

"Limited
Distribution"



CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES
MARINE SCIENCES BRANCH
MINISTÈRE DE L'ÉNERGIE DE MINES ET DES RESSOURCES
DIRECTION DES SCIENCES DE LA MER

DFO - Library / MPO - Bibliothèque



10029010

ATLANTIC OCEANOGRAPHIC LABORATORY
BEDFORD INSTITUTE

LABORATOIRE OCEANOGRAPHIQUE DE L'ATLANTIQUE
INSTITUT de BEDFORD

Dartmouth, Nova Scotia
Canada

Library - Bedford Institute

AOL / MSB

MAY 6 1971

DARTMOUTH, N.S.

REVIEW OF THE LAYOUT OF THE CONTAINER PIER IN
HALIFAX HARBOUR - APRIL 1969

by

H. J. A. NEU

APRIL 1969

AOL REPORT 1971-1

PROGRAMMED BY
THE CANADIAN COMMITTEE OF OCEANOGRAPHY

65675

"Limited
Distribution"

ATLANTIC OCEANOGRAPHIC LABORATORY
BEDFORD INSTITUTE
DARTMOUTH, NOVA SCOTIA,
CANADA

This is a manuscript which has received only limited circulation.
On citing this report in a bibliography, the title should be
followed by the words "UNPUBLISHED MANUSCRIPT" which is in
accordance with accepted bibliographic custom.

REVIEW OF THE LAYOUT OF THE CONTAINER PIER
IN HALIFAX HARBOUR - APRIL 1969

by

H. J. A. NEU

APRIL 1969

AOL REPORT 1971-1

SYNOPSIS

At the request of the National Harbours Board, the latest design of the proposed container pier at the Ocean Terminals (see Fig. 6) in Halifax Harbour has been reviewed and evaluated in terms of the probabilities of occurrence of significant swell action at the pier face.

In the absence of firm information on tolerable limits for container loading, we are not in a position to estimate the number of days per year during which container ships could not be worked. However, it is likely the number will be considerably larger than for days lost in general cargo handling in ships of similar size, having regard for the great weight and size of containers.

The location of the pier is inherently subject to wave action from the open sea. There will be some concentration of wave energy at the pier face as presently laid out due to reflection from Pier "B" and refraction around the breakwater. Proposals are submitted for modifying the layout of the container pier and placing breakwaters to minimize the effect of ocean waves at the pier face. A proposal which would permit undisturbed container handling is included.

TABLE OF CONTENTS

	<u>Page</u>
SYNOPSIS	iii
LIST OF ILLUSTRATIONS	vii
INTRODUCTION	1
INITIAL INVESTIGATION	1
CONTAINERIZATION	6
LAYOUT OF THE CONTAINER PIER	6
SUMMARY	13

LIST OF ILLUSTRATIONS

	<u>Page</u>
Fig. 1. Layout of Pier "C"	2
2. Wave refraction diagram of a 6-second wave train in the harbour	3
3. Wave refraction diagram of a 10-second wave train in the harbour	4
4. Wave pattern of a 6-second wave train at the Ocean Terminals .	5
5. Wave energy and disturbance of harbour operation	7
6. Layout of Container Pier	8
7. Wave refraction diagram of a 6-second wave train at the Container Pier	10
8. Wave refraction diagram of a 10-second wave train at the Container Pier	11
9. Wave refraction diagram of a 14-second wave train at the Container Pier	12
10. Proposed breakwaters at the harbour entrance	14
11. Proposed alternative layout of Container Pier	15

REVIEW OF THE LAYOUT OF THE CONTAINER PIER
IN HALIFAX HARBOUR - APRIL 1969

INTRODUCTION

During several informal meetings in 1966, the office of the National Harbours Board in Halifax approached the Bedford Institute for advice on the design and layout of a new pier at the south end of the Ocean Terminals referred to as Pier "C". It was suggested later that the problem of waves and swells in the harbour and at the proposed pier be studied to provide recommendations for their reduction or elimination.

The original design of Pier "C" proposed by the National Harbours Board is shown in Fig. 1. Since it was anticipated at this stage that the new pier would handle mainly general cargo, the terms of reference were for improvements to this type of trans-shipment facility.

INITIAL INVESTIGATION

The investigation commenced in the fall of 1967. Phenomena which cause ships to oscillate were analyzed by applying systematic interpretations based on theoretical principles. Significant design concepts for guiding the layout of installations in the harbour and recommendations for improving the proposed Pier "C" were formulated and reported in AOL Manuscript Report 1968-3, "Waves in Halifax Harbour", May 1968.

It became evident from this analysis that Halifax Harbour, and in particular the Ocean Terminals where Pier "C" is located, is not sufficiently protected from ocean waves (see Fig. 2 and 3), which frequently cause sufficient disturbance to affect ships in any part of the harbour south of George's Island, except in the Eastern Passage. Evidently, to improve conditions, waves must be prevented from entering the harbour, be dissipated within the harbour, or their effect must be kept to a minimum through the proper layout and design of the wharf. An important criterion in the design of a pier is to prevent energy concentrations along its walls.

The most important conclusions with respect to the design of Pier "C" were:

- 1) Ocean waves which cause moored ships to oscillate spread in arc-shaped curves over the harbour so that their crests pass the Ocean Terminals at an angle somewhat less than 90 degrees. This is shown on the refraction diagrams of Fig. 2 and 3.
- 2) As demonstrated in the report, wharves should be located so that they are nearly normal to the wave crests. To follow this principle the major wharves of Pier "C" would have to be located not normal but parallel to the coast.
- 3) Waves reflecting from Pier "B" propagate into the area adjacent to Pier "C", where they are superimposed on the incoming waves, thus providing large energy concentrations in the area of interest (Fig. 4).

Several proposals which took these aspects into consideration were submitted. They included two breakwaters at the entrance to Halifax Harbour and a number of modifications to the original design of Pier "C". The former would provide improved protection for the entire harbour, while the latter would result in improving wave conditions only at Pier "C". On July 10, 1968 a

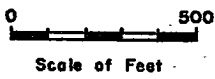
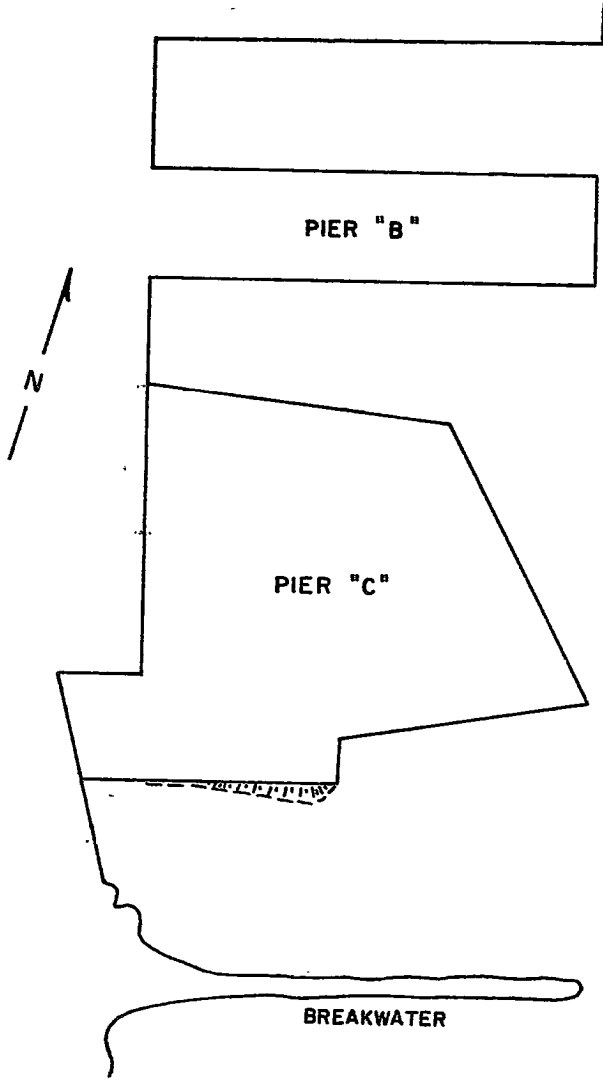


Fig. 1. Layout of Pier "C".

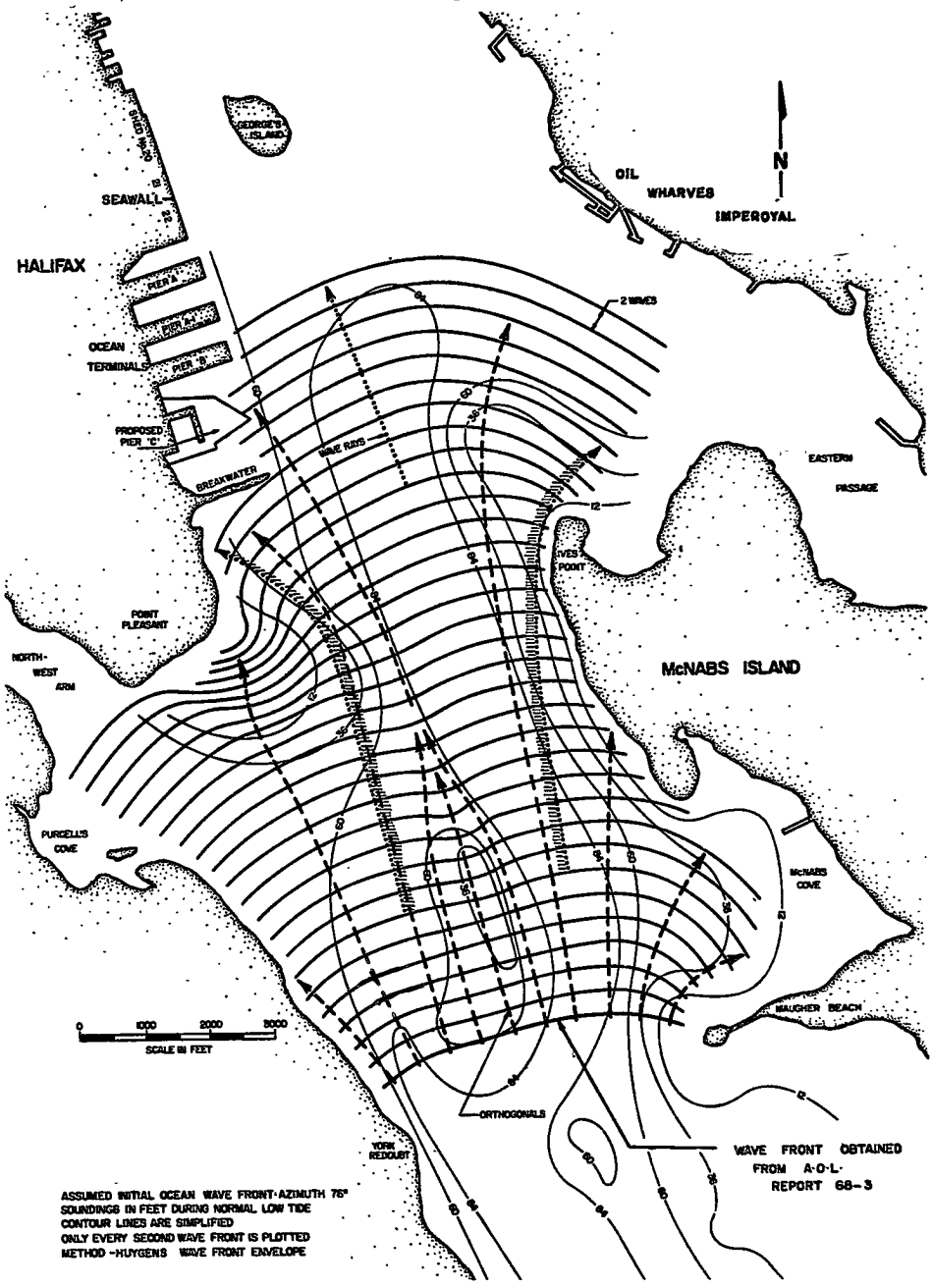


Fig. 2. Wave refraction diagram of a 6-second wave train in the harbour.

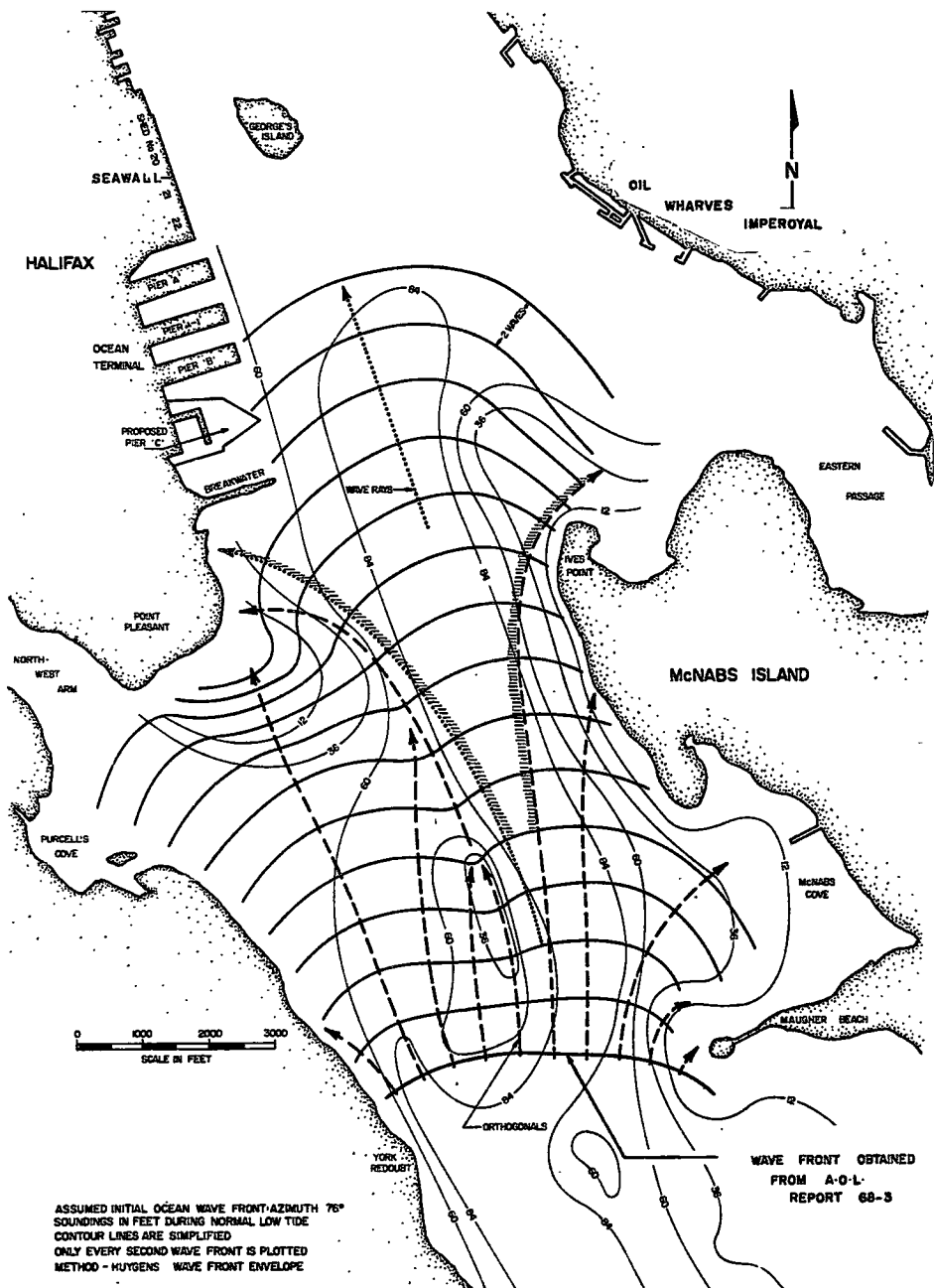


Fig. 3. Wave refraction diagram of a 10-second wave train in the harbour.

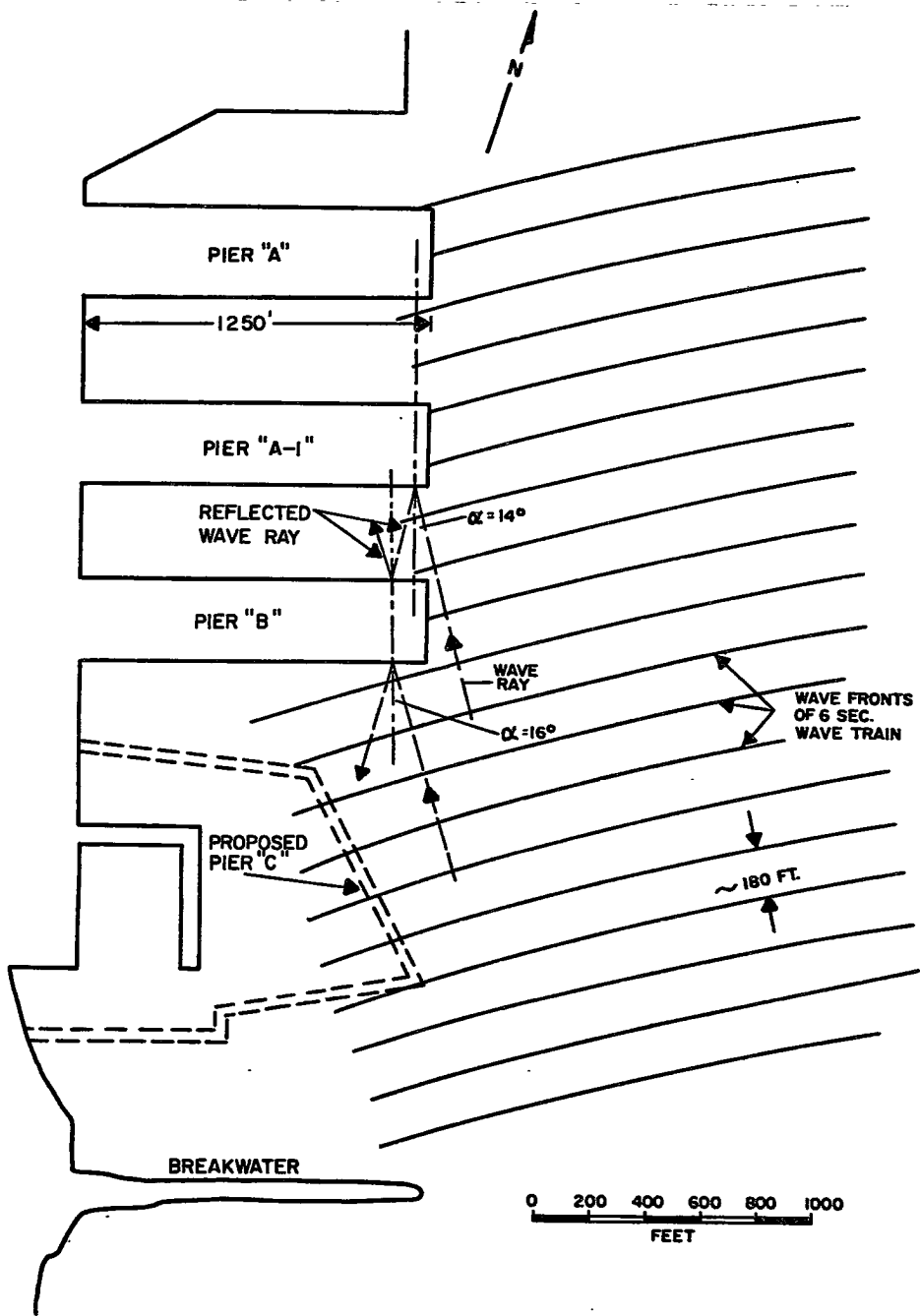


Fig. 4. Wave pattern of a 6-second wave train at the Ocean Terminals.

lecture was given at the Bedford Institute in which the problems were discussed and proposals for improving the harbour and Pier "C" were submitted to federal, municipal, and shipping agencies concerned with developing the harbour.

CONTAINERIZATION

During the course of the investigation, a new mode of trans-shipment was gaining wide acceptance in the field of transportation. This had potential application at Pier "C", provided conditions at the pier were suitable.

This type of trans-shipment, referred to as "containerization", is a system by which cargo is transported interchangeably (within uniform containers) by different forms of transportation; the container ship being the waterborne link in the system. The economy of this type of trans-shipment lies in the standardization, the speed of handling, and the rapid transport of the shipping units in accordance with strict timetables. Any excessive delay in trans-shipment caused by wave action works to the disadvantage of this type of transport system.

There are no known criteria which specify the permissible movement of container ships while loading or unloading, and inquiries have not provided a satisfactory answer. A study of this subject is, therefore, urgently required.

The predominant motions of ships at the Ocean Terminals are vertical, in the order of 5 to 6 feet with average periods of 5 to 7 seconds, coupled with sideward sway. The rate of vertical movement can be as much as 3 to 4 feet per second. The impact between the ship and a container weighing 30 tons lowered with the same speed at which the ship rises could be more than 150 foot-tons. Obviously, such an impact would cause severe damage to the vessel and the container.

Thus, the question arises as to whether such calm conditions can be provided in Halifax Harbour. At the existing terminals, general cargo handling appears to be difficult on 15 to 20 days annually, i.e., during this number of days the energy level in the form of waves is too high for cargo handling. Since container loading can be performed only at considerably lower levels of wave energy, it can be concluded that container trans-shipment will be more frequently disturbed by wave action than conventional general cargo handling. This is illustrated by the graph in Fig. 5 which, based on a gaussian distribution curve, shows the probable relationship between wave energy in the harbour and its occurrence.

LAYOUT OF THE CONTAINER PIER

To keep Halifax Harbour competitive in the field of transportation, the National Harbours Board decided to modify Pier "C" to a container pier. The new design, Fig. 6, was released in March 1969 and the Bedford Institute was asked to review it with respect to wave action and its possible interference with loading operations. In addition, the question was asked as to whether an extension to the Point Pleasant Park Breakwater would provide sufficient protection for container loading.

It must be understood that the appraisal of the conditions is based on theoretical principles, which provide primarily qualitative results. As has been stressed several times, reliable quantitative results can be obtained only through model studies. However, owing to the time factor, this is now impossible. Therefore, to provide some form of quantitative evaluation, the sea

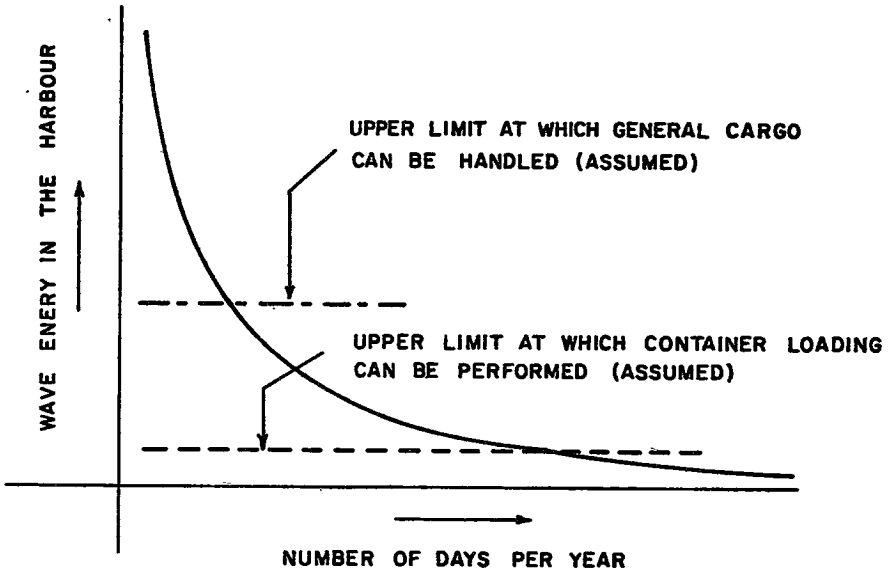


Fig. 5. Wave energy and disturbance of harbour operation.

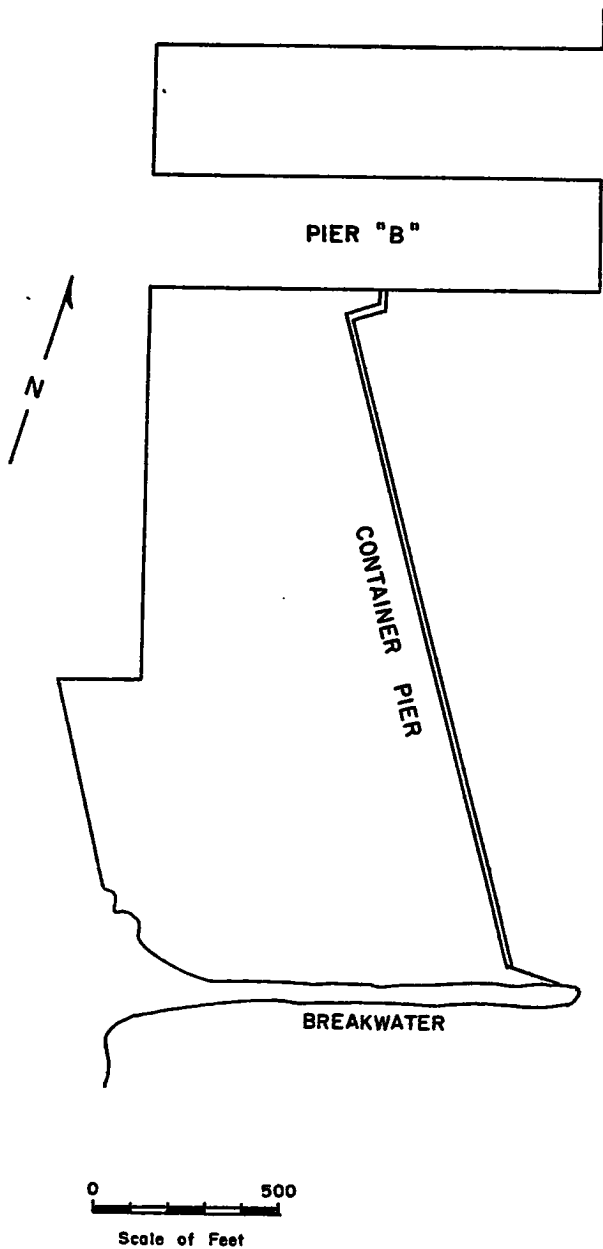


Fig. 6. Layout of Container Pier.

condition at the pier is evaluated by comparing it with the sea condition at the Sea Wall of Sheds 20, 21, and 22 farther north.

First, to obtain a general comparison of the state of the sea at the two places, assume either that Pier "B" does not exist or that the wall of the container pier is flush with the seaward ends of Point Pleasant Park Breakwater and Pier "B". Under these circumstances, the waves would pass along the container pier as they do along the sea wall. However, as shown in Fig. 2 and 3, the waves spread in arc-shaped curves over the harbour and the energy contained in the wave fronts disperses; the magnitude decreasing in proportion to the increase in length of the wave fronts. The orthogonals (wave rays), which indicate the rate of dispersal, reveal that the energy in the area of the container pier is approximately twice that at the sea wall at Sheds 20-22. Since the energy of waves is proportional to the square of their height, it follows that the waves are 30 to 40 percent higher near the container pier than at the sea wall.

The container pier is designed that its outer wall intersects Pier "B" halfway along its south wall. This arrangement creates problems which are difficult to solve. To demonstrate this, refraction diagrams of waves with periods of 6 seconds, 10 seconds, and 14 seconds, were plotted for the area adjacent to the container pier, as shown in Fig. 7, 8, and 9, respectively. The shapes of the initial wave fronts were derived from AOL Report 1968-3.

From the distribution of the wave fronts and the direction of the orthogonals, it can be seen that the shallower section east of Point Pleasant Park Breakwater directs the energy of the waves of all three periods toward the container pier and Pier "B". The orthogonals, which are spaced at 200-foot intervals, indicate that the energy which affects the area is derived from a front 700 feet wide, off the end of Point Pleasant Park Breakwater. Approximately half of this energy propagates toward the container pier and the other half towards Pier "B". The part which strikes Pier "B" is reflected toward the container pier, where it is superimposed on the initial wave, causing wave heights of appreciable magnitudes. It is probable, therefore, that with the proposed arrangement disturbances from waves will be several times more severe at the container pier than along the sea wall.

The question arose as to whether extensions to Point Pleasant Park Breakwater would improve conditions. Very little improvement can be expected by setting the container pier back 200 feet behind the tip of the breakwater. An extension to the breakwater of 400 feet would provide increased protection against the initial ocean waves, but none against the reflected waves from Pier "B". So it is probable that the disturbances would be similar to or worse than those at the sea wall. A 700-foot extension to the breakwater might provide increased protection although the effect of diffraction of the wave energy around the head of the breakwater has not been taken into consideration.

Whether this improvement is sufficient for loading or unloading container ships cannot be decided upon on the basis of the available information.

Thus, it must be assumed that the container pier in its proposed form would be unsuitable for container loading during a considerable number of days annually because of the relatively large amount of wave action in the area adjacent to the pier, and by the reflection of waves from Pier "B" which would cause an energy concentration at the container pier.

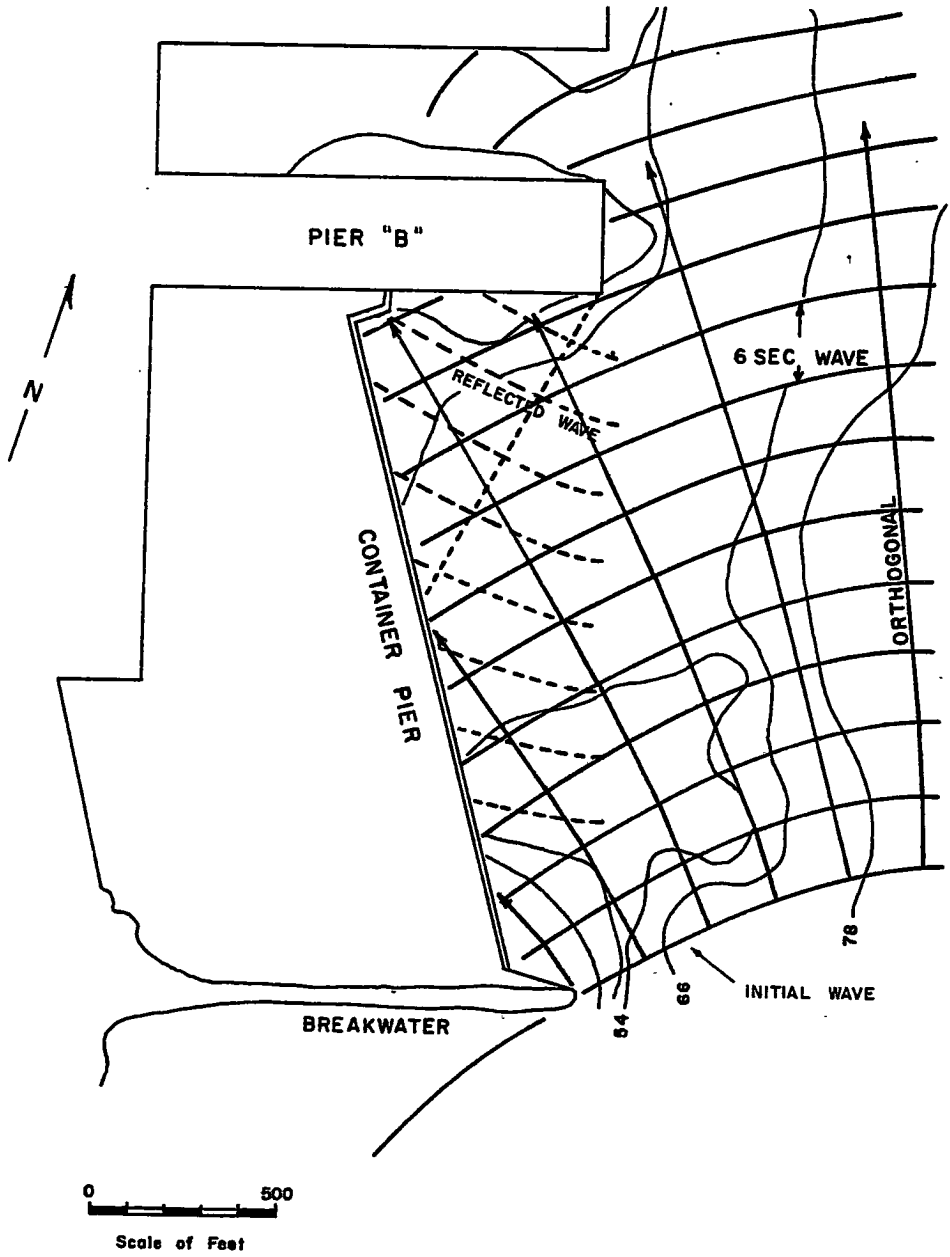


Fig. 7. Wave refraction diagram of a 6-second wave train at the Container Pier.

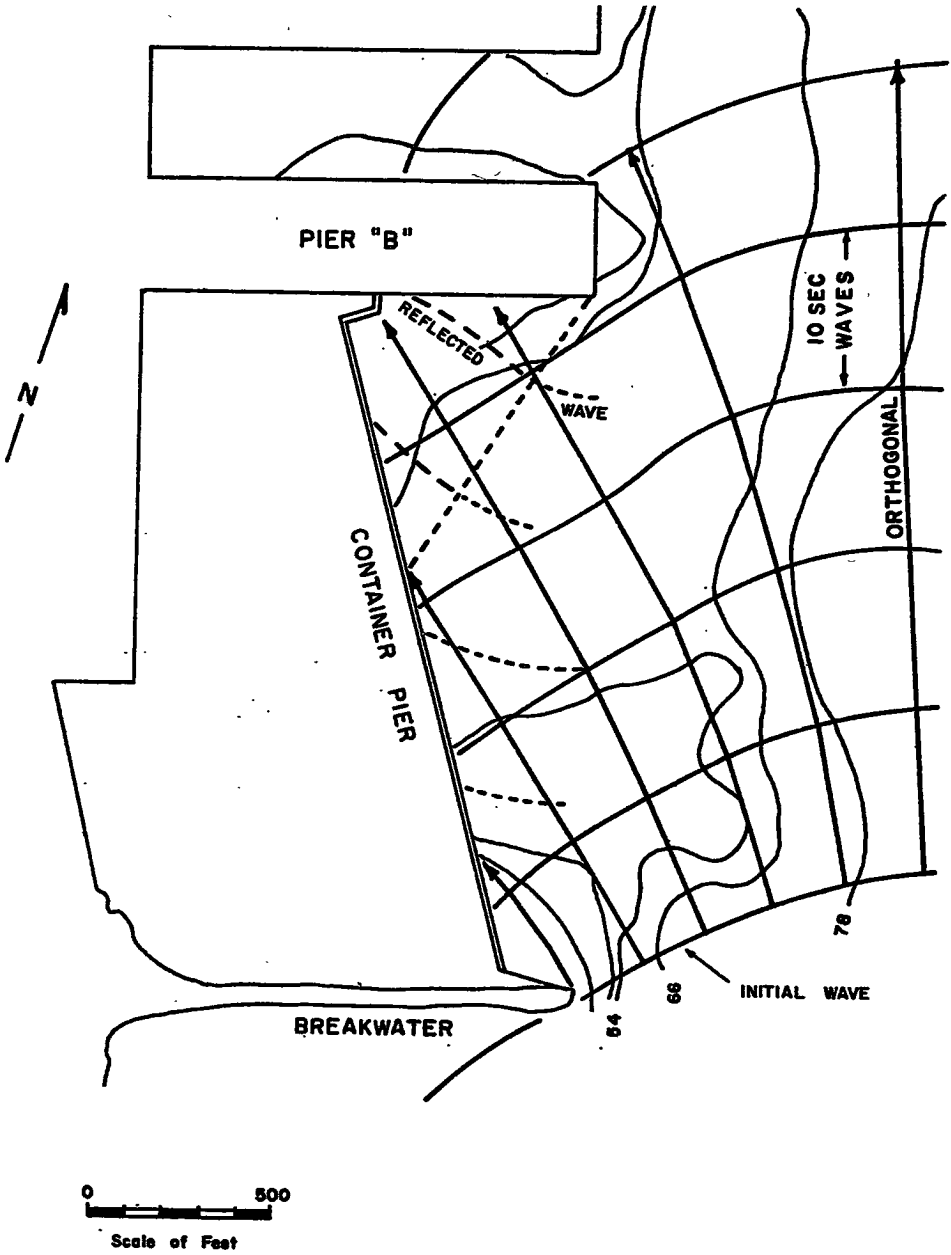


Fig. 8. Wave refraction diagram of a 10-second wave train at the Container Pier.

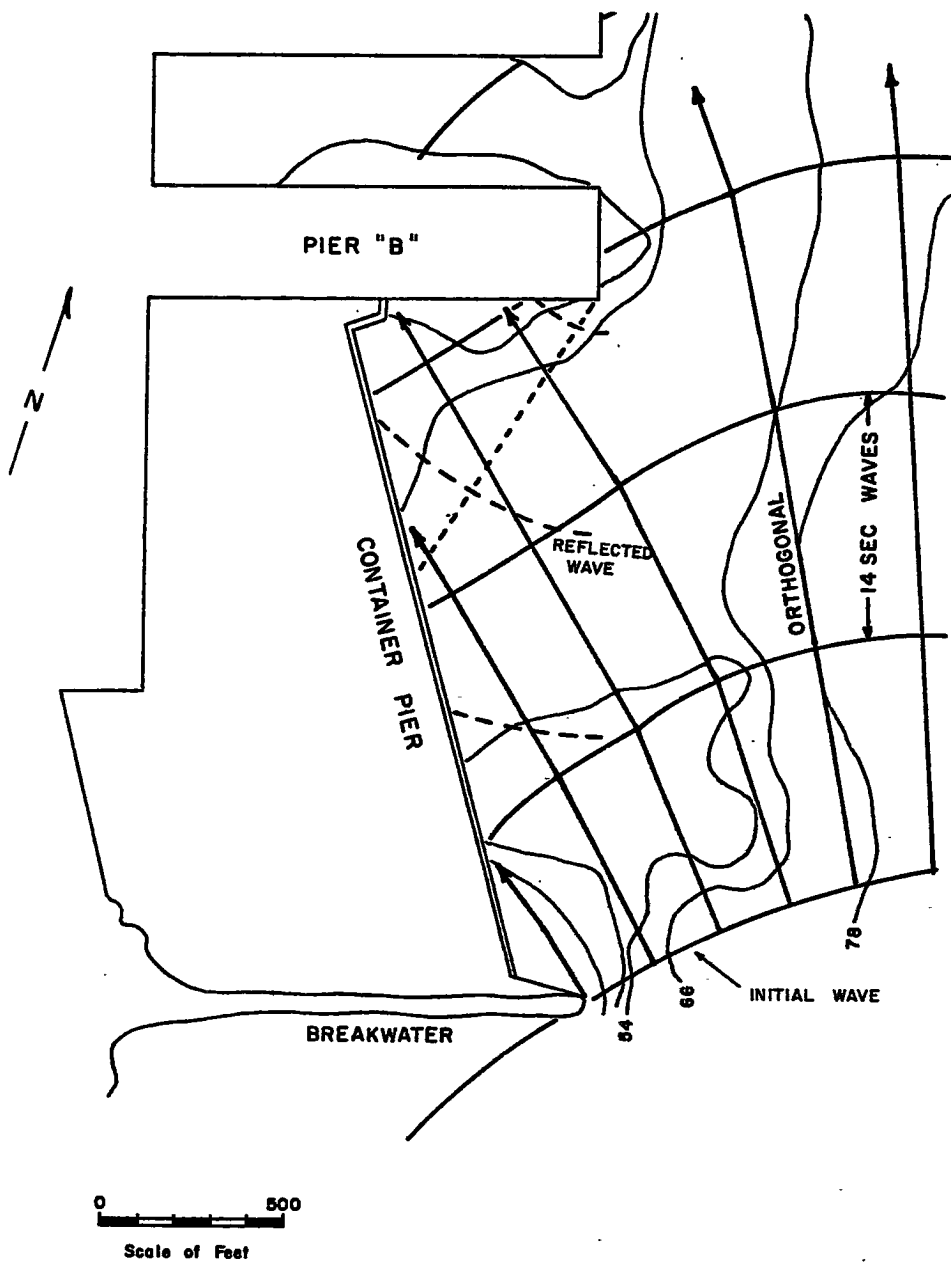


Fig. 9. Wave refraction diagram of a 14-second wave train at the Container Pier.

The disturbance caused by the reflected waves could largely be prevented by moving the wall of the container pier eastward until it is in line with the ends of Point Pleasant Park Breakwater and Pier "B". This arrangement would then be comparable with that of the sea wall, although the wave energy would be approximately double and the ship motion, therefore, greater.

Protection against the energy of the initial ocean waves can be provided only by breakwaters. As stated previously, an extension to the Point Pleasant Park Breakwater of about 700 feet would provide a considerable improvement in the wave conditions at the container pier; however, the improvement would be only local and of little benefit to the harbour as a whole. As demonstrated in AOL Report 1968-3 and shown in Fig. 10, breakwaters of comparable size, placed at the entrance to the harbour, should provide protection to the entire harbour, including the container pier.

After the pier is completed and before a breakwater is installed, there will be periods of considerable wave movement along the wall. These periods may have to be bridged by some temporary means of providing suitably calm water. If calm conditions all year round are a prerequisite for a particular container operation, only one solution is possible - an enclosed basin into which waves are prevented from entering. Such an arrangement was proposed in AOL Report 1968-3 under "Still Water Basin at Pier C", but is no longer possible since the area of the basin is included in the container pier.

However, this concept could still be implemented by including Pier "B" and the adjacent basin in the container loading area, as shown in Fig. 11. Container ships, which are rigidly scheduled, would be berthed and loaded in the basin between Pier "B", which would be part of the container pier, and Pier "A-1". A floating structure would close the basin and reflect the waves so that only a negligible part of their energy could enter the dock. A laid-up vessel, a large barge or a specially-built floating concrete structure, might be used as a closure. For most of the year, when the ships are undisturbed by waves, the basin would remain open and the mobile closure could be moored off Point Pleasant Park Breakwater as an extension to the breakwater.

SUMMARY

- 1) For the design of measures to minimize wave motion at a container pier, it is of vital importance to know the permissible movement of ships during loading. As these data seem to be unavailable, a study should be implemented immediately.
- 2) The wave energy in the general area of Point Pleasant Park Breakwater appears to be approximately twice that at the sea wall.
- 3) Wave reflections from Pier "B", superimposed on the initial ocean waves, create energy concentrations along the face of the container pier which could be several times larger than those experienced at the Sea Wall.
- 4) Extensions to the Point Pleasant Park Breakwater of less than 700 feet will probably provide insufficient protection for berthing container ships. The final solution depends largely on the results of 1).
- 5) In the light of these conclusions, it would be advisable to consider other improvements, such as breakwaters at the entrance to the harbour.

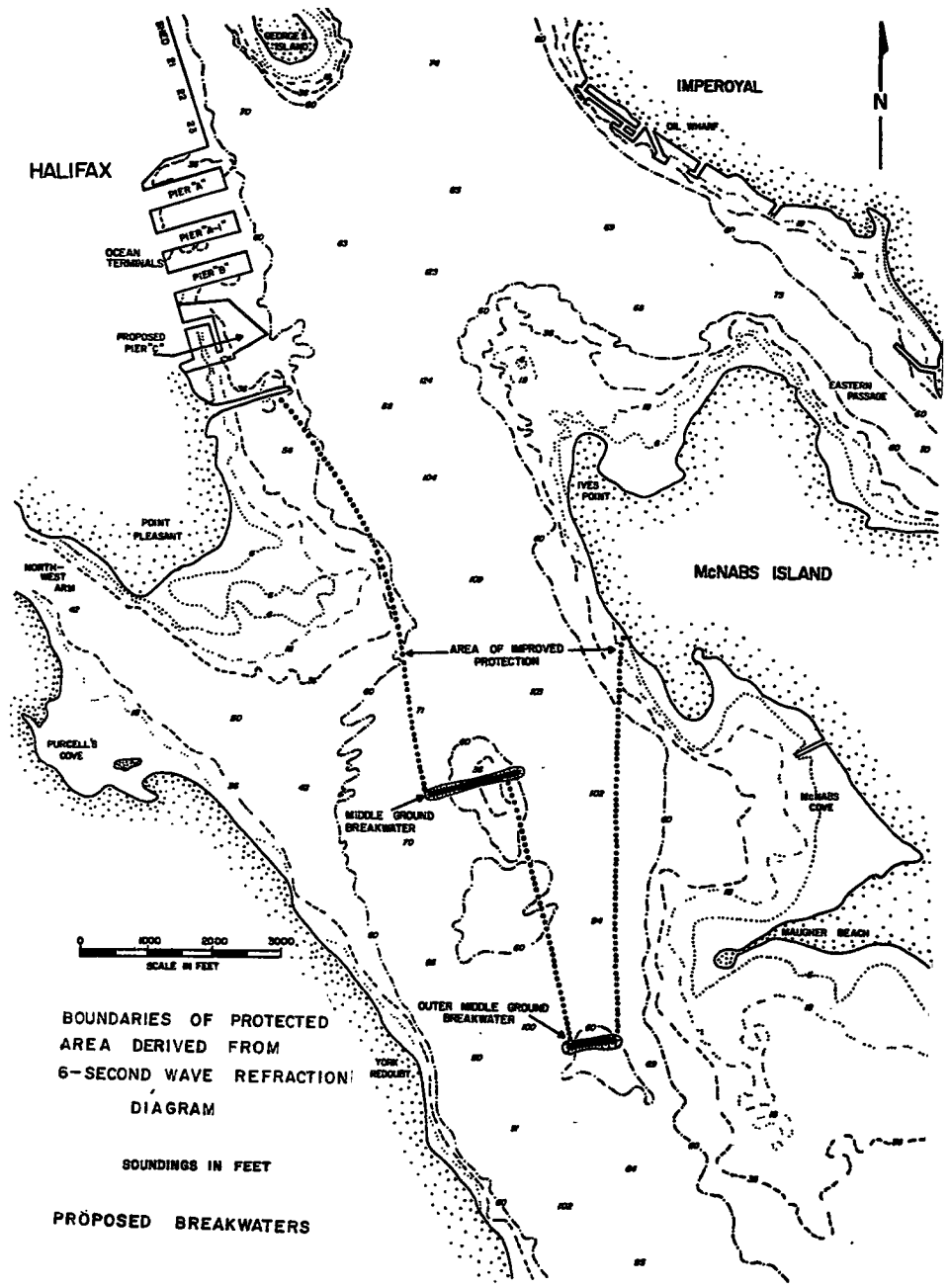


Fig. 10. Proposed breakwaters at the harbour entrance.

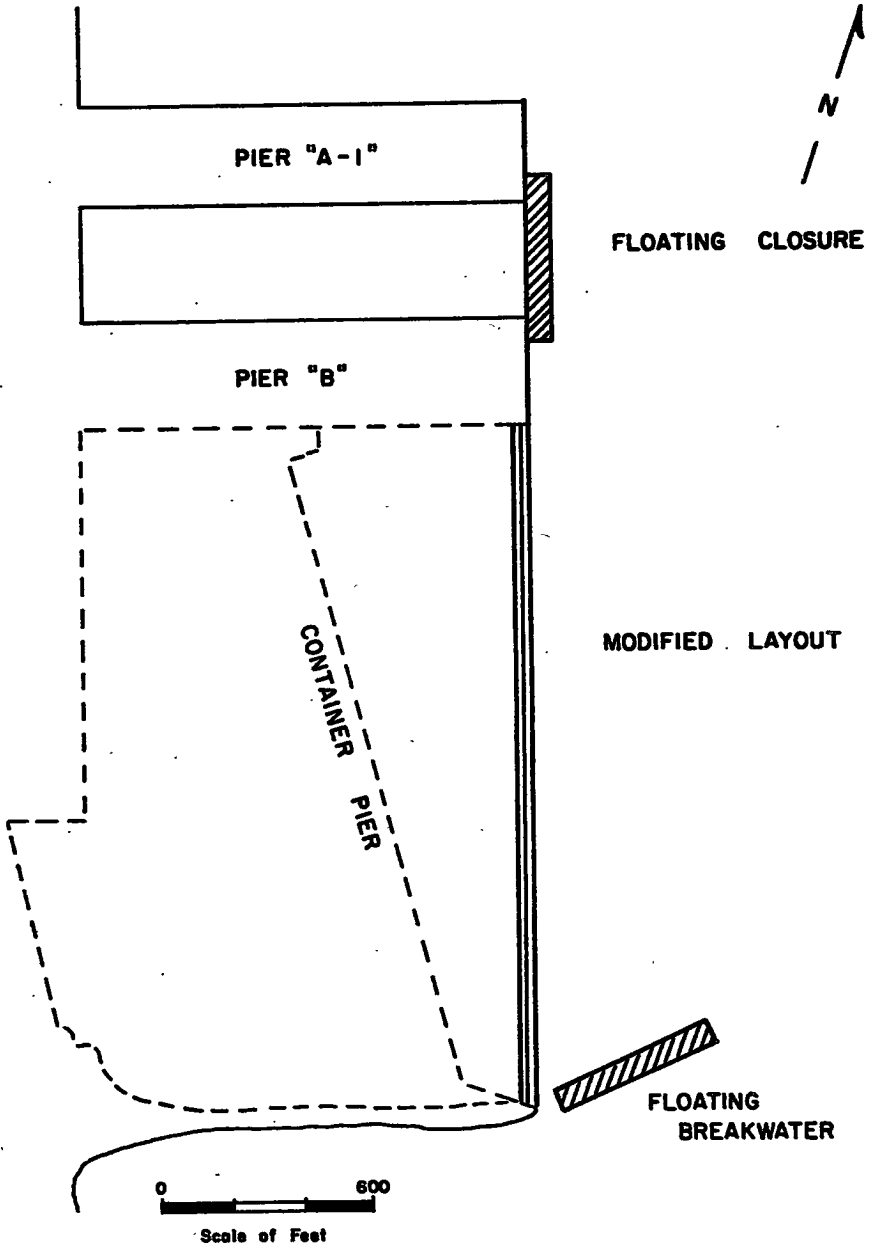


Fig. 11. Proposed alternative layout of Container Pier.

- 6) For a rigidly scheduled container service and for the transitional period between the completion of the container pier and the provision of an effective breakwater system, the operation of a semi-enclosed basin is suggested to provide the required stillwater condition. The implementation of this proposal would provide Halifax Harbour with at least one pier at which all-year-round container loading would be assured.