

1946

NEW ZEALAND

REPORT OF THE ROYAL COMMISSION

TO INQUIRE INTO AND REPORT UPON TRANS-HARBOUR FACILITIES IN THE
AUCKLAND METROPOLITAN AREA AND THE APPROACHES THERETO

*Laid upon the Table of the House of Representatives by Command of His Excellency the
Governor-General*

*Royal Commission to Inquire into and Report Upon Trans-harbour
Facilities in the Auckland Metropolitan Area and the Approaches
Thereto*

GEORGE THE SIXTH by the Grace of God, of Great Britain, Ireland,
and the British Dominions beyond the Seas, King, Defender of
the Faith :

To our Trusty and Well-beloved the Honourable Sir Francis Vernon
Frazer, of Wellington, Knight Bachelor, M.A., LL.B. ; William
Richard Beaver, Esquire, B.C.E., A.M.Inst.E. (Aust.), of New
South Wales, Engineer ; and Roland Harry Packwood, Esquire,
O.B.E., A.M.Inst.C.E., District Engineer of the Public Works
Department at Auckland : Greeting.

WHEREAS we have deemed it expedient that a Commission should issue
to inquire into, examine, and report upon the matters hereafter set forth
which relate to trans-harbour facilities in the Auckland Metropolitan
Area and the approaches thereto, and report upon proposals that may
be made for the provision of further facilities in the public interest :

Now know ye that We, reposing trust and confidence in your
knowledge and ability, do hereby nominate, constitute, and appoint
you, the said

Francis Vernon Frazer,
William Richard Beaver, and
Roland Harry Packwood,

to be a Commission to inquire into and report upon the following
matters :—

- (1) What trans-harbour facilities are necessary in the Auckland
metropolitan area and the approaches thereto to provide
adequately for future traffic requirements of all kinds, both
from within and from outside the metropolitan area,
including through traffic, having regard to improvements
in the railway and roading systems in the area that are
contemplated by the Railways Department and the roading
authorities respectively ;

- (2) Should the facilities include means of direct access between the city and the North Shore suburbs in addition to or instead of the existing ferry services ;
- (3) If so, what should be the nature of this direct access, and where should it be located :—
- (a) If by a bridge, what should be the minimum navigational clearances, and what should be the provisions for traffic on the bridge and its approaches ;
- (b) If by a tunnel or tunnels, what should be the number of such tunnels and what provisions for traffic should be made in each ;
- (c) In either of cases (a) and (b) above, what will be the approximate cost of the proposed access, including the necessary approaches ;
- (d) If any other alternatives are investigated, what are they and what would be the approximate cost of each ;
- (4) Upon what basis or bases can such direct access be provided and financed, with special reference to construction, maintenance, and operation ;
- (5) If such direct access is not considered necessary at present, within what period of time will the probable growth of population, and the use of motor-vehicles together with other forms of transport, render it necessary ;
- (6) If you consider that the existing ferry services should remain in operation, either with or without other means of direct access, what improvements, if any, should be made in the services now provided ; and
- (7) Generally, any other matters arising out of the premises that may come under your notice in the course of your inquiries, and which you consider should be investigated therewith :

And We do hereby appoint you, the said

Francis Vernon Frazer,

to be Chairman of the said Commission :

And for the better enabling you to carry these presents into effect you are hereby authorized and empowered to make and conduct any inquiries under these presents at such time and place as you deem expedient, with power to adjourn from time to time and place to place as you think fit, and so that these presents shall continue in force, and the inquiry may at any time and place be resumed although not regularly adjourned from time to time or from place to place :

And you are hereby strictly charged and directed that you shall not at any time publish or otherwise disclose save to His Excellency the Governor-General, in pursuance of these presents, or by His Excellency's direction, the contents of any report so made or to be made by you, or any evidence or information obtained by you in the exercise of the powers hereby conferred upon you except such evidence or information as is received in the course of a sitting open to the public :

And We do further ordain that, using all due diligence, you report to His Excellency the Governor-General in writing under your hands and seals not later than the thirty-first day of July, one thousand nine hundred and forty-six, your findings and opinions of the matters aforesaid, together with such recommendations as you think fit to make in respect thereof :

And, lastly, it is hereby declared that these presents are issued under the authority of the Letters Patent of His late Majesty dated the eleventh day of May, one thousand nine hundred and seventeen, and under the authority of and subject to the provisions of the Commissions of Inquiry Act, 1908, and with the advice and consent of the Executive Council of the Dominion of New Zealand.

In witness whereof We have caused this Our Commission to be issued and the Seal of Our Dominion of New Zealand to be hereunto affixed at Wellington, this twenty-second day of March, one thousand nine hundred and forty-six, and in the tenth year of Our Reign.

Witness our Trusty and Well-beloved Sir Cyril Louis Norton Newall, Marshal of Our Royal Air Force, Knight Grand Cross of Our Most Honourable Order of the Bath, Member of Our Order of Merit, Knight Grand Cross of Our Most Distinguished Order of St. Michael and St. George, Commander of Our Most Excellent Order of the British Empire, on whom has been conferred Our Albert Medal of the First Class, Governor-General and Commander-in-Chief in and over our Dominion of New Zealand and its Dependencies, acting by and with the consent of the Executive Council of the said Dominion.

[L.S.] C. L. N. NEWALL, Governor-General.

By His Excellency's Command—
R. SEMPLE, Minister of Works.

Approved in Council—
W. O. HARVEY, Acting Clerk of the Executive Council.
(P.W. 34/2734.)

REPORT

To His Excellency Sir Bernard Cyril Freyberg, upon whom has been conferred the Decoration of the Victoria Cross, Knight Grand Cross of the Most Distinguished Order of Saint Michael and Saint George, Knight Commander of the Most Honourable Order of the Bath, Knight Commander of the Most Excellent Order of the British Empire, Companion of the Distinguished Service Order, Doctor of Laws, Lieutenant-General in His Majesty's Army, Governor-General and Commander-in-Chief in and over His Majesty's Dominion of New Zealand.

MAY IT PLEASE YOUR EXCELLENCY,—

His Majesty's Commission, dated the 22nd day of March, 1946, and issued under the hand of Your Excellency's predecessor and the seal of His Majesty's Dominion of New Zealand, directed us to inquire into, examine, and report upon the trans-harbour facilities in the Auckland metropolitan area and the approaches thereto, and to report on proposals for the provision of further facilities in the public interest. The specific matters into which we were directed to inquire are set out in detail in the order of reference embodied in His Majesty's Commission.

The Commission decided that the most satisfactory procedure to adopt in making its inquiry was to summon a number of persons, including officers of the Government and of local and public bodies, to give evidence in respect of matters in which, by reason of their special knowledge and experience, they were particularly qualified to assist it; and to issue a general invitation to other persons who desired to make representations to the Commission to submit written statements of their views on any of the subjects contained in the order of reference. If, after considering a written statement, the Commission thought it desirable to hear the writer in person, or if the writer desired to be heard in person, the Commission invited him to attend and give oral evidence to supplement his written statement. In other cases, where some amplification appeared to be necessary, a further written statement was asked for.

Public sittings for taking evidence and hearing submissions were held at Auckland from the 15th May, 1946, to the 12th June, 1946. During that period the Commission sat on 17 days and examined 67 witnesses. It received 85 exhibits and also obtained voluminous data from Government Departments and other sources. The transcript of the proceedings filled 1,271 typewritten foolscap pages. The members of the Commission visited those parts of the Auckland metropolitan area in respect of which improved road and rail facilities are planned, and made themselves familiar with the locations of the different works contemplated in the recently announced Auckland Metropolitan Development Plan. They also made detailed inspections of the existing ferry services between the City of Auckland and the North Shore suburbs, and investigated the roading systems of the North Shore and the east coast bays and the means of access to the ferry terminals. Their investigations included an examination of the possible sites for the erection of a bridge across the harbour and for the construction of a tunnel under the harbour, and, in each case, an examination of the location of the necessary connecting roads and causeways.

The Commission desires to acknowledge the assistance it received from the bodies and interests represented before it. In the great majority of cases it was evident that much care and thought had been devoted to the preparation of material for submission to the Commission. The Commission wishes also to place on record its appreciation of the able and painstaking work of Mr. B. C. Magill, who was appointed to act as Secretary to the Commission. Mr. Magill was responsible for a vast amount of detailed work, which was performed to the entire satisfaction of the Commission.

The detailed report and recommendations of the Commission follow.

INTRODUCTORY

The Auckland metropolitan area is not authoritatively defined. The area included in the Auckland Metropolitan Co-ordinating Planning Scheme is not co-terminous with the Auckland urban area as defined by the Government Statistician. Another area, that within the circumference of a circle with a radius of 13 miles from the chief post-office at Auckland, has also been described as the Auckland metropolitan area. For the purposes of our inquiry we have regarded the Auckland metropolitan area as comprising the Auckland urban area, the population of which in 1945 was 263,370, and parts of the Birkenhead and Takapuna Ridings of the Waitemata County and a small part of the Borough of Takapuna not included in the urban area. The northern boundary of these additional areas is approximately the arc of a circle of $9\frac{1}{2}$ miles radius with the chief post-office at Auckland as its centre, extending from Albany to the sea-coast north of Brown's Bay. The inclusion of the areas to which we have referred brings the total present population to 268,000, of which 35,000 are resident in the North Shore boroughs and in those parts of Waitemata County that can be regarded as being more conveniently served by means of a bridge across Waitemata Harbour, or a tunnel, under it, than by the proposed new road from Dairy Flat to Whenuapai and Auckland, or by the existing roads leading to Auckland from the north and north-west.

Though roads exist by which vehicular traffic between Auckland City and the North Shore area and the remainder of the North Auckland Peninsula can avoid crossing Waitemata Harbour, a long and circuitous journey is necessitated. For all practical purposes the only route to the North Shore area and points farther north involves crossing the harbour. The projected new road from Auckland City via Whenuapai to Dairy Flat, at which point it will join the existing No. 5 State Highway to the north, will, if located where at present proposed, provide a route to the north approximately $4\frac{1}{2}$ miles longer from the chief post-office than that provided by a bridge crossing the harbour from St. Mary's Bay to Northcote and linking up with existing highways on the North Shore; and this distance may be reduced by a relocation of the new road. It is probable that the greater part of the vehicular traffic to and from points north of Albany or Dairy Flat will use the new road, which will, for the greater part of its length, be a high-speed road, in preference to saving $4\frac{1}{2}$ miles or less and incurring the payment of bridge tolls; but part of that traffic, more especially the pleasure traffic, will no doubt prefer to travel across the harbour by means of a bridge. We stress the point, however, that the population living north of Albany, and at present numbering 80,000, will be adequately provided for by the new road, and that the justification for the erection of a bridge rests mainly on the probable use that will be made of it by the residents of the North Shore area, who at present number 35,000, by the commercial firms supplying their requirements, and by visitors to the area.

We have therefore had special regard to statistical data in respect of the rate of increase of population in the North Shore area, the number of motor-vehicles in the area in ratio to population, the rate of increase in the number of vehicles crossing the harbour by means of vehicular ferries, and the relative percentages of traffic movements between the business area of the City of Auckland and the North Shore area and between the city business area and the suburban areas on the south side of the harbour. We received evidence from a number of sources indicating the influence on future trends that would probably be exerted by the existence of a bridge or other form of direct access between the City of Auckland and the North Shore area. We have given careful consideration to this evidence, and have taken into account a number of factors, particularly post-war factors, that may tend to accelerate or retard the increase of traffic, and have reached the conclusion that, though by reason of economic factors such as present-day shortages of materials and labour and high freights and costs generally it would be unwise to make an immediate start on the construction of a bridge or its approaches, there are sound reasons for recommending the early commencement of the necessary investigations and studies of the project; and we consider

that the commencement of actual construction work in five years or, at the most, ten years would be warranted by the volume of traffic that might reasonably be expected to make use of the bridge when it was completed. It is estimated that the construction of the bridge and its approaches will occupy five years, and we consider that if general economic conditions warrant the commencement of construction work in 1951, the bridge, when opened in 1956, will pay its way from the outset.

A Commission of inquiry appointed in 1929 reported on 22nd April, 1930, and made recommendations as to the site, alignment, type, and dimensions of a proposed bridge across the Waitemata Harbour from the Fanshawe Street (eastern) end of St. Mary's Bay to Stokes Point, Northcote. It expressed the opinion, however, that the time for the erection of a bridge would not arrive for twenty years. We desire to express our deep appreciation of the assistance afforded to us by the investigations of the former Commission, which dealt comprehensively and most capably with the issues placed before it for consideration. We have, however, had the advantage of information that was not, and could not have been, available to it, and in the light of this knowledge we have been compelled to depart in a number of respects from its recommendations.

SPECIFIC FINDINGS AND RECOMMENDATIONS

We now report our specific findings and recommendations in respect of the several matters set out in the order of reference, as follows:—

(1) What trans-harbour facilities are necessary in the Auckland metropolitan area and the approaches thereto to provide adequately for future traffic requirements of all kinds, both from within and from outside the metropolitan area, including through traffic, having regard to improvements in the railway and roading systems in the area that are contemplated by the Railways Department and the roading authorities respectively?

A bridge is undoubtedly a desirable traffic facility, and there are sound economic reasons for its inclusion in its due place in the Government's programme of improvements and extensions planned for the metropolitan area of Auckland. Nevertheless, having regard to the greater urgency of other public works, in particular housing, hydro-electric extensions, rural development (including roads, highways, and bridges), and works necessary to relieve congestion of city traffic, we do not regard it as a "necessary" facility at present, though it will certainly become so at the expiration of the minimum period required for its completion, which we have fixed at ten years, which period, however, may for economical reasons require to be extended to a maximum of fifteen years. The construction of a bridge within the next few years would create a competitive demand for materials and labour which would, under present circumstances, seriously hamper the Government and local bodies in overtaking arrears in their respective programmes of urgently necessary works. In addition to the large capital sums involved in such works, there is to be considered the further outlay on the large fleet of passenger vehicles (buses and trolley-buses) which, when a bridge is built, will be required to cope with peak loads of passengers, now dealt with by ferries having capacities of upwards of 1,000 passengers. If, as we think, the majority of this traffic should be catered for by trolley-buses (consuming electrical energy instead of imported fuel), the provision of electrical equipment and wiring is also to be considered. These items are likely to be in short supply for some years to come. For these reasons we consider that it would be most inopportune at present to embark on construction work of such magnitude.

(2) Should the facilities include means of direct access between the city and the North Shore suburbs in addition to or instead of the existing ferry services?

The existing passenger and vehicular ferry services, augmented and improved in the manner referred to later in our report, will reasonably meet the needs of traffic for the next ten to fifteen years, at the expiration of which time direct access by means of a bridge will undoubtedly have become urgently necessary. When the bridge is in service, scope will still remain for passenger ferry services to a limited number of points, but the vehicular ferry services should then be discontinued.

(3) If so, what should be the nature of this direct access, and where should it be located—

(a) If by a bridge, what should be the minimum navigational clearances, and what should be the provisions for traffic on the bridge and its approaches?

(b) If by a tunnel or tunnels, what should be the number of such tunnels and what provisions for traffic should be made in each?

(c) In either of cases (a) and (b) above, what will be the approximate cost of the proposed access, including the necessary approaches?

(d) If any other alternatives are investigated, what are they and what would be the approximate cost of each?

We recommend that direct access should be by means of a bridge, located as follows : north abutment on Stokes Point, Northcote ; south abutment on reclaimed land at the western end of St. Mary's Bay Boat Harbour, adjacent to Point Erin Park. Direction of axis of bridge, 207° true.

(a) *Navigational Clearances* :—

Horizontal Clearance : Main span, 800 ft., centre to centre of piers, allowing a net horizontal clearance (between fenders) of approximately 750 ft.

Vertical Clearance : At mid-point of main span, 137 ft. above the level of high-water ordinary spring tides, which for this purpose is defined as 5 ft. above mean sea-level. Over the central 500 ft. of the main 800 ft. span, clearance 132 ft. minimum.

Provision for Traffic :—

(i) On bridge, four-lane carriageway, 44 ft. between kerbs, plus two 6 ft. footpaths.

(ii) On south approach, four-lane carriageway, 48 ft. between kerbs, plus cycle-track and footpath, 12 ft. : total width, 60 ft. The irregular space between the formed inner edge of the roadway and the foot of the cliffs, varying in width but with a minimum of 10 ft., to be formed and metal-surfaced for parking.

(iii) On north approach, 60 ft. formation, designed for ultimate four-lane carriageway as on the south approach, but bituminous-surfaced in the first instance as for two vehicular lanes only, the other two to be provided when traffic warrants. Footpath and cycle-track to be formed during first phase of construction, and provision for convenient parking-spaces to be made as required.

(iv) Approach roadway adjacent to southern abutment to be widened to provide space for toll-collection facilities and traffic safeguards.

(v) Surface of roadway on main 800 ft. span to be on vertical curve allowing sight distance of 500 ft.

(vi) Loading to be in accordance with the Main Highways Board's "first-class standard," regard being had to the desirability of providing for heavy military vehicles. We agree, however, with the view of the 1929 Commission that the transport of exceptionally heavy loads could be better and more cheaply provided for by the use of the Harbour Board's floating crane, and that it would not be economical to construct a bridge of the length proposed to a standard that would permit very unusual and infrequent loads to be carried over it.

(vii) Lighting of bridge and approaches to be in accordance with latest modern standard.

(viii) Provision to be made also for the carrying of water-mains, gas-mains, and electric light and telephone wires, preferably under footpaths, and for overhead wires and fittings for trolley-bus operation. The cost of installation of these services has not been provided for in our estimate. Consideration should be given also to making provision for facilitating the possible future installation of electric-power cables.

(b) We do *not* recommend a tunnel or tunnels. Although a tunnel is preferable to a bridge in several important respects, the cost of a vehicular tunnel would be prohibitive. Even a two-lane tunnel with 23 ft. carriageway would cost more than a four-lane bridge with 44 ft. carriageway, having more than three times the traffic capacity.

(c) We estimate the cost of the bridge and its approaches, *at present-day prices*, to be—

	£
Bridge structure	2,200,000
Approaches, including contingent alterations and improvements to feeder roads and streets and compensation for land (first stage only)	550,000
Loan charges and interest during construction	250,000
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	£3,000,000
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If, as we recommend later in this report, construction of the bridge and approaches is deferred for five to ten years, we are of the opinion that the cost should not exceed the following:—

	£
Bridge structure	1,750,000
Approaches, &c., as above (first stage only)	450,000
Loan charges and interest during construction	200,000
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	£2,400,000
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The first stage of the work on the approaches is defined as the construction of the principal through route, commencing at the intersection of Beaumont and Fanshawe Streets, Auckland, and terminating at the intersection of Napier Avenue and Lake Road, Takapuna, including the reconstruction of Napier Avenue, together with the provision of a branch approach connecting with Curran and Sarsfield Streets, Auckland, including the improvement of those streets, and the provision of lateral connections to a limited number of existing streets in Northcote and Takapuna.

The second stage of the work on the approaches is defined as the improvement of roads and streets on the North Shore leading to the approaches or to the bridge structure itself, the extension of the principal through route to Bayswater and Devonport, and the improvement and strengthening of arterial city streets leading to the south abutment. The second-stage work, we consider, will be paid for out of revenue and will not be a charge on the capital fund. Similarly, the conversion of the approaches (first stage) to four-lane standard when required to meet traffic increases will be paid for out of revenue.

(d) No other alternative is considered necessary.

(4) Upon what basis or bases can such direct access be provided and financed, with special reference to construction, maintenance, and operation ?

(a) *Construction and Capital Finance.*—The execution and financing of a work of such magnitude is beyond the resources of any local body or combination of local bodies. The entire responsibility for providing and financing such a work can be assumed only by the Government, which should also reserve full control of and responsibility for the administration, maintenance, and operation of the completed project. We do not recommend the granting of a charter to any public authority or private organization to construct and operate the bridge, though we consider that the construction, in whole or in part, might, if the Government so decides, be carried out by private enterprise under contract. Our detailed recommendations under this heading are as follows:—

(i) Investigations, surveys, borings, designs, specifications, and economic studies to be carried out by the Government as soon as the necessary specialist staff is available.

(ii) On completion of the work detailed in the foregoing subparagraph (i), the Government to determine (regard being had to the economic conditions affecting construction then existing) the date on which construction work is to commence, and to invite tenders in New Zealand and abroad for so much of the work as it decides to have executed by contract.

(iii) The whole of the capital cost of the bridge and approaches to be provided by the Government, and to be recoverable with interest (subject to the recommendation contained in the following subparagraph (iv)) from the revenue derived from tolls as hereinafter set forth.

(iv) £500,000 of the capital cost to be interest free for twenty years, the intention being that the non-recoverable compound interest on that sum for that period shall be regarded as a direct Government contribution to the project. The remission of compound interest on £500,000 for twenty years at 3 per cent. per annum is equivalent to a free grant of £400,000, and at 4 per cent. per annum is equivalent to a free grant of £600,000.

(v) We consider that any system of rating designed to offset the betterment which will accrue from the provision of direct access by means of a bridge is impracticable of application. We believe that the most practicable and equitable means of financing the bridge is the institution of a system of tolls so devised as to spread the charges over both direct users and those who derive indirect benefit from the bridge. We recommend accordingly, and we suggest that tolls be levied on—

- (a) Motor-cars.
- (b) Passengers in motor-cars and commercial vehicles (excluding drivers).
- (c) Passengers in public conveyances (buses and trolley-buses), the vehicles being toll-free.
- (d) Cycles and motor-cycles.
- (e) Commercial vehicles according to carrying capacity.

Later in this report we supply comparative data on the subject of tolls and suggest a scale of toll charges.

Both the capital outlay and the annual cost are affected in a large degree by rates of interest, which are reflected in the sum allowed for interest during construction and in the earnings of the annual sums which we suggest should be set aside for a sinking fund and a contingencies and development fund. Having regard to the amount of the capital outlay and the desirability of providing finance therefor at a uniform rate of interest, we recommend that the financing of the project should be on the same basis as a State undertaking such as a railway, highway, or hydro-electric works. As works of this nature are at present subject to a fixed rate of interest of 4 per cent., we have assumed that this might be regarded as the appropriate interest-rate on the cost of the bridge and its approaches. In this connection we refer to a condition proposed some years ago by private interests that desired to be given a charter to construct and operate a harbour bridge, that the Government should guarantee interest at a fixed rate on the capital outlay. This, in our opinion, would have created a gilt-edged investment. We think that the Government should retain such an investment in its own hands and apply surplus income for the specific purposes we recommend later in this report, including the reduction of toll charges. On the other hand, the earnings of the sinking fund and of the contingencies and development fund, to which we shall later refer, may fluctuate from year to year and may fall below an average rate of 4 per cent. We have therefore assessed the average interest-rate to be earned by these funds on the more conservative basis of $3\frac{1}{2}$ per cent., which, in the case of the sinking fund alone, would be sufficient to amortize the interest-bearing portion of the capital cost of the bridge and its approaches in approximately sixty years.

We recommend that an amount equal to $\frac{1}{2}$ per cent. of the capital cost (less the interest-free sum of £500,000) of the bridge and its approaches be paid annually into a sinking fund, and that a similar amount be paid annually into a contingencies and

development fund, into which all surplus revenue not immediately required will also be paid. We propose that the contingencies and development fund, together with accumulated surpluses, be applied to and for the following purposes :—

(i) Supplementing the earnings of the sinking fund if they should fall below the estimated average rate of $3\frac{1}{2}$ per cent. per annum.

(ii) Extending and improving the approaches as and when necessitated by increases in the volume of the traffic.

(iii) By arrangement with the appropriate local bodies, extending and improving the streets and roads feeding traffic to the approaches.

(iv) Meeting the cost of making good any extraordinary damage to the bridge and its approaches not covered by the allowance for ordinary maintenance and upkeep.

(v) Assisting the appropriate local bodies to meet the cost of providing special facilities—*e.g.*, bus terminals and shelters—necessary for the efficient handling of increased traffic.

(vi) Reimbursing the interest-bearing portion of the capital sum provided by the Government at an earlier date than that at which it would be amortized by means of the sinking fund.

(vii) After reimbursement of the portion of the capital sum referred to in the preceding subparagraph (vi), reimbursing the sum of £500,000 provided by the Government interest-free for a term of twenty years, with interest accruing thereon at the rate of 4 per cent. per annum from the expiration of that term.

We recommend that, after making such provision as the Government deems prudent for the matters referred to in subparagraphs (i) to (vii) and after reviewing the actual financial results of operation, the Government, if it is satisfied that a reduction of toll charges is warranted, should reduce such charges directly and/or by making provision for return and other concession rates. We are strongly of the opinion that the contingencies and development fund and any accumulated surpluses should be entirely at the disposal of the Government, to be used for the foregoing and other purposes of a cognate nature at such times and in such manner as it considers proper.

In our answer to the question set out in clause (3) (c) of the order of reference we estimated the capital cost of the bridge and its approaches, at *present-day prices*, to be—

	£
Bridge structure	2,200,000
Approaches, &c. (first stage only as previously defined) . .	550,000
Interest during construction	250,000
	<hr/>
	£3,000,000
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The above estimate was arrived at after paying due regard to factors such as the following :—

(1) World-wide shortages of steel, paint, and construction plant; lack of competition among contractors; and abnormally high freights.

(2) Local shortages of cement, timber, electric energy, fuel, technical staff, skilled labour, and transport.

If, as we recommend, a period of at least five years is allowed to elapse before incurring any expenditure save on investigations, designs, and economic studies of the project, we venture the opinion that the capital cost should not exceed £2,400,000, made up as follows :—

	£
Bridge structure	1,750,000
Approaches, &c. (as above)	450,000
Interest during construction	200,000
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	£2,400,000
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(b) *Annual Costs and Revenue.*—We calculate annual costs on the conservative basis that the capital cost of the bridge and approaches, with interest during construction, is £3,000,000, as set out in our answer to clause (3) (c) of the order of reference. From this we deduct the interest-free sum of £500,000, leaving net capital cost for purposes of computing annual expenditure at £2,500,000.

Estimated Daily Revenue—		£	s.	d.
Motor-cars, 4,000 at 1s.	.. .. .	200	0	0
Motor-lorries, 1,000 at 2s. 6d. (average)	.. .. .	125	0	0
Passengers, 16,000 at 1d.	.. .. .	66	13	4
Sundries (bicycles, motor-cycles, &c.)	.. .. .	8	6	8
		<hr/>		
		£400	0	0

Estimated Annual Revenue—		£
£400 (daily revenue) x 365	.. .. .	146,000

Estimated Annual Costs—		£
Interest at 4 per cent. on £2,500,000	.. .. .	100,000
Sinking fund: $\frac{1}{2}$ per cent. on £2,500,000	.. .. .	12,500
Contingencies and development fund: $\frac{1}{2}$ per cent. on £2,500,000	.. .. .	12,500
Maintenance, operation, and administration	.. .. .	20,000
		<hr/>
		145,000
Estimated annual surplus		£1,000

While we have considered it wise to frame our revenue and expenditure account on the basis of the capital cost of the bridge and approaches being £3,000,000, we reiterate the opinion we have already expressed that the cost may not exceed £2,400,000. We invite attention to the subjoined Table I, which shows the effect on surplus earnings of capital costs ranging downwards from £3,000,000 to £2,400,000:—

Table I.—Surplus Revenue calculated on the Basis that the Interest-rate is 4 per cent. as shown above, that Revenue is £146,000 as set out above, and that Net Capital Cost is taken as Gross Cost, less the sum of £500,000 interest-free for Twenty Years

Net Capital Cost.	Annual Expenditure.	Surplus.
£	£	£
2,500,000	145,000	1,000
2,400,000	140,000	6,000
2,300,000	135,000	11,000
2,200,000	130,000	16,000
2,100,000	125,000	21,000
2,000,000	120,000	26,000
1,900,000	115,000	31,000

We have also considered it wise to make our estimate of revenue from traffic on a conservative basis, and in doing so we have had regard to the possibility of the growth of traffic being retarded for some years by continuing shortages of motor-vehicles, motor-spirit, and tires. It is to be noted, too, that the traffic volume on which we have based our estimate of revenue is that which may be expected in ten years time, and that

traffic will probably tend to increase at a more rapid rate after the bridge is completed. The subjoined Table II illustrates the effect on surplus earnings of variations in traffic volume :—

Table II.—*Surplus Revenue calculated on Basis that the Net Capital Cost is £2,500,000 as above, that Annual Expenditure is £145,000 as above, and that Traffic Volumes vary as shown hereunder*

Daily Traffic Volume.					Revenue from Sundries.	Annual Operating Result.	
Toll-paying Vehicles.			Toll-paying Passengers.	Non-toll-paying Buses.			Total Vehicular Traffic.
Total.	Cars.	Trucks.					
3,750	3,000	750	12,000	375	4,125	£ 6½	£ 35,470 deficit
*5,000	4,000	1,000	16,000	500	5,500	8½	1,000 surplus
6,250	5,000	1,250	20,000	625	6,875	10½	37,470 surplus
7,500	6,000	1,500	24,000	750	†8,250	12½	73,939 surplus
8,750	7,000	1,750	28,000	875	9,625	14½	110,409 surplus
10,000	8,000	2,000	32,000	1,000	11,000	16½	146,878 surplus

* Toll-paying traffic assumed by Commission for 1956.

† Estimated traffic in 1965.

This table ignores increased costs of administration (toll-collection, &c.), resulting from increases in traffic volume.

The most important item in the annual expenditure is the interest to be charged on capital cost. For the reasons we have already given, we consider that the rate should be fixed at 4 per cent. per annum. The subjoined Table III shows the effect on annual expenditure of variations below and above that rate :—

Table III.—*Effect on Annual Financial Results of Variations in the Interest-rate charged on Net Capital Cost, where Net Capital Cost is taken as £2,500,000 and Annual Revenue is £146,000 as shown above*

Interest-rate, per Cent.	Operating Results.
3	£ 26,000 surplus.
3½	13,500 surplus.
4 (rate recommended by Commission)	1,000 surplus.
4½	11,500 deficit.
5	24,000 deficit.

We append a further table—Table IV—of comparative toll charges, from which it can be seen that the rates recommended by us, which we regard as initial rates only, compare favourably with those charged in other cases that we have cited. We recommend also that, as and when the revenue position permits, the Government reduce the toll charges as suggested earlier in this report, either directly or by the provision of return and other concession rates, or both.

Table IV.—Comparative Statement of Toll Charges

Item.	Toll Charges proposed by 1946 Commission.	Tolls proposed by 1929 Commission.	Toll Charges specified in Auckland Harbour Bridge Empowering Act, 1931.	Toll Charges proposed by Auckland Harbour Bridge Co., Ltd., in its Submission to 1946 Commission.	Toll Charges on Sydney Bridge as at 11th May, 1945.	Toll Charges on all New York Tunnels and Bridges.
Motor-cars—	s. d.	s. d.	s. d.	s. d.	s. d.	Cents.
(1) Small .. ..	.. ..	.. ..	0 9	.. ..	.. ..	..
(2) Five-seater .. ..	.. ..	.. ..	1 0	.. ..	.. ..	..
(3) Up to seven-seater .. ..	.. ..	.. ..	1 8	.. ..	.. ..	..
(4) All	1 0	1 0	.. ..	1 0	0 6	50
Motor-cycles	0 3	.. ..	0 6	0 6	0 3	25
Motor-lorries—						
(1) Up to 1½ tons	1 6	1 6*	1 7	.. ..	.. ..	..
(2) Up to 2 tons .. ..	.. ..	2 0	.. ..	.. ..	0 9	50
(3) 1½ to 3 tons	2 6	3 0†	1 11	.. ..	1 6	..
(4) Up to 4 tons	3 0	5 0	2 7	.. ..	.. ..	..
(5) Up to 5 tons	3 6	7 6	3 1	.. ..	.. ..	75
(6) Up to 6 tons	4 0	.. ..	3 9	.. ..	.. ..	..
(7) Up to 7 tons	4 6	.. ..	4 4	.. ..	.. ..	..
(8) Up to 8 tons	5 0	.. ..	5 0	.. ..	.. ..	..
(9) Up to 9 tons	5 6	.. ..	5 7	.. ..	.. ..	..
(10) Up to 10 tons	6 0	.. ..	6 3	.. ..	2 0	Dollars, 1
Average of above rates used in calculating revenue	2 6	.. ..	.. ..	2 6	.. ..	..
Passengers in vehicles—						
(1) All	0 1	.. ..	.. ..	.. ..	.. ..	..
(2) On buses only .. ..	.. ..	.. ..	0 1	0 1	0 0¼†	..
(3) In private motor-vehicles	.. ..	.. ..	.. ..	.. ..	0 3	..

* Up to 1 ton.

† Up to 3 tons.

‡ Though only ¼d. is designated as toll, the additional fare charged is 1d.

We append for comparison a schedule of the charges at present made by the Devonport Steam Ferry Co., Ltd., which include Harbour Board tolls. We have noted, in this connection, that an application has been made by the company for authority to increase its charges.

*The Devonport Steam Ferry Co., Ltd.—Schedule giving Passenger and Vehicular Fares
(Showing also Details of A.H.B. Tolls on Vehicles)*

PASSENGER TICKETS

Type of Ticket.	Singles.		Returns.		Weeklies.		12-trips.		Quarterlies.		Half-yearly.		Yearly (Male).		Yearly (Female).		Yearly (Family).		Yearly (Children).		
	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	
Children	..	0 2*	0 3	0 3	0 9	0 9	..	3 0	..	30 0	..	53 0	..	92 6	..	82 6	..	137 6	..	12 6†	7 6
Adults	..	0 5	0 9	0 9	2 3	2 3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Bicycles	..	0 2	0 2	0 2	0 9	0 9	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Apprentices	1 9	1 9	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Workers	2 3	2 3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

* Under fourteen years.

† Under twenty-one years.

VEHICULAR TICKETS

Type of Vehicles.	Toll.		Freight.		Total.		Toll.		Freight.		Total.	
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
Motor-cycles, motor-cars, and buses—												
Motor-cycles ..	0 2	0 10	0 4	1 2	0 4	1 6	2 0	4 6	2 0	6 6	2 0	6 6
Motor-cars—												
Baby ..	0 2	1 4	0 4	2 2	0 4	2 6	2 0	8 6	2 0	10 6	15 0	110 0
Baby, A.T.H. ..	0 2	1 10	0 4	2 8	0 4	3 0	2 0	10 0	2 0	12 0	17 6	130 0
5-seater ..	0 3	2 3	0 6	3 3	0 6	3 9	..	..	..	..	..	..
7-seater ..	1 0	5 0	1 6	7 0	1 6	8 6	..	..	..	..	..	..
Buses—												
15-20-seater ..	1 3	7 6	1 9	9 6	1 9	11 3	..	..	..	..	..	..
20-30-seater ..	1 3	9 3	2 0	11 6	2 0	13 6	..	..	..	..	..	..
30-40-seater ..												
Trucks and vans—												
Trucks—												
1½ tons ..	0 3	2 0	0 3	2 3	0 3	2 6	0 6	2 9	0 6	3 3	0 6	3 9
1¾-3 tons ..	0 3	2 3	0 6	2 9	0 6	3 3	0 9	3 5	1 0	5 0	1 0	6 0
3-4 tons ..	0 6	2 9	1 0	3 6	1 0	4 6	1 6	4 9	2 0	6 6	2 0	8 6
4-5 tons ..	0 6	3 0	1 3	4 6	1 3	5 9	1 9	6 6	2 6	8 3	2 6	10 9
5-6 tons ..	0 9	3 6	1 6	5 6	1 6	7 0	2 3	7 9	3 0	10 3	3 0	13 3
6-7 tons ..	0 9	4 0	1 9	6 6	1 9	8 3	2 6	9 3	3 6	12 0	3 6	15 6
7-8 tons ..	1 0	4 6	2 0	7 6	2 0	9 6	3 0	10 6	4 0	14 0	4 6	18 0
8-9 tons ..	1 0	5 0	2 3	8 6	2 3	10 9	3 3	12 0	4 6	15 9	5 0	20 3
9-10 tons ..	1 3	5 6	2 6	9 6	2 6	12 0	3 9	13 3	5 0	17 6	5 0	22 6
10-15 tons ..	1 6	6 6	3 9	16 3	3 9	20 0	5 3	20 0	7 6	28 6	7 6	36 0

Quarteries.

12-trip Concessions.

Returns.

Singles.

Return (Load Two Ways).

Return (Load One Way).

Single (Empty).

Single (Loaded).

(5) If such direct access is not considered necessary at present, within what period of time will the probable growth of population, and the use of motor-vehicles together with other forms of transport, render it necessary ?

Having regard to the probable growth of population and the density of the traffic likely to benefit from and make use of a bridge, we consider that a bridge will become a necessary facility, economically justifiable, within a period of time estimated by us at ten to fifteen years, but to be determined more precisely by general economic conditions prevailing five years hence—*i.e.*, in 1951. Within that period of five years, as we have already recommended, the necessary surveys, borings, investigations, designs, economic studies, negotiations, and other steps necessary to establish a reliable estimate of the cost of construction of the bridge and its approaches should be undertaken by the Government. We discuss the probable growth of population and the resulting increase in traffic in a later part of this report.

(6) If you consider that the existing ferry services should remain in operation, either with or without other means of direct access, what improvements, if any, should be made in the services now provided ?

The ferry services have provided a cheap and flexible means of passenger transport which it would be advantageous to continue in modified form even after the bridge is in service. Those residents of Stanley Bay and Devonport who do not possess cars will be served more efficiently and economically by the retention of the passenger service by ferry to those points. In our opinion, the most desirable and necessary improvement is the provision of an all-night vehicular service, which the Devonport Steam Ferry Co., Ltd., informed us that it hoped to commence about the end of July, 1946. We record our view that, after due allowance is made for conditions arising out of the war, the company has met, as far as reasonably possible, all demands made upon it, and has given satisfactory evidence of its intention to improve its services. The two large vehicular vessels recently acquired by the company and the new passenger ferry vessels that it contemplates building will enable better services to be provided during the period that will elapse before the bridge is completed. In so far as the vehicular service is concerned, the use of the larger vessels and the provision of a more frequent time-table, especially during peak-loading periods, should cater with reasonable expedition for some years to come for all but Sunday and holiday peak-time traffic. It would obviously be uneconomic to provide a sufficient number of vessels and landing facilities to obviate occasional delays to traffic and the consequent formation of queues. The task of the company would be simplified if more use were made of the Birkenhead vehicular service thereby relieving the strain on the Devonport vehicular service, and we are of the opinion that immediate steps should be taken to attract traffic to the former service by improving the roads and streets leading to the Birkenhead terminal, as recommended by Sir Francis Frazer following his recent inquiry. Such improvements will remain as an amenity to the district after the bridge is in service, and accordingly we recommend Government aid on a generous scale to enable the local authorities to make early arrangements for carrying out the work to be performed within their respective areas, which it is estimated will cost about £20,000. We understand that the improvement of No. 5 State Highway between Wairau Road junction and Birkenhead is to be undertaken by the Main Highways Board and will be charged against its funds. In view of our recommendation that the bridge should be completed between ten and fifteen years hence, we do *not* recommend that the Auckland Harbour Board proceed with its plans for duplicating the vehicular ferry terminals at Mechanics Bay and Devonport or for providing a new combined passenger and vehicular ferry terminal at Little Shoal Bay. Such improvements as the Auckland Harbour Board deems necessary should be planned and executed on the clear understanding that direct access by means

of a bridge will be available within fifteen years, and possibly in ten years. We subscribe to the following views expressed by the Auckland City Engineer in the very able and comprehensive report presented by him to the Commission :—

(1) It can generally be accepted that the vehicular ferry service, from the long-term point of view, is of a temporary nature, and cannot be taken into consideration in determining the street layout of the city.

(2) However well located a bridge or tunnel may be, it seems that, even with a full system of causeways, a portion of the population would be (only) indirectly served thereby, and there is a practical possibility that certain of the North Shore areas will continue to be served by ferries at least for many years. It would not be unreasonable to assume that the proportion of the population that would be directly served by bridge or tunnel would be at most two-thirds, and possibly less in the initial stages of development.

(3) While the Auckland City Council should view the project from the metropolitan aspect in order to secure proper functional planning, it must also be mindful of the fact that there are as yet large undeveloped areas within its boundaries, and such a project would introduce costly problems in respect of street works and allied problems. The Council has also costly developmental improvements to meet in the future.

In amplification of our views on the subject of ferry services, we express our belief that for many years a passenger ferry service between the city and Devonport could compete with the proposed bridge in serving those residents of Devonport (including Stanley Bay) who live near to the waterfront, by providing a quicker and cheaper transport service than could be given by a bus service crossing the bridge. It is probable that apartment-houses will increase the density of population on the waterfront of Devonport and that a majority of the residents in that locality will prefer the ferry service. We are of the opinion that if the Devonport Steam Ferry Co., Ltd., is willing to continue passenger ferry services to Stanley Bay and Devonport, it should be allowed to do so; and in order to enable the company to formulate its plans for the future we suggest that, if our report is adopted, the Government should announce its decision at the earliest possible date.

With respect to the vehicular ferry services, we are of the opinion that, regard being had to delays, damage, and inconvenience unavoidable in a ferry system, there will be no justification, and indeed no scope, for continuing them after the bridge comes into use.

We summarize our recommendations concerning the ferry services as follows :—

(1) The provision of an adequate fleet and of improved and augmented services (including all-night services) to cope with the increased volume of traffic which will occur within the next ten to fifteen years.

(2) Avoidance of heavy capital expenditure on permanent works, such as the duplication or enlargement of existing ferry terminals or the creation of new terminals, the cost of which, according to evidence submitted to us, would amount to a substantial part of the cost of the bridge and approaches.

(3) Improvements to the roads and streets leading to the Birkenhead ferry terminal, for the purpose of relieving congestion at Devonport by attracting more traffic to Birkenhead, should be arranged for forthwith, and adequate subsidies should be granted to the local bodies concerned to enable them to effect such improvements in the shortest possible time.

(4) Such improvements to present passenger terminals as the Auckland Harbour Board deems advisable and necessary to be planned on a short-term basis only, and an assurance to be given by the Government that direct access by bridge will be an accomplished fact within a maximum period of fifteen years.

(5) A similar assurance to be given to the Devonport Steam Ferry Co., Ltd., together with an intimation that, while the vehicular ferry service will be discontinued when the bridge comes into service, no restriction will be placed on the continuance of a passenger service to Stanley Bay and Devonport, and possibly Bayswater.

We stress the point that, in our opinion, a statement setting out the Government's intentions is due, at the earliest possible date, to all interests concerned, and particularly to the Auckland Harbour Board, the local authorities concerned in metropolitan planning, and the Devonport Steam Ferry Co., Ltd., in order to enable them to formulate their respective plans and policies.

(7) Generally, any other matters arising out of the premises that may come under your notice in the course of your inquiries and which you consider should be investigated therewith ?

We record our opinion that, when direct access to the North Shore area is an accomplished fact, co-ordination of the road passenger transport services on both sides of the harbour will become necessary. At present the bus systems on the North Shore cater to some extent for local traffic, but their principal function is to convey passengers to and from the ferries. When the bridge is opened for traffic, the greater number of the passengers now using the ferries will travel across the harbour by bus. If the southern terminal were near the city bridge-head, the influx into the city of a large fleet of North Shore buses would create a difficult parking problem, especially during peak-time periods, and also would make it necessary to provide connecting services for the conveyance of passengers to and from different parts of the city and southern suburbs ; and if, as we consider desirable, the North Shore buses were routed to different parts of the city and southern suburbs, confusion and complication with the city transport system would result unless both systems were under one control and were operated as a single system. We therefore recommend that at the appropriate time the area controlled by the Auckland Transport Board be extended to include the North Shore area or such part of that area as is urbanized. We recommend that the bus services crossing the bridge and serving the principal North Shore localities be operated by the Board, and that local services and feeder services to the Board's routes and to the ferries on the North Shore be operated either by the Board or under license from the Board. We recommend, further, that the Board provide for the North Shore localities a scale of fares and concession rates similar to that which it provides for correspondingly distant localities on the southern side of the harbour ; and in this connection we refer to our earlier recommendation that public conveyances shall be permitted to cross the bridge free of tolls, the only toll being the 1d. paid by each passenger. This toll, we suggest, can conveniently be collected by means of the issue of special tickets to be sold to passengers by the conductors or drivers of buses, payment of the proceeds to the controlling authority of the bridge being made monthly or at other stated intervals. We also recommend that the Auckland Transport Board consider according high priority to the principal North Shore routes when planning trolley-bus services to expand or replace its present services, and that the Board make provision for the through or circular routing of the North Shore buses to suitable areas in the city and southern suburbs. In passing, we express the opinion that a trolley-bus system appears to be well suited to the terrain and transport requirements of the North Shore, and that such a system can easily be incorporated in a unified system for the whole metropolitan area. However, whether a service by trolley-buses or by fuel-driven buses is decided upon, we are convinced that that service can be operated satisfactorily only as an integral part of a single metropolitan system under the control of one central authority. Such a system affords the only practicable means of avoiding intense traffic congestion at a single city terminal and the attendant delay and inconvenience to passengers occasioned by transferring to and from connecting vehicles at such a terminal, and of providing convenient co-ordinated through services between the North Shore area and the city and southern suburbs. We are of the opinion, too, that only a metropolitan transport organization can economically maintain a general reserve fleet sufficiently large to enable an adequate number of vehicles to be made available for handling the exceptionally high peaks of traffic at week-ends and on holidays that are a feature of North Shore passenger transport.

The Auckland Transport Board has indicated its willingness to have its area extended to include the North Shore area if such an extension is desired.

GENERAL DISCUSSION

We considered it advisable, when preparing the section of this report which sets out our specific findings and recommendations, not to overload that section by incorporating the detailed reasons for our conclusions. We now proceed to discuss more fully, under appropriate headings, the more important considerations by which we have been guided in framing our report, and to place on record certain data that we think can be more conveniently considered in this part of our report.

(1) NATIONAL VALUE OF DIRECT ACCESS TO THE NORTH SHORE

This would be considerably affected by the provision of a State highway from the city boundary at Avondale to Whenuapai and Dairy Flat. Such a highway alone would meet the need for better communication with areas farther north, and, despite the views expressed by a number of witnesses, we consider that part at least of the motor traffic to and from the north would prefer this route to the bridge route, if only to avoid payment of tolls. There are, however, adequate grounds for our belief that a harbour bridge will be of sufficient national importance to justify substantial financial support from the Government. We mention the following :—

(i) Its value for defence purposes in times of war in providing direct all-weather access to the naval base and other military installations, and in reducing the cost of maintaining them in peace.

(ii) Direct saving of cost of transport of construction materials for Government housing schemes on the North Shore, and bringing within close range of the city large areas suitable for further housing development.

(iii) The North Shore beaches are worthy of being rated as a national asset, and direct access to them will benefit not only tourists and motorists, but the less well-to-do families.

(iv) However efficiently the ferries are conducted, the services are subject to interruption by fogs and storms. Congestion and irksome delay must always occur during peak-loading periods, and especially when holidays create abnormal peaks of traffic ; and it is manifest that to require the provision of services of sufficient capacity to eliminate these delays would be unreasonable and uneconomic. In the aggregate, the economic losses entailed by the use of a system which inevitably involves great waste of time, though difficult to assess precisely in money terms, must be very considerable.

We have been greatly impressed by evidence indicating the many ways in which the present restricted access affects the welfare of the North Shore area. The population at present numbers some 35,000, and the forecast of the population of the North Shore boroughs in 1965, as given in the Metropolitan Planning Report for 1943, is 55,000, to which we have added another 8,000 in the remainder of the North Shore area, making a total of 63,000. This is the largest community in New Zealand not directly served by rail, and the only populous area wholly dependent on a ferry service. Although, in a strictly technical sense, a bridge is not a link in the present declared main highways system, and accordingly the local authorities are not eligible for direct assistance from the Main Highways Board's funds, we consider that a strong case has been presented for the provision of Government finance in the form that we have recommended.

(2) BRIDGE OR TUNNEL

Estimates of the cost of a bridge and approaches conforming to the recommendations of the 1929 Commission, and subsequently amended to comply with the requirements of the Auckland Harbour Board, have now to be increased very substantially, probably by as much as 70 per cent. The estimate of the 1929 Commission was nearly £2,000,000, but this was for a bridge 4,740 ft. long terminating in St Mary's Bay boat harbour and connected to the foreshore by a long embankment. The Auckland

Harbour Board stipulated that the length of the structure should be increased to approximately 5,340 ft. to minimize detriment to St. Mary's Bay boat harbour. On the northern side the approaches consisted of a long causeway from Northcote to Stanley Bay, via Bayswater Point. An expensive feature of this scheme was that two bridges, totalling 1,700 ft. and possibly 2,000 ft. in length, had to be provided to preserve the tidal flow into and out of Shoal and Ngataringa Bays. A present-day estimate for the bridge and its approaches, by the Fanshawe Street - Northcote - Bayswater - Stanley Bay route, would be not less than £3,400,000.

Turning to the alternative of a tunnel, evidence was tendered to us respecting the estimated cost of a two-way vehicular tunnel on the same site as the bridge. The data available as to level of bedrock, while sufficient for an approximation, were not comprehensive enough to fix a firm figure, but the probable cost was stated by an experienced engineer to be of the order of £4,000,000, and this for a tunnel only 6,300 ft. long with 8-per-cent. grades. In our opinion, however, a better route, from the point of view of traffic distribution and city expansion, would be from Parnell to Devonport. As the depth of rock was unknown over the greater part of this route, the Government, at the request of the Commission, met the cost of surveys and borings, which, while not extensive enough for detailed design purposes, were sufficient to determine, with a reasonable degree of accuracy, the length and grades of a vehicular tunnel. Two types were considered:—

- (i) Bored entirely in rock.
- (ii) Part length bored in rock and the remainder prefabricated, floated to site, sunk, and jointed in a dredged channel.

An essential feature of a tunnel is that it must be at such a depth as will not cause interference with port development. Regard being had to this, and in the light of the information provided by the borings, the best route appeared to be as follows: the southern portal is located on Strand Road near the railway-station, about a quarter of a mile from the foreshore. Here there is room for a spacious plaza. This location is very suitable from the point of view of city traffic distribution. Passing under the railway-tracks near Campbell's Point overbridge, the route of the tunnel lies slightly to the west of the eastern tide deflector, in which position it will be well clear of future wharves. Crossing the harbour channel nearly at right angles, it passes under the northern foreshore at a level that ensures that there will be no interference with future wharves or quays. The northern portal is located on the foreshore of Ngataringa Bay close to the foot of Alison Avenue.

The invert of a tunnel bored in rock with adequate cover would be about 170 ft. below high-water level. The probable lengths of the two types of tunnel, allowing grades not exceeding 1 in 20, would be—

- (a) Bored in rock, 10,000 ft.
- (b) Part bored and part pre-cast, 9,300 ft.

It is emphasized that these figures are approximate only, and much more detailed investigation would be necessary before the precise length, or the most economical type, of tunnel could be decided upon; but they indicate that the probable cost of either type would be not less than £3,500,000, and possibly £4,000,000. This outlay would provide a single two-way tunnel with 23 ft. roadway; but for a considerably lesser sum it is possible, in our opinion, to provide a four-way bridge with more than treble the traffic-carrying capacity. Furthermore, the costs of maintenance, including drainage, lighting, ventilation, and traffic control, would be considerably higher for a tunnel than for a bridge. Various proposals for tunnels, accompanied by estimates of costs arrived at by comparisons with existing tunnels in other countries, were placed before the Commission by witnesses who had virtually no information as to the depth

and character of the sea-bed of the Waitemata Harbour, and whose estimates, therefore, were purely conjectural. Advocates of a tunnel in preference to a bridge stressed several obvious advantages, among the principal of which were—

- (i) Non-interference with aircraft.
- (ii) Lesser vulnerability in wartime.
- (iii) Better relationship to existing traffic centres on both sides of the harbour.
- (iv) Less imported materials.

However, apart from other disadvantages, cost alone, in our opinion, is sufficient to decide that a tunnel is a much less favourable proposition than a bridge. We have, however, taken cognizance of the possibility that, with continued improvements in the technique of tunnelling, largely made possible by the use of more efficient construction plant, costs may decrease; and at some future date, when it becomes necessary to provide augmented trans-harbour traffic facilities, the construction of a tunnel on the route we have suggested may become a practicable alternative to duplication of the bridge. In this connection we draw attention to the suitability, as a common approach to both bridge and tunnel, of the route we have recommended for the second stage of the northern approach to the bridge—that is, from the head of Shoal Bay via Bayswater to Devonport.

Advocates of a bridge cited examples such as Sydney, San Francisco, and Vancouver, none of which we regard as strictly comparable with Auckland, in support of their contention that a bridge was economically justifiable, and several witnesses had obviously gone to considerable trouble to collate information. The majority of the interests represented preferred a bridge to a tunnel.

(3) DISCUSSION OF BRIDGING PROBLEM

In an endeavour to find the best and cheapest solution of the problem, we have thoroughly examined all the schemes placed before us and have kept to the forefront the need for long-term planning in a work of this magnitude. Floating bridges, either of the arch type adopted at Hobart, or of the heavy continuous pontoon type adopted at Lake Washington, near Seattle, U.S.A., with opening or lifting spans, were considered; but in our opinion they are not suitable for Waitemata Harbour because of its tidal range, high current velocities, and occasional rough water, and because the provision of any form of opening or lifting span would involve intolerable delay to both shipping and road traffic, and the use of the waterway would also be greatly impeded for yachting.

We early reached the conclusion that long spans on high piers were unavoidable, and that the most favourable location for the northern abutment was Stokes Point, Northcote.

The 1929 Commission also selected Stokes Point for the site of the northern abutment. The alignment it proposed for the bridge was partly straight and partly curved, extending across Waitemata Harbour, intersecting St. Mary's Bay breakwater about its mid-length, and then continuing in a curve to connect with a long approach leading to Fanshawe Street. The route proposed practically bisected the boat harbour, and in order to meet the objections of the Harbour Board the length of the bridge structure was increased from 4,740 ft. to 5,340 ft.

In other designs subsequently proposed on the same alignment, the length of the bridge structure ranged from 5,340 ft. to 6,400 ft. On the route we propose, the length need not exceed 4,100 ft., representing a very considerable saving in capital cost and maintenance. Apart from the question of length, however, there are other objections to the route adopted in former schemes. We mention the following:—

- (i) The axis of the bridge is not normal to the line of the strongest tidal currents in the navigation channel.
- (ii) The southern terminal is not favourably placed for distributing traffic to the higher levels of the city.

(iii) The approaches on the south side impair St. Mary's Bay, while the causeways on the northern side cut off large areas of Shoal and Ngataringa Bays and prejudice their possible development.

(iv) The northern approach does not lead directly to the future centre of gravity of the North Shore population, though favourably located to serve the needs of the Borough of Devonport, which in 1929 was by far the most populous of the North Shore boroughs. The Devonport Borough Council, however, fears that a bridge will prejudicially affect the local passenger ferry service, and considers that, because of the greater travelling distance involved, it will be of little value to Devonport residents. We do not subscribe to this view.

These objections, we consider, can be overcome by altering the alignment of the bridge and its approaches as follows: while retaining the position of the northern abutment in the position chosen by the 1929 Commission on Stokes Point, Northcote, it is recommended that the axis of the bridge be swung 12° to the west, thereby becoming more nearly normal to the direction of maximum currents and thus facilitating navigation for large ships. On this alignment the southern abutment would be located on a reclamation at the west end of St. Mary's Bay boat harbour below Point Erin Park and close to the foot of the cliffs. In this position the bridge would clear by an adequate margin the roadway formed along the St. Mary's Bay breakwater. The existing reclamation, now used as an area for hauling out yachts and other small craft, would be widened to accommodate the road approach and toll-collection facilities. This would necessitate the provision of another hauling-out area at St. Mary's Bay or elsewhere, which, however, would present no difficulty. One branch of the approach would turn eastward to connect with Fanshawe Street, by means of a waterfront road skirting the cliffs. In this position the road approaches would not impair the boat harbour. Furthermore, we consider that a waterfront road in this location would be a civic amenity and would form the first stage of a future continuous highway, by-passing built-up areas and linking with the future northern highway to Whenuapai.

Large quantities of spoil will be required to form the southern approach along the foreshore of St. Mary's Bay and to reclaim an area at the western end of the boat harbour adjacent to the southern abutment of the bridge, where the approach has to be widened to accommodate toll-collection facilities. The best means of obtaining this spoil would be to dredge it from the bed of the boat harbour. The consequent deepening and enlargement of the mooring-space would be very advantageous. Dredging by itself can be a comparatively expensive process, but if combined with reclamation in the manner we suggest the cost becomes quite reasonable. We have dealt at some length with the subject of the boat harbour because we regard it as a very valuable civic asset. Such an opportunity to carry out dual-purpose dredging seldom occurs, and we recommend this instance as one that should not be lost.

A second branch of the approach would connect with the foot of Curran Street and Sarsfield Street, providing useful direct access to existing arterial streets leading to the higher levels of the city and to its north-western and western suburbs. A point of importance is that, while the airport remains at Whenuapai (which may be for many years), the route via Curran Street and the Great North Road would provide direct and easy access from the North Shore to the airport.

Still another point in favour of the alignment we have chosen may be mentioned as of possible future importance. Should the traffic volume of the distant future warrant duplication of the bridge, the second structure could be sited close to and parallel with the original structure and its southern terminal could be sited on the top of the cliff fronting Point Erin Park about 60 ft. above sea-level. In this position, by means of a simple variation of the gradient proposed for the original structure, the new bridge would give easy and direct connection with existing city streets on the higher levels, while the original structure would continue to distribute traffic to and from the low-level

waterfront roads. At the higher level we mention there would appear to be little difficulty in connecting the second bridge with the proposed underground railway-station near the Town Hall. Such a connection might be of interest if the railway system were to be extended to the North Shore, though this possibility may be regarded as remote in view of the probability of a trolley-bus system serving the North Shore area more efficiently than a railway.

On the northern side we propose that the approach descend to the foreshore as planned by the 1929 Commission, but that instead of diverging east to O'Neill's Point, Bayswater, it should continue along the foreshore to the head of Shoal Bay (Napier Avenue), thus leading almost directly to the existing centre of population of Takapuna and the future centre of gravity of the entire North Shore population. Birkenhead and Northcote residents would make use of existing roads and streets, but these are not considered suitable to carry the additional strain of the expected volume of high-speed traffic proceeding to and from other parts of the North Shore area.

By forming a branch of this approach to Barry's Landing and by continuing the approach southward to Devonport, a future high-speed by-pass of the existing highway can be created, though we do not regard this work as a necessary part of the initial programme, and recommend it only as a second-stage development, to be constructed as and when warranted. Some points in favour of the future road system envisaged by us are :—

(a) Should a tunnel be constructed in the future, the by-pass would connect the most likely site for the northern portal with the future centre of gravity of the North Shore population. We have referred elsewhere to this circumstance in our discussion of the possibility of a tunnel being constructed from Parnell to Devonport.

(b) The relatively small areas of the upper reaches of Shoal and Ngataringa Bays cut off by the approach highway do not involve any bridging, or at most one very small structure, and thus the 1,700 ft. or 2,000 ft. involved in the proposal of the 1929 Commission can be avoided. If drained by means of culverts with flood-gates, these areas could be reclaimed at small cost and would become of considerable value. This, however, is a long-term matter, and can be arranged between the Harbour Board and the respective local bodies concerned; but we commend it as one that should not be overlooked as being worthy of consideration at the appropriate time or times. The conversion of these mangrove mud-flats into pasture lands could be achieved in a period of six or seven years after completion of the approach roads, which would serve as the principal stop-banks for excluding tidal waters. Thereafter, as and when the demand arose, portions of these areas contiguous to roads could be set aside and developed as industrial or recreational sites. Whatever the final purpose might be, the reclamation of these unsightly areas would be of benefit to the boroughs concerned.

(c) Waterfront roads in these locations, connected by short laterals to a limited number of feeders on one side only, would by-pass built-up areas and permit relatively high speeds for traffic destined for the closely populated areas of Takapuna and the more distant areas to the north.

(d) As well as the elimination of bridging, the road system that we have planned makes possible substantial reductions in the quantities of earth-work required and of the rock necessary for protection against wave action. An obvious disadvantage of the route we propose is that it entails greater travelling distance for residents of Devonport, of the order of $1\frac{1}{2}$ miles. However, in view of the

retention of the Devonport passenger ferry service, we think this disadvantage is outweighed by the advantages accruing to the residents of the remainder of the North Shore area. Part of the western end of Bayswater Peninsula and the extreme southern end of the Borough of Takapuna will suffer a similar disadvantage, but not to the same degree. We append a table setting out relative mileages by different routes :—

Road Distances via Harbour Bridge

Point of Origin.	Destination.	Route.	Distance.	Shortening.
Centre of population, Devonport (1946)	C.P.O., Auckland	Existing North Shore Borough streets, Fanshawe Street, and Customs Street, Auckland	M. ch. 9 69	M. ch. ..
		Stage I of 1946 Commission's route, Fanshawe Street, and Customs Street	8 10	1 59
		Stages I and II of 1946 Commission's route, Fanshawe Street, and Customs Street	7 60	2 09
	Top of Queen Street, Auckland	1929 Commission's route	6 25	3 44
		Existing North Shore Borough streets, Curran Street, Ponsonby Road, and Karangahape Road, Auckland	10 40	..
		Stage I of 1946 Commission's route, Curran Street, Ponsonby Road, and Karangahape Road	8 61	1 59
Centre of population, Takapuna (1946)	C.P.O., Auckland	Stages I and II of 1946 Commission's route, Curran Street, Ponsonby Road, and Karangahape Road	8 31	2 09
		1929 Commission's route	6 76	3 44
		Existing North Shore Borough streets, Fanshawe Street, and Customs Street, Auckland	7 32	..
	Top of Queen Street, Auckland	Stage I of 1946 Commission's route, Fanshawe Street, and Customs Street	5 74	1 38
		1929 Commission's route	6 34	0 78
		Existing North Shore Borough streets, Curran Street, Ponsonby Road, and Karangahape Road, Auckland	8 03	..
Junction Napier Avenue and Lake Road, Takapuna	C.P.O., Auckland	Stage I of 1946 Commission's route, Curran Street, Ponsonby Road, and Karangahape Road	6 45	1 38
		1929 Commission's route	7 05	0 78
		Existing North Shore Borough streets, Fanshawe Street, and Customs Street, Auckland	7 10	..
		Stage I of 1946 Commission's route, Fanshawe Street, and Customs Street	5 52	1 38
		1929 Commission's route	6 56	0 34

The above tabulation draws attention to the fact that Devonport residents will journey approximately 8 miles to reach Auckland City, while Takapuna residents will travel approximately 6 miles; and also to the fact that the distance from Devonport to Auckland via stages I and II of the approaches recommended by the 1946 Commission is 1 mile 35 chains longer than via the route recommended by the 1929 Commission, whereas the distance from Takapuna to Auckland is reduced by 40 chains. It is to be noted, in this connection, that the present and ultimate centres of gravity of the entire North Shore area are situated in the Borough of Takapuna, and that accordingly the saving of 40 chains will benefit a continually increasing percentage of the North Shore population.

Regarding the southern approach, which we recommend should form a waterfront road skirting the foreshore of St. Mary's Bay, we attach much weight to the evidence tendered by the Engineer to the Auckland Harbour Board regarding the industrial development likely to take place in the near future in areas fronting the upper reaches of the Waitemata Harbour. At no great cost in the way of dredging and reclamation, valuable sites can be made available to industrial concerns seeking deep-water, road-served frontages. Furthermore, it does not appear difficult to connect these sites with the existing railway system by means of a branch railway from Avondale. The potential value of such industrial development is undoubted. The Harbour Board's Engineer stated that several inquiries had already been received as to the prospects of sites being available in the near future. We therefore consider the prospective value of a low-level waterfront road forming part of a route leading to future industrial sites, combined with its immediate value as a by-pass of existing built-up areas and its function as an approach to the bridge, are very strong points in its favour.

An unavoidable concomitant of the construction of a waterfront road from Fanshawe Street along the foreshore of St. Mary's Bay is the necessity to extinguish riparian rights; but experience in this and other countries shows that the continued existence of such rights hampers civic development, and we consider that in this case the interests of the few owners who may be injuriously affected by extinguishment of their riparian rights should not be allowed to stand in the way of the creation of a most desirable civic asset.

The through distance from Fanshawe Street to Northcote by the route we propose is 24 chains longer than that along the route fixed by the 1929 Commission and adopted in subsequent proposals that were brought to our notice; but against this additional distance may be offset the value of the direct access to Curran Street and other existing streets which will be afforded to traffic destined for the higher levels of the city, the Whenuapai Airport, and the future waterfront road to which reference has been made. This advantage, together with others we have mentioned, leads us to recommend the adoption of the alignment we have proposed.

Clearances of Main Span, Vertical and Horizontal.—Some further aspects of the bridging problem, all of which affect its cost, will now be mentioned.

As stated above, we early reached the conclusion that the only type of bridge suited to the requirements of navigation and road traffic was a high-level, fixed structure. Any form of opening span would cause intolerable delays and difficulties to shipping and road traffic. It is noteworthy that the papa on which the piers of the principal navigation span will be founded lies at such a depth as to justify a long span, and accordingly we see no reason to depart from the length of the main span as recommended by the 1929 Commission—viz., 800 ft. centre to centre of piers. Regarding the vertical clearance, evidence was tendered to show that there was a trend towards reduction of the height of ship's masts, which appeared to warrant a lower vertical clearance than that adopted by the 1929 Commission; but our inquiries established the fact that radar installations in naval vessels require a vertical clearance of approximately 130 ft. Bearing this point in mind, and having regard to the probable universal installation of radar equipment in mercantile vessels, we think the clearance set by the former Commission—viz., 135 ft.—cannot be substantially lowered, however desirable it may be to effect reductions in the gradients and cost of the bridge. We consider, however, that the central 500 ft. of the soffit of the main span should be curved to parallel a vertical curve in the carriage-way. We recommend a vertical clearance at the mid-point of the main span of 137 ft., decreasing to 132 ft. at 250 ft. on each side of the mid-point—in other words, a minimum of 132 ft. over the central 500 ft. of the main span, and a maximum of 137 ft. at its mid-point. Over the remainder of the main span—that is, for distances of 150 ft. at both ends—it will be advantageous for design purposes progressively to decrease the clearance of 132 ft. as shown in the outline plan accompanying this report, with the dual object of lowering the highest point of the bridge structure and of increasing the depth of the cantilever arms.

Bridge Gradients.—The former Commission set a standard of 1 in 20 on both sides of the central span for the bridge and its approaches. Having regard to the improved efficiency of modern transport, some steepening of the gradient may be considered allowable, with consequent reduction in the length and cost of the structure. This, however, would tend to slow down the heavier commercial vehicles and affect the ultimate traffic-carrying capacity of the bridge. We therefore see no reason to depart from the original gradient of 1 in 20, or 5 per cent., though we fully considered the effect of increasing it to as steep as 1 in 18·18, or 5½ per cent., which would have the effect of shortening the bridge considerably. While on the subject of grades, we cite examples of well-known Auckland streets, details of which were supplied at our request by the City Council. These indicate that gradients of the order we propose, and some very much steeper, are by no means uncommon, though generally they apply over shorter distances :—

(1) Victoria Street East, between High and Kitchener Streets :	
Gradient for a distance of 2½ chains	1 in 7·8
(2) Wyndham Street—a short length between Queen and Albert streets :	
Gradient for a distance of 1½ chains	1 in 8·6
(3) Parnell rise, between Augustus Terrace and Bedford Street :	
Gradient for a distance of 6 chains	1 in 8·7
(4) Victoria Street West, between Albert and Elliott Streets :	
Gradient for a distance of 3 chains	1 in 9·5
(5) Wakefield Street, for a short length between Queen Street and St. Paul's Street :	
Gradient for a distance of 3 chains	1 in 9·8
(6) Upper Queen Street, between Turner Street and City Road :	
Gradient for a distance of 10 chains	1 in 11·05
(7) Wellesley Street West, between Albert and Federal Streets :	
Gradient for a distance of 2 chains	1 in 11·5
(8) College Hill : General gradient	1 in 11·7
(9) Wellesley Street West, between Queen and Lorne Streets :	
Gradient for a distance of 2 chains	1 in 13
(10) West End Road : Gradient for a length of 8 chains immediately west of the tennis-courts	1 in 14·8
(11) Union Street, from Napier Street to Wellington Street	1 in 16
(12) Great North Road, for a length of 4 chains flanking northern boundary of Auckland City Council property	1 in 17·2
(13) Princes Street, Bowen Avenue to Shortland Street	1 in 20·7
(14) Lower Symonds Street, Alten Road to Grafton Road	1 in 22
(15) Anzac Avenue, Beach Road to Eden Street	1 in 22
(16) Anzac Avenue, below Alten Road	1 in 22
(17) Pitt Street, Grey's Avenue to Wellington Street	1 in 24

The gradients tabulated above may be compared with those of two streets which would be traversed by traffic proceeding to the higher levels of the city from the southern bridge head, viz.—

(18) Curran Street : General gradient	1 in 11·7
(19) Sarsfield Street (regraded) and Shelly Beach Road (alternative route for heavy vehicles)	1 in 18·6

Width of Bridge.—The width of carriage-way set by the former Commission was 40 ft. In the statement put forward on behalf of M. R. Hornibrook (Proprietary), Ltd., it was recommended that the width be 60 ft. Examples of fairly recent American practice brought to our notice provide 27 ft. carriage-way. After taking into account the estimated population of the North Shore area in 1965, its ultimate population, and the resultant volume of traffic, we consider that a minimum of four traffic lanes should be provided, which, according to modern standards, will require 44 ft. between kerbs.

(4) AIR-BORNE TRAFFIC

A point of considerable importance is the possible obstruction to air traffic caused by a bridge on the Stokes Point - Point Erin site. We quote in full the submission tendered by the Air Department:—

AIR DEPARTMENT
CIVIL AVIATION BRANCH

3/1/24 CA
923

31st May, 1946.

Memorandum for
The Secretary,
Auckland Trans-harbour Facilities Commission.
C/- Public Works Department,
Auckland.

AUCKLAND HARBOUR BRIDGE—OBSTRUCTION TO FLYING

WITH reference to your circular memorandum of the 3rd instant, officers of this Department have given consideration to the effect that the presence of a bridge across Auckland Harbour will have on aviation activities in the vicinity of Auckland, and I wish to present the following views:—

(i) That the existence of a bridge across the Waitemata Harbour on any site east of Kauri Point/Point Chevalier cannot be construed as an obstruction to any aircraft manoeuvring to land at, or after take off from, any existing land aerodrome in the vicinity of Auckland. It is desirable, however, that the selected site should not be further west than Birkenhead.

(ii) Although, particularly in the future, all commercial and Air Force aircraft will be fitted with radio and have the advantage of radio and other suchlike aids to navigation and aids to facilitate approach to and landing at main aerodromes, there will always be a large number of smaller club and private aircraft not equipped with such aids. The presence of a bridge in any locality on the harbour over what would be otherwise comparatively an unobstructed waterway would constitute a danger to the aerial navigation of such unequipped aircraft manoeuvring in the vicinity under conditions of poor visibility or extremely low ceiling—conditions not uncommon over the Waitemata. This aspect is not considered of sufficient weight to merit serious consideration in the arguments for or against the provision of a bridge across the Waitemata. Regulations can be imposed prohibiting the passage of aircraft into this area under such conditions and below a safe altitude.

(iii) To permit of the safe manoeuvring of the smaller amphibious and marine aircraft (based on Hobsonville or any point on the Upper Harbour) landing or taking off in the restricted water channels of the Upper Harbour, it is most desirable that a site for the bridge should not be selected further west than Birkenhead.

(iv) To facilitate the passage of large marine aircraft under tow or taxiing under their own power and on the surface of the water, between the landing areas down harbour and such repair bases as may be up-harbour or *vice versa*, it is deemed desirable that, for the major span of the bridge across deep water, the underside of the structure should not be less than 40 ft. above high-water spring tide and the unobstructed span between piers should not be less than 500 ft.

(v) The presence of a bridge across the harbour anywhere between Birkenhead and North Head will definitely constitute a serious obstruction to the landing and take off of large marine aircraft based on Mechanics Bay and utilizing the harbour waters west of Bean Rock for landing and take off in the commonly used directions. However, it is certain that other considerations will require the abandonment of Mechanics Bay Base within a few years and before the projected harbour bridge could eventuate. In the event of a major marine airport for Auckland still remaining a requirement for the future, it is considered that the marine airport base facilities and water-landing areas would be established eastward of the Waitemata based on sheltered water of Tamaki Straits. In that event, the projected harbour bridge could not be deemed an aerial obstruction to marine aircraft based and operating outside the bounds of the Waitemata Harbour waters. It is further considered that water-borne ship and boat traffic on the Waitemata will require the use of water areas *other than* those westward of Bean Rock as a permanent marine airport.

(vi) It is probable that the use of marine aircraft on air services operated by Tasman Empire Airways and R.N.Z.A.F. will terminate within three years and a change over effected to land-based aircraft. However, it is by no means certain that the future development of the marine aircraft, especially for long-range heavy air transport, will not necessitate the provision and maintenance of a major marine airport in the vicinity of Auckland. For the reasons set out in para. (v) above, such a permanent airport will not be practicable within the confined waters of the Waitemata.

Conclusion.—Although the presence of a bridge across the Waitemata Harbour is not desirable nor supported from the aviation viewpoint, there is insufficient justification to seriously oppose the proposal.

General.—It is not considered necessary for an officer of this Department to attend at the deliberations of the Commission and give evidence, though this can, and will, be arranged if the Commission deems it essential. The submission made herein is available for consideration and publication with the Commission's findings and may be said to represent the views of Air Department.

(Sgd.) T. A. BARROW, Air Secretary.

Because of the conflicting views which have been publicly expressed, and in order to meet doubts that may arise, we have decided that the authoritative statement quoted above should be recorded in our report.

(5) DEFENCE ASPECTS

A similar conflict of opinion was evident regarding the desirability or otherwise of a bridge or tunnel from the viewpoint of defence, and also regarding the vulnerability of a bridge as compared with a tunnel. Here again we have been aided in our deliberations by an authoritative statement supplied by the Chiefs of Staff Committee, which we quote in full :—

5th June, 1946.

The Chairman,
Auckland Trans-harbour Facilities Commission,
C/- P.W.D.,
Auckland.

AUCKLAND TRANS-HARBOUR FACILITIES

1. The Chiefs of Staff have considered the subject of trans-harbour facilities for Auckland. They are in agreement that improved facilities are highly desirable. The defence of Auckland will be greatly assisted to the following advantages :—

(a) Simplification of movement problems in the defence of the northern beaches and the Auckland fortress area generally.

(b) As an aid to E.P.S. in war or national emergency—

(i) In the evacuation of population.

(ii) Assistance in the event of air attack—fire-fighting, &c.

2. They consider however that, from the Services' point of view, no bridge should be built across the harbour. They are definitely in favour of the tunnel. The reasons against bridges in either of the proposed sites are—

(i) *Bridge, Parnell-Devonport.*—Damage to this bridge might close the whole harbour and, failing that, might seriously cut off the Naval Base from its fleet units. There is a real danger that Auckland, as a marine base, would be closed for a lengthy period.

Such a bridge would be a definite obstacle in the use of the harbour as a seaplane base.

(ii) *Bridge, Fanshawe Street-Northcote Point.*—Extensive damage to this bridge would limit very considerably the potential berthing space in the Upper Harbour, which might well be required if a fleet of any size were based on Auckland.

It would be an obstacle limiting the harbour for seaplane use, especially for the Hobsonville Base.

3. The Chiefs of Staff would favour a tunnel of the deep-level type either from Parnell to Devonport or from the vicinity of Fanshawe Street to Northcote. They have no strong views on which site is chosen, but from the defence aspects the Northcote proposition would be preferable, the reasons being—

(a) That the tunnel via Northcote serves the North Shore area more centrally.

(b) That portals of the tunnel would not be associated as a target with the Naval Base and *vice versa*.

If a tunnel were built at the Devonport end it must not pass under Calliope Dock or the subterranean fuel-tanks at the Naval Base.

A pre-cast tunnel of the type discussed before the Commission is more vulnerable than that already suggested. This risk would be acceptable to the Chiefs of Staff, provided that the proposed road extension to Dairy Flat was carried out. Such a tunnel would be less vulnerable than a bridge to normal air attack.

4. Whether a road extension or a tunnel is constructed, or both, satisfactory alternative means of transportation—*e.g.*, the present ferries—should always be readily available.

5. The Chiefs of Staff attach great importance to the proposed Point Chevalier - Whenuapai - Dairy Flat Road, giving, as it does, better and quicker access to North Auckland area and an alternative means of communication to the North Shore. The road will facilitate the movement of tanks, guns, and vehicles forward of Whenuapai and will therefore enable an invader to be dealt with on the beach or shortly after landing. The road will facilitate the defence of the aerodrome. The

submission as to parachute attack may be regarded as irrelevant, as it might equally well be said that the aerodrome would be subjected to bombing and/or naval bombardment and that therefore the extension of the road was unnecessary.

6. Summarized, the Chiefs of Staff opinions are—

- (a) A tunnel rather than a bridge.
- (b) The Fanshawe Street - Northcote site preferred.
- (c) Definitely no bridge, Parnell-Devonport.
- (d) Road extension strongly recommended.

(Sgd.) J. R. PAGE, Lt.-Col., Secretary, Chiefs of Staff Committee.

Referring to the opinions expressed in the summary contained in paragraph 6 of the above-quoted statement, we do not at present recommend the construction of a tunnel on any site because of its prohibitive cost. We take the view that the points made by the Chiefs of Staff Committee against the construction of a bridge crossing the harbour on approximately the alignment recommended by us are intended not so much as definite objections to such a bridge as arguments in favour of the alternative of a tunnel. Having regard to the contemplated provision of road access to the north via Whenuapai and to the views expressed by the Air Department, we do not think that the considerations advanced against the construction of a bridge on the site recommended by us are sufficiently cogent to outweigh its very great value to metropolitan Auckland, together with what we believe to be its military value.

(6) FORECASTS OF POPULATION AND TRAFFIC

For the purpose of our report we have described the Auckland metropolitan area as including part of the Waitemata County, between Albany and the east coast north of Brown's Bay, within a radial distance of $9\frac{1}{2}$ miles from the chief post-office at Auckland. Though our limitation of the radial distance to $9\frac{1}{2}$ miles may appear to be conservative, we think that we should point out that we are not entitled entirely to ignore the implications of the word "metropolitan" and extend the area indefinitely. We consider, however, that it is probable that a large part of the traffic proceeding to and from the additional area lying within a radial distance of 13 miles from the chief post-office, Auckland, will find it more convenient to travel by the bridge route. The northern boundary of this area extends from a point near the junction of the No. 5 State Highway and Postman's Road to a point on the sea-coast slightly north of Okura River. Traffic proceeding to and from a still more distant area served by the East Coast Bays Road to a point as far north as Silverdale will also find the bridge route more convenient. We have indicated both the $9\frac{1}{2}$ miles and the 13 miles arcs on the locality map accompanying this report. Our estimates of population and traffic, which now follow, are in respect of the area bounded by the $9\frac{1}{2}$ miles arc.

Allowing for an increment of population since the census of 1945, we assess the present-day population of the four North Shore boroughs at 30,500. A forecast of the 1965 population contained in the report of the Auckland Metropolitan Planning Scheme, dated July, 1943, was 55,000, while the ultimate population was estimated at 96,000.

The estimate of population for 1965 assumed improved forms of transport between all parts of the North Shore area and the city. We point out, however, that estimates made in 1943 could not have taken into account the recent announcement of the Government's plans for improvements to the rail and road transportation systems, and of its intention to proceed with large-scale housing projects, all on the south side of the harbour, and likely to attract population to that side. Furthermore, because of the existence of deep-water berths and port facilities, with road and rail connections thereto, it is certain that industries will develop far more rapidly on the city side of the harbour than on the North Shore, and that the majority of the population engaged in industry will prefer to reside on the southern side, in close proximity to their work. Again, it is by no means certain that the rapid increase in urban and suburban population which resulted from the establishment of industries during the war years will continue at the same rate.

Reviewing the relevant factors which enter into estimates of the traffic likely to use the bridge, we mention the following, all of which have some restricting influence :—

(i) Toll charges must have some deterring effect.

(ii) Passenger ferry services to Devonport and Stanley Bay will provide a quicker, possibly cheaper, and more convenient service than buses, especially for residents close to the waterfront in those areas. A single bridge or, for that matter, a tunnel, wherever located, cannot serve all centres of population without disadvantages to some, however complete may be the system of feeder roads and approaches.

(iii) The tendency to be socially independent of the city, engendered by isolation, may continue, and even increase, as the North Shore communities become more self-contained, both severally and as a composite unit.

Estimates of future traffic submitted to us were based on the annual records of ferry traffic up to the present time, and are subject to the objection that those records include traffic originating from or destined for areas north of Albany, the volume of which is not precisely determinable, but was stated to constitute from 10 per cent. to 15 per cent. of the total. In our estimates which follow we have disregarded the traffic from and to areas beyond Albany, and have adopted what we think to be the more accurate method of assessing the volume of future traffic by reference to the analogy afforded by examples which, in our opinion, more closely represent the conditions that will obtain when the bridge is in service. The most useful statistics for our purpose are based on pre-war tallies of traffic on the Hutt Road, which in 1939 gave a traffic volume of some 8,000 vehicles per day with a then population of 40,000 resident in the Hutt Valley, similarly situated with respect to Wellington as the North Shore will be to Auckland, but with the difference that there is a competitive rail service instead of a ferry service. The figures above quoted show a ratio of vehicular movements to population of 1 to 5. The southern suburbs of Auckland, with full facilities for communication with the centres of activity in the city, show a ratio of vehicular movements to population of about 1 to 2½. Having regard to all factors, we assess population and traffic as follows :—

Population

Year.	Population of Four Boroughs.	Part Waitemata County.	Total Population.	Net Population likely to use Bridge.
1956	38,000	6,000	44,000	30,000
1965	42,000	8,000	50,000	35,000
Ultimate	96,000	22,000	118,000	100,000

Traffic

Year.	Net Population likely to use Bridge.	Ratio of Toll-paying Vehicles to Population.	Vehicles per Day.		Total Vehicles per Day using the Bridge.
			Toll-paying.	Non-toll-paying.	
1956	30,000	1 : 6	5,000	500	5,500
1965	35,000	1 : 4½	7,500	750	8,250
Ultimate	100,000	1 : 4	25,000	1,800	26,800

We now proceed to correlate the above estimates of daily vehicular traffic with the traffic-carrying capacity of the bridge, which we have recommended should have a four-lane carriageway. American authorities state that the "practical or working

capacity" of a two-lane highway may be rated at 8,000 vehicles per day, while that of a four-lane highway may be rated at 28,000. With adequate traffic regulation, however, the capacity may be expected to be perhaps 50 per cent. greater—*i.e.*, 12,000 vehicles per day for two lanes and 42,000 vehicles per day for four lanes. This reserve capacity will be available to cope with short peak-load fluctuations in the volume of traffic. Assuming, as for this purpose we do, that the bridge will be opened in 1956, we estimate the total vehicular traffic in 1965 at 8,250 vehicles. That volume slightly exceeds the "practical or working capacity" of a two-lane highway. Our estimate of the ultimate volume of traffic is 26,800 vehicles, which is slightly below the rated "practical or working capacity" of a four-lane highway. We consider that these volumes clearly determine that a four-lane carriageway is appropriate for the bridge, and we have recommended accordingly. It follows, also, that until the traffic volume approaches the ultimate to be expected from the metropolitan area there need be no doubt as to the bridge having reserve capacity to cope with any additional traffic from extra-metropolitan areas—in other words, the bridge alone could meet the requirements of the far North as well as of the North Shore area. This consideration at once gives rise to a question regarding the necessity for another outlet via Whenuapai and Dairy Flat and this we propose to discuss in our concluding review.

(7) CONSTRUCTION OF BRIDGE AND APPROACHES

Judged by world standards, neither the superstructure nor the substructure presents any unusual problems of design or construction. Without citing numerous examples in more distant countries, we may compare the proposed Auckland bridge with the Story Bridge at Brisbane, which was completed in 1940 by an Australian organization. This has a main span of 924 ft., compared with the proposed main span of 800 ft. of the Auckland Harbour bridge; and the deepest pier of the former was founded at 132 ft. below ground-level, under conditions that necessitated pressure in the air-locks of 54 lb. per square inch, practically the same as may be expected in the case of the deepest pier of the Auckland bridge. Much longer spans and deeper piers than in the case of either the Brisbane or the Auckland bridge are relatively common in other countries. Nevertheless, the Auckland bridge will far exceed in magnitude, difficulty, and cost any bridge hitherto designed or constructed in this country, and very careful and detailed investigation and planning are called for before the final scheme is adopted. Regarding the substructure, the deepest piers are located at sites where, owing to the depth of water and the strong and variable tidal currents, the accurate positioning and sinking of caissons will call for considerable resource and skill. The founding of the deepest caisson will involve working by the pneumatic method under a pressure which is close to the limit for that method, and any increase in depth will add greatly to the difficulty and cost.

Although none of the five reinforced-concrete arch spans of the bridge is as long as the central span of the Grafton Bridge, they constitute in the aggregate a much greater work. However, the technique of arch design and construction has advanced very considerably since the Grafton Bridge pioneered the way.

The principal span of 800 ft. far exceeds in magnitude that of any highway bridge or railway bridge in New Zealand, but ample precedents are available for both design and erection procedures.

The proposed reclamation at the west end of St. Mary's Bay, on which the southern bridgehead is proposed to be located, should be one of the first works to be constructed, as it will form a spacious and conveniently situated construction depot readily accessible by road and water.

The approaches to the bridge constitute in volume a work comparable with the Auckland - St. Heliers waterfront road, though somewhat simpler to execute. Reference has been made to the advantages of dredging as a means of forming the embankments of the southern approach. The formation of the longer but generally shallower

embankments of the northern approach will afford scope for the use of modern mechanical equipment, such as drag-lines of the larger type employed by the Public Works Department. The whole of the work involved in stages I and II of the complete approaches and their ancillary works will cost approximately £1,000,000, although, as recommended earlier in this report, only stage I, costing about half the total sum, should be charged to capital, the balance being executed in phases as necessitated by increased traffic and financed out of revenue.

In our discussion of the southern approach to the bridge we made passing mention of its possible function as a link in a future waterfront road ultimately extending from St. Heliers to Whenuapai. This waterfront road is, of course, no part of the bridge plan, but we deem it worthy of mention because of its potential value as a tributary in the general system of approaches to the bridge. Similarly, we draw attention to the possibility that at some future time a waterfront road from Chelsea to the northern bridge-head at Northcote may be of value as part of the general system of approach roads on that side of the harbour, by-passing, as it would, the built-up areas. We do not, however, envisage industrial expansion to the same degree as on the south side; but we do foresee a considerable demand for residential sites in the more accessible areas along the waterfront, which would then be in close proximity to the city.

Our estimates make no direct provision for these waterfront roads on either side of the harbour, but their value to the general system of approaches suggests their inclusion in the contingent works which might be subsidized from the contingencies and development fund.

(8) ÆSTHETICS

The site does not lend itself to achieving symmetry in the spans, owing to the difference in level between the two abutments, one being on high land at Northcote and the other on a low reclamation. Furthermore, the highest part of the bridge structure is over the navigation channel, which is not centrally placed. Again, the composite design (part steel and part reinforced concrete) creates more difficulties than an all-steel superstructure in the achievement of ideal proportions; and the depth and cost of piers must be an overriding factor in the final determination of span lengths. Despite these limitations, however, it is considered that a structure proportioned as outlined in the plans accompanying this report conforms reasonably well with the requirements of æsthetics. We consider, also, that a large-scale work such as this deserves appropriate treatment of its site. At relatively small outlay the land adjacent to both bridge-heads could, and we think should, be converted into attractive gardens. As the cliff fronting Point Erin Park will require to be cut back to conform to the curve of the roadway, the opportunity should be taken to form terraces on the batters, and to establish shrubs thereon. Similarly, the terracing of Stokes Point, Northcote, would be worth while, and would enhance the appearance of the bridge.

(9) ADVISORY PANEL

We reiterate our view that the Government should assume the entire responsibility for the design, construction, and administration of the bridge and approaches, as it alone has at its command the necessary organization and resources for handling such a project. The project is, however, a matter of the greatest moment in the planning of metropolitan Auckland and will profoundly influence future plans. We therefore consider that the Government should seek local expert advice on the functional planning of a work of such vital importance to the whole metropolitan area. We suggest the appointment of a representative advisory panel of engineers, consisting of experts whose local knowledge and specialized skill and experience would very materially assist the Government. The panel should, we think, be a consultative but not an executive body, whose function would be to consider the many and varied aspects of the project affecting local and public bodies and metropolitan interests generally, and to

transmit to the Government its opinions thereon. We consider that a panel constituted as follows would ensure adequate local representation and would enable the Government to be fully informed on the local implications of the different aspects of the project :—

- (i) An Engineer of the Ministry of Works, as Chairman.
- (ii) The Engineer-Superintendent of the Auckland Harbour Board.
- (iii) The Auckland City Engineer.
- (iv) The Engineer-Manager of the Auckland Transport Board.
- (v) The Professor of Engineering of Auckland University College.

Membership of such a body will not in any way conflict with the duty that each individual member owes to the Council or body for which he normally acts in his official capacity, and the members will have the advantage of being able to consider, as a body, all metropolitan aspects of the project. We have in mind the analogy of the functions of District Highways Councils and their relation to the Main Highways Board.

The inclusion of the Professor of Engineering at the Auckland University College is strongly recommended because of the educational value of the work to local engineering students, who, we think, should be given every facility for studying the practical problems of construction. The more advanced students should be afforded every opportunity of participating in the actual work as part of their practical training for a degree. Furthermore, the fullest use should be made of the Engineering Laboratory for the testing of materials during the course of the work.

(10) JUSTIFICATION FOR TOLLS

In an earlier section of this report we recommended the institution of a system of toll charges as being the most practical and most equitable means of financing the cost of the bridge and its approaches, inasmuch as such a system would ensure that the cost would be met by all who derived indirect or direct benefit therefrom. We were influenced in making this recommendation by the fact that in other parts of the world bridges and tunnels serving metropolitan traffic more conveniently than ferries are almost universally financed by means of toll charges. Australia provides several examples, and the United States of America provides still more. In view of the existence of this world-wide practice, we are able to make a clear distinction between the financing of ordinary State and main highway construction, including the erection of bridges necessary to carry highways over rivers, and the financing of the construction of special facilities, such as costly bridges or tunnels over or under large navigable waterways, intended principally to provide more conveniently for the requirement of metropolitan traffic. In the one case the necessity is largely physical, in the other it is largely economic and is induced principally by the growth of metropolitan traffic. Nevertheless, we have in another section of this report stressed the national value of a harbour bridge, and have accordingly recommended that the Government should recognize this aspect by providing financial aid to the extent and in the manner we have suggested. While we are of the opinion that tolls on highways are in general undesirable, we can find no sound reason against the financing by this means of the construction of special facilities of the nature of an Auckland Harbour bridge.

REVIEW

We have, we think, considered the project from every angle, and now propose to supply answers in advance to certain questions which may be anticipated concerning the justification for undertaking so expensive and extensive a work.

Firstly, how does the project compare with others, for example, the Sydney bridge and its approaches?

We answer this by stating that, although the population of Sydney is roughly five times that of Auckland, the respective outlays are estimated to be in about the same ratio, regard being had to the conditions prevailing at the time the Sydney bridge was

constructed. Many other recent examples of similar large-scale works could be cited to demonstrate that the magnitude and cost of this project are not disproportionate in the case of metropolitan Auckland.

Secondly, what justification is there for the imposition of toll charges?

We have already stated the general principles, and we now point out that the prospective users of the bridge already pay tolls and ferry charges at rates considerably in excess of those we propose; and we have demonstrated that the rates recommended by us are sufficient to make the project financially self-supporting. We also draw attention to the fact that land and property values on the North Shore have been established under the handicap of limited and indirect access, and we regard the imposition of toll charges as the only practical means of ensuring that the enhancement of values which will accrue through improved and direct access shall not be provided entirely at the expense of the general taxpayers, and that the beneficiaries shall contribute by payment of tolls.

Thirdly, how does this project affect other works contemplated by road and railway authorities for the improvement of the transport facilities of metropolitan Auckland?

The announcement by the Government of the works referred to in clause (1) of our order of reference preceded our sittings and has formed a valuable and indeed indispensable background to our deliberations. It is not part of our function to suggest the order of priority in which we think the respective items comprising the Government's programme of works should be carried out, but we consider that it is incumbent on us to direct the attention of the Government to the need for reconsideration of its plans for the contemplated northern highway outlet via Whenuapai and Dairy Flat. If our recommendations concerning the bridge are adopted, the whole aspect of this proposed northern outlet becomes changed, and it will then be open to question whether —

(a) The proposed northern highway should extend beyond Whenuapai, at all events for many years; and

(b) The standard of construction should be lowered to that of a highway of only local importance. The money so saved would represent a substantial part of the cost of the bridge.

Fourthly, what scope will there be for the ferry services when the bridge is open for traffic?

The Devonport Steam Ferry Co., Ltd., informed us that its Devonport passenger service was more profitable than its services to Chelsea, Birkenhead, Northcote, and Bayswater. Indeed, it stated that the Devonport service "carried" the other services. We have recommended that the Devonport and Stanley Bay services should be continued after the bridge is completed, and we consider that there will be ample support forthcoming from the residents of Devonport, Stanley Bay, and part of Takapuna to enable adequate services to be provided at reasonable rates. The existence of the bridge will not, of course, affect the continued expansion of the company's services to Waiheke and other points outside the North Shore area.

GENERAL CONCLUSION

But for the post-war factors to which we have already referred, we should have had no hesitation in recommending commencement of the construction of the bridge at the earliest possible date, because we consider the provision of direct access to the North Shore area as overdue. We are compelled, however, to take cognizance of the fact that both the Government and the local bodies have six years arrears of public works to overtake, among them literally hundreds of smaller bridges in the Auckland Provincial District alone. All these can be classed as overdue, either in the interests of the safety of the travelling public or as essential aids to rural development and therefore

to production ; while the principal value of the Auckland Harbour bridge will be the improvement of the internal means of communication of a metropolitan area. Moreover, so long as every country in the world is restoring war damage or overtaking arrears of developmental work in an effort to increase production, the costs of bridging-works must remain at their present high level. We cannot overemphasize the need for devoting adequate time to investigations and studies of this project, all directed towards economy. This consideration is of the utmost importance in the planning of a project which is expected to become financially self-supporting from the outset, because any reduction in capital cost will be reflected both in the scale and in the period of application of toll charges. Our recommendation, therefore, is that, as soon as the specialist staff is available, investigations and economic studies should be put in hand, and the actual date of commencement of the work itself should be determined in the light of the economic conditions prevailing when the designs and specifications are completed.

This, our report, is respectfully submitted for Your Excellency's consideration. We transmit herewith a bound copy of the verbatim record of our proceedings, together with the exhibits placed before us ; and we append, as part of this report, for the purpose of illustrating our proposals—

- (i) Locality map.
- (ii) Site plan of suggested bridge.
- (iii) Outline of suggested bridge.

We return the Commission with which His Majesty was graciously pleased to favour us.

In witness whereof we have hereunto set our hands and affixed our seals at Wellington this 26th day of July, 1946.

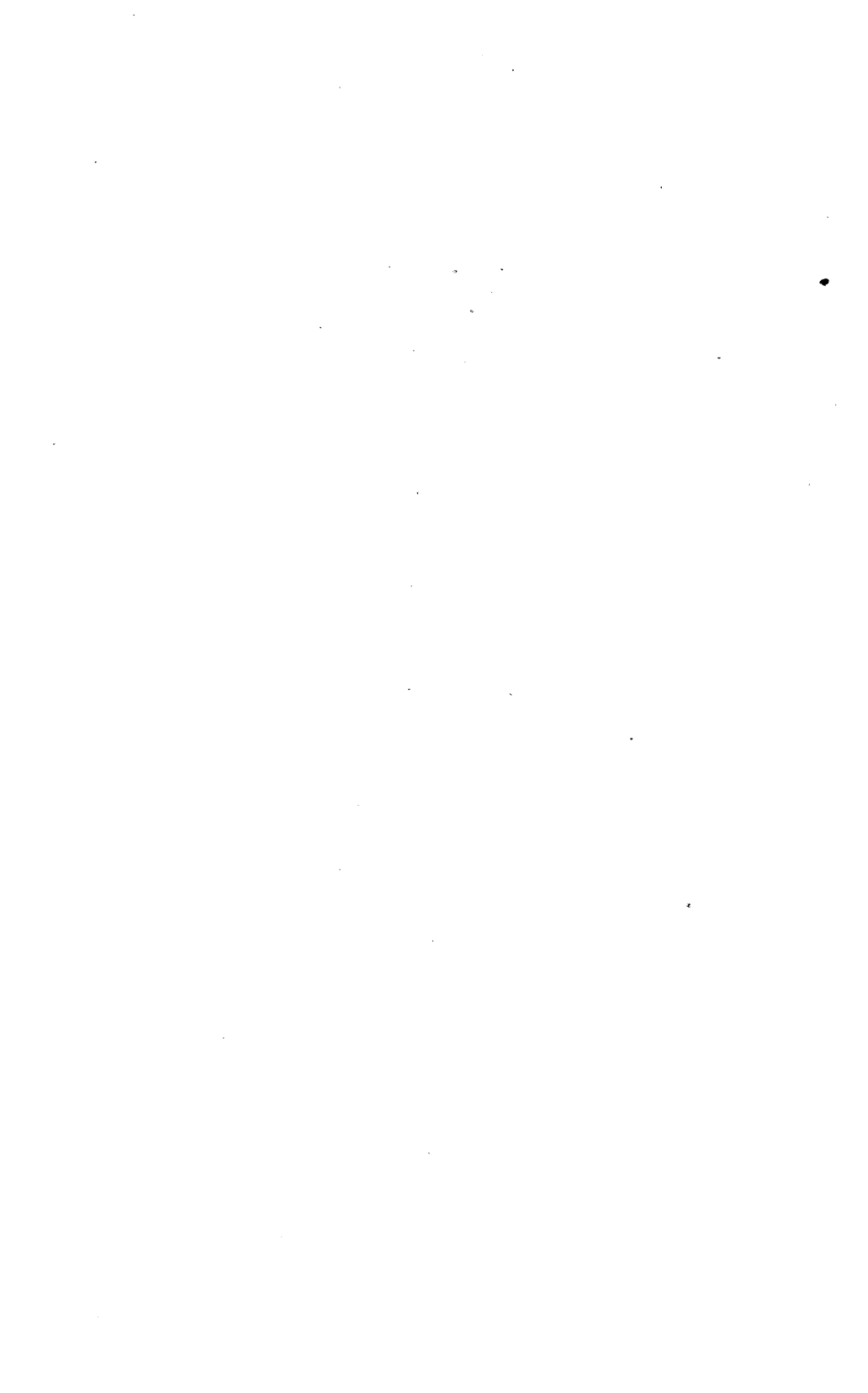
[L.S.]
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[L.S.]

F. V. FRAZER, Chairman.
W. R. BEAVER, Member.
R. H. PACKWOOD, Member.

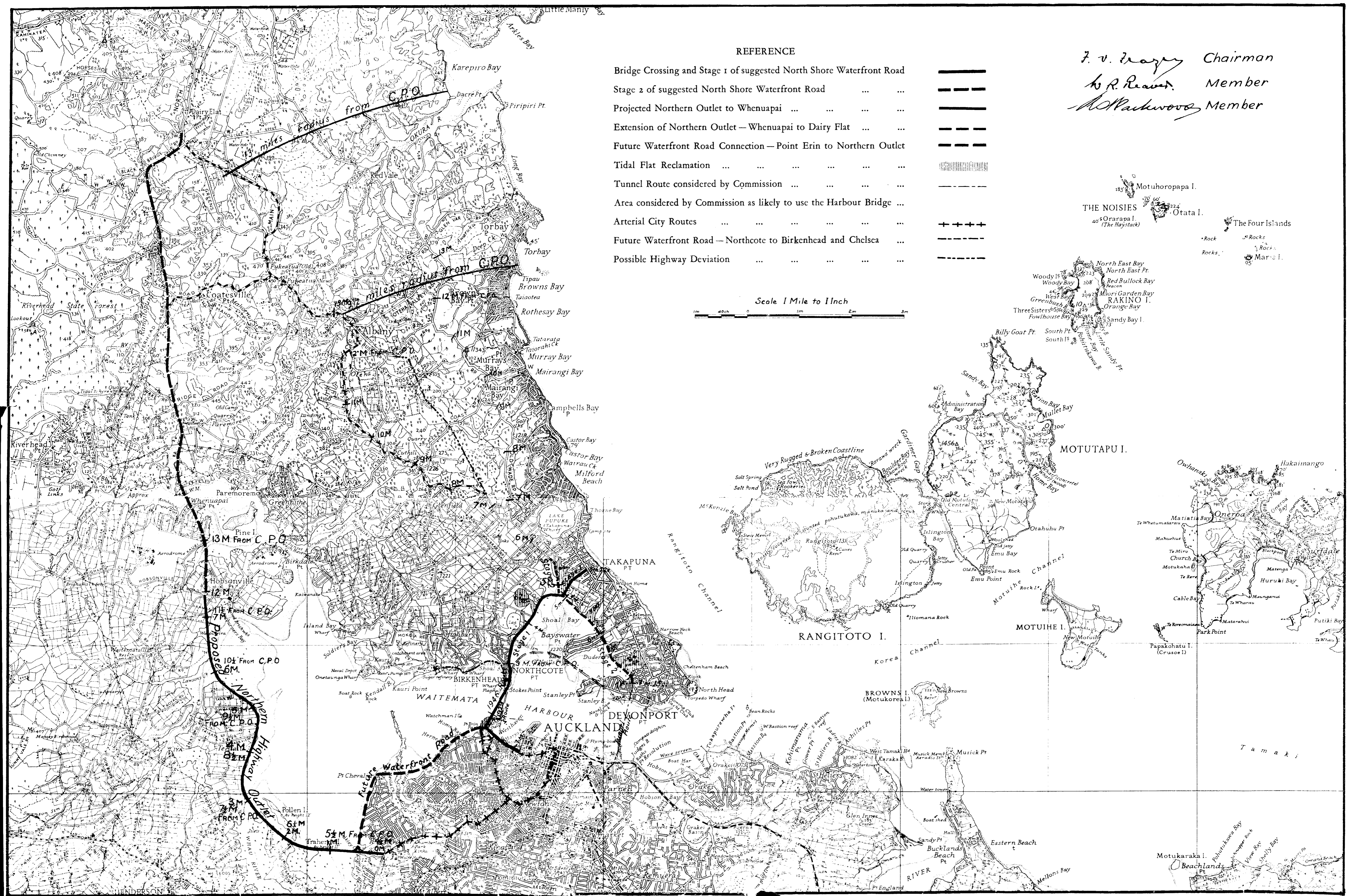
Approximate Cost of Paper.—Preparation, not given ; printing (920 copies, including maps, £145.)

By Authority: E. V. PAUL, Government Printer, Wellington.—1946.

Price 2s. 9d.]



AUCKLAND TRANS-HARBOUR FACILITIES COMMISSION 1946 LOCALITY MAP



REFERENCE

- Bridge Crossing and Stage 1 of suggested North Shore Waterfront Road =====
- Stage 2 of suggested North Shore Waterfront Road -----
- Projected Northern Outlet to Whenuapai -----
- Extension of Northern Outlet - Whenuapai to Dairy Flat -----
- Future Waterfront Road Connection - Point Erin to Northern Outlet -----
- Tidal Flat Reclamation |||||
- Tunnel Route considered by Commission -----
- Area considered by Commission as likely to use the Harbour Bridge -----
- Arterial City Routes +++++
- Future Waterfront Road - Northcote to Birkenhead and Chelsea -----
- Possible Highway Deviation -----

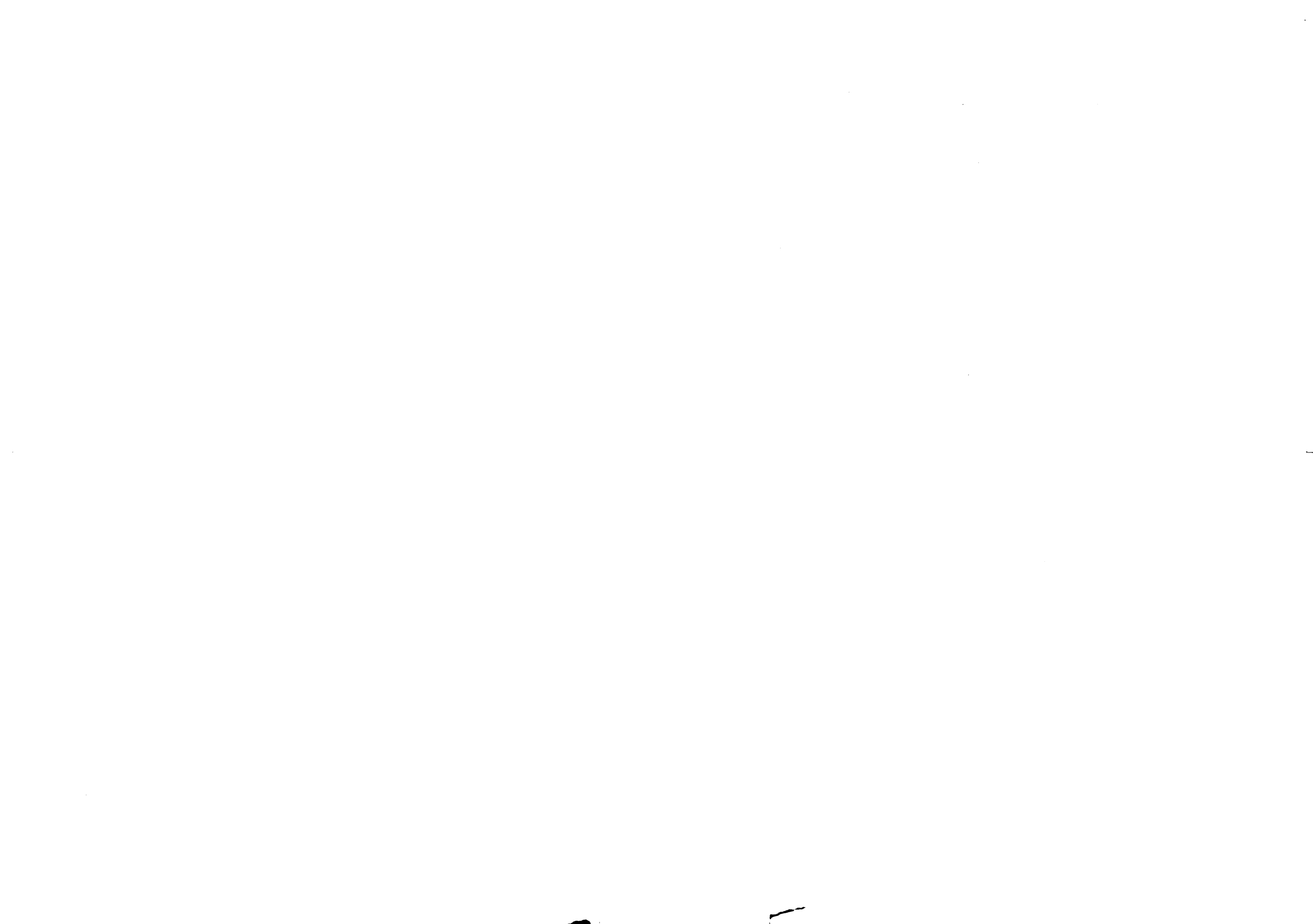
F. v. Wray Chairman
H. R. Rees Member
A. Mackwood Member

Scale 1 Mile to 1 Inch
 1m 40cm 0 1m 2m 3m

Motuhoropapa I.
 THE NOISIES
 40° Orarapa I. (The Haystack)
 Otata I.
 The Four Islands
 • Rock
 • Rocks
 • Rocks
 • Marie I.

Woody Is.
 Woody Bay
 West Bay
 Greenbush
 Three Sisters
 Fowlhouse Bay
 North East Pt.
 North East Pt.
 Red Bullock Bay
 Moori Garden Bay
 RAKINO I.
 Orange Bay
 Sandy Bay I.

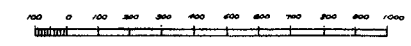
Billy Goat Pt.
 South Pt.
 South Is.
 Administration Bay
 Mullet Bay
 Muriwai Bay
 Home Bay
 Very Rugged & Broken Coastline
 Salt Spring
 Salt Pond
 McKenzie Bay
 Rangitoto I.
 Rangatoto Channel
 Korea Channel
 MOTUTAPU I.
 MOTUIHE I.
 Browns I. (Motukorea I.)
 BROWNS I.
 Oneroa
 Matiatia Bay
 Te Whetumatarau
 Te Miro Church
 Motukaha Pt.
 Te Rere
 Cable Bay
 Te Wharau
 Matarahui
 Park Point
 Papakohatu I. (Crusoe I.)
 Tamaki
 Motukaraka I.
 Beachlands Pt.
 Mellons Bay



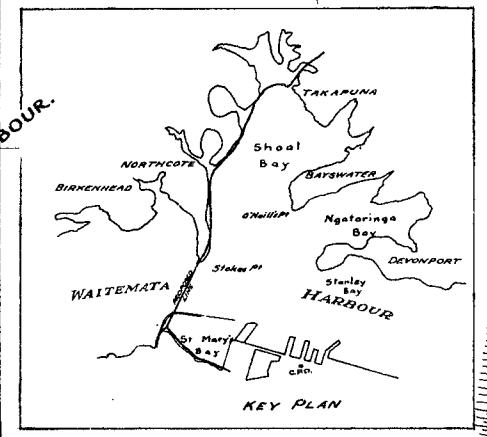
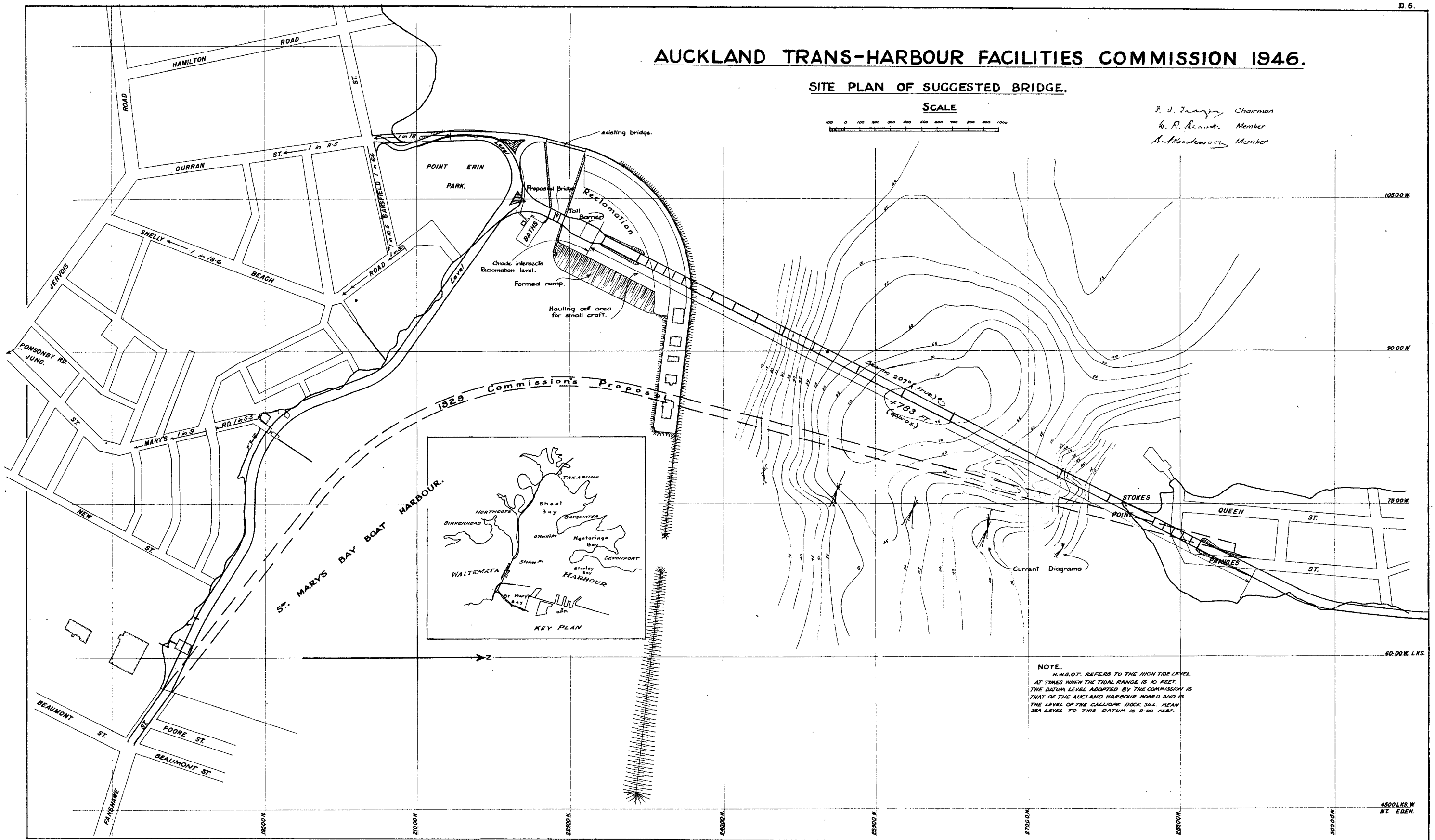
AUCKLAND TRANS-HARBOUR FACILITIES COMMISSION 1946.

SITE PLAN OF SUGGESTED BRIDGE.

SCALE

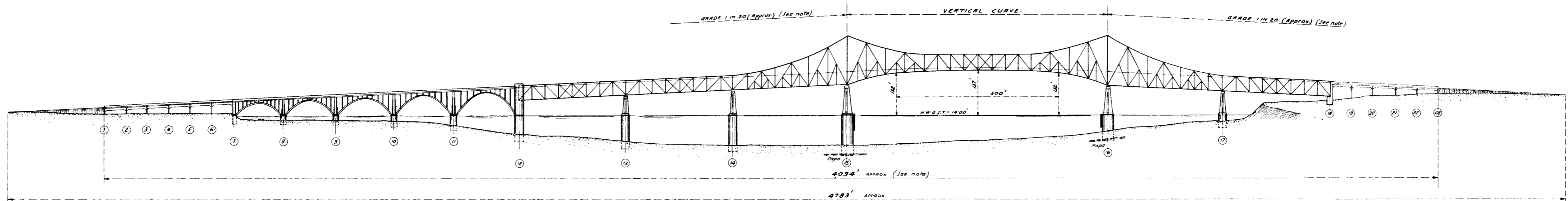


P. J. Tanga Chairman
G. R. ... Member
A. ... Member



NOTE.
 H.W.S.O.T. REFERS TO THE HIGH TIDE LEVEL AT TIMES WHEN THE TIDAL RANGE IS 10 FEET. THE DATUM LEVEL ADOPTED BY THE COMMISSION IS THAT OF THE AUCKLAND HARBOUR BOARD AND IS THE LEVEL OF THE CALLAGHER DOCK SILL. MEAN SEA LEVEL TO THIS DATUM IS 9.60 FEET.

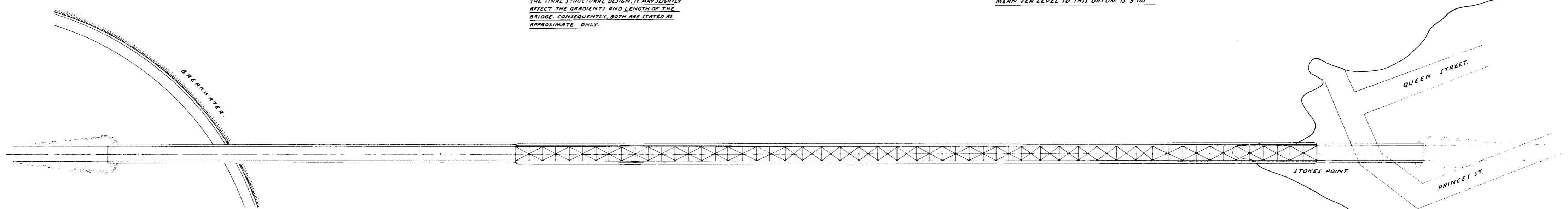
1050.0 N
 80.00 W
 75.00 W
 60.00 W LKS
 4500.0 E
 4600.0 E
 4700.0 E
 4800.0 E



NOTE - THE LEVEL OF THE SURFACE OF THE ROADWAY AT THE CENTRE OF THE MAIN SPAN HAS BEEN ASSUMED, FOR PRELIMINARY PURPOSES, TO BE 10 FEET ABOVE THE JOINT OF THE SUSPENDED SPAN. SHOULD THIS DIMENSION BE VARIED IN THE FINAL STRUCTURAL DESIGN, IT MAY SLIGHTLY AFFECT THE GRADIENTS AND LENGTH OF THE BRIDGE. CONSEQUENTLY, BOTH ARE STATED AS APPROXIMATE ONLY.

- ELEVATION. -

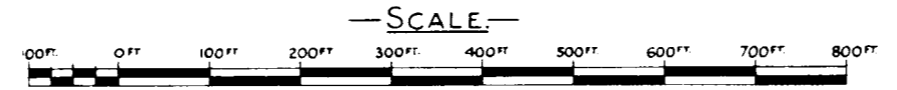
NOTE: H.W.O.S.T. REFERS TO THE HIGH TIDE LEVEL AT TIMES WHEN THE TIDAL RANGE IS 10 FEET. THE DATUM LEVEL ADOPTED BY THE COMMISSION IS THAT OF THE RUCKLAND HARBOUR BOARD AND IS THE LEVEL OF THE CALLIOPE DOCK SILL. MEAN SEA LEVEL TO THIS DATUM IS 9'00"



- PLAN. -

— AUCKLAND TRANS-HARBOUR FACILITIES COMMISSION 1946. —

— OUTLINE OF SUGGESTED BRIDGE. —



Chairman
Member
Member

