost. That estimate comprises the dredging to deep water. The \$25,000,000 covers the railway and all, including one storage elevator.

EXTRACT FROM THE EVIDENCE OF MR. F. C. T. O'HARA, DEPUTY
MINISTER OF TRADE AND COMMERCE.

Practically the whole difficulty surrounding the Hudson Bay route lies in navigating Hudson strait.

Before it is possible to operate the route at all from a commercial standpoint, wireless stations must be established for at least five months in Hudson strait, and also wireless communication with Port Nelson. Operators would have to winter there.

The minimum period of navigation appears to be from the 1st of August to the 15th of October, extending some years to three or four months. The period quoted is the minimum period.

With aids to navigation provided any ordinary ship could make one trip in and out without any danger.

Any ordinary ship, if suitably strengthened to enable her to pass through the light fields of ice, could make two trips in and out, provided aids to navigation were established. Even then more than ordinary dangers to navigation must be expected during the latter part of the season of navigation.

The ships should not be over 3,000 tons deadweight capacity, carrying from 100,000 to 150,000 bushels of grain. They must be fitted with wireless and have a draught not over 17 feet on arrival. More than average speed and horse-power would appear to be necessary.

It is likely that insurance could only be obtained at a high rate, and even then for one round voyage in midsummer.

This, of course, would probably be changed after the route is a while in operation.

The statement that no grain of the new crop would be available for shipment while the Hudson Bay route is open is not a serious disadvantage of that port.

While the new crop would not commence to reach Port Nelson until about the 15th or 20th September, yet the grain of the previous year's crop received prior to that date would be available for shipment by the first boats out each year in the same way as is grain which is received during the winter months at Fort William and Port Arthur. The flow from one crop year to the next is almost continuous.

There is a question, however, whether the average grain exporter or dealer would desire to ship grain to Port Nelson in view of the risk he will have to take against having his grain stored there for 8 to 10 months (upon which charges will have to be paid) as against the advantage of winter and spring rail shipments and earlier opening of navigation from Fort William and Port Arthur. During such time the grain will not deteriorate; on the other hand it is more likely to mature and be of greater value intrinsically, yet the owner will be unable to take advantage of the market fluctuations

and his grain can only be marketed the following year at the season when the price is usually lower than it is during the spring. An exporter can always send his grain to Fort William and Port Arthur and hold it there for better prices—shipping it winter or summer, at any time he so desires. This will be impossible at Port Nelson.

The following are some of the respective distances:—

	Miles.
Port Nelson to Liverpool	2,975
Montreal to Liverpool.. { via Belle Isle	2,760
{ via Cape Race	2,960
Winnipeg to Port Nelson	886
Moosejaw to Fort William (C.P.R.)	817
Winnipeg to Fort William (C.P.R.)	420
Fort William to Montreal (rail)	995

Experiences in navigating Hudson bay widely vary. One captain has a favourable voyage and reports few difficulties, and naturally is very optimistic as to the route. Another has a bad voyage and his opinion is entirely the reverse. Some ships have come safely through, though at times, from ice or heavy weather, they report having been in serious situations.

In all the reports, however, the utmost caution appears to have been the sole cause of a successful outcome. Difficulties in the nature of magnetic variations, varying currents, ice, fog, heavy gales and heavy seas are not infrequently referred to in the reports of Hudson Bay navigators. These conditions may not be so bad as they actually appear and may be regarded by navigators as all being in the nature of their day's work. Yet, it is sufficient to make one hesitate to take a favourable view of that route, even allowing for more than ordinary conditions of navigation.

AUTHORITIES QUOTED AND EXTRACTS OF OPINIONS.

First.—Period of navigation.

Captain Anderson says as to safe navigation during the summer season, year by year, the question is open to individual opinion.

The seasons vary considerably. Some are excellent and some are bad.

Navigation in Hudson bay may be relied upon from the 15th of July until the 15th of November, with an extension of a week at either end according to the season.

Winter conditions generally prevail in Hudson bay until the latter part of June, and the heat of the sun does not loosen up the ice sufficiently to make navigation safe until the middle of July.

Captain Webb says that from the last week of July until the 15th of October, navigation should be fairly safe for ordinary trading vessels, provided ordinary precautions are taken and there is a competent master in charge.

From his experience, and from reports by other vessels entering Hudson bay at the beginning of the season, there would appear to be nothing gained by leaving Halifax before July 10.

Mr. Harling says, for the three midsummer months, any ordinary vessel could navigate the Hudson bay and straits with comparative safety.

Herbert E. Saunders says that in his opinion the season under ordinary conditions should open about August 1, and vessels can remain in safety at Port Nelson until October 27, which practically gives a working season of three calendar months.

Captain Wakeham says that he agrees with Captain Gordon in fixing the date for the opening of navigation in Hudson strait for commercial purposes by suitable vessels at from the 1st to the 10th of July. I consider that navigation should close from the 15th to the 20th October.

Captain Bartlett of Polar fame says he would consider navigation on the Hudson Bay route safe from the last of July to November, but with ships constructed to contend with the ice and with a good ice pilot on board could navigate the bay from early in July until late in November.

He was in Hudson bay as far as lake Hudson late in September, 1911; no ice was then in sight. He said he had fished at Cape Chidley as late as the first week in October without seeing ice.

Captain Kean says that in his opinion navigation in the Hudson bay would be safe during August, September and October. In July, ice would frequently be met with, and in many cases very hard and heavy.

The service in most seasons would begin about the end of June and continue until the end of November, with the class of ships such as the Newfoundland sealers.

Captain Kean has seen a heavy jam of ice as late as the 18th of August, but this is the exception rather than the rule. Most years the coast is clear in July.

Second.—Construction and style of suitable vessels.

Captain Webb says, as to the construction and style of suitable vessels, that the class of cargo vessels employed should not be more than 3,000 tons deadweight capacity. Draught on arrival about 17 feet.

Captain Anderson says that on account of the presence of ice in Hudson strait at any time of the year, vessels trading there ought to have their own bows especially strengthened to resist the ice.

Captain Wakeham says, I do not believe that the ordinary tramp ship of commerce should be ever risked in heavy ice.

Captain Bartlett says that vessels should be constructed the same as the Newfoundland sealing steamers.

Captain Joy says steamers should be especially built, have a speed of not less than 14 or 15 knots an hour, and draw 22 feet of water.

Third.—Aids to Navigation.

Captain Webb is of the opinion that if aids to navigation were established the period of navigation might be considerably extended. He says that in his opinion, although the difficulties of converting Nelson into a seaport and Hudson straits into a regular trade route are great, yet with proper and practicable management this will become an accomplished fact.

Captain D. R. Davies says that having taken considerable interest in the port, he made it a point to examine for himself as closely as possible as to the likelihood of the port becoming a success. In his opinion he believes the port will meet a long felt demand. (This was speaking of Port Nelson.)

Fourth.—General Difficulties of Navigation.

Captain Webb says that during the period from the last week in July until the 15th October, ice conditions may have to be encountered; such navigation, however, is contingent upon avoiding fields of ice which might cause temporary delays. These fields are usually moving and usually present in the straits.

Captain Bartlett says that the difficulties and dangers, apart from ice, would be owing to fog, tides, compass attraction and shallow water, but when surveyed and coasts and inlands have been lighted it will only be an ordinary voyage to go back and forth.

Captain Joy says that ice, tides, and fogs are the chief difficulties attendant on the Hudson Bay route.

Fifth.—Hudson Straits.

According to Mr. G. J. Desbarats, the principal danger is in the navigation of Hudson straits. This is a magnificent channel with a width of from 30 to 100 miles, and with no known dangers in the way of shallows or rocks. Icebergs are, however, generally found in the straits, and while these constitute a serious danger in foggy weather or on a dark night, they are easily avoided in the day time or in clear weather. Navigation of these straits should not be very much more dangerous than the navigation of the gulf of St. Lawrence during the iceberg season.

For the past 200 years, according to Captain Anderson, all records agree that Hudson strait is more or less filled with heavy drift ice and bergs during the first half of July, and that there would be very little advantage entering before the middle of the month. Hudson bay and strait do not freeze across, but are so covered with masses of ice that navigation is practically impossible for seven months of the year. During the winter months the intense cold forms a thick haze over the ice, making it impossible to pick up and take advantage of any open leads through the ice pack. Practically the same conditions prevail later in the spring, from the heat of the sun over the ice.

The main party from the steamer *Minto*, in charge of Captain Anderson, left Halifax on July 8, entering Hudson strait with the schooners *Chrissie*, *Thomey* and *Burleigh* in tow on the 28th. She reached Fort Churchill on August 7 and the anchorage off Port Nelson on the 17th.

Captain Davies reports that Hudson strait was entirely blocked, the *Alcazer* entering on July 20, 1913, and it took practically eleven days to navigate the strait.

The year 1911 was an unusual year. The following is the record of ice conditions in Hudson strait from the Hudson's Bay Company's journal, as observed from Erik cove:—

1911.	
July	19—Straits and bight packed with ice.
"	20—Ice still tight on shore.
"	21—Water showing in straits.
"	22—Straits still blocked with ice.
"	24—Ice a little slacker in straits.
"	27—Ice appears to be loose in straits.
"	29— <i>Beothic</i> arrived.
August	7—All ice gone.
"	10—Cove filled with ice. Straits appear to be blocked.
"	12—No ice in sight.
"	13—No ice in sight.
"	18—Heavy frost.
"	19—No ice in sight.
"	22— <i>Pelican</i> arrived.
September	—Some fierce gales during month.
October	—No ice all month, but considerable wind and snow during month.
November	8—Harbour packed full of ice. Straits fairly clear all month.
December	6—No water to be seen in straits now.

Captain Wakeham reports on the 21st July, 1897: "Since we got clear of the Fox channel ice on the 15th, we have seen no ice to impede any ship; in fact we have been in open water all the time."

The ice mentioned on the 15th he refers to as follows: "We had no opportunity of measuring its thickness, but so far as we could judge much of it must have been fully 40 feet in depth. An ordinary ship would have been in grave danger in this pack as it was extremely heavy grinding, shoving and swinging every direction. The *Diana* behaved admirably. We gradually got into more open water."

On the 18th July they steamed through about 25 miles of ice, most of the time going full speed. On the same day Captain Wakeham reports: "Any suitably protected steamer that could manœuvre easily could have gone through the ice to-day as easily as we did. A more powerful ship could have made better time in the light, brassy ice, but among the larger pans the *Diana* could do better owing to her ability to turn quickly."

In 1897, Captain Wakeham passed out of the strait on the 20th of July and saw no ice.

He went back into the strait on the 23rd July, and states: "At 9.30 a.m. bored our way through a heavy bar of close-packed ice and emerged into clear open water. It would not have been possible for an ordinary freight steamer to have pounded her way through the ice which we have met since yesterday evening as quickly as we have. We have driven the *Diana* straight through that which would have brought an ordinary vessel to grief at once. There was no disposition to run together or nip, and any vessel could have laid by safely in it, while through most of it the way was fairly open."

Later, he reports snow squalls and gales in September.

He passed into the strait on the 15th of October and out of it again on the 30th.

Captain Thos, McKenzie reports that he does not think you are going to get through Hudson strait into the bay even with suitable steamers before the 15th or 20th of July, and that he would not advise risking coming out of the bay after the 10th or 15th of October.

Captain Fisher states that there is no regularity in the movements of the ice. It all depends on the winds. He says the earliest date on which he entered the strait was on the first of July. That year he got into the bay on the 19th of July. Some years he entered the strait the 1st August, got into the bay on the 9th August, and saw no ice. In September it usually takes a week to ten days to work out of Hudson strait.

From the 23rd of June to the 8th of July, Captain Wakeham reports the strait was blocked a distance of nearly 250 miles, notwithstanding that his ship, the *Diana*, made good progress owing to her handiness and ability to turn quick.

There is a sort of fog, Captain Wakeham says, that will always make navigation in the Hudson strait extremely risky after the middle of October.

Sixth.—The Channel.

Captain Bartlett gives it as his opinion that Fox Channel ice is the worst bar to early navigation, as it sweeps across and blocks the mouth of the strait. This, however, loosens with turn of tide.

Captain Couch says that Fox Channel ice starts to move south about the middle of September, and if it should reach the northern head of Mansel island, against which it becomes solidly packed, egress that winter would be impossible. Coates island is the worst place. On one occasion we encountered three tides in the strait, and our steamer, the *Belladventure*, was jammed in the ice four days from the 15th of July.

Speaking of the channel into Nelson, Captain Webb says the main channel leading up the river is perhaps a mile wide on the average. Navigation in the channel is perfectly safe. At the entrance to the channel the water shallows up. There is, however, a 20-foot channel there at low water. The channel is perfectly straight.

At the entrance of the channel there are some patches 18 feet deep, yet there is 20 feet available up to within three miles of Root creek. With a certain amount of dredging, however, a 20-foot channel would be available up to within a mile and a half of Root creek.

Captain Anderson says the main channel is a straight channel and very simple to navigate. There is plenty of water at most points and the channel is amply wide. It is not possible for vessels of over 17 feet to proceed up the main channel at low water.

Captain Davies says, speaking of Nelson, the port has many advantages, as the channel for fully nine miles is perfectly straight south 37 degrees magnetic, and the ground good holding. The channel is also well protected on both sides by shoals and boulders.

Seventh.—Currents.

Mr. Harling says that the current out of Nelson river is very strong. The current is said to be about 5 knots. During the period that navigation is comparatively safe the boats should be strengthened. This is a comparatively easy thing to do.

Mr. Saunders says that from his own personal experience he is satisfied that the navigation and anchorages in many other rivers are far more dangerous and difficult to navigate than the Nelson river.

Mr. W. J. Stewart, hydrographer of the Naval Service, states there is very little to guide a vessel at the present time to make Port Nelson, even in clear weather. If the weather be thick he has to keep his lead going anywhere over 7 fathoms deep. With the establishment of a town, their buildings and smoke conditions might help him, but at the present, he states, from a mariner's point of view, the outlook at Port Nelson is not good. He further states, over the bar he will have none too much water under him and will still be exposed to the full sweep of the sea. In this exposed locality it will be difficult for the mariner to keep in a dredged cut and for the engineer to maintain. Inside the bar, whilst he will have deep water, he will have strong currents to contend with, and none too much in which to swing at anchor, and very little shelter from the sea and none from the wind.

The current from the Nelson and Hayes rivers is very swift, a great volume of water being discharged into the Nelson roads. When this current combines with the ebb tide and sets against the heavy northerly gales which prevail here in August and September, a very bad sea is raised, especially, as may be imagined, inside the five-fathom line of sounding. The Hudson Bay vessels have found much difficulty in making and holding their position in Nelson roads, and on more than one occasion have been obliged, after waiting some days for favourable conditions, to abandon all idea of discharging; and Captain Kean says the difficulties to be encountered apart from the ice would be very strong currents running there and a very heavy rise and fall of tides, between 16 and 17 feet.

Eighth.—Situation and Difficulties at Nelson.

The shores at Port Nelson are all low with a thick growth of small trees. The inner part of the harbour is very shallow from Seal islands to Rock creek, where the port is $3\frac{1}{2}$ miles wide. The bottom is very uneven, with huge boulders that uncover at low water.

Mr. Stewart, also, in his report of March 31, 1911, gives one or two instances where vessels were unable to discharge at Nelson in view of the heavy seas. In one case a vessel for forty-eight hours had to steam full speed ahead with both anchors down with a heavy sea breaking on board. After remaining in the vicinity for ten days the vessel had to proceed to Churchill to discharge her Nelson cargo.

The entrance to the Nelson river does not generally freeze up until the end of December or the first of January, and occasionally remains open all winter; still the heavy drift ice coming down makes it unsafe for any vessel to ride at anchor in the channel. The river ought to be safe for navigation from the middle of June until the first of December.

Speaking of conditions at Nelson, he says on the 13th of August, the wind was very fresh from the north, and as the current held the *Minto* broadside to the weather, heavy seas were breaking over the decks. Bags filled with seal oil were used to good advantage on the weather side, smoothing the water considerably and preventing seas from breaking on board.

Captain Webb says it is often a matter of extreme difficulty to secure a reliable observation of the sun or stars while making for the mouth of the Nelson river, as clouds and overcast weather is the rule rather than the exception. The land is so low and shoal water extends so far seawards that the present beacons are quite inadequate.

Ninth.—Wrecks.

Mr. Harling says that the *Allette* and *Cerense* were wrecked in 1913, yet from all information extant at the moment it appears that these wrecks should easily have been avoided with ordinary care.

EXTRACT FROM THE EVIDENCE OF MR. J. G. DESBARATS, DEPUTY MINISTER OF THE NAVAL SERVICE.

The navigation of the straits as far as depth of water is concerned is an easy matter; there is a very fine wide channel, the dangers are few, and there is no particular difficulty in navigating at that point, except from snowstorms, which are prevalent.

The magnetic conditions are poor. The bay is fairly near to the North Magnetic Pole, therefore the deviation of the needle is changing very fast as you go across the bay, and navigation has to be conducted with great care because the needle is not reliable, it is changing its direction continually. There are also magnetic areas; there is one near Fort Churchill, where, as far as we could see, the needle was utterly unreliable, and if there was bad weather, and a ship could not get observations, she would have to be navigated with great care.

We had a train run twice a week over the road to the end of steel to bring out fish and a fair amount was brought out.

We have a scheme for a wireless station at the entrance to the strait and another in the middle to cover the navigation of the Hudson strait. The erection of these stations is very expensive in this locality.

Questioned as to the most economical kind of vessel to use in the Hudson Bay strait, the witness answered that the larger the vessel the more economical the operation, and the size would be limited by the draught of water in the harbour.

EXTRACT FROM THE EVIDENCE OF CAPT. FREDERICK ANDERSON, HYDROGRAPHIC BRANCH, DEPARTMENT OF NAVAL SERVICE.

In 1912 I was with the *Minto* in Hudson bay. Just to show the difference in seasons we left Hudson strait on the 6th November and there was not a bit of ice in sight anywhere. We left Port Burwell coming out on the 6th. I had been off north of Mansell island on the 2nd November, and there was no ice in sight. We went full speed towards the straits; there was not a bit of ice anywhere. The distance through the straits is about 500 miles. The distance from Port Nelson to Port Burwell is 1,000 miles.

We made through the straits 10 knots an hour. At 240 miles a day it would take about four days to go from Nelson to Port Burwell. About eight days from Sydney.

To investigate, to see what the conditions were like, I made another run at full speed through the straits, to the west entrance, and then came back again to Port Burwell.

About the end of October or the beginning of November I took a couple of days to go to Mansell island. I was there on the 2nd November at noon, and I left there at that time. I did not know how long the fine weather would continue. Before four o'clock the weather broke and there was a blizzard on that evening. We came right back to Port Burwell.

We went through it, we did not worry about that.

Snowstorms start about the 13th to the 15th September, and you are liable to have them every day throughout the season after the middle of September. They are

very, very serious. The needle is not affected. With the ordinary tramp you must slow down, because while the ordinary large fields of ice are not bad, there are growlers or huge masses of ice with but only a small portion showing above the surface, and if a tramp steamer were to strike one, it would finish her. Of course it was different with the ships I had.

That season of 1912 was a particularly open season. What Commander Gordon found in 'three years' experience up there is much the same as I would say.

Commander Gordon says: "Having now made voyages on three years to Hudson straits, 1884-85-86, and having carefully examined the reports by the observers as to the formation and movements of the ice in Hudson straits, I have the honour to submit the following statement in regard to the navigation of these waters."

"I give the following as the season during which navigation may, in ordinary years be regarded as practicable for the purposes of commerce; not, indeed, to the cheaply built freight steamer, commonly known as the 'ocean tramp', but to vessels of about 2,000 tons gross, fortified for meeting the ice, and of such construction as to enable them to be fair freight carriers."

"I consider that the season for the opening of navigation of such vessels as the above will, on the average, fall between 1st and 10th July. The closing of the season would be about the first week in October, partly on account of the descent of old ice from Fox channel into the western end of the straits; this old ice being rapidly cemented into solid floe by the formation of young ice between the pans; in such ice, no ship, however powerful, could do anything to free herself. At this time, too, the days are rapidly shortening and snowstorms are frequent, though not of great duration."

I am not a sea captain. I have never had sea-going experience.

In the spring of 1914 the *Bonaventure* was caught in the ice fifty miles east of Cape Chidley. She was there from about the 10th or 12th of July to the 1st of August. There is a current along the north shore of Hudson straits to the west. The ice gets in between Resolution island and the mainland. But generally it passes into the strait south of Resolution island and to the eastward along the south shore coming out.

On the north shore the current is going west. Then it goes round through Hudson bay, passing south along the western shore and north to the east side, passing out through the western entrance to Hudson strait and thence eastward along the south side of the strait.

I have seen icebergs—although the tide was on the ebb—drifting in against the tide. I have seen a series of icebergs apparently charging through the huge fields of ice and dashing the ice away up in the air. You would think the iceberg was charging through the ice, but as a matter of fact the icepack was being carried out by a 7-knot current. The surface current would be running in one direction and down below, at a depth of 30 fathoms, there may be a current in the opposite direction.

I have seen icebergs as far up the straits as Eric cove. They have been reported at the entrance to James bay, but they do not come into Hudson bay as a rule. The icebergs come down Fox channel and they are carried out by the current along the south shore of Hudson straits.

I have seen one outside Port Burwell about 200 feet above the water, and there would be about five or six times as much under water.

The ice from Baffin bay comes down through Davis strait. This ice is carried into Hudson strait by the flood tide and out again by the ebb tide, and in the spring of the year the Fox channel ice comes down and passes out through the strait continually. You will find the ice packing much more closely on the south shore.

Along the south shore of Hudson strait, between Button island and Chidley, the ebb tidal current is seven knots and the flood about five knots. That is the fastest current in the whole strait.

I was caught out there in the ice, north of Button island, in the spring of 1914. The tide changed from flood to ebb and the ship was caught in the ice. The field ice was all coming in whirlpools, and we had to tie up to a large pan of ice to prevent the propeller of the ship from being torn off. We made the ship fast, with the stern well protected, with wire hawsers, which were brought as tight as a fiddle string by the current and the whole pan was carried around in a circle.

I will tell you of an incident about which you remind me. Captain Reid was up north in the *Minto* in 1913 or 1914—I think 1914—in connection with the Marine Department, placing lights, I think it was, in Hudson bay, and he ran into a field of ice in Hudson strait. He had been accustomed to crossing the Northumberland straits, and his experience was with the soft kind of ice to be met there. As soon as he got near enough to realize the thickness and nature of the ice he stopped the ship, hitting the ice gently, and if he had not done so, the ship would have been seriously damaged, because the ice was so different from what he had been accustomed to; it was hard, blue ice, ten or fifteen feet above the water.

There are, as a rule, open places in the straits, but off Resolution island is a particularly bad point at the east entrance to the strait, and it closes all this opening up. The ebb tide will open up the ice pack a certain amount and then on the flood tide it comes together again.

You will find the tide about 15 feet at Port Burwell; springs rise 19 feet; neaps, 14½ feet.

Then along the straits, further than Sugluk harbour there is only a 6-foot tide. The tide is about 30 feet at Ash inlet, on the north shore. At Churchill spring tides rise 15 feet; neaps, 10½ feet. There is quite a high tide about Big island; that is, in the middle of the north shore of the Hudson strait there is a very high tide; I think it is 30 feet.

There is a difference between the north and the south side of the strait. That makes it very bad. Commander Wakeham was nearly lost off Big island. He was squeezed in the ice flow.

Down in James bay there is not very much tide, but at Port Nelson there is about 15 feet tide on the average.

Port Nelson is as good a port as you can get there.

Churchill is a very good harbour as far as it goes; it is small, though. I do not think it is large enough to accommodate the number of ships that you would have, to make a proposition worth while.

You could put fifty ships in Port Nelson.

I do not think you could get more than three or four ships in Churchill. It is a small harbour—a half dozen ships would fill it up pretty well. There is lots of water there, and construction would not be expensive. If piers were established where ships could lie, you could put more ships in the harbour.

Personally, I think Port Nelson is the better place for a harbour, because the conditions which prevail at Churchill are Arctic conditions. You have Eskimos at Churchill.

Port Nelson is more temperate, and down there at the mouth of the Nelson river there is the possibility of water communication through to lake Winnipeg and right through the country. There are a number of points to be considered about Port Nelson.

A boat with 20-foot draught will go into Nelson. You could not take a ship drawing more than 20 feet up to the terminal at Nelson.

The channel is a quarter of a mile wide. The width of the shallow water is about 15 miles from shore to shore.

The mud flats are all dry at low water and nothing but channel is left. It is about half a mile wide.

I towed two schooners through the strait behind the *Minto*, and the ice would close behind us very quickly. I damaged both schooners, and one so much that I had to beach her at Wakeham bay for repairs. That was in the spring of 1911.

A powerful tug, kept in readiness at some point along the strait, for the purpose of going to the assistance of a vessel in trouble would be good, but seaplanes would be the best in connection with the wireless stations, to find the leads and see where the open water was, and report by wireless, so that ships could be informed.

The point is to keep ships out of trouble. A powerful tug might be of value if a ship got into trouble.

Hudson straits are never frozen over.

During the flood tide it closes pretty tight and you have to wait in the ice until it opens up again with the ebb tide.

15,000-ton boats are rather large I think for handling in the ice. I think there would be difficulty in handling them in the straits. A 5,000-ton boat is about the largest, I would suggest, that could operate there. A ship for that kind of route needs to be protected, reinforced with heavy plates and double frames upward. I think a 5,000-ton boat would be a pretty large boat to operate.

About 60 or 70 miles off Fort Churchill there is a spot where we have difficulty with the needle. The magnetic needle at this point swung 90 degrees, then it came back again. It oscillated a bit, then came back to 10 degrees.

The steamer, I think it was the *Earl Grey*, the ice-breaker, passed over the same place and her compass was swinging around dangerously, and they went straight by the sun until the danger was passed, in about an hour's time. They could not use the compass at all. The compass was lost for about half an hour. One place seemed to be very bad, and I stopped the ship at once and took a sounding and found 68 fathoms, and a gravel bottom. We took observations at once, and fixed the position of the ship, and after holding our course for about half an hour, the compass gradually came back to normal again. It was not a place where serious results could happen.

One year, the Hudson Bay company delivered their freight at Churchill, and it took a year to bring it overland, then they delivered to Nelson. They anchor off some distance, about 20 miles out, and bring it in in York boats.

The *Cearense*, wrecked in the channel, did not make the slightest attempt, so far as I can see, to find the channel going in. I was right on the ground at the time she was wrecked. She inquired the passage from me, and I gave it, and she paid no attention to the directions.

I was off the entrance to the harbour at Nelson in 1913. The wind blew about 75 to 90 miles an hour—that was about from the northeast, a blizzard—and there was not very much sea around there, just the usual slop from the wind blowing hard. There was no very big sea.

These are known dates at which the straits have been entered, have been passed right through. The entrances are both given here:—

1910, eastern entrance, that is Cape Chidley, July 18.	
1910, western entrance, July 21, 3 days passing through.	
1911, eastern entrance, July 25. . . . }	4 days passing through.
1911, western entrance, July 29. . . . }	
1912, eastern entrance, July 15. . . . }	5 days passing through.
1912, western entrance, July 20. . . . }	
1913, eastern entrance, July 16. . . . }	8 days passing through.
1913, western entrance, July 24. . . . }	
1914, eastern entrance, Aug. 1. . . . }	7 days passing through.
1914, western entrance, Aug. 8. . . . }	

I see from Commander Gordon's report, that in 1885 the eastern entrance was passed on July 20 and the western entrance July 20—there is some mistake in that date. They passed through the straits somewhere about July 20.

1886, eastern entrance, Aug. 1. . . . }	19 days passing through.
1886, western entrance, Aug. 30. . . . }	

Date of leaving Hudson strait, 1910 and 1911, November 15. There is no doubt that if they can get through the western entrance, they can get through the eastern entrance. The eastern entrance will not be closed until well into December. The northern pack does not come down until perhaps Christmas time.

These figures are from past records. The pack does not come down that shore until about the middle of December—down the Baffin Land shore, the east entrance.

The Fox channel ice is the ice which chiefly regulates navigation; that is the chief bar to navigation. It comes down at any time. You expect it any time at all, as a rule any time after the first of October. I have heard of the straits being almost closed early in October, and later on I have been at that point and have seen no ice at all. I have passed fields of ice in the straits, but found no ice at all at that point (north of Mansell island). This is very heavy Arctic ice, huge pans of ice, some apparently clear ice, and some might be a quarter a mile across and standing out of the water 25 feet, pretty thick, pretty heavy ice. I have been in my cabin and have looked out the port light and could rub the ice with my hand.

There was no ice shove. The ship I had would not stand an ice shove, but would stand a certain impact at the bow. A ship designed by the late Mr. Newman for Hudson Bay service is cut away forward with projection at the stern to protect the rudders. She is a 5,000-ton ship, taking approximately 170,000 bushels. She has some passenger accommodation on deck, and is strengthened forward with fairly heavy frames and steel plating.

I do not think the comparative cost between this vessel and one of ordinary type would be very much increased, as it is only the forward part that is strengthened.

Even with the modern aids to navigation, ships in this region should have special bow construction, as they might be caught in the flood tide and would have to wait until the ice loosened with the ebb tide, in order to proceed.

Wireless and hydroplanes would aid tremendously in enabling a vessel to keep out of trouble. I never had that assistance. We went to the masthead for information regarding the ice fields.

Wireless telegraphy and hydroplanes would make navigation in Hudson strait child's play in comparison to what it has been. As to its result in lengthening the season, that would be hard to say. Further investigation under that head might show, but I do not think it would extend the season beyond the latter part of November.

It would make it much safer than at present. Hydroplanes kept at the wireless station north of Mansell island would be of use. That is the most important point.

Entering Hudson strait during the spring you cannot get through the passage between Mansell island and the mainland—the safest passage is to the north. When you get to the Hudson bay keep to the north, the ice all goes to the south. Ships have tried to pass through between Mansell island and the mainland in the spring and have been forced to turn back; but in the fall of the year I think there is a very good chance of getting through. Fox channel ice does not come into the bay, it drifts down into the entrance between Coats and Mansell island, and I have seen it pass out many times.

The straits themselves are open; they are packed full of ice, but it is moving all the time, they are never frozen over. The Hudson bay itself never freezes over.

We have records showing that the straits never freeze over, but there are such masses of ice passing in and out for a certain distance with each successive tidal current, at the east entrance, and passing out through the west entrance, that it would be unsafe, in fact it would be impossible to navigate any ship. That ice loosens up in the spring, but as a rule closely packed during the winter—without any open water showing.

I have records from cape Wolstenholme from a Hudson Bay company's officer. He kept a record all winter. The ice loosened up a bit and you could see

open water in the spring, but most of the time you could not see any open water at all; the straits were practically jammed full of ice. He could see many miles across. Cape Wolstenholme is about 2,000 feet high, and is on the very northern point of the strait, at the west entrance, the most critical and most dangerous point.

James bay is peculiar again. It is open probably about the first of July or the latter part or middle of June, but then the ice from Hudson bay is jammed down there, and there might be difficulty in getting past the entrance to James bay.

About the first week in August, 1912, the *Beothic* left Port Nelson to go to James bay, and she was eight days in heavy ice fields off the entrance to James bay—trying to break her way through, before she could enter the bay.

There is good water right down to the bottom of the bay.

If I am not much mistaken you can get 20 feet of water down to Snake point.

EXTRACTS FROM EVIDENCE OF D. W. McLACHLAN, ENGINEER-IN-CHARGE OF HUDSON BAY TERMINALS.

I am engineer in charge of the work at Port Nelson on Hudson bay. I have been in charge from August 6, 1913. Nelson at that time had been selected as the terminal. The minister went up in 1912, the year before I went up, that was the confirmation of the former selection. I left Halifax on the 4th of July, Sydney on the 8th of July and arrived at Nelson on the 6th of August. We were stuck in the ice, we were stuck about a week in the strait about half way through the strait, then we got away from there and I think we got over to 140 miles from Nelson on about the last day of July and we were stuck there until the 4th. We got loose from that ice on the evening of the 4th, and we arrived at Nelson on the 5th and went in on the 6th. It was heavy ice, enough to stop one of those Newfoundland sealers. I was in the *Bonaventure*, which is just as good an ice-breaker as there is, she was a Newfoundland sealer. There was practically nothing done at the terminal when I got there. I ran it a year and four months the first time, but I have gone back each spring about the 1st of April. I came out sometimes about the 1st of December; sometimes I did not come out until the middle of February. I always go and come overland by way of Le Pas. I have made only the one trip by water.

We have a bridge about two-thirds of a mile long built from the shore out towards the natural channel. Then we have an island built there about one-half mile long and about 400 or 500 feet wide. The front face of that island is not built yet, it will be deep water wharves when it is built. The island is partly filled. The front face of this island where the deep water wharves will be, lies parallel to the natural channel and eight feet from it, that is to say, there is a natural channel running up and down the axis of the estuary. If a line was drawn parallel to the natural channel and along the edge of it you would probably have to go down seventy feet or more to get hard material for a foundation.

Apparently at some past geological period there was a channel there which was about ten times as large as the present natural channel, and that original natural channel had sloping banks rising up, and those banks were quite straight and uniform, and, of course, hardpan. That has been filled up with deposits of sand—great big pockets of sand—and perhaps on top of that another pocket of soft mud, or it may be underneath it, and on top of that again a big deposit of soft clay. In the natural channel the surface is paved with stones, sometimes large and sometimes small. Those stones have evidently been carried away by ice. It is always one stone deep. The current varies. It is about three knots in the channel opposite our works. That would be the maximum. As you go down some miles it gets more. About sixteen miles out you get a current of about eight miles an hour. I know that eight miles out from the island the maximum current on ebb is about five miles an hour. Ten miles out the current is 5.7 miles an hour and 11½ miles out it is 7½ miles an

hour. At 13 miles out, where the current reaches its maximum, it is 8 miles an hour. From there on it gradually gets less and from there to the ocean it gets less all the time. The maximum is, 17 miles out, 8 miles an hour. Undoubtedly it was caused by the hydraulic conditions resulting from the configuration of the shore. There is a long, deep hole 6 miles long. In one place the water is 90 feet deep. At the outer end of this hole the velocity is greater. The average tide of the island during the neap week would be 11 feet. The average tide at the island from spring week would be about 15 feet. We have had a 20-foot tide at Nelson caused by wind at the island, a northwest blow coming along at spring tide. We have also had very low tides occasionally; some of less than 8 feet. We consider a tide of less than 10 feet unusual. A boat obviously has to follow the natural channel. We are on shore with the freight cars, as it were, and the bridge is the means which we took of getting from the shore to the edge of the natural channel. We found that we could not block the current. We could not combat nature. If the water insisted on running up and down parallel to the shore the only thing to do was to tunnel underneath it or to build a bridge. Once we got to the edge of the natural channel we knew that we were getting to the ships anyway, and we knew we could get a good foundation. We want to interfere with the currents as little as possible. Our terminals contemplate keeping a ship even when it is lying against the wharf, lying like a fish in the water or a ship at anchor, the current coming down quietly and going by it. The channel in which the boat will lie when tied to the wharf will have a current about the same as that in the natural channel and running up and down the face of the wharf. At that point it is only a moderate current. The 3 knots I have given you opposite the island might be more than this. I do not consider that a $3\frac{1}{2}$ or even a 4-mile current would interfere with the ships lying at the wharf.

The upper or inner end of the deep hole is 8 miles from the end of the island. The end of our bridge turns off from the end of the island and the island lies up and down the stream and parallel with the natural channel. Half a mile of the island is built, and that shown on the plan is a proposed extension. The full length is 9,000 linear feet of deep-water wharf, with some additional length for approaches. I cannot extend that island farther up for some time.

Nine thousand feet is the length of the island. Taking 450 feet for a boat so as to work it out evenly, there would be accommodation for twenty ships. That is my proposed scheme at the present time. The island is half a mile long now. The idea is that the ships will come in from the deep channel. We will come up to the end of the island with a 300-foot channel just dredged to 20 feet. I was going to go along the wharf the full 9,000 feet and connect with a big channel which is here, in such a way that the current would come down from the upper end and flow out at the lower end. I would dredge to 20 feet at the entrance channel and to 30 feet at the wharves, and the ships would have sufficient depth under their keels to come up at high water and lie in their berths at the wharf at low water. There is a bar at the mouth of Port Nelson estuary, a matter which we have very carefully investigated.

The island will be built of timber cribwork. It will have 30 feet of water at low tide, 50 at high tide. On the front face it will be about 500 feet wide, with a retaining wall at the back, and we will fill it in with dredging as far as we can. We built the front with the cribs the same as they do in Quebec or Montreal. We propose to found these deep-water wharves on the edge of the old natural channel. We intend to follow out the slope to a point where we will get 30 feet. We follow out the hardpan until we get about 30 feet at low tide. Our cribs will be founded on hardpan, but we will have little or no hardpan to excavate. That has all been carefully studied and this wharf built so that there will be very little hard material to be dredged. None of the deep-water wharves are built. We have a supply of gravel about 12 miles away—stones about the size of your head. I consider that we deserve a great deal of credit for being able to build the bridge. It has been in place for three years and the ice has never moved it. It is timber, built as cheaply as we could

possibly build it. The bridge itself is carried on the cluster of piles. There are pockets left open, and in those pockets we drove 12 by 12 timbers. They are driven down deep in the hardpan; the whole bridge is carried on piles. The length of the bridge is about two-thirds of a mile.

Last winter we knew that the charter which was prepared and published was not right and we went back and thoroughly surveyed the entrance to Port Nelson all over again, with the result that we got the channel in a different place from the one shown on the charter. The result is that we effected a great improvement in the entrance to Port Nelson. We now have a channel there that has 20 feet of water at low tide. That means that when you have the height of the least tide to be expected you get a channel that is 33.7 feet deep. Every ship has to wait for the tide. If they are in the ocean they have to stay there. They get no protection outside. Outside this bar there is no protection other than what is anywhere in Hudson bay. If the storm is too bad they have to go to sea and steam around.

There is no harbour outside this bar. You can come into Port Nelson at any time; you can see the beacons we have on shore or the beacons that we will build; or if you can see the buoys you can come in. A windstorm does not stop you; but a fog does, or a snowstorm. I do not say that snowstorms are prevalent, but I certainly have seen a great many of them. Thick hazes—what we call thick days—are prevalent. By many navigators they are not considered prevalent, but they certainly do occur.

The country up there is peculiar in this way, that if the wind starts blowing in one direction it blows in that direction for about a month without stopping. It is a most peculiar country in that if it starts doing something it gets into the habit of doing it. If it starts to rain, it will rain all summer; if it starts to blow, it will keep on blowing. It is the most peculiar country that I ever saw.

The original channel on the charter, that is Captain Anderson's charter we were using until we knew better, or in the absence of better information.

Deep water in the Hudson bay is about 22 or 23 miles out from the island. Two beacons or ranges that could be seen 23 miles away would have to be built up very high.

The channel that we found this summer has a direction which really leads to the shore more quickly than the channel coming straight up the estuary would lead and we can build a beacon on shore and another one behind it a mile or so that will probably be about 90 or 100 feet high, and we can see those from deep water in Hudson bay. We can see those beacons before leaving deep water and we can keep in range with them until we come into the range of two other beacons to be built on the other shore, then we will come along those until we come to a point about 12 miles away from the end of the island, and that of course, is a shore distance. We can build other beacons in the river up near the island. The channel I got this summer enables us to navigate to within 12 miles, whereas before that, we would have to stay at 21 miles or 22 miles out.

We could not anchor a ship in a storm out in a channel. If a storm were on we would have to go to sea. This new channel is a natural channel without any dredging. The depth is 20 feet at low tide, 23.7 at high tide and about 40 at spring tide.

The great advantage of the new channel found this summer is that at first it leads towards one shore and then towards the other shore and finally up the centre of the estuary, so that beacons can be built on shore so close that a ship can see the first pair and steer towards them keeping them on range until the second pair come in line and then along these until the third pair come in line and then up towards these until well into the estuary. The width of the channel at the narrowest point is 1,200 feet. The first shoal near the channel is eight miles from the north shore. At that point where I said it was 1,200 feet wide, it is 30,000 feet or six miles, from shore. On the other side from it to the shore it is about twelve miles.

There are a number of narrow places, one at mile 14, one at mile 15, and one at mile 17 and one at 18 miles from the island.

Dredging anywhere out in this outer estuary would be an awfully difficult problem.

I will not say there is no silt coming down the river, because the whole place is muddy, but I do not believe there is any change occurring in that estuary; I believe now, it is the same as it has been and will be the same a hundred years from now.

Buoys will stay in position in the new channel during the navigation season, but further south in the swift part of that channel it is a great problem to get a buoy to stay. You put a buoy there and it goes out to sea or sinks so it cannot be seen. We have a terrible job really to make them stay in position. We can put buoys in on the flats and they will stay all right, but they are misleading so far from the channel, because it is the strength of the current that makes the difficulty. The best buoys we found are large wooden barrels anchored with chains and heavy rocks.

We anchored the tug all right in every part last summer except near the outer end of the deep hole, there is good anchoring inside the seven mile point. There is plenty of depth of water from seven to 13 miles out, but the material is such that we have had difficulty in anchoring a tug. It is not regarded as good anchorage.

Outside that bar we certainly get rough wind, but the waves get less and less as you go up the estuary. It is my judgment that ships will not have difficulty from a north-east wind in lying against the wharf. I base that opinion on our experience in Newfoundland boats and our temporary wharves along the shore. We have not lost much time unloading lighters and we have tied up our boats to those wharves for the last five years.

The channel at the point where we do our lighting is about two thousand feet wide.

As long as there is no fog I do not see that there will be any danger in navigating up through the channel. You will have to keep in sight of your buoy or beacons. The right thing to do would be to see both. About mile 8 the bottom is soft mud with a paving of stone on top.

When a tug or boat of any kind drops its anchor that anchor may glance off the stones for a little distance, but it generally brings up all right and the whole ground is considered by marine men to be good. Of course, we have boats that drag. This refers to all the distance from the island. It is considered good holding ground by marine men. Further out the samples that I was able to get from tallow put on the end of very heavy lead and dropped on the bottom, always showed yellow sand and gravel. From mile 8 out to about mile 13 I found yellow sand and gravel. That is not considered good holding ground.

Our experiences with the tug in some cases, especially, showed that the tug dragged. We could not anchor the tug with her anchors. She was a steam tug about 100 feet long. On the other hand the evidence that we have with regard to large boats anchoring in the deep hole is altogether confined to the upper end of that hole, by that I mean the section between mile 8 and 9 and between mile 7 and mile 8, the length of the deep hole is about five miles. We found last summer that the deep hole is very much narrower than it is shown on the published charts. At mile 8, in the deep hole, the width is already about 1,200 feet, so that the deep hole, so far as navigation of the channel is concerned, is only wide enough and no more as we need to take a ship into shore.

The present channel between the ocean and Quebec is 1,000 feet wide. The *Alcazar* anchored in the deep hole, but her captain made a great deal of noise about his doing so. He did a lot of talking about the danger he was undergoing. I tried to get the captain to go in further where it would be easier for us to unload but he would not move from where he was. He claimed that his anchor had dragged a little, he claimed a lot of things of that nature.

The deep hole extends from mile 8 to mile 13. Captain Mack, in the *Noscopi*, anchored about $4\frac{3}{4}$ miles from the island. He was not anchored within three miles from the deep hole. At the upper end the width of the deep hole is about 2,700 feet.

The ice in the estuary breaks up on the last day of May or the first day in June. The ice in the estuary is of three kinds. First of all the channel generally is smooth in winter for three miles above our work and that ice is about five feet thick in the

spring from the edge of that smooth ice into the shore we have what we call rafted ice. It would be from eight to ten feet thick and very rough, then out from the head of the deep hole that smooth ice changes again and goes back into rafted ice again. From the head of the deep hole out to perhaps where the *Cearance* lies, or perhaps a good many miles beyond, it may remain open all winter or it may become a mass of terribly rough rafted ice depending on the severity of the winter. Usually we expect to go out of the harbour about the 1st of June, but last spring it did not go out until the 13th of June. After the ice goes out it comes back, but it comes back broken up. The tide that takes it out only goes out a certain distance and the ice keeps coming back in chunks until away on very late. I cannot really recall the latest date that we have seen ice coming back that was serious, but it comes back for a long while in such a way that you could not put out any buoys. Any buoys put out beyond say the Arlette would be carried away, in fact there certainly was enough ice out there hovering about to carry away buoys until the first of September one year.

During September there is no ice. I have never known of any ice in that month that would do any damage to anything. The young ice that forms in the harbour generally appears from the 7th to the 11th of October. That did not interfere with navigation, but that ice gets thicker and thicker until about the 15th of October when we begin to beach our plant as quickly as we can, and by the 18th of September all our scows, tugs, dredges, pontoons and all those things are ashore.

The time does not vary from year to year very much. I do not think we have ever lost more than 24 hours in a season by putting them in too soon, and I do not think we have ever had any serious loss from not putting them in soon enough. From the 1st of September to the 15th of October I have never seen anything that would obstruct navigation in the harbour. The last thing we do before we beach our tugs is to take up the buoys. About the 18th to the 22nd of June the plant all goes into commission. We cannot put out the buoys until we know that the drifting ice is not going to take them away. We always put them out as early as we can. We lost half our party by putting them out too soon. The buoys at the outer bar should never be put out until the 20th of August because if they are I think the chances are very great of losing them.

One of the difficulties in connection with navigation at Port Nelson is the very fact that it is probable that a ship could come in earlier than the buoys could really be put out, that is, there might be enough ice out there to take away the buoys and still there might not be enough to stop a ship from coming in. Certainly no buoy could have stayed in that outer estuary on August 29, 1917, because I was there in a gasoline boat on that date and the shallow flats were studded with grounded masses of ice and in many places on the bar itself there were masses of ice one hundred feet square grounded.

This ice comes down from the west coast. It comes apparently from the northern section of the bay and keeps drifting south, and finally melts away. It lies like a great blanket up against the coast between cape Tatnam and cape Henrietta Maria. It is heavy. I have measured, and found chunks aground in 33 feet of water.

I think beacon lights would help navigation. A boat would have to come in without buoys. The only thing that you would have to depend on in that case would be the range lights. It would require very high beacons. Beacons can be built that can be seen from deep water in Hudson bay into our works at Nelson without using buoys at all, and that would lengthen navigation.

Churchill is land-locked. The anchorage area is very small. About three ships could anchor there and swing on their bow anchors.

The whole place is covered with enormous boulders; on the land, in the water, everywhere. I never saw as many boulders in all my life as I saw at Churchill. They could be removed, of course. The Churchill river is on an average two miles wide, and I am sure I was never more than one hundred feet away from a boulder on that trip. The river is about two miles wide and two feet deep for thirty miles, and the

shore is flat and low. Churchill really consists of a small harbour at the mouth, deep enough to provide swinging room for three ships, anchored by the bow, and then a large lagoon-like area back of it, that fills and empties with the tide. It is about two miles wide at the mouth of that lagoon.

I went up to Churchill in a tug. There was an awful storm, and when we were going around Knights Hill beacon we practically touched bottom, about nine miles off shore; that would be about 20 or 30 miles from Churchill.

A Hudson bay pilot told me that we should never have allowed ourselves in going to Churchill to get into water less than 9 fathoms deep. He said a boat going into Churchill should feel her way in with the lead. That means that there is a channel not less than 60 feet deep. In making the port I would have had a picnic at Churchill as compared with the difficulties which we have had at Nelson from the engineering point of view. The barren lands are simply peat bogs. They are frozen from a depth of about 20 inches from the surface down as far as you would like to go. They never thaw out. We don't know how deep they go, because we never dug a hole more than 9 or 10 feet deep. We found from samples taken that it consists of 95 per cent of water and 5 per cent of peat. It stinks even when frozen. The surface area as far as you could see was practically barren. Occasionally, a live willow would be seen. Fully one third of the surface area was covered with water. You could push a pole down through the 8-inch mat and then a little further through the soupy liquid before you hit the frozen peat. The whole area was absolutely flat. I understand that there is 25 miles with no creeks crossing. This barren-land area extends practically all the way from 15 miles north of Nelson clear up to within, I suppose, 10 miles of Churchill. Building a railway line to Churchill, I think, on the original location that was chosen in 1908, you would cross about 30 miles of barren land.

There is no grass anywhere in that country. The barren lands cross the Churchill river. You see barren lands all along the north side of the Churchill river for, I suppose, 15 miles. You would see the barren lands just one third of the way down on the bank, and for the next one third, there would be trees, and below that devoid of trees, on account of ice jams. Where those trees are you would get a good railway bed.

Mr. Armstrong, of the Hudson Bay Railway engineering staff, ran a location across to Churchill. They ran it through, but whether they ran it through barren lands knowing that they could go somewhere else, or whether they ran it through barren lands knowing they could not go somewhere else, I don't know, but they did run it over barren lands. Any dredging they do at Churchill is difficult and expensive.

I have made a study of ships, and I found that the most common ship on the ocean was between 3,000 and 4,000 tons gross. From this I reached the conclusion that the ship which a port in Hudson bay should be built to accommodate, was a ship of between 5,000 and 7,000 tons gross, and that provision would have to be made for a ship drawing 26 feet 3 inches of water; her gross tonnage something over 5,000 tons, and her dead weight carrying capacity about 7,000 tons. It may be that special ships will be built to navigate Hudson bay, and these will not adhere to the usual dimensions of ocean tramps.

A ship coming into Port Nelson should come in along the Tatnam coast, using its lead to keep a safe distance from shore until she finds March Point beacon, Sam's Creek beacon, or a new beacon which we have built several miles north of Sam's creek, now called Carter's beacon. This done, she should move to a position $8\frac{1}{2}$ miles from Carter's beacon, and anchor there, awaiting high tide. From this point, she should see 2 ranges lighting up the channel; the nearer one $16\frac{1}{2}$ miles away. She should proceed along this range $5\frac{1}{2}$ miles, passing through a channel 1,200 feet wide, and 30 to 20 feet deep; going out 2 feet less. This will have to be added by reason of the ship not being able to reach this point when the tide is at its highest. At the end of the range at a distance 13 miles away, the ship should observe 2 other ranges toward which she should turn and continue along the new course almost 4

miles. On this latter course she would travel through a channel 1,200 feet wide and 20 feet deep at low water. Along this latter course and the course preceding it, there is no area wide enough or deep enough for a ship drawing 26 feet 3 inches to anchor and remain throughout low tide. If she did, she would be upon the bottom when the tide fell to its lowest. At the end of the course last described, the ship arrives at what we call the outer end of the deep hole. At this point the velocity of the water on the ebb tide is very great, being 8 miles an hour; 2 hours after high water at the island. At this point, also, we have difficulty in maintaining buoys. The current is so strong that buoys are submerged a large part of the time and give assistance only at slack water. We have had to place buoys in on the Flats where the depth of the water was not great; it was not so swift. At this point, too, the ordinary tug's anchor would not hold her excepting near the time of low and high water. At this point, the ship having completed the former course should see on her right 2 ranges which will have to be built near the present "Wreck Alett." The nearer of these range beacons or lights will be a distance of 8 miles away and the ship will have to turn and steer for them and keep them on line for a distance of 5 miles, at the end of which she has reached the upper end of the deep hole and is at a point 8 miles from the end of the island. On this course she has passed through a channel which was one half a mile wide at the beginning of the course and near the end about 1,200 feet, the surface of which at no point projected closer to the range line than 300 feet, affording to ships a width of 300 feet on either side of a range line in which ships can safely navigate. Water varies from 30 to 90 feet velocity, $7\frac{1}{2}$ miles low end to 5 upper end. The material in the bottom is yellow sand and gravel. I do not consider it safe for the ordinary steamer drawing 26 feet of water to anchor. The sailing ship *Benmore* always dragged, and gave as much trouble when anchored between mile 7 and 8 from the island, which is the upper end of the deep hole. A ship entering Port Nelson, having arrived at the upper end of the deep hole, which is 8 miles from the island, would continue on the line of other range beacons for a period of $5\frac{1}{2}$ miles to a point $2\frac{1}{2}$ miles from the island. Through this section the ship would travel in a channel which is not less than one-half a mile wide throughout the greater part of its length, and has considerable areas where the depth at low water of average spring tides is not more than 18 feet and passes over certain spots where the depth is only 17 feet. To these depths must be added 13 feet in order to obtain that available at high water of low neap tides. On the incoming journey, therefore, there is available 30 feet, and on the out journey 29 feet. The ship having arrived at the point $2\frac{1}{2}$ miles from the end of the island, enters an artificial channel the width of which is proposed to be 300 feet. The above proposed channel is 20 feet at low water and is to be dredged. There is no good anchorage for ships of 26 feet of water from deep water to the island, but I do not consider it necessary to anchor ships in Port Nelson, though it would be a convenience to do so. Dredging to create anchorages would be very expensive. A ship in going from deep water to Hudson bay must weather any storms that may come during her stay at Port Nelson while tied to the wharf, but the 20 miles of relatively shallow water from deep water to the port cause the deep sea rolls or waves to be broken up, and while serious so far as small light vessels were concerned, would not affect a large vessel.

Captain Freakley and other captains concur in this idea. Throughout the greater part of the navigation season, buoys should be used and with buoys ships could enter and leave in thicker weather than by means of range beacons. But ice conditions during August and after the 18th of October will displace or carry away any buoys in place, and reliance could not be placed upon them. There would probably be a period before buoys could be placed and also a period after which they would be taken up, during which ice conditions would not prevent a ship entering or leaving Nelson. At Nelson, during August, September and October of some years it rains 15 days a month. In other years in these months it rains only for a day per month. Our men

usually lose one day a week on account of bad weather. Fogs are more prevalent when there is loose ice about. I have memories of ships being held at the outer bar at least two days on account of thick weather and inability to see land marks or the tug which we sent to pilot up the men. We have had snow storms in every month of the year, and the worst summer storm ever experienced was about the middle of September.

The question of fog is an important one. Captain Pence said that during the months of July, August and September, in 1915, there was about 15 per cent foggy weather, but as a rule very much less than that after September 1, each season.

At Port Nelson we have a dry dock 200 feet long and 46 feet wide.

My knowledge of Churchill is derived from about 6 hours spent in it September 26, 1917, and 1 hour on the 29th, with 3 days spent in a trip up to Churchill river as far as the mouth of the Deer river. I do not conceive that any one visiting Nelson for a similar period would be enabled to express any opinions of great value. The entrance to Nelson was picked up through the fog, the beacon on the top of the hill being seen almost as soon as the land. The entrance to Churchill is easily made, and once inside of the natural breakwaters which overlap each other, the harbour was found to be sheltered, and the tug anchored in very good still water. The area of deep water inside of Churchill harbour is small. Back of the area shown upon the published chart there is a right wide lagoon-like enlargement of the harbour, which is 5 miles long and about 4 miles wide. This fills and empties in the tide, and the large quantity of water discharged from it on the ebb tide is the cause for the existence of the deep water area generally called Churchill harbour. On either side of the harbour, running back into the country at an angle of about 90 degrees with one another are two mountain-like rocky ridges, which form the natural breakwaters for the harbour. The area between these rocky ridges has been filled with boulders, sand and gravel. Any dredging required for the creation of a basin in front of dock walls on the foundations of same would be very difficult to do, so far as the excavation is concerned, but disposal could be made in Hudson bay with ease. For the construction of deep water wharves, there is available right at the work a large amount of rock, and I am told that not many miles away there is a large deposit of gravel.

From what I saw on the Churchill river trip, I judged that from Fort Churchill to about 7 miles south of the point of junction with the Deer river there are no difficulties to the building of a railway. Between the above two points, there is a distance of 30 miles about which I have only indirect information. These are the barren lands, actually a peat bog, frozen perpetually from 20 inches below the surface to unknown depths. This peat being 95 per cent, water would settle and shrink enormously if thawed and drained. It may be possible to avoid a large part of the barren lands and to obtain drainage into the Deer river. I do not know. I have thought a great deal about the difficulties of building a railway across barren lands, and the only way that I can see would be by the construction of a continuous pile trestle or a continuous timber platform. The Hudson Bay railway throughout almost its entire length is not built of solid material, such as clear sand and gravel, but is constructed out of the vegetable material of the country. This creates an embankment which is compressible and has a tremendous shrinkage, and would require a large amount of ballast continuously applied for a great many years. In dry seasons, I fear train operation will cause a great many fires in the moss, and these in turn will cause smoke, which will envelop the whole country, as occurred in the very dry seasons of 1915.

We dug trenches about 10 feet deep right along parallel with the sills of the buildings we were erecting and put a timber in the bottom, and put posts on top; filled the trench back, and put the sills on top of the posts and put the building on top of that. Those buildings never sunk.

In another place we took a steam pipe, drilled a hole and put the steam pipes on it, thawed out the ground, and before it had time to freeze again with an ordinary pile-driving equipment we drove piles. Then we let the piles freeze up and put the buildings on top of them. We even put machinery on the foundation, an engine, etc., and they never moved at all.

No doubt in building a railway over the barren lands the same methods can be used. A 12-inch timber platform would isolate the frost below from the heat above.

The branch to Churchill would be about 150 miles long. I don't think there would be any grade pretty nearly level. My opinion is that Nelson can be made deep enough for all purposes. The ice action in the Nelson and Churchill rivers is somewhat different. At the head of navigation on the Nelson, 53 miles above Port Nelson, we have seen ice jams 55 feet above the summer level, and as late as the first of July banks of that height were still remaining. It is said jams have been known 75 feet high. On the Churchill the ice jams at the head of the tide 8 miles from the entrance do not appear to rise more than 5 feet above water level.

Very little timber in the vicinity of Churchill and Nelson of commercial value. We have used some 1,250,000 feet, and expect to get more.

Regarding the navigation season from the Atlantic to Port Nelson, my opinion is that in the early part of the season the ice conditions immediately off Nelson will govern, and that at the end of the season the ice conditions at the head of Mansell island will govern. The latest ice at the mouth of the Nelson estuary occurred in the season of 1917. On August 13 of that year the ice appeared to stretch in a continuous belt from Nelson shoals towards cape Tatnam, and I consider a tramp steamer could not pass through. On August 29 in the same year I found the ice stretching in a great belt just off the outer bar. Beyond this seaward the surface area of the water seemed to be densely packed, though a tramp steamer might be able to worm her way through at considerable danger to herself. Anything in the nature of buoys in the outer bar and for many miles inside it would have been carried away had they been placed. During the next few succeeding days ice was seen floating about in the estuary at within 8 miles of the island. The experiences of this particular season are extreme. In the year 1915 a Newfoundland sealer arrived at Port Nelson on the 1st of August and the tramp steamer *Sheba* arrived in 1916 on the 8th of August. They both met considerable ice. I do not think that any ship arriving at Port Nelson earlier than the 20th of August has done so, since I have been there, without encountering ice at some point or other on its voyage.

The latest departure from Port Nelson was on October 22, 1915, when the tramp steamer *Sheba* and two sealers, *Belleventure* and *Adventure*, left. The only ice they encountered was a belt about 12 miles wide near the head of Mansell island. The earliest difficulty with the ice during my stay at Port Nelson was when the tramp steamer *Sinbad*, which left Nelson on the 30th September, 1913, encountered ice in the vicinity of Mansell island, got frightened and came back to Nelson, but made a second attempt, leaving Nelson on the 13th of October, and made the journey successfully. During that same season the tramp steamer *Alette*, which left Port Nelson on the 7th of October, encountered ice near Mansell island and received a hole in her bow and returned to Nelson, wrecking herself on the 16th. Regarding extension of the later part of the season, I believe much can be done by the installation of a wireless on Mansell island and the employment of airships and seaplanes to determine the movement of the Fox Channel ice, and by notifying ships leaving Port Nelson of the areas covered by ice and those yet remaining open. The Fox Channel ice spoken of is the ice which has been formed by the winter preceding, and not by the approaching one. No one knows where it comes from or why it arrives at that time of the year.

The opinions of the various fishermen and sailors who have been in our employ at Port Nelson for the last five years have been to the effect that even though the

fish in Port Nelson were very plentiful, there is no fishing season during which it would ever pay to work them. I have often tried to get tug captains to test the fish when they would be at the outer entrance to the estuary, but I have never been able to really get much information. Some have expressed the opinion that if there were a large supply of fish on the east coast of Hudson bay the bird life would be much greater than it is. On the other hand, we do know that for periods of a week or two at a time there is quite a supply of fish in the estuary, which Indians and ourselves are able to catch by setting nets along the shore. In some cases we have used a sweep net with success, but those periods of plentiful supply are always followed by a month or more during which very few fish can be obtained, and we have never found that it paid to despatch men for this work, as the value of the fish obtained does not pay the expenses entailed, even though the fresh food was of great value in the feeding of a camp of 600 men. At certain periods in the summer the number of white whales or porpoises that cruise up and down the estuary at Port Nelson are numerous. They weigh from 1,200 to 1,400 pounds. We do not as a rule find fish in their intestines.

The amount of dredging we have done at Nelson is inconsiderable compared with what we have to do. The equipment we had at Nelson was not at all suitable for the work we had to do. For years, ever since the war broke out, we have had the greatest possible need for a couple of dipper dredges and the Government would not buy them. They said the war is over and we do not want to incur additional expense at present. The result is that we have been fiddling with the matter of dredging and we have not made any real attempt. I say the cost at Nelson would be two and a half times greater than anywhere else for anything done in the way of dredging. We cannot tell what it would cost, and what it has cost is no criterion of what it will cost.

If you hire a man you only get sixty days' work out of him and you have to pay him enough to live on for the whole year. You have to pay that man a whole season's wages for doing perhaps sixty to ninety days' work. Almost anywhere else in Canada you can get eight or certainly seven months' work out of a man and we do not get more than three.

I assume we could work our dipper dredge equipment only sixty days per year. On two five-cubic-yard dipper dredges which I tried to buy four years ago I figured only sixty days per year and only 20 hours per day, and we would get per year only 120,000 yards.

The men would go into commission about 1st of July and they would stay in commission until the 15th of October, about two and a half months, but they would lose a large part of the time due to bad weather and that kind of thing. If you need a man for sixty days, you must pay him a year's wages. For any work we do at Nelson we can employ them six and a half months and do it pretty cheaply, but when we have to go out in the water it is quite different. If we had the railroad you could probably employ men just as is done for the harbour.

Another unfortunate thing about construction work at Nelson is that it has to be done at the same time as the harvesting in the Northwest. I made an estimate of wages for a five-yard dredge. The wages per year to be about \$20,000. Labourers may get some other work after our employment ends, but the tug captain, dredge men, and deck hands are different. They may do a little, but they do very little during the winter.

EXTRACT FROM THE EVIDENCE OF MR. V. STEFANSSON, ARCTIC EXPLORER.

I have spent altogether ten winters and twelve summers north of the Arctic circle. The principal time has been spent from Behring strait in American Alaska east to Canada, and then through Canadian territory east to about 100 miles east of the

mouth of the Coppermine river; then inland to Great Bear lake and in general all over the country north and east of that lake. I have crossed three times from the Arctic ocean inland over the divide into the Yukon basin; once I crossed over the divide to the ocean again.

I have been twice the entire length of the Mackenzie once in 1906 and again in 1908, that is from Edmonton to the mouth of the Mackenzie.

Whether it is Alaska or the mainland of Canada or the Canadian islands, 75 per cent of the time we have lived on game, sometimes as long as a year and a half at a time entirely on game, without tea, or salt, or flour, or bread, or anything of that kind—just on the products of the rifle. It was the most healthful sort of life and food, and a most attractive sort of occupation. Blubber is a very valuable article of food. It is very similar in taste to cream when fresh and similar to mutton fat when it is boiled. Its nutritive value is similar to that of butter or bacon and is four or five times that of fresh lean meat per pound.

The Mackenzie is forested all the way down by spruce forests which, doubtless, will be of local value when the country becomes settled; but so far as I can see the presence of the forest is in the main a disadvantage. The most valuable country is that which is not covered by forests.

The name "barren grounds" is a libel. If you called it prairie, it would give you a more correct idea of the country. I do not say the country is identical with the Manitoba prairie, but that term would convey a fairly accurate idea of the country.

I went from Manitoba into Dakota when I was young and I was brought up there in the cattle country. At any time when I was a mile from home I could not see it, could not see anything but the rolling prairie. If at that time I had been magically transferred into the middle of Banks island I could not have told that I was not still in Dakota. If I had been a botanist, I would have recognized that the grass was of a different character, but a casual observer would not know there was any difference.

There is grass as far north as any islands that are to be found. The Ontario school geography says that the mainland of Canada north of the tree line is covered with lichens and mosses. That is absurd. They are found in low places, it is true. In Ungava it is said to be rocky, and there is little soil. Whenever you have little soil and many rocks, you have lichens growing on the rocks. But in most of northern Canada that is not so. Anyone who has seen this country knows it is a grass-covered country; lichens are a secondary form of vegetation. They are plants that flower, and commonly grow immediately on rocks.

The value of those grasses for food purposes may be inferred from the fatness of the animals that live on them.

The temperature of the country is about the same as Manitoba. Manitoba is one of the best portions of Canada, and while you may prefer the climate of Victoria, the growth and population of a country does not depend so much upon the agreeableness of the climate, as upon its resources. The climate of Manitoba is stimulating, like a cold shower. There is something to be said for a tepid and perfumed bath, but there is also much to be said in favour of a cold shower.

Sir Frederick Stupart (the director of our meteorological survey) told me that for twenty-five years he has had an observatory where I was born on lake Winnipeg. He has also had during the same period an observatory on Herschell island, in the Arctic Ocean, and during those 25 years the lowest temperature recorded at Herschell island was 54 degrees below, and 55 degrees below zero on lake Winnipeg.

If you go south from Herschell island towards the mountains, towards Dawson, you will find it getting colder and colder in the winter. In the mountains back of Dawson you have a temperature of 75 degrees below, that is on account of the altitude and the distance from the sea from Slave lake. If you were to emigrate from lake Winnipeg to Slave lake and if you did not take with you a thermometer, but depended only

on your sensations, you probably would not notice any difference in the winter. You would see of course, that the sun is lower, but I do not think you would notice much difference in the temperature although the average temperature might be five degrees lower and winter a little longer.

In the Northwest territory west of the tree line, the grasses have plenty of time to mature and that is the point, because after they once mature they keep their nourishment the year.

The musk oxen are fatter in the early winter than in the summer. The fatness of the caribou does not depend on feed, it depends on the breeding habits of the animal for instance, the bull caribou put about 50 pounds of fat on their back in September. By the end of October they do not have an ounce of fat on their backs, that is at the beginning of the rutting season they are fat, at the end they are lean, but the cows are still very fat and at Christmas time the bulls have lost their fat but the cows are still fairly fat. In February you find the old bulls begin to fatten while the cows get thinner, so you see that it is not the feed that controls the fatness, it is really the breeding habits of the animals.

The musk oxen keep fat throughout the whole year.

These grasses prevail throughout the whole northern territory, from the tree line as far north as 80 north latitude—where the soil is suitable whenever it is not rocky.

Beginning at the international boundary the tree line practically coincides with the crest of the Endicott mountains, then running east the line goes to the Mackenzie about fifty miles above the mouth across there, and it follows parallel to the coast, within fifty miles from it for some distance, and then when you get in the vicinity of Liverpool bay you find the trees almost down to the foot of the bay and the line runs across the neck of the Bathurst peninsula and near Melville mountains and strikes the valley of the Horton river. The tree line just about follows the valley of the Horton river, there being only in a few places trees to the east of it, though there is a forest to the west, and when you come down within fifty miles of Bear lake you come to a continuous forest; the tree lines run east there to Dismal lake. There are trees on the west end of Dismal lake and on the east end of it, but none in the middle. The tree line runs a little south from Dismal lake and then east to the Copper mine river. Then it extends down the valley of the Copper mine river almost to the mouth and back again; that is, just in the valley of the Copper mine, but to the east of that, by Eskimo information, I know that the trees recede farther from the coast, and that the line runs in a general south westerly direction towards Fort Churchill, and Hudson bay.

Now, the country that is most valuable for immediate development, in my opinion, is that country which has no trees, or at least country that has trees only in the river valleys, with the uplands bare. The Horton river, the Coppermine river and the Dease river are such rivers; that is, there are plenty of trees in the river valleys, but the uplands are good grazing land, extending back. That is why there are so many wild caribou there.

I think the grasses are mainly annual, but the main thing is that vegetation is abundant. It is shown by the fatness of the animals that it is also nutritious. Turnips are known as far as a little north of the Arctic circle. At fort Good Hope, which is easily six miles south of the Arctic circle they have large crops of potatoes and vegetables. Fort Good Hope is four or five miles from the mouth of the Mackenzie river.

Moose are increasing in the forestry area. A herd of caribou passed our camp at the head waters of the Dease river on Bear lake. The trail they made was four miles wide and there was scarcely a square foot in that whole area, unless it might be in the shelter of a high rock, where it was not covered with foot prints. There were probably over one million in the herd.

David Thompson, one of the early explorers of the Hudson Bay Company, says that he saw one of these herds pass him and he estimated that there were at least three and a half million in the herd. I think these herds are temporary gatherings of caribou and that a month later you would not find them in one herd. They would probably be scattered into an indefinite number of bands.

The domestic reindeer or caribou at the age of two and half years will average 150 pounds dressed meat, but the wild caribou is considerably larger, I should say 250 to 300 pounds. The reindeer and caribou are practically the same. The domestic reindeer and the wild caribou always fraternize when they meet. There are many cases in Alaska of domestication of the caribou. They are easily herded in large bands. The Americans in Alaska have made a success of the domestication of the reindeer.

About thirty years ago a missionary by the name of Sheldon Jackson began to advocate the introduction of reindeer into Alaska in the interest of the Eskimo and he finally was able to convince the American Government, and between twenty and twenty-five years ago they introduced 1,280 reindeer into Alaska. These 1,280 reindeer have developed into 170,000 and since two years the meat has been on the markets.

The meat is good and sells higher than beef, although it can be produced very much cheaper. About fifty animals to the square mile have been raised on some ranches year after year.

The herds are increasing at the rate of doubling every three years. Eskimos are used for herders, the herders are usually on foot, but they occasionally ride the reindeer themselves. They drive around on reindeer sledges, which are sometimes like toboggans. They herd them as we do large herds of sheep, and if you will come and see my motion pictures you will see dogs driving reindeer exactly in the same way as sheep dogs drive sheep. They tend to roam somewhat like cattle and stampede somewhat like cattle.

The snow fall in the north is very slight, so that you can see the grass sticking up through the snow. The animals seldom have to scratch for it, they can get it easily. The snow fall in the Northwest territories is not more than one-quarter or one-half as heavy as in Manitoba, and what little snow does fall much is swept away by the wind into the deep ravines or into the lea of the hills. On 95 per cent of the land you can see the grass sticking out here and there through the snow.

The area of pasture land in Canada suitable for these animals is estimated at three million square miles, so that the actual grazing land at a conservative estimate would be one million square miles, which would support fifty million reindeer.

The musk ox is a better animal than the reindeer for many reasons. He does not stampede or roam, then they have the faculty of defending themselves, if a wolf or stray dog were to attack them he could not kill or drive them away. I estimate the number of musk ox on Melville island is about 4,000. I should think there would be anywhere from ten to twenty thousand musk ox on the mainland of Canada and on various islands. If you start with a herd of five or ten thousand domesticated reindeer you can incorporate each year a certain number of wild reindeer. As to their length of life, Mr. Lindeberg, of Nome, Alaska, has a reindeer cow still breeding that has had 26 cows. She is 28 years old. One of the advantages of musk oxen is their wool. A musk ox produces about 50 pounds of excellent quality of wool each year. Just now it seems that the musk ox is the most valuable animal in the world, if domesticated, he needs no hay, and no barns to shelter him. He could not be killed by blizzards and hardly by wolves. He produces three times as much meat as the domestic sheep and three times as much wool, and no one could tell the meat from beef.

The wool is of an excellent quality and one manufacturer is now engaged in making cloth from it. I should say they would dress on the average 400 pounds under domestication, but you would not kill them under four years old.

My suggestion is that a permanent experimental station be started on Melville island, bring a certain number of animals in each year and gradually accumulate a herd and eventually the business after it had become established would extend further south and to Labrador.

You find musk oxen within 400 miles from the north pole, and they are grass eaters. There is plenty of coal in all those islands except Victoria island, plenty in Banks island, Melville island, Ellef Ringnes Island and Amund Ringnes island.

During the winter we spent on Melville island we had two camps, 90 miles apart, both located at coal mines. One produced a bituminous shale that would leave a residue, almost the same size and shape as the piece that you would put in the stove. The other was a good quality of coal similar to the Ladysmith coal which we carried on one of our ships.

I think Churchill would be the best place to establish a musk-ox ranch because we know that it is good musk country. They have inhabited the vicinity within the last hundred years. It is convenient to the Hudson Bay railway and I have a good deal of faith in Hudson strait. The land we are speaking of is the coming great grazing country of the world. This and the tracts are in the same latitude in Siberia. In temperate lands the raising of potatoes and apples and wheat are more profitable. The semi-arid lands of Washington, Arizona, and Alberta are being converted into agricultural lands by irrigation. The grazing lands are consequently getting less and less and the price of meat and wool will not come down; and if we continue to be a meat-eating and wool-using people the vast lands of the north will have great value. The people who tell me about the difficulties of navigation up north commonly exaggerate them. The basis of our success in our last expedition was the fact that we ignored the people who harp on supposed impossibilities. They told me exactly why it was impossible to do the things that we have since done. People who should have known better had no faith in the food-producing power of the north. I started north over the ice from Alaska, carrying no food. The authorities were against it and said it could not be done safely—starvation would inevitably result—but we never missed a meal, our dogs never missed a meal and we travelled 10,000 miles without losing a dog. Our critics had completely under-valued the resources of the north. A most outrageous thing, I think, is to say, as our school geographies do, that the northwest country is a country covered with lichens, part is in fact forested and the open country is mainly prairie country, grasses and not lichens form the main part of the vegetation. You do not find muskeg and moss except in rocky places. Wherever the land is level and not rocky you find grass.

I have seen coal in nearly every island north of Canada. There is a copper-bearing district from the northeast country of Bear lake, running 100 miles east by 200 miles north, where copper is well known to outcrop here and there. At present the cost of mining that copper is prohibitive but if you once got the country settled the cost of mining would be reduced and the other resources of the country will in general increase in value through the settlement of the country that will result from the taking up of the reindeer industry.

The fishing in Great Slave and Great Bear lakes will probably be found to be the best in Canada, the best in the world. I have seen trout weighing 50 pounds up there. The bays begin to freeze over about the 20th October and by the 10th or 20th November the whole lake is frozen over.

I do not know of any evidence to show that the tree line is going south. I do know a good deal of evidence in the other direction, because the glaciers in Greenland and southern Alaska are retreating, getting smaller every year. So far as we know the climate is getting warmer. We have caught codfish in the Arctic ocean which seemed to be identical with the Atlantic cod. We caught herring in tremendous schools in 100-fathom sweep nets. You would get a boatload practically at a sweep. Then there are whitefish and many other kinds of fish. In starting a herd of reindeer in the north

in my opinion you should secure Alaska reindeer for the west side and Norwegian reindeer for the east side because it is more convenient. The Alaska reindeer is a better breed but larger than the Norwegian but it is very easy to take reindeer straight across from Norway past Iceland to Hudson bay. It is a short ocean voyage.

The reason Dr. Grenfell did not make a success of his reindeer venture was that he started on too small a scale. Both the reindeer and musk ox will give substantially the same return in meat and in wool that our other animals do, without any hay or barns, without any coddling, and with very little care. There are two things that musk ox need in the way of care. One is that they do not at the present time breed at the right season; that would have to be arranged for, just as we do to-day with our domestic sheep. You would also have to protect them from wolves at the calving time; reindeer you would have to protect from wolves all the time. I would say that one of the things that the Government ought to do would be to exterminate the wolves of northern Canada; that may seem to be a big task, but it is not when you look at the returns you would get. The Americans are exterminating their wolves. They do it by employing rangers. Each ranger costs the Government from \$4,000 to \$5,000 a year, but he turns in all the skins and their sale brings back to the Government most of what they pay to the ranger.

There are a few ptarmigan in the southerly islands, geese and ducks are numerous in the southerly islands but very few farther north. Musk ox will never cross ice. If we once get musk oxen on Melville island, their descendants will never leave it. Caribou, however, migrate between the islands. You will find caribou on every island.

EXTRACT FROM THE EVIDENCE OF CAPT. NORMAN E. FREAKLEY,
HUDSON'S BAY COMPANY NAVIGATOR.

I am a navigator in the employ of the Hudson's Bay Company. I have been navigating Hudson bay and straits since 1898, in both steam and sailing vessels. The first were the old sailing vessels that the Hudson's Bay Company used; they were especially constructed for the Hudson bay and straits trade, being strongly built to contend with ice conditions. I have also navigated Hudson bay and straits in an ordinary wooden sailing vessel which had been strengthened specially for the voyage, and latterly with steamers which were specially constructed for the seal fisheries on the Labrador coast, where they have to contend with heavy ice conditions. These vessels are very much the shape of the ordinary steamer, only, perhaps, not so full in the bottom, and the bow is so raked that in striking the ice they will slide up on it instead of striking a solid blow. This special bow probably reduces the carrying capacity by 5 or 10 per cent; it would not exceed 10 per cent. I have navigated Hudson straits the end of October. Difficulties arise in the vicinity of Mansell and Nottingham islands and cape Wolstenholme. The late ice coming down Fox channel blocks the entrance to the west end of Hudson straits. It comes down Fox channel and swings eastward through Hudson straits to the Atlantic. In the bay, as far as I have been able to learn, the general set of the current is south down the west side, east across the south end, at the entrance to James bay, and north by the east coast, thence into the straits. That is the general trend of the current, although this set is affected to a lesser or greater extent at different points by the diurnal rise and fall of the tide and by the outflow of the large rivers flowing into the bay. There is a considerable northerly set of current up the east coast of Hudson bay between the off-lying islands and mainland of Ungava; this current attains a velocity of 4 miles an hour in places. Some of the Fox Channel ice may find its way into the bay, but the greater part of it swings to the east when leaving Fox channel and passes through Hudson straits into the Atlantic. The ice met in Hudson bay is formed there and does not come from Fox channel.

Towards the end of October the last ship to pass eastward through Hudson bay and straits from Port Nelson, in 1915, was the tramp steamer *Sheba*, convoyed by the sealing steamers *Adventure* and *Bellaventure*. These three vessels left Nelson on October 22, 1915, for Halifax, and got through safely. In 1904, however, one of the Hudson's Bay Company vessels had to turn back from Mansell island on October 17, on account of ice. She wintered at Charlton in James bay. This, however, was a sailing vessel; probably had she been a steamer she would have got through, but it is dangerous to put any vessel into heavy ice so late in the season. You will readily understand that in entering ice in the spring or summer you do so with the knowledge that even if you are stuck it is only a matter of time before the ice will ease up and release the ship again, whereas late in the season a vessel becoming caught is liable to remain all winter, if she is not crushed and totally destroyed by ice pressure.

There is no particular channel through Hudson straits or bay. The straits never freeze over from end to end and remain so for any length of time. According to reports from Hudson's Bay Company's posts situated on the north and south sides of Hudson straits, the straits never freeze over entirely, but there are vast fields of ice passing through from west to east all winter. At times the straits are completely blocked by these fields and at other times there are extensive areas of open water.

The general set of the current through Hudson straits is from west to east. There is a constant southerly set down Fox channel swinging to the east around cape Dorset and between Salisbury and Nottingham islands, joined in the vicinity of this point by the current which flows up the east side of Hudson bay and into Hudson straits between Mansell island and cape Wolstenholme. From the east end of the straits part of the Arctic current flowing down the west side of Davis straits enters Hudson straits by Resolution island and flows west along the north shore of Hudson straits as far as Big island; at this point this current is met by the current from Fox channel and Hudson bay and diverted southward across the straits to the south shore of Hudson straits. In other words, the current in Hudson straits may be divided into three movements, the easterly current from the west end of Hudson straits on both sides as far as Big island, the westerly current on the north side of the straits from Resolution to Big island and an easterly current on the south shore of Hudson straits from opposite Big island to cape Chidley. At points these currents attain a great velocity. At some places seven miles per hour at spring tide. They are generally stronger along the shore than at mid-stream. The danger to any vessel caught in heavy ice in one of these currents would be obvious. There are no icebergs in Fox channel or Hudson bay and comparatively few in the west end of Hudson straits, but numerous in the eastern portion of the straits. Coming from Davis straits they enter Hudson straits on the north side, with the aforementioned current, passing up Hudson straits on the north side of Big island; there meeting the eastern flow of the current, they swing across the straits to the south and pass eastward to the Atlantic along the south shore. Bergs are rarely if ever seen west of Charles island. These bergs originate presumably in Greenland. Field or pack ice only comes down Fox channel. In thickness it would run from one to one hundred feet.

At Nelson or Churchill the bay freezes from ten to thirty miles from shore, varied according to the season. I have wintered at Port Nelson and also at James bay.

During my stay of three and a half years at Port Nelson, 1913 to 1917, the earliest ship to reach that port arrived on the 1st of August, the latest the 22nd of October. The bay ice is of a different type to the Arctic ice; it drifts in large floes and consists in part of frozen snow, whereas the Arctic is heavy blue solid ice. In the centre of Hudson straits there is a light current of probably one or two knots an hour, along the shore, in places, four or five to seven knots.

It is customary if ice conditions permit to make a straight and as short a course as possible through Hudson straits. When there is ice it is advisable to enter on the north side taking advantage of the westerly current and avoiding the heavy tide rips

around cape Chidley. Early in the season open water is most likely to be found on the north side. Coming out late in the season vessels keep more to the southward and pass between Button islands and cape Chidley, if they are able to make this point with day light.

Ice in the straits is drifting field ice although it may be temporarily jammed.

Ordinary tramp steamers have been employed by the Department of Railways and Canals to run between Halifax and Port Nelson, for instance, the steamships, *Alcazar*, *Sinbad*, *Sheba*, *Sharon*, *Durley Chine*, *Cerense*, and *Allette*. Of these, the *Cerense* was wrecked at the mouth of the Nelson river on September 13, 1913, and the *Allette* leaving Port Nelson on September 14, 1913, encountered ice and damaged her bow. She returned to Nelson and was beached on October 7. It is possible that a tramp steamer leaving Halifax early in July might be six weeks getting to Port Nelson, whereas, in September she could make the passage in eight days. September and early October are the most open months in the year. I have seen steam sealing vessels stuck in Hudson straits for several days unable to move. A specially constructed steamer could buck ice that would stop a tramp.

The earliest I have passed through Hudson straits and bay was with a sailing vessel. We arrived off the Moose river in James bay on the 29th of July.

I have been at Port Churchill several times. It is not very large. Churchill harbour has an area of about one and a half square miles, and of this about half a square mile is suitable for anchoring ocean-going vessels. On account of the depth of the water there is room for three ocean-going steamers to swing at anchor. Spring tides are 16 feet, neap tides about 11 feet. The entrance to Churchill harbour is clearly defined and is about 2,000 feet in width with 1,100 feet between the 18-foot contours. There is as much as 90 feet of water in the channel and not less than six fathoms outside. The current through this entrance, at ebb tide, is 5 to 6 miles an hour, but the entrance from the sea is short, not much more than its own width.

In the small area before referred to there is about 30 feet of water; this shoals gradually on the west side but is fairly deep inshore on the east side.

With a strong northeast wind, or gale, a swell heaves in from seaward, but not enough to bother a large ship. The holding ground is not good and a vessel is likely to drag with the wind in this direction, but with a moderate steamer it is a safe harbour.

Nelson is a different proposition altogether. It is more open. Churchill is a land locked harbour, whereas Nelson is an open roadstead with a long channel to get into it.

It was Marine Superintendent for the Department of Railways and Canals at Port Nelson for over three years, during which time I superintended the buoying of the steamer channel, the piloting of the steamers in and out, and the lighterage of the freight to and from the steamers. The highest tide on record at Port Nelson was 20 feet; average spring tides 16 feet and the neap tides about eight. A vessel of 3,000 tons is large enough to navigate the Hudson straits and Port Nelson under present conditions. There would be no difficulty in navigating a vessel of 5,000 tons through the straits provided you did not encounter ice and she did not draw too much water for Nelson river.

The big grain carriers of the Great lakes draw about twenty feet. I do not think the ordinary lake grain-carrying vessels would be fit to navigate Hudson straits. Provided ice is not encountered, there is no limit to the size of vessel that can navigate Hudson straits.

While lighthouses and wireless stations, fog and signals and hydroplanes are necessary for Hudson straits, I do not know if the aids referred to would lengthen the season, but it would make a considerable difference in the length of time for the vessel's passage and the vessel by making shorter trips could make a greater number of them. We are liable too to have snowstorms or hailstorms at all seasons, but they do not interfere more than they do with navigation around the Nova Scotia coast

during the winter. Some years are better than others for navigation through the straits. Ice breakers would not be of much use in the straits. Ice in the straits proper is more or less continually on the move. I think a powerful ice breaker could keep the Churchill and Nelson rivers open, but it is the ice in the Hudson straits that controls the situation.

I have landed cargoes at Nelson and Churchill and as a ship master I would say that Churchill is the easier to get into and best sheltered harbour of the two. Vessels approaching Nelson get in touch by wireless and the pilot is picked up about 20 miles from the inner anchorage. The difficulty starts in picking up the mouth of the river. The vessel approaching Port Nelson first makes the land in the vicinity of cape Tantam and steers westward, keeping in about 9 fathoms of water until Marsh point is sighted. The course is then altered to the northward and the ship anchors in the vicinity of the outer buoy in about six fathoms of water. The coast line in the vicinity of the mouth of the Nelson river is very low and difficult to see except in very clear weather.

The outer buoy is about twenty miles from the inner anchorage. The channel is buoyed each season as soon as the ice is out of the river, the buoys being taken up again in the fall as soon as the ice commences its reappearance. They are laid about the end of July and taken about the end of October.

Range lights would be useful specially in the early season or late season when the drifting ice might move the buoys. I would also suggest a light-ship in place of the outer buoy about twenty-five miles out.

Docks are under construction but not yet built. Nelson is not a natural harbour but an open roadstead. The vessel lies in the river about one and a quarter miles from the shore and the freight is lightered to the land.

One is a natural harbour and the other is artificial. At present the deep water area has only capacity for three steamers, each say 400 feet long, to swing clear of one another at anchor. With dredging and dock accommodation many more vessels could be accommodated, according to the form of docks constructed. Regarding the construction and cost of the same, that is a question I would refer to the engineers to decide. Speaking as a mariner, Churchill is undoubtedly the more accessible harbour of the two. From a mariner's point of view, Churchill harbour is more easily approached, entered, and offers more shelter at present than Port Nelson. As far as I know, the bottom of Churchill is composed of hard-pan and loose stones, affording a poor holding ground for anchors, whereas the bottom of the Nelson river, at the anchorage, is clay or mud strewn with boulders and stones. I should judge the two places are very similar, but the bottom at Churchill is somewhat harder. All coasts between are liberally strewn with boulders. The entrance of Churchill harbour is short and deep, while the entrance at Nelson has a channel about 20 miles long, with 20 feet of water at low tide over a boulder strewn bottom. The rock outcrop is on both sides of Churchill harbour. There is no rock outcrop at Nelson at all. For general navigation in these waters I would say a vessel of 3,000 tons is best. Any vessel larger, especially ships of 10,000 tons, would be unwieldy amongst ice and would have too deep draught. A large vessel is slow in turning and must have considerable headway to give her steerage way; this necessary headway would prove disastrous if she struck anything, and it is impossible to navigate amongst field or packed ice without striking at times. A 10,000-ton ship, say, with her engines stopped and the headway off her, swinging round with the wind, should she strike on a big floe of ice, would damage herself considerably by reason of her own great weight, whereas a smaller vessel would sustain no damage. A 5,000-ton ship would not be easily handled amongst heavy ice, but if properly protected it would help considerably.

The ice goes out in Churchill about the same time as in Nelson, but both Nelson and Churchill are clear of ice before any vessel can pass through the straits in the spring, and the straits are again closed to navigation before the rivers are frozen up

in the fall. So far as Nelson roadstead and Churchill harbour are concerned, ice goes out about the middle of June, and navigation could start there about the middle of June, but the straits are not navigable at that time. Navigation is closed about the last of October or first of November. During the season there is no trouble getting a ship into Churchill, the entrance is well defined on both sides and is deep. It is like going into the harbour of St. John's Newfoundland.

Northeast is the worst wind that we have at Nelson. The northwest wind is off land and would not trouble us. With a strong northeast wind and ebb tide there is quite a choppy sea at the mouth of the Nelson river. I would not attempt to take a ship in there under certain weather conditions. I would go into Churchill at any time, as long as I could see to pick up the entrance to the harbour. I would not attempt to go into Nelson at low water; I would wait for the high tide. Leaving Hudson straits and bay out of the question, the *Nascopie*, of 2,600 tons, might navigate Nelson from July until November.

In the winter of 1913 local craft was put into quarters at Nelson on the 16th of October; in 1914 on the 19th of October; in 1915 on the 23rd of October; 1916 on the 18th October.

It is difficult to keep the buoys in place when there is ice drifting in the river. These should be lifted as soon as the ice starts to make, and navigation, if continued, should be done with the use of range lights or beacons. The rime forms around the buoy, which makes it difficult to tell from a distance whether it is a buoy or a knob of ice.

EXTRACT FROM THE EVIDENCE OF CAPTAIN J. E. BERNIER, ARCTIC EXPLORER.

I have been on nearly every island in the Arctic, except the new islands that were found by Steffansson. I have been navigating since 1904 in three different ships. I have been in Hudson bay on three trips. The ice is one of the difficulties that close the eastern part of the straits; that is, it takes two seasons before the ice comes down. The icebergs come from Greenland down along the coast. There are two kinds of ice that comes down here; the old ice, that is, what we call the growlers. A growler is a piece of ice irregularly formed. You cannot tell the depth of it when you see it. It is very hard to navigate a steamer there. About the end of October it comes down and closes the straits so that after October there is danger of the ship meeting that old ice during a gale. It is very important that ships should be built especially for ice navigation. The *Fram* was built for ice navigation and survived. The *Guss*, afterward called the *Arctic*, is a ship that has done eleven years and is now as good as ever; also the *Rooseveltdt*. These ships were built especially for ice navigation, and they have stood the test, they have done their work, and they are proofs that for navigating in Hudson bay and the Arctic ocean, where there are four different kinds of ice it is necessary to have ships especially built for ice navigation. It is a mistake to send in tramp steamers. They may sometimes hit a piece of ice, and if it is old ice the ship is done for. The ship should be double-framed forward and have thicker plates. She has to have good power. The extra strength would reduce the carrying capacity by about 5 per cent. You only need to strengthen forward. Once you pass amidships, the after end never strikes the ice, except sideways. The hull should be shaped so that the ship will go on top of the ice, instead of pushing. The hull must have a forward slant so that when the ship encounters a big piece of ice she will go on top. She shakes herself, displaces that ice, and goes on. When you are pushing a piece of ice, when there is other ice in front, you have to push the whole thing. You have to do the same as is done in Siberia. All the ships there have the bow so shaped that the ship will go on top of the ice. This ice is, of course, loose ice.

During the spring the Fox channel and the bay, which is a very large area, discharges this ice towards the strait and that is the reason that in June especially the channel is pretty well filled. But a vessel built for ice, if there were wireless stations on Resolution island, Ashe inlet, and Cape Wolstenhome, could be advised on which side of the channel there was the least ice. In the past when we came from the sea, we had no information whatever, and if we happened to get into the ice and the pack closed, we had to go back or wait, and it would not suit a fast vessel to wait. But if she got wireless messages she could make the clear water. One day's wind would clear the ice away from the coast, and then the vessel could go in, she could make the 250 miles in a day. In the bay there is what we call an ice raft. That breaks away from the coast and seems to gather together. That ice would not hamper a modern vessel. In the fall of the year part of the north Fox channel ice breaks off and comes down in here, and closes this part in the last days of October. I went in on the *Arctic* on the 13th of October, and I found a good deal of ice, and went south of Mansfield and never saw ice after that. I went to Fullerton and arrived on the 16th of October. There was no ice whatever in the bay, nor in the east part of the strait, except a few icebergs and they were no impediment. I should say after November a vessel could not pass the straits but could navigate in the bay. When you enter the strait you have 55 per cent of variation; when you get to Churchill you have none, therefore a ship has to change its course very often to meet that. Since the Government has taken hold they have corrected the variation, they have found out the right variation and that makes it far safer now than it used to be.

Aids to navigation will give a captain pointers as to where to pass at certain times. I don't think these aids would lengthen the season any more in the fall than say late October or 1st of November. If we have information from the shore, that knowledge may perhaps mean a trip more for the ship. I would think that in clear weather seaplanes would help a great deal, but not in the fog, which is like a wool sheathing, the same as we see it on the mountain top. Observation from the land would be safer. If you got your position from the wireless station it would help, otherwise sometimes when you are in the ice for three or four days and the tide is running back and forth your position is not very certain and it becomes dangerous. If we had a proper ship we could go through the straits up to the 1st of November, and I think with the help of wireless we could go through there in June. Whalers used to go through there in June. Captain Adams and Captain Comber used to go early in July, sometimes in June. They had no steam power. I think, with properly constructed vessels, you could navigate from the 15th of June until the 1st of November.

I do not think it would be advisable to go later than that, because you would have to go through that big old ice. A proper vessel would go through all right, but it would not be any benefit to be at Churchill or Nelson any earlier than that.

The average season of navigation is four months. With wireless I would say four and a half, perhaps.

In midwinter there is open water in the straits sometimes, but the ice is struggling to go through Fox channel eastward. There is always ice moving out. An ice breaker would do away with lots of the difficulty, but against that you would have a lot of trouble navigating because of fog. Sometimes you can see land when you are ten miles away; other times, when you are five or six miles away, you would think you were right on it. This is not really fog; it is steam caused by reason of the water being warmer than the air, and a kind of vapour rises higher than your mast.

You would not be able to see the ice to go through. You could not pick out a lead. You might put your nose into something that you wouldn't like.

At the entrance of Hudson strait there is any amount of codfish. I did not fish in the bay, but we found tommy-cod, which would show that there must be some codfish. Further east we used to take two or three hundred fish a day. At Fullerton we caught a

few halibut, but no cod. We caught salmon further north. When I was north of Baffin Land I found that every river along there was teeming with fish. I had the best market in Quebec for the fish I brought from there—salmon trout. They weigh from ten to fifteen pounds. Some of them are speckled. I wintered seven winters on those Arctic islands.

There is plenty of grass on all the low lands, any amount of vegetation and caribou. On Melville I saw many hundreds of caribou and musk-oxen. There is especially on Melville, Banks and Victoria islands a great deal of animal life.

There are snow squalls in the straits in the summer. Sometimes I have gone through a snow squall for four hours, and then all of a sudden the weather has cleared.

Probably in the latter part of October, if there is a strong northeast wind, and if the ice is coming down, it may close the straits for a whaler, but for a steamer of the ice-breaking class, that would not stop it. Our experience for years has been with the heavy vessels. I found coal on mostly all the islands. I found coal on Melville island, and Banks island, and at point Barrow. It is a brown lignite of old formation. I have been working there, at Ponds inlet and Salmon river and Miles inlet, from Baffin Land. There is a large deposit of coal there, a vein seven feet thick. I took enough to coal my ship back. It burns equally as well as Sydney coal. It has more gas in it. I might describe the residue by saying that the engine and everything gets coated. It burns well. The residue is like the ashes of wood, or grass probably. It slacks as soon as it is mined. We found no difficulty in burning it. You could mine it in the winter time and get a vessel to go through the first thing in August and she would have to leave there by the first of October, that is at Baffin Land.

I should prefer port Churchill, because a ship can come in and she is in a harbour. In Nelson you have to anchor away out; before you get a chance to come in you have to contend with all that danger. Suppose you dredge there and next spring is an exceptionally fine spring and there is a heavy thaw. Your channel is filled up with sand and the channel is somewhere else. The work that you have done is lost. At Churchill you have a big body of water. Of course, some dredging would have to be done. It is land-locked. There (indicating Fort Churchill on the map) is the work of nature, and when a man has to work against nature there is no money in it.

Going into Nelson when the weather is clear you can go in at any time. When the weather is foggy you have to wait out there for three or four days. The channel is so far away that you can hardly see the land when you are anchored, and sometimes when it is not very clear you may be ashore before you see the land. From the nautical point of view, I prefer Churchill. The tide, too, is less at Churchill than at Nelson. There are good harbours in Hudson straits, useful as harbours of refuge. Port Burwell is a good port except in southerly winds. The gales there are squally. They are not usually steady.

The strait of Belle-Isle is navigable from June to December. The size of the ship in Hudson bay does not matter. It depends on the port you are entering. I should say 4,000 tons, if you find a suitable place for loading and discharging. Any ordinary size of ship could navigate in Hudson bay and strait. The size would not matter, as long as the vessel was a sea-going ship and properly built for ice navigation. A large ship can be used in the bay and strait.

EXTRACTS FROM EVIDENCE OF COL. WM. P. ANDERSON, MARINE DEPARTMENT.

The consensus of the testimony gained from a study of the reports and from statements of experts is that the Hudson bay and strait are navigable for a minimum of three months and a maximum of four months in the year with specially protected vessels. So far as I can judge, the navigation conditions of Hudson bay and strait would be about the same as navigation conditions in the White sea. Conditions

throughout the north country, when you get accustomed to them and understand how to meet them, are never as bad as you expect them to be. That has been our experience everywhere. There would be about 25 per cent loss in cargo capacity by reason of the necessary strengthening of the vessel and about the same additional cost in construction. A heavy ice-breaker might take in a convoy of ships during the open season. We have more information about the navigability of the strait than we have about the bay. I think myself that it is probable that on the west shore of Hudson bay navigation would be possible for a longer period than it would out into the Atlantic. The west shore of Hudson bay is gradually sinking; consequently you have a condition of wide flats, both on land and out from the shore. This goes almost practically all the way from Chesterfield inlet to Nelson, excepting off Churchill. The whole of the shore from Chesterfield inlet is low; at Churchill itself there is good water in the approach; but the shore between Nelson and Churchill and between Churchill and Chesterfield inlet is shoal. There is nothing to impede the entrance to Churchill from the outside. The evidence seems to show that the Hudson bay is less encumbered than the strait and that the season is somewhat longer.

It does not freeze over, but it freezes out for several miles. With the help of an ice-breaking steamer you can always get through from 12 to 15 inches of board ice. I think that would lengthen the season at Churchill to about five months. Personally, I feel satisfied that there is going to be quite a large trade in Hudson bay itself, independently of the strait, from fish and pulpwood and possibly minerals. My opinion is that snow squalls are more frequent in that country than fogs; they are not really fogs, but water chilled by the air. I do not think this would affect navigation when there is much ice. From the 1st August to the 1st November is the normal period of navigation of the strait. You might get in a few days after the 1st November. The season varies from year to year. It was the middle of August the year I sent up a man with aids to navigation, with automatic lights, unwatched lights to be put up at salient points in the strait and bay, and he was so much delayed in getting the work done that he could not finish it that year. Aids to navigation would help. Most of the navigation of the straits has been done without any help in giving a man assurance of his location. If a sailor can get an absolutely certain point of departure it is a great help to him. I think seaplanes might be of advantage in advising a ship by wireless where the ocean leads were and where the best open water was.

I think to establish an aeroplane station on Mansel island and wireless aids ought to be of valuable assistance during the navigable season. I do not think it would extend it. It would make navigation more regular. I do not attribute much importance to the ice that you will meet at the east end of the strait—the berg ice—that can be dodged. I have seen a good deal of berg-ice conditions in the strait of Belle Isle and up the Labrador coast, and it is easy to dodge that. It does not close up and it does not crowd you ashore, or anything of that kind.

There would need to be more than one aeroplane station. It would require one at each end. The strait is 500 miles long, and would require two or perhaps three aeroplanes. I would rather have more aeroplanes and less wireless stations. The aeroplane can get a birdseye view over a large extent at once. To be of use you ought to see a lead for fifty miles. I think an aeroplane would be more suitable than a seaplane.

EXTRACTS FROM THE EVIDENCE OF LANCE CORPORAL RICHARD WHITE, NAIN, LABRADOR.

I reside at Nain, on the Newfoundland-Labrador coast. I have lived there since 1912. I have been through Hudson straits to Hudson bay. I know Port Burwell. As a rule the eastern entrance of the strait is blocked with ice in November.

The Indians have told me, natives who live at Port Burwell, that during the winter there is more or less open water in the straits. Local ice never forms there, except in the protected bays and coves on account of the current, but the ice comes down through Davis strait and from Fox channel. The ice in the Atlantic entrance is principally from Baffin bay and Davis strait and that the bay entrance is from Fox channel principally.

Ducks and aquatic birds are killed by the natives all during the winter at Port Burwell. They hunt seals in the winter and use their kayaks. I have been in the straits as early as the first week in August but I was never there after the end of September. If it is the intention to navigate the waters of Hudson bay and strait, I think aids to navigation like areoplanes, to discover the leads through the ice, and wireless telegraphy would be of great advantage. There is a very valuable sea trout fishery at Port Burwell. Every river in that vicinity is teeming with large sea trout. And in the past there was a considerable cod fishery carried on there by a steamer from Newfoundland. Cod fishing is done by the natives at Port Burwell. There are halibut banks there, but they are some distance off the coast. I never heard of any herring. The only other sea animals are the seal, the walrus and the white fish, that is the white whale, numbers of which are caught. They often catch the white whales, in the seal nets. They get enormous quantities of seals there. White whales run from 15 to 25 feet in length.

EXTRACT FROM THE EVIDENCE OF EDWARD E. PRINCE, DOMINION
COMMISSIONER OF FISHERIES.

I have for twenty-five years paid special attention to Hudson bay fishery resources. I have been to Nelson river, Saskatchewan, north of the Pas, and west, in what you might call the basin of Hudson bay. I went overland, not by Hudson strait.

On the western shore of Hudson bay and James bay, the shallowness is extreme, and the large amount of ice which forms and breaks up and moves about backwards and forwards there is rather a menace both to fish life and to the food of fishes. One would not expect to find very large fishery resources there, but on the eastern coast of Hudson bay conditions are different. You have deeper water and high shores and a great number of islands, which shelter the water, and I have evidence that there is a real abundance of fish on the east side of Hudson bay.

There are three sections to the fisheries; first, those of the open sea, second, the estuary fisheries or the fisheries of the mouths of rivers, and then there are the fisheries of the rivers proper and the lakes. Fish occur there, undoubtedly of the cod family, and the food of the cod occurs. I got from Dr. Bell specimens of capelin, caught at Moose Factory. Cod always follow the capelin, and the scientific man would say that where there are capelin, cod should occur.

There are several kinds of cod. The Arctic cod and the true cod do not extend very far into the bay. They are around cape Wolstenholme. The west of Ungava bay is, I think, about the last locality where true cod are got—the large cod. But there are several species of cod in the Arctic. One is called the Ogac; another is the Saida.

The true salmon does not appear to be frequent in Hudson bay. Its northern limit is, I think, Ungava bay. The Hudson Bay salmon is called Hearn's salmon, after the British explorer Hearn, which runs from 2 to 18 pounds weight.

They are very abundant; they are a migratory fish and go in and out into the bay and up the rivers again. The famous explorer Ross said that the fish were so abundant that he could almost walk upon the backs of them in Big Whale river.

Then there is a sea-trout and flat fish. There is also the large white fish. White fish are typical fresh water fish, but in Hudson bay quantities come down and hang

about the estuary. They are valuable food, they range up to 6 pounds. Then there is the lesser white fish, sometimes called herring, corresponding to the so-called lake herring, which are quite abundant. They are better than the sea herring having less bones. Then there are gold-eye herring and true herring, and ling. Ling belongs to the cod family. It is a very ugly fish with a large head something like a white fish.

Because of the cold water these fish are better than those produced in southern waters. Mr. Stefansson said he considered ling one of the best fish for food. Its liver is regarded as a dainty.

There are jackfish or pike in the rivers or lakes, and the landlocked salmon occurs. Also the sturgeon in practically all the rivers of Hudson bay occur. It is the King sturgeon. Sturgeon yields a variety of products such as oil and leather, and the caviar or salted roe is a valuable product; the flesh is good. They weigh sometimes 100 pounds.

All reports are that fish in Hudson bay, particularly on the eastern side, are extremely abundant. The white whale is the most abundant of the whale tribe, especially on the west side of the bay. The natives eat them. They eat the flesh and eat the skin, regarding it as a great delicacy. It is jelly like, and good leather is made from the whale skin. There are immense schools of them that could be harpooned from canoes or driven ashore in bays. The oil is exceedingly good. They are from 1,200 to 1,500 pounds in weight, feed mainly on capelin. The narwhale also occurs there and is 12 feet to 16 feet in length, but is quite valuable; has a long ivory tusk and one of these is now worth from \$60 to \$80. The walrus is also plentiful. It yields ivory and hide and blubber—the total weight of an average specimen is about 2,000 pounds. The walrus is really being decimated, great numbers have been killed simply for the ivory.

The amount of ivory got from Marble island, by United States whalers, was extraordinary.

The polar bear is extremely valuable and comes in the fish class, almost, because he is more in the sea than out of it. His hide makes him very valuable while the weight of the flesh may be from 800 to 2,000 pounds.

I think the Alaska salmon should be introduced into Hudson bay. They are very productive and I think they are well worth experimenting with.

There is also the Inconnu—it is something between a salmon and the white fish—runs up to 40 pounds in weight. It occurs in the Mackenzie river, also in Great Bear lake waters and Great Slave lake. It might be introduced into Hudson bay.

The fish in the lakes south of Hudson bay are largely white fish and grey trout, sturgeon and pike perch. The last we call the dore—the yellow pickerel.

EXTRACT FROM THE EVIDENCE OF JOHN LAMBERT PAYNE, STATISTICIAN, DEPARTMENT RAILWAYS AND CANALS.

I am statistician for the Department of Railways and Canals. For a number of years I have given very studious attention to the proposition of a railway to Hudson bay. I have been studying the problem from the standpoint of its practicability as a railroad, and in that connection it seems to me that you have three problems indicated:—

- 1st, that of traffic;
- 2nd, that of storage;
- 3rd, that of ships.

You must have traffic for a railroad. What prospect is there for traffic? You have west of this railroad a very large wheat-growing area. Regina is related to Port Nelson in like manner as it is to Fort William. If you assume that 100,000,000

bushels of wheat could be diverted to the Hudson Bay railroad, then you would have a traffic of 3,000,000 tons. This wheat will be taken to Liverpool. Assuming that the freight rate is equal to that of the C.P.R. between Regina and Fort William you would have these 3,000,000 tons to transport on that basis, that is, carried at the rate of .620 cents per ton per mile—that is the exact equivalent of 24 cents per 100 pounds between Fort William and Regina. Now on that basis if this railroad should be fortunate enough to transport 100,000,000 bushels it would earn \$7,890,000 in round figures.

Now, as to the cars coming back. On the C.P.R. 35 per cent of all cars that are moved eastward are taken back empty. All railroads have that problem of the empty car, but this railway has it exaggerated to a very high degree, there would be so little return traffic. Of course that same condition has already arisen in every new country through which a railroad is being projected. This is true of the C.P.R. We have only a small percentage of the railways of Canada paying their way. Assuming that these cars all go back empty, this makes a very serious traffic situation. The railway must compete with the other railways to get this wheat, and you have three railways competing for it, and they are able to get 65 per cent of their cars filled on the return trip westward.

If you are depending on wheat supply for your traffic, when you consider the cost of storage, the cost of the railway, the investment in ships, you are really spending \$10 to do a certain definite thing which you would be accomplishing just as easily by spending \$3.

The engineers are in our own department and I have asked them what was the expectation for local traffic, and they have always shaken their heads and said there did not seem to be any. The facilities for traffic often create traffic. I think it would be unreasonable to expect that the road would be utterly barren.

EXTRACT FROM THE EVIDENCE OF THE HON. MR. COCHRANE, P.C., M.P.

I was at one time Minister of Railways for the Government of Canada. It was during my term of office that the Port of Nelson was selected as the terminal of the Hudson Bay railroad. The selection was finally decided by me largely on the report of engineers. I went myself to both places, Nelson and Churchill. The port of Nelson was nearer and the railroad would be shorter. The engineer reported that it would be necessary to cross the bad lands for a long distance where the bottom was all the way down from six to ten feet before you got to anything like hard stuff, and I thought the building of the road would be a very difficult proposition.

The tenders to go to Churchill was four million dollars more than to go to Nelson, and while the harbour at Churchill would be easier to develop for a small harbour, yet the difference would not be as much as the difference in cost of building the railroad. Neither one of them was at that time very much of a harbour. But before I was there a boat drawing 20 feet of water went up to Nelson to where the harbour has been developed. No work had been done when I was there.

When I came into office the contract for the first section had been let; there was not much work done; but the contract for the first section was let, and supplies had been sent to Nelson.

The selection of a terminal had not been finally made then, but I think if you will look up *Hansard* you will find that Mr. Graham, my predecessor, said his records from the engineer had been in favour of Nelson, the same as mine. I questioned the engineer and satisfied myself. Of course, I saw both places, but my opinion as to a harbour would not amount to anything. I am not an engineer and it would only be a guess.

The surveys were made to Split lake, and that is where the change would have taken place, at Split lake.

Churchill is a better harbour in one way, but it is very small. If there was ever any business of any account done there, and in my opinion it would cost fully as much as Nelson, to develop, providing you made a harbour of any size, but the initial development would be cheaper.

There would be more dredging at Nelson than at Churchill. Another big factor is the fact that it is ninety miles further on a railroad and on a railway that is a big item in hauling, and in building.

The expense of the material that would have to be hauled in that ninety miles would be considered and there is also the question of whether or not the railroad would stand up after it was built, on account of the foundation.

I think that the proper aids to navigation going through the straits and the channel will help it wonderfully, but I think the straits are an even harder thing to overcome than the port. We were two days in coming through the straits. I feel that with proper aids to navigation the straits can be used longer than most people at present time think, both longer and more effectively.

EXTRACT FROM THE EVIDENCE OF THE REV. W. G. WALTON, MISSIONARY.

I have been a missionary on the east side of Hudson bay for 27 years. I have been once through the straits, but I hear news of them every year from Hudson Bay captains. My district extends to the mouth of the straits. My parishioners subsist largely by fishing and hunting, with some Government aid thrown in. They get chiefly white fish and tulibee and speckled trout in James bay. In Hudson bay they still get the white fish, the grey trout and what is called the Hearn's salmon, which is really, I think, a sea trout, averaging from five to twelve pounds in weight. I have seen them as high as 30 pounds. The fish we have there are excellent. They are fairly plentiful at Belchers islands and all the way from cape Jones up to cape Wolstenholme. Some of the salmon are large. One man brought down three fish weighing 97 pounds; then we have cod fish. We have always called these rock cod. They are not the Atlantic cod, but similar to the Greenland cod. We have not many seals, but they get some walrus also. Capelin are fairly plentiful in the Whale river. I have found grass in the water wherever I have gone.

EXTRACT FROM THE EVIDENCE OF MR. J. B. TYRELL, MINING ENGINEER.

I am an engineer. I have been three separate years in Hudson bay itself and several years more in the country to the west of it. In the bay I have been as far north as Chesterfield inlet and in the country west of it as far as the north bend of the Dubawnt river, and that is as far north as I have been.

I have been over the route of the Hudson Bay road fairly closely. North of Churchill the west coast is fairly low and as far as one can see from the shore treeless to the vicinity of Chesterfield inlet and Ferguson river. To the south of Churchill where I travelled it is treeless for a distance back from the shore. Much of the country has the general appearance of the stony parts of the prairie country in the provinces of Saskatchewan and Alberta. It is covered with grasses or sedges. The country is low and would come down to near the shore. Within thirty or forty miles from the shore the trees were small black and white spruce and tamarack, with a few larger spruce close to the river valleys. Farther from the shore is larger timber of much the same character with Banksian pine and poplar coming in as well.

This timber would be suitable for pulp. The whole country from Churchill southward to the Severn river, which is one great swamp with scattered spruce and

tamarack over it. It rises on an average of five feet or thereabouts to the mile from the bay inwards. So it has that much drainage. This is probably the largest continuous swamp in the world. It represents the ancient bottom of Hudson bay because the bay once extended over that area. The actual amount of timber, except along the banks of the rivers, is comparatively small.

North of that wooded country is a country covered with grasses and sedges, known as barren lands, which country supports a large number of grass eating animals. I went through that country twice with canoes, once down the Dubawnt and once down the Kazan river. I was then on the geological survey of Canada. There would be no trouble whatever with pack horses across that country. There was abundance of feed in the summer time on this prairie country to feed the pack horses. When I was descending the rivers I lived entirely on my rifle.

The term "barren lands" as used in the north is a slight alteration from what the half-breeds call the "bare grounds," that is, the treeless grounds. It does not apply in any way to the barrenness or want of vegetation of the country, further than that it does not support trees. With regard to moss, it does not grow north of the line of growth of forest. There is no moss on the barren grounds. Grasses and sedges grow thin, similar to the grasses seen on the prairie and in other places, but moss grows only where it is under the shadow of the trees. Consequently there is no frozen moss on the barren grounds; the surface of the ground can be seen almost everywhere under the growth of grass. There are lichens growing on the rocks—usually known as "reindeer moss," but that is not a true moss at all. Ordinary bog moss does not grow on the barren lands.

There is a stretch of country along nearer the shore between Churchill and Nelson that has very few trees on it. It is fairly open and grass-covered. It is over that stretch that we walked down in the winter from Churchill to Nelson.

I have not been up the Deer river.

I also walked in the winter from Churchill to Split lake and to the north end of Norway House. There would be no trouble at all building a railway on that level plain from Churchill to Nelson.

It is not correct to describe that country as consisting of 6 inches of moss, and then ice and frozen peat. The soil is gravelly and stony. It is mixed gravelly soil, often called "hardpan," that forms the surface. When you get to trees you get true bog moss. The swamp begins when you get back far enough to get under the trees. On that swampy area there are no great basins full of water or moss as there are in the rocky country to the south. There is just the even blanket of moss over a level stony soil. This big swamp extends from Churchill southward up the Churchill river and across the Nelson. I was not up the Churchill river. I only went across inland. But south it crosses about the fishing lakes south of the Churchill river, and thence it extends southward across the Nelson river, about Split lake, then across the Hayes at Knee lake or a little below it, and thence it extends across the country to the southwest.

I have not personally followed it any further than the Severn river. The width of the swamp would be about 100 miles. I have described practically the southwest line which lies from 400 to 500 feet above the bay, because the land rises, as I have said, at an average rate of 4 or 5 feet to the mile.

Between the southwest side of the Arch-Hudsonian swamp and the prairie country is a great rocky area such as occurs all through northern Ontario and northern Manitoba, dotted with ponds and lakes. An exceedingly rocky country that we all know so well as forming the rocky barrier north of the main agricultural portions of Ontario and Manitoba. I travelled once on foot from York Factory to Norway House and once from Churchill to Split lake and Norway House, and thence on both occasions to Selkirk. My object in travelling on foot directly across country was to see the line of the

projected Hudson Bay railroad. It was in 1893-94, December and January. There was snow, but you could see very well what kind of country you were travelling over. We had to dig down every night through the snow to make our beds. The snow does not get deep. In December when we came out it was not very deep, just a few inches.

There would be no trouble in building a railroad, even if it were necessary to get to the bottom of the moss; it would only be necessary to remove 2 to 5 feet of it, according to the inequalities of the underlying clay. From Split lake to Churchill there would be no trouble in building a railroad. I remember that we crossed one high gravel ridge, 26 years ago. There is a big gravel ridge across and between Churchill and split lake. I climbed up over it. I remember it very well. There was not enough snow on the ground to obscure the gravel. On the middle portion of the line of the Hudson bay there is quite a long stretch of road where not much gravel has been found.

Hudson bay once reached much farther inland than it does now. As the sea receded, it left a series of gravel beaches roughly parallel to the shore, very similar to the gravel ridges that run northward through western Manitoba. A gravel beach that you could run on pretty nearly all the way from Nelson to Churchill.

Within a comparatively few yards from the banks of the rivers you get to the average thickness of moss. Conditions are the same on the Hudson Bay railway. In many of their ditches they have gone down to the underlying clay and have got a perfectly solid bottom. The "hardpan" or hard stony clay is right under the moss. In some places there is a certain amount of sand over the hard stony clay, but in most cases the hard stony clay forms the surface. Animals do not feed on that moss. It is swamp moss such as they are using in the hospitals for dressings.

Nelson harbour is a shallow V-shaped basin of water, with the water flowing over a bottom of hard, stony clay. There is no bar at the mouth of the Nelson. The bottom all across the mouth is hard stony clay, with a few boulders lying on it. That extends right up into the V-shaped basin, so that if one dredged a straight channel down into that stony clay, it would stay dredged just as long as you wanted it. It would not fill in. The current and tide would keep it quite clear. It would be more inclined to scour.

There are errors in the chart. The words on the chart are: "deep, soft and at low tide." you can walk on that tidal flat at low tide with slippers on, without getting your feet wet. The ground is hard, stony clay. It is very hard and is swept smooth and clean by the water. It extends to the channel on the east side and I am satisfied that it extends underneath the channel and that it can be dredged easily, but not with a sand pump dredge. There is no silt in the Nelson river except what is broken down by the storms from the northwest bank of the estuary. The upper portion of the stream is a fairly clear ater river that does not bring down list. The river current is rapid and the tide ebbs and flows very fast.

With aids to navigation, and a reasonable amount of dredging that could be made a good safe chanel. Of course, across the wide mouth of the Nelson river you have very shallow water, so that when there is a storm, even a northeasterly storm, the waves break on that shallow bottom far out, so it is hardly fair to say that you get the full force of the storm in the harbour. You do not. The breakers are far out. It has spent itself by the time it gets in.

There are two or three points about Churchill harbour that might interest you. It is completely land locked by rocky points and there is a relatively small lagoon just inside those rocky points. There is also a large and very shallow basin, say eight miles long and a mile or so wide, with rocky sides extending southwest from the present deep basin. That larger basin has been said by some to be filled with sand; and by others to be filled with rock. Actually it is filled with hardpan or clay that I have spoken of. It is a rocky basin filled with hard stony clay—not many very large boulders. They vary in size greatly, but the average would not be much bigger than your fist. A few might be two feet or more in diameter. The tide runs out of

the mouth of that lagoon at say eight or ten miles an hour at spring tide. My idea of the proper method of enlarging that basin, if it needs to be enlarged—and of course it would need to be if it were used as a harbour for any number of ships—would be to shatter the stony clay with charges of dynamite. Each time that a blast was fired with the outgoing tide, the current would carry the greater portion of the blasted material out into the open ocean—all except the boulders—and the large masses. There would be no difficulty dredging the remainder with a heavy bucket or dipper dredge. There are very few boulders that could not be handled with an ordinary dipper dredge. At Churchill the tide might be allowed to do a lot of dredging work for you, because the water is a hundred and twenty feet deep at the entrance.

When I was looking over the ground at these two harbours I was acting as geologist on the staff of the Geological Survey of Canada.

At spring tides it would be difficult for steamers to go in for about four hours out of the twenty-four.

Nelson, I think, can be made a harbour. That is, I think it can be made so that ships can lie quite safely in it, and that freight can be loaded into ocean-going ships; but it will take very much more money to make a harbour at Nelson than it will at Churchill. If the same money had been spent at Churchill that is said to have been spent at Nelson, a large basin could have been dredged, which would have been a rock-protected and absolutely land-locked harbour, one of the finest harbours in the world.

I am a mining engineer, not a civil engineer, but I should say that the extra cost of building the railroad from Nelson to Churchill would be a very small fragment of the huge expenditure necessary to make a harbour at Nelson. That is the huge extra expenditure over what would be required to make a harbour out of Churchill.

I may say here that I have the utmost confidence in the railway to Hudson bay being of definite economic value to the country. I believe firmly, and I have made a study of the matter for a great many years, that when that railroad is completed to the bay and a harbour is constructed, either at Nelson or Churchill, or at both, it will be of great service in both export from and import to the Northwest.

It is largely due to the fact that the Hudson Bay railway was under construction, that new mining areas were discovered to the west of the road, and it looks as if branches might have to be built from the road before the road itself is completed to the terminals. The minerals already discovered are gold, copper and zinc.

One copper mine, the Mandy, had a beautiful vein of copper ore, one of the finest I have seen in the northern portion of North America. It ran about 20 per cent pure copper.

There is quite a considerable stretch of very fine arable land along the railway. From Le Pas northward for twenty or thirty miles limestone comes close to the surface and the land is not of very great value. From there for a hundred and fifty or two hundred miles is a stretch of beautiful clay land, just as fine land, as far as I could see, as any in Manitoba. It is partly wooded. I think there is coal in this district.

I estimated the area of this arable land in Northern Manitoba, adjacent to this railway at 5,000 square miles. Afterwards Mr. William McInnes, of the Geological Survey, reported that my estimate might be raised to 10,000 square miles. That is land fit for settlement. It is not a grass covered country for it is largely covered with poplar and spruce; it is much like the Dauphin district. It is better land than that near Selkirk, which is chiefly a stony clay; near Winnipeg and from there west, the soil is underlain by stratified deposits laid down in glacial lake Agassiz, similar to those of northern Manitoba. It is an undulating country; there is abundant rainfall and there are many beautiful lakes and streams. The climate is suitable for grain raising; the soil very similar to the clay land in Northern Ontario.

The country is covered with a scattered forest of spruce and poplar. It would yield a few cords of pulpwood to the acre all over the rocky country.

There are three points that have occurred to me in connection with the fishery resources of Hudson bay: At the mouth of the rivers on the west coast of the bay the traders and natives set nets, as they do down on the shore of the Bay of Fundy and elsewhere, when the tide is out. When the tide rises a few fish get into those nets and when the tide falls again the fish are taken out. I have seen these nets and they appeared to me to contain a small whitefish or herring. The employees of the Hudson's Bay Company, living at Churchill and Nelson rivers were, for the most part, Orkney fishermen who had entered the employ of the company. These men did not do much fishing in the bay, but they went inland to the lakes and caught fresh water fish and freighted them out to support the men at the posts on the bay. I have seen schools of thousands of white porpoises in the mouth of the Nelson and Hudson rivers. I have seen them in enormous numbers and the Hudson's Bay Company had white porpoise fisheries at Churchill and Nelson for many years on account of their great abundance.

I do not know the east coast from that standpoint. So far as the development of the mining industries on the west coast by the opening up of the railway, I would say that a railway terminus would provide a centre on the shore of the bay from which prospecting could be carried on into the Keewatin Greenstone country to the north. In similar country to the south we find mineral deposits. I have little doubt that when these Greenstone areas northwest of Hudson bay are accessible to prospectors they will be found to be rich in mineral wealth; when we can run up with a gasoline launch from Nelson or Churchill to Chesterfield or Wager inlets or to any of the other harbours on the northwest side of the bay, we may confidently expect discoveries of valuable minerals to be made. As one acquainted largely with the north country I think the prospects make the road to Hudson bay worth while, even for the development of the country itself.

There is a magnificent stretch of country worth prospecting around the bay. Near the railway the prospectors have entered and are finding minerals. I believe that for the development of the country itself the Hudson Bay railway is worth building. Our pessimists have always objected to building railroads into new parts of the country and every railroad that we have built into new country has justified its building. The country immediately west of Hudson bay would be good pasture land for reindeer and musk ox. I have no doubt large numbers could be kept. There are undoubtedly many millions of wild caribou in this country. You should kill off the wolves and wolverines.

I happened to see the first herd of reindeer that went into Alaska. It was not a success. Afterwards they brought the proper kind of animal and they multiplied very fast.

I travelled in an open Peterborough canoe along the west shore of Hudson bay up to the 16th of October before shore ice formed. A reasonably good steamer should be able to travel for two or three weeks longer than a Peterborough canoe.

Interruption by Mr. Walton: "I travel in a Peterborough canoe every summer on the east side as late as the 5th of November."

I think a reindeer ranch proposition on the west coast would be quite feasible. I saw great stretches of grass land, and also I saw vast herds of caribou which live on grass exclusively. They seemed to get abundance of feed.

There is no snowfall to interfere. Most of the caribou go south in the winter-time to the edge of the woods where the snow does not pack. They live in enormous numbers there.

EXTRACT FROM THE EVIDENCE OF MR. W. A. BOWDEN, CHIEF ENGINEER, DEPARTMENT OF RAILWAYS AND CANALS

I am chief engineer, Department of Railways and Canals. I have had 32 years' experience. I have been to Port Nelson and through the straits. My personal interest in the Hudson Bay railway matter dates from the year 1893. Along about 1907 it became a question for the consideration of the engineers of the Department. Commander Gordon had been out in 1884 and 1885. He reported that ordinary steamers could not navigate the straits earlier than July 10, and that the latter part of October would mark the close of the season. In 1897 Commander Wakeham was sent out with a specially selected vessel to determine how early and late the straits could be navigated. It was a sealer called the *Diana*, a vessel that could resist ice pinches which would crush an ordinary vessel. He arrived off the eastern end of the straits on June 22, and without difficulty passed the first third of the distance, when he encountered ice with which he battled until July 10, most of the time around Big island. He got through to Mansell island on the 13th. The bay was open at the time, free from ice. He did not proceed to the eastern end; he went up near Salisbury island, where he arrived on the 15th of July, and was caught in the ice for a few hours, and thereafter he cruised in the straits, and he reports that he encountered no further ice conditions after the 15th of July. The *Diana's* net tonnage was 275; gross tonnage, 473; horse-power, 70.

Commander Wakeham was not materially hindered by ice after July 15. He then left the straits, returning the latter part of August; went through to Churchill, arriving on the 28th. During the month of September he was cruising about the straits; on the 21st of September he was at cape Chidley, and he had some snowstorms during that time. On October 10 he started through the straits from the eastern end to the western. He reached Diggs on the 23rd or 24th of October, turned around and went back to Douglas harbour, where he spent about a week. He left Douglas harbour on the 29th October and was down on the Labrador coast on the 31st, not having encountered any ice. October 31 he passed out the eastern end. We do meet ice from Fox channel in the straits. We do not know the origin of that ice or how long it takes coming down. It drifts around, being encountered first in the neighbourhood of Mansell island. About October 10 or 15 is when we first observed it. This ice does not stop navigation. I have been endeavouring to get the boats out later every year. I have been meeting with a good deal of opposition, but I have put forward the dates very materially. I have sent out vessels leaving Port Nelson on October 22. An unprotected steamer there had no difficulty in making the straits. This was an ordinary single-decked tramp steamer without any ice strengthening whatever, 290 feet long, 3,400 tons, named the *Sheba*. I purposely did not strengthen the three ships which we purchased: the *Sheba*, the *Sharon*, and the *Durley Chine*. I decided that it was desirable in the interest of the project as a whole that they should know what an ordinary vessel could do. The probabilities showed that with care in navigation the vessel would not be wholly lost. With some knowledge of ice navigation they can avoid the greater dangers. These vessels made a number of voyages to the bay without any trouble, going early and coming late.

In 1916 we were unable to get Newfoundland sealers on account of the war, and we made two voyages with the *Sheba* and two with the *Durley Chine*. None of those vessels were at all seriously damaged on that route during this time. I made the passage in 1914.

The *Sheba* was selected expressly for handling construction materials; she is an ordinary tramp style of ship. I would recommend for permanent traffic on the bay and straits during the season of navigation as an economical boat a boat of about 400 to 410 feet in length, about 8,500 tons capacity, and not exceeding 25 feet draught.

Previous to 1909 Port Nelson had never been considered as a terminal for the Hudson bay route. While there was not much tangible information against Nelson,

Churchill was better known by reason of its use by the Hudson Bay Company. Churchill was a small natural harbour for the boats that the Hudson Bay Company sent out to the bay. It was an excellent port of refuge and answered as a natural protected harbour of sufficient size for their business. Largely on that account I think paper locations had been put on the map, drawing railroad lines to Churchill. There have been no lands acquired along the route of the Hudson Bay Railway or Port Nelson terminal by private parties. An area two miles by ten was reserved at Port Nelson. I have no knowledge as to the extent of land ownership around Churchill. In 1908, John Armstrong, a railway engineer, was appointed to make a location survey to the bay. He was not particularly restricted to any terminus on the bay, but Churchill was incidentally mentioned in his instructions. He pointed out that in going to Churchill he would be passing by Nelson, which should be investigated, and he was told to investigate. He reported on October 30, 1909, and his report is published as a sessional paper in 1910. The gist of this report and all successive reports with respect to the harbours is that for vessels of the character of the *Sheba*, Churchill is a protected harbour, whereas port Nelson is an open estuary in which the force of the sea is very greatly reduced by the mud flat extension from the point at which a vessel would anchor out to the bay. Relatively there is no comparison between the two harbours for the use of an occasional vessel of that size. But at Churchill the natural harbour was so small that not more than three vessels could anchor in the harbour at one time. I am referring to vessels of the type of the *Sheba*.

With respect to vessels of the size which we may hope will some day navigate the straits, Armstrong's report at that date would show that there was no protection whatever. Such a vessel would have to anchor in the mouth of the port. Whereas the deep hole at Nelson would look after a fleet of such vessels, always with the qualification that the anchorage is not ideal. This report, however, is greatly in error, it had been hurriedly made. With inadequate facilities, by the engineers, and does not fairly represent the conditions. It is signed by Armstrong that field work was done at Nelson by Mr. Fry and the original drawings were made by Fry at Churchill. I don't think Armstrong had been either at Nelson or Churchill when he made that report and without personal knowledge. The measurements were made by his subordinates in the winter time, from the ice. We have made no further surveys at Churchill by our own staff. The same people who made the blunders at Nelson have made blunders at Churchill to the detriment of Churchill. The class of blunders that they made at Nelson was to the benefit of Nelson, and the blunders made at Churchill were to the detriment of Churchill, as it works out. The error at Churchill, however, is not serious. It is that the deepwater area is shown somewhat smaller than it really is. Instead of having the deep water area restricted to the neighbourhood of the harbour, as shown on the Armstrong drawing, it really extends half a mile inside. Its width, however, is not more than a thousand feet. The surveys demonstrated that a very easy line could be got to Port Nelson; that a line having heavier construction over a considerable area, and also necessitating a considerable stretch of construction across the tundra, could be got to Churchill. By tundra, I mean that character of country in which the moss is practically submerged in water—a small skin of moss overlaying a foot of semi-liquid peat which in turn rests upon perpetually frozen material of depth unknown and is made up chiefly of water. The construction to Churchill meant a longer line. Nelson had the obvious and positive advantage of being a shorter line. The difference is anywhere from 67 to 82 miles. The same line would be used to a certain point on the route from which the branches would turn either to Nelson or to Churchill. The actual final determination between the two did not take place until August, 1912. The call for tenders was made on alternative routes. Our estimates showed the Nelson line to be about \$3,000,000 cheaper than the Churchill line. The contractor's tender was about \$4,000,000 more for the Churchill than the Nelson.

In view of the difference in the tender costs there was a strong preference for Nelson—there were other reasons. The expenditure on the Hudson bay system is not for the purpose of furnishing protection for vessels, but to get the grain overseas as cheaply as possible, and the extra length of line to Churchill, with its consequent extra cost of maintenance, would offset a very considerable capital expenditure at Nelson. For 10,000,000 bushels development Churchill would not be cheaper than Nelson; but for twenty-five or thirty millions Nelson terminals would cost less than Churchill. The railway has an advantage of four millions and operating preference is all in favour of Nelson.

This route is not adding to our congestion on the seaboard but is really giving us an addition to the spout from the western provinces, it is of real advantage to the west and relieves the transcontinental roads of a substantial amount of traffic during the season of congestion. A very moderate volume of traffic would pay operating expenses if the full existing through rate was equitably divided between the railway and the steamships.

Local traffic won't amount to very much along the road. The mines are unfortunately not immediately contiguous to the line. I think copper ore might be shipped over the road.

There is no reason why a vessel of a certain type cannot run as safely to Port Nelson as she can to Montreal, during a certain season of the year, and during that particular time insurance rates should be no higher than to Montreal. I would say that during the month of September navigation to Port Nelson is as safe as to Montreal.

Our experience with regard to insurance was this, we put thirty-eight vessels through the straits during the season of 1914 and had no serious accidents of any kind. In 1913 the two vessels that were lost, their loss had nothing whatever to do with the ice or the merits or demerits of the harbour. One of them was several miles out of her course; the other was deliberately run aground.

I think August 1st would be a better date to consider as the opening of navigation, rather than July 10th as suggested by Captain Gordon and Commander Wakeham, closing not later than November 1st—how much later than that we do not know. A wireless station established on the northern shore of Mansell island to form a base for aviators who might fly over that western end of the strait, giving information as to the nature progress and location of the ice floes, would I think materially extend the length of the navigation season. Through the straits themselves there is no menace to navigation, whatever, other than the shoaling on the western end of Charles island. This is not a distinct shoal but shoal water. This menace would be wholly removed at the western end by the installation of an ordinary light together with a fog-signal. Apart from that, the strait is free from navigation difficulties. The feasibility of the route might well be determined by the operation, for a few years, of vessels by the Government. I think twelve vessels, six to be owned by the Government,—which might have five per cent extra expenditure for ice strengthening—and six ordinary tramp steamers to be chartered. This would form the basis of the experiment. A vessel working in ice is generally given a considerable dead rise so that the ice pinch will lift her up. We have operated ordinary tramp steamers during three months of the year. We think it can be continued with boats of a larger size, of the same type. A two million bushel elevator would be ample, the rest of the grain would be stored in the interior of the country. I would not store in large quantities at the bay.

Twelve vessels would carry a traffic of about eight million bushels. These would be used only as an experiment to demonstrate the feasibility of the route. We could use one hundred vessels on the route, but that is a thing of the future.

The Government vessels would make three trips in the year, that is why we would have them ice strengthened. From 7,500 to 8,500 tons would be the size of the vessels I would recommend, when speaking of deadweight capacity of vessels entirely.

I think continuous winter navigation of the straits would be impossible. It is conceivable with proper aids to navigation that we may add the whole of November to our present open season, but that is not probable. I think too much has been made of the snowstorm and the fog. Freight steamers, moving at half speed, can continue through in fog or snowstorm. These snowstorms are just flurries of short duration.

It is utterly out of the question to hope to get in one hundred or one hundred and fifty vessels on that route all of a sudden. The Government must demonstrate the feasibility of the route before private owners are going to send in their vessels.

Captain Anderson was making hydrographic surveys in 1914 and was caught in the ice off cape Chidley, at the same time we came along with five vessels, we were outside of him and had no difficulty in entering the straits. The *Sheba* was one of these. We went in at the north side of the strait near Resolution island. We were not very far off Resolution island. The north channel was free, the other closed, that shows what advantage wireless would be. I think aeroplanes would be of great advantage.

I believe in the feasibility of the route. The route would do for grain and livestock going out, coal, structural steel and package freight coming in. Practically the size of the vessel is determined by the capacity of the port.

If Mr. Tyrrell meant that a rational location of a line to Churchill can be made without crossing any of the barren lands, all that I can say is that he is wrong, absolutely, positively, unequivocally wrong. If the traffic gets so great that Port Nelson cannot handle it then go to Churchill; but Nelson is first for the traffic of the size we figure on; Churchill has probably the better harbour, that is the cheaper in original construction. We have had more vessels at one time in Nelson harbour during construction than could possibly have entered Churchill.

Churchill is a mass of boulders. At Nelson, there are boulder ridges along either side of the channel, the boulders are in the clay. I do not think, as Mr. Tyrrell says, that dynamite could be used with very great effect in clearing Churchill. I am speaking solely from reports. I know Mr. Tyrrell, he is a reputable man who is up in his profession as a geologist. I do not know of him as a civil engineer.

I think the excavation would have to be done by dredging and our information from the engineer was that the material at Port Nelson could be handled by a hydraulic dredge, but the material at Churchill could not, it would require dipper dredges.

We use a clam dredge at Nelson in connection with the hydraulic. It would have been better to have had a dipper dredge. Total estimates of the port was \$11,000,000 and a million dollars for the elevator. A two-million-bushel elevator would cost more than a million. These figures were made for 1913 at normal prices outside. Even at pre-war prices an estimate of twelve millions for the port would not apply to what we are proposing to carry out now. At present I cannot guess what it would cost but at pre-war prices, and free from interruptions and losses already caused by the war we should have completed the railway for sixteen millions and the harbour work for thirteen millions at normal prices. The interruption of the war has cost a few millions. The railway is nearly completed. There is only part of the work which has doubled in cost. We have expended some twenty millions already. The original estimate was around twenty-seven or twenty-eight millions. According to the statement of January, 1919, we then expended \$13,720,000 on the railway and \$6,321,000 on the terminals. Of the railway end of the enterprise we have the grading completed through to Port Nelson. The principal bridges are completed in a permanent manner and are very fine structures. They are all steel. There is very little trestle work along the route. We have spent a good deal of money on the water supply and have not got the question satisfactorily solved yet. The river water is fresh at low tide.

The island which is the site for the wharves should take care of five or six 7,500-ton vessels. Probably ten might anchor in the deep hole, which would make fifteen or

sixteen vessels taken care of at one time. Probably in four years' time the port could be made ready for use as a harbour for shipping grain. Then if the boats come for the cargoes I think there would be no difficulty in handling 15,000,000 bushels. As a matter of economy it is perhaps desirable that the steel should be there before we do anything more.

I have always considered Nelson the better terminus. Armstrong favoured Nelson from 1912, but I am quite willing to take my share of that responsibility. I do not think Armstrong was even at the bay. He based his report on the reports he got from his engineers. The actual construction was not further than fifty or sixty miles out of Le Pas when the contract was let for Nelson. Churchill was not rejected as impossible for railroad construction. Churchill was rejected on purely commercial grounds, such as mileage, which apart from operating cost in the future means a definite increase in the cost of the railway. And for a large harbour development Nelson would outstrip Churchill anyway. You would be passing up a good port to go to an inferior port. By inferior port I mean requiring a larger expenditure of money because for a large development Churchill would actually cost more than Nelson. For a small development Churchill would be cheaper than Nelson. But the extra cost of the railway would destroy that advantage and the extra rail haul of the grain remains in perpetuity.

EXTRACT FROM THE EVIDENCE OF MR. E. E. CLAWSON, DEPARTMENT OF MARINE.

I am the officer in charge of lighthouse construction for Hudson bay and strait. I established nine beacons in the strait and one beacon at March point, Hudson bay. All the beacon lights were established on land. We also sent twenty ice buoys and gave them to the Department of Railways and Canals to establish in the river. We maintained lights in the strait and cape Tatnam during the season of 1915.

EXTRACT FROM THE EVIDENCE OF MR. J. W. TYRELL, CIVIL ENGINEER.

I am a Dominion land surveyor and civil engineer. I have on more than one occasion been in the Hudson Bay district. I have gone both over land and by water. I have been there five different times. My first visit was in 1885. I was then hydrographer and I took the soundings. We went in by way of the straits during July, 1885. The ice delayed us considerably. We arrived off the entrance to the strait in the month of June and encountered ice. We did some surveying of the adjoining coasts drifting in the ice and returned to St. Johns for repairs—to have some iron sheeting put on the bow. She was a wooden ship, a sailing barque with auxiliary steam power. We were not suited for coping with obstacles. It was all we could do to get along in ordinary open water, without pretending to do much battling with ice. We met the ice north of port Chidley, at the eastern entrance, between that and Resolution island. When we returned to the straits we had no further difficulty, but passed through. The *Neptune* had been up the year before and located five observation stations at various points in the straits and we went up to relieve the stations and take off the men. I remained on board until our return in the autumn. Then I was left off at Ashe inlet, on the north shore of the straits, and remained there all winter taking tidal and meteorological observations. But during the summer of 1885 I accompanied the ship. We surveyed several of the islands down the east shore of the bay.

We met an enormous amount of walrus, which swarmed about the shores of these islands. The walrus lives on clams and other shell fish, and we found them in great numbers.

During the month of July we crossed the bay to Churchill, and I spent some days apparently surveying the mouth of the river. Since that I have made a more complete and accurate survey of it. Later we went on to the mouth of the Nelson and to York Factory, and I made a survey of the mouth of the Nelson river. We took a great many soundings. We went up the Nelson as far as Flamborough Head, a distance of about 30 miles by river. At Flamborough Head the banks rise high, although they are very flat. It was about the first of August when I finished the survey at Nelson. I did not see any ice there and remember it was very hot and that the mosquitoes and black flies were as bad as I have seen them anywhere.

I do not recollect on that tour having any difficulty whatever in connection with the navigation after our first obstruction, which was in the month of June. I do not think we saw any more ice. We passed out through the straits to the station, where I spent the winter. I occupied the time during the winter months with my dog sleds taking journeys east and west and surveying the coast. I had two men. We got a continuous observation, night and day, during the winter both of the meteorological conditions and of the action of the tides and the temperature, winds, and snowfalls. The lowest temperature we had was 42 below. I have experienced it colder than that in Winnipeg. We had Government tested thermometers. There are very strong tidal currents through the straits, particularly at the narrow points, like the entrance, the centre and where the channel is congested by islands. We took our observations every hour of the day and night for a year and a half. There are no big icebergs in Hudson strait—they do not go across the straits; they went on to the west.

We had an observation point 400 feet above the sea, and I had a telescope built into a cairn on top of that cliff, and I used to go up every day to look at the conditions through the telescope. I could see a long distance, clean out to the middle of the straits. The ice was almost constantly on the move as in the tidal current, the maximum of which was 8 miles an hour.

Outside of two months there were open leads all the time. They were the months of January and February, I think. My belief is that the straits are navigable for about five months in the year, figuring on aids to navigation—July, August, September, October, and November. I think the ice at the eastern and western extremity of the straits would not interfere particularly during those five months.

On the 5th of June, 1886, I was still occupying my shack at the Ashe point and a whaling steamer came into the strait and anchored right in front of our station without knowing we were there. The ice in the harbour was still firm but there was no ice to be seen in the straits. The captain told me that he had not seen a pan of ice in Hudson strait up to that time and he passed on the next day into the west. His ship was a Dundee whaler. I think she was wood. He got through all right and returned in the autumn.

We met a great number of seals. A friend of mine, Senator Blanchard, from Newfoundland, established a very successful cod fishery in Ungava bay. We got great numbers of other kinds of fish—salmon, white fish, sturgeon. Seals frequented all the shores of the straits and bays.

My second trip to Hudson bay was a good many years later, in company with my brother, J. B. Tyrell. It was in '93. I went overland from Edmonton, through lake Athabaska, down the river Dubawnt, and entered Hudson bay through Chesterfield inlet. On the Thelon river, which is a magnificent stream, I found the banks well timbered with fine spruce, well developed white and black spruce. It did not extend back a great distance from the river but occupied the valley. I came across the remains of moose along the banks of this river. I did not see any living animals. I saw great bands of musk oxen which I photographed. The stream is about a quarter of a mile wide—about the size of the Ottawa river. It was teeming with fish, splendid white fish. It is navigable up to a certain point from the bay.

Between Churchill and Nelson we were further from the coast than twenty miles. The distance from Churchill to Nelson in a straight line is 120 miles. We were probably thirty or forty miles in from the coast. The country bore chiefly tamarack and small spruce. Near the coast it is bare.

My third trip was a railroad exploration trip. On the trip now being considered, we followed the regular route of the Hudson bay, travelling from the fort to York Factory, then up the Hayes river to Oxford House, and from there to Norway House.

In 1900 the Department of the Interior asked me to go out and make an exploration of the divide between Great Slave lake and Hudson bay, with a view to railway construction between the head waters of the Hudson bay and the Mackenzie river. I went out and spent eleven months on that work. We found the country covered with grasses and large herds of reindeer or caribou.

On the last expedition we started from Prince Albert and passed through to the head of lake Winnipeg, followed the route of the Nelson river as far as Split lake, and from Split lake we portaged north. The proposed route would go on the north side. I did not actually locate a railroad. I went through taking notes of the character of the country with a view to locating a route, and the north side was the route that we selected. From Split lake I portaged across to what is known as the little Churchill river and descended into Great Churchill and followed the Great Churchill to its mouth. That is the route we followed and I stopped to take official photographs, etc., on the way.

When descending the Great Churchill river, from fifty to one hundred miles up the stream there were very remarkable sand ridges, so remarkable that I exclaimed to my companions, "Why, here the railroad is already built for us." That was on the south side of the Churchill in the direction in which the railroad would be built if it were built to Churchill.

There is continuous solid land to the mouth of the Churchill from the head of lake Winnipeg. I saw nothing, and I was there to investigate the possibilities of railway construction, I saw nothing between the head of lake Winnipeg and the mouth of the Churchill river in the way of serious objections. I saw some swamps, but no railroad that ever was built was built without getting some swamp. There was nothing in the way of impossible or impassable barriers. Of course, I did not see it all the way across, but from what I did see following the route I did, I would say it was quite feasible. The character of the country as far as I could see, it is quite suitable for railroad construction, not a difficult country at all. I have been right across there from a point about thirty miles from Churchill to Churchill. I have travelled down there in the winter time and never saw anything in the way of impassable land. As a matter of fact it is hardpan boulder clay, meaning that it is old beach bottom. Many years ago the bay covered all that territory.

I have made a chart of the Churchill river, which chart indicates that there is a natural harbour land locked at Churchill which at a comparatively small cost could be greatly enlarged by dredging. It is only sufficiently deep for immediate use. It has been used for years.

With the *Arlotte* we steamed right up and cast anchor and remained safe and comfortable during the survey work.

I have been at Nelson on several occasions. The broad flats are an indication of just what the bottom is. beyond it is hard boulder clay. It would be possible to dredge with a dipper dredge at Churchill. It would be too hard for a suction dredge. Dynamite would assist, but it would have to be dredged also. The boulders do not run very large, from pebbles up to two or three feet across. The large ones are comparatively rare. I do not think one-twentieth of the material would be boulders. I have a very decided opinion which I have expressed on many occasions as to which of the two, Nelson or Churchill, is the more desirable harbour.

I am very strongly of the opinion, and always have been, since I surveyed them both, that Churchill was decidedly preferable.

I consider, and have always considered that the expense of making a harbour at the mouth of the Nelson was prohibitive.

I have absolutely no financial interest of any kind in Churchill or in Nelson.

I think a basin sufficiently large to accommodate an enormous quantity of ships could be made at the mouth of the Churchill at very much less than it costs to build a harbour at Nelson. I think that Churchill is by far the preferable harbour from any point of view.

Ships have difficulty in getting into the mouth of the Nelson. I have been stranded thirty miles off the mouth of the river in a little boat on the flats.

Coming down on my last trip in just a little shallow boat we went aground out of sight of land. We had a crew of Eskimo who were supposed to know the river like a book and they undertook to take me in by the best channel they knew of, but we went aground about ten miles off the land and had to stay there until the tide lifted us off some ten hours later, and when surveying the harbour in the *Arlette*, we were anchored thirty miles off the mouth of the river and the whole district there is so shallow that terrific seas got up rapidly. Our anchors began to slip and we let our oil tanks run to prevent the sea breaking over us, and even with that we had to cut loose and go out to sea to avoid being carried on shore. That is the condition of things at the mouth of the Nelson and I do not think these conditions can ever be entirely removed.

We did not find that Mr. Bowden has said, the side shoals break the force of the waves. We found it extremely rough in the shallow water. When we were out on board the *Arlette* Commander Bowden did not care to bring this ship into the narrow channel. For three hundred years the Hudson Bay ships have been anchored out where we had. To this day they lighter their goods in little boats. I was there in 1905.

At that time the Hudson Bay people were still loading and unloading their cargoes by means of lighters. The Hudson Bay people make Churchill their main shipping point and distribute their goods from there to a great extent, because it is the natural harbour of the western coast.

Churchill is a perfectly land-locked harbour. I believe the Hudson Bay route for the transportation of western grain is perfectly feasible and very desirable. I think Churchill harbour is open for five months in the year. Observations have been taken for over one hundred years, and from my observations I believe that the straits are navigable for five months in the year. I think that is all you could safely rely upon. In some years it would be more, because the year Captain Guy came there on the 5th June he did not see a pan of ice. I would not count on navigation in June, but I think you could safely rely on navigation during July, August, September, October and November. There would be some new ice met with in November. That would bring it to the first of December. There would be new ice, of course, in the straits during the month of November, but the new ice is only light and does not endanger navigation, although it might delay it.

The land northeast of lake Winnipeg and down around Split lake is quite fit for settlement, and I observed not only in one place but in many places natural features of the country what geologists would call moraines, I think, immense gravel ridges constructed by the force of nature. They had much the appearance of great railroad embankments, principally they were constructed by the action of glaciers. I observed them particularly marked in the vicinity of Churchill. The sandy gravel part is such that it would not support timber. In many cases it was overgrown with timber. It would make ideal railway valleys.

The current in the Churchill river cleans out the ice as soon as it breaks up. It has no chance of remaining there.







