Provision of General Cargo Facilities at the Port of Darwin

Report

This study investigates evaluates the various options that could be taken in improving port facilities in Darwin, with particular reference to the impact of Cyclone Tracy.

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BUREAU OF TRANSPORT ECONOMICS

PROVISION OF GENERAL CARGO FACILITIES

AT

THE PORT OF DARWIN

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FOREWORD

Before cyclone *Tracy*, the provision of additional port facilities for Darwin had already become a pressing problem. Such a rapidly growing city has considerable requirements not only for normal supplies but also for household and other investment goods.

The cyclone has left the diminished population with much greater needs for imported household goods and, in addition, substantial needs for construction materials.

Against this background, the study investigates and evaluates the various options that could be taken in improving port facilities in Darwin.

The work was carried out by the Materials Handling Branch which is headed by Mr I.J.C. Kent. The project was the responsibility of the Engineering Projects Section under the direction of Mr J.E. Bleasel. Those principally engaged were Mr R.W. Shuttleworth, Mr S.W. Brooke and Mr D.J. Lyons.

The Bureau of Transport Economics acknowledges the assistance received from the Northern Territory Port Authority, the Department of Northern Australia, the Department of Housing and Construction, the Australian National Line, the Western Australian State Shipping Service and the Darwin Branch of the Waterside Workers' Federation of Australia.

J.H.E. TAPLIN
Director

Bureau of Transport Economics
October 1975

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SUMMARY

An investigation of the current operations of the Port of Darwin indicated that the two principal conclusions reached by the Parliamentary Standing Committee on Public Works in 1970, relating to general cargo facilities, were still valid. These were that:

- The Port of Darwin is suffering severely from congestion and there are considerable cargo handling difficulties.
- General cargo facilities should be retained in the Stokes Hill/Fort Hill area.

The Parliamentary Standing Committee went on to recommend the construction of the works referred to it. However, despite this and more recent recommendations only minor improvement works have been carried out, although the need for general cargo improvement is as great as ever.

The more specific findings to emerge from the current study were that:

- In the medium term, the quantities of general cargo imported annually by sea are expected to remain roughly at present levels.
- In the short term, an improved port is needed to handle the considerable amount of material required for reconstruction of the city of Darwin.
- An improvement in port facilities is economically justified and would provide substantial benefits.

Four options for improved port operations have been examined and evaluated:

- Option A uses the existing Stokes Hill Wharf and provides for the immediate transfer of discharged cargo to a new shore-based storage and distribution facility, at a capital cost of $2.8m (see Figure 5).

- Option B, costing $6.1m and also based on Stokes Hill Wharf proposes major expansion of the wharf structure itself (see Figure 6)

- Option C involves the construction of a new berth at Fort Hill and minor extensions to Stokes Hill Wharf. This option is the most expensive at $10.8m (see Figure 7).

- Option D involves the construction of a new berth at Fort Hill but no modification to Stokes Hill Wharf. It would cost $8.0m (see Figure 8).

Evaluation of the options over a twenty year period showed that each option can provide a net economic benefit. The highest rate of economic benefit is given to Option D, whilst other benefits, non-quantifiable in money terms, also favour Option D.

It is concluded that construction of a new, operationally land-backed berth at Fort Hill is warranted. Furthermore, because of the volume of cargo that will be generated by the reconstruction of Darwin, it is concluded that the maximum financial and operational benefit would be obtained by completing the new berth as soon as possible.

1. INTRODUCTION

1.1 TERMS OF REFERENCE

In December 1974, the Australian Minister for Transport, at the request of the Australian Minister for the Northern Territory, arranged for the Bureau of Transport Economics to investigate facilities existing at the Port of Darwin. The agreed terms of reference state that the B.T.E. should undertake a 'study into ways of overcoming some of the problems associated with the Port of Darwin...(to)...include the investigation of current handling procedures and indicate ways of improving the management and methods of cargo handling on the wharves...(and)... indicate what could be done regarding extension and/or relocation of facilities'.

Because of the essential role of the port in facilitating the post-cyclone reconstruction of Darwin, the Department of Northern Australia requested that the study of the handling of general cargo receive the first priority and, in particular, that the need for extension and/or relocation of facilities be investigated.

1.2 BACKGROUND

A plan showing the Darwin port area is shown in Figure 1. Historical Notes on the development of the port are included at the end of the report as Annex A.

Darwin in 1960 was a relatively small and isolated city, with a population of approximately 14,000 supplied almost exclusively by small break-bulk general cargo vessels from Australia's west and east coast cities. By 1974 the population had increased to 47,000 and the general cargo imported annually by sea had increased from 48,000 tonnes to 150,000 tonnes.

Congestion, and consequent delays to ships and consignees using the Port of Darwin, reached very high levels in the late 1960's. Maunsell and Partners were commissioned in 1968 by the Department of National Development to advise on the best methods of meeting the sea transport requirements of the fast-growing capital of the Northern Territory.

1.3 MAUNSELL AND PARTNERS' REPORT

The Maunsell report recommended that separate facilities for small ships and bulk cargoes be provided at sites at Frances Bay and East Arm, respectively.[2] It stated that 'satisfactory

future development of the existing port of Darwin for general cargo is largely dependent on the extent to which it is possible for any new berths to be land-backed and have adequate storage area behind them for containerised and unitised cargoes'. Maunsell recommended that this new berth be constructed between the existing Fort Hill and Iron Ore wharves, with land-backing provided by reclamation and by the removal of the iron ore stockpiles. The two alternative locations proposed by Maunsell for this berth, which was to have cost about $2 million (1968), are shown in Figure 2.

An inter-departmental committee was subsequently constituted to review the consultant's report. The committee agreed with the consultant's conclusions and recommended adoption of the consultant's broad proposals. The consultant's report and the inter-departmental committee's recommendations were submitted to Cabinet in 1969 which approved in principle the development of the port along the lines recommended. Cabinet directed that a steering committee be established with the responsibility of translating the broad proposals of the consultant into a specific plan of development.

1.4 THE STEERING COMMITTEE

The Steering Committee made further investigations which included an assessment of user requirements and the detailed examination of a number of alternative development proposals, which required extensive site investigations and technical studies in the port area. In evidence before the Parliamentary Committee on Public Works in 1970, the Steering Committee in conjunction with the Department of Works put forward specific recommendations for a new berth to the west of Fort Hill (see Figure 3, the 'Island Scheme'). The reasons given for the change in location were first, that the Port Authority had doubts about the safety of the approach to the consultant's recommended berth, in that it required ships to come close to the structure of the Iron Ore Wharf in an area of strong tidal currents. Second, the consultant's berth would have eliminated the Boom Wharf, an increasingly useful berth for oil rig tenders at that time.[5] The 'Island Scheme' offered an easier seaward approach but was further from the shore and more expensive at an estimated $4.4 million (1970).

In its report, the Parliamentary Committee on Public Works agreed with the general contention of the need for port improvements and recommended the construction of the works referred to it, which included the island berth at Fort Hill, the small ships facility at Frances Bay, the Frances Bay access

PORT OF DARWIN - general view, low tide, December 1974

road and the Bulk Port facilities at East Arm, at a cost then estimated at $19 million.

However, tenders received for portions of the scheme indicated that development costs had been seriously underestimated. Additionally, the assumptions of continued exports of sorghum and iron ore, upon which the financial justification for East Arm bulk port development was based, were called into serious question. All development work ceased; meanwhile, industrial unrest and technical problems with the ANL container vessel introduced in 1970 resulted in a decline in the quantity of seaborne cargo imported into Darwin.

1.5 COMMISSION OF INQUIRY

The Northern Territory Administration established a Commission of Inquiry in 1971 relating to the operation of the port, particularly the source of delays, and to make recommendations for measures to improve operations. The Commissioner, G.J. McDonell, reported in January 1972, and stressed the fact that the shorter turnround time of the unitised and containerised vessels now serving Darwin has reduced berth occupancy to an acceptable level.[8] He also drew attention to the fact that ever-increasing quantities of general cargo were being carried overland into Darwin, and suggested that earlier predictions of general cargo traffic through the port could thus no longer be considered valid.

Despite the Commission's strong recommendations to proceed with the development of the Frances Bay area, no works have been implemented except for sections of the Frances Bay access road. This road was originally suggested in the Maunsell Report and later endorsed by the Public Works Committee to improve access to the port area.

1.6 LATER PROPOSALS

The Commonwealth Department of Works and the Northern Territory Port Authority (NTPA) both subsequently issued rather less ambitious proposals for piled jetty structures at Fort Hill West. (See Figure 4, and Piled Berth in Figure 3). These were relatively small structures, and were to have relied upon the immediate transfer of cargo to shore-based storage sites. They were to have cost approximately $5 million (1972) and $4 million (1973) respectively. They have not been constructed.

Prior to the cyclone port traffic had increased so that it surpassed even 1969 levels, despite continuing improvements to the overland routes to Darwin, while port facilities in 1975 are largely unchanged from those analysed by Maunsell in 1968.

2. GENERAL CARGO TRAFFIC

2.1 POPULATION

Since 1960, Darwin experienced rates of growth which were high by national standards. Between the census of 1961 and that of 1966 the population increased to 21,671 at an above average annual rate of 6.9%.[13] During the period 1966-71 the population grew at 11.3% per annum, with the rate exceeding 12% in 1969-70 and 1970-71. Between 1971 and 1974 growth slowed to around 8%, with the population exceeding 48,000 by the end of 1974. Population figures are shown in Table 2.1.

As an indicator of growth, employment in the Australian Public Service (APS) has been the most reliable. In the 8 years between 1966 and 1974 the ratio of APS employment to total population varied only between 6% and 6.7%. Furthermore, the average annual growth rate over the same period was 9% for the APS whilst the corresponding figure for Greater Darwin was 10%.

2.2 GROWTH PROJECTIONS

The destruction caused by cyclone *Tracy* in December 1974 has invalidated demographic as well as economic forecasts made prior to that date. Although three-quarters of the population were evacuated in the weeks following the cyclone for reasons of both public health and safety, the mid 1975 population level was approximately 70% of that in 1974. The future of Darwin for quite some time will essentially be 'planned' rather than 'natural' growth.

The public sector in Darwin occupies a dominant position and during the period of reconstruction this influence can be expected to become even stronger. However, beyond the general concern to 're-build Darwin' there are few guidelines for the future. The report 'Darwin Planning Guidelines' produced by the Cities Commission in March 1975 illustrates the present dilemma. The reference to future population is '... for the purposes of this report...a maximum of 60,000 (persons) in 1980'. It later refers to a range of 55,000 to 100,000 persons by 1985. Government policy in respect of Darwin after the reconstruction period would be the major determinant of future infrastructure requirements on a long-term basis.

2.3 PRESENT PATTERN OF GENERAL CARGO TRANSPORT

Public administration plays a large role in the Darwin economy. It has been estimated that approximately 45% of the city's workforce is employed by government, with others,

particularly the construction industry, being dependent on public sector expenditure.[13] In contrast, manufacturing industry accounts for only about 6% of employment compared with an average of 30% in other medium to large Australian cities.[13]

As primary industry exports have fallen to a low level and secondary industry is minor, total exports are negligible and the Darwin freight traffic is almost entirely one way. The absence of back loading means that Darwin freight rates are comparatively expensive. It also means that the total throughput of Darwin's freight facilities can only be approximately half that which could reasonably be expected for facilities of similar size with balanced imports and exports.

Until about 1970 Darwin was supplied from other parts of Australia almost exclusively by sea. There is a break of some 1000km in the rail network between Larrimah, south of Darwin, and the rail heads at Alice Springs and Mount Isa. Whereas shipping still remains the principal means of supply from Perth, supplies from Adelaide and the east coast are increasingly being carried overland. Table 2.1 shows the population and import levels since 1958. Diagram 2.1 shows the source of general cargo shipping imports to Darwin since 1963.

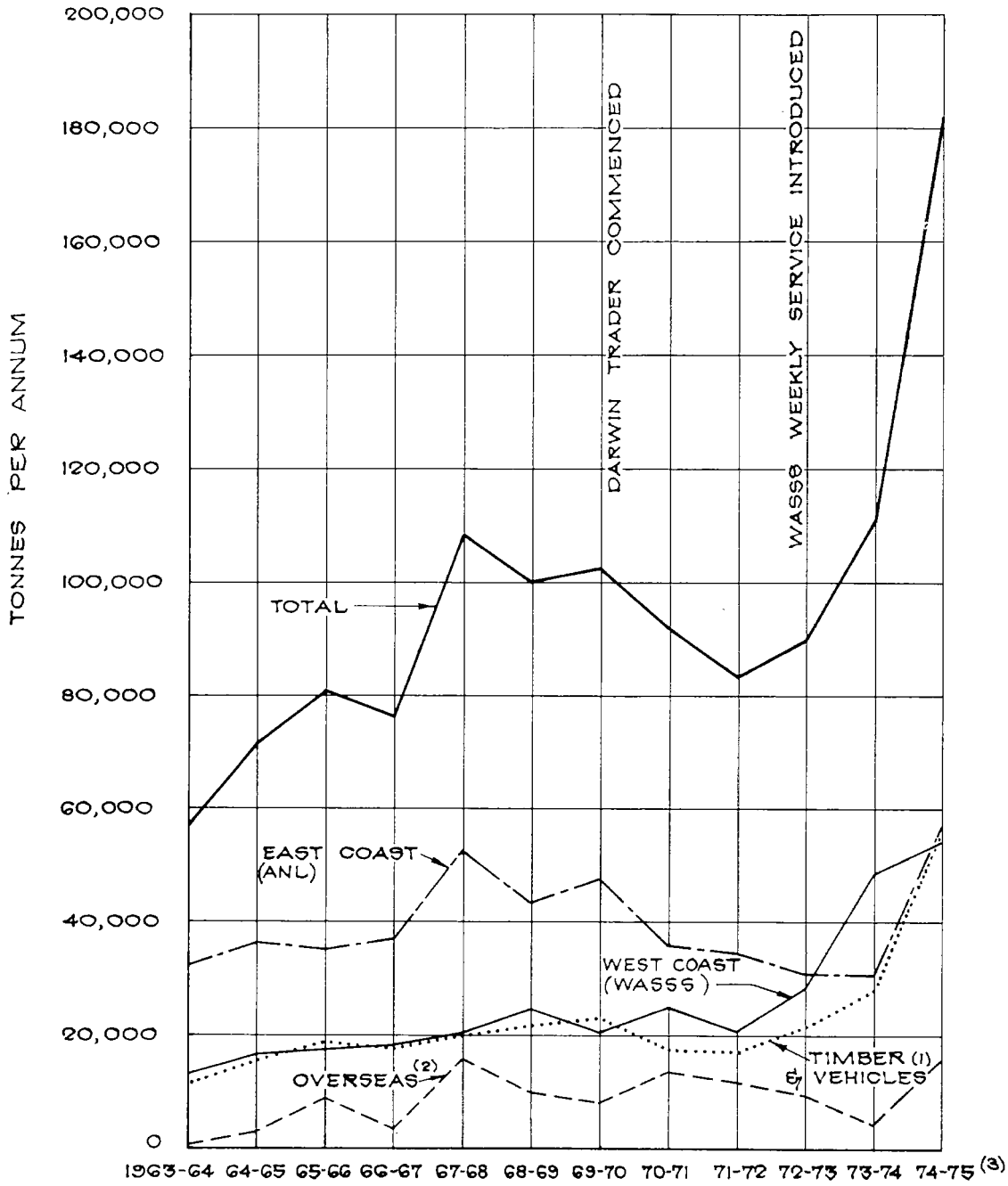
TABLE 2.1

DARWIN POPULATION AND IMPORT LEVELS

Year Ending 30 June	Population of Greater Darwin Area ('000)	General Cargo Imports ('000 tonnes) Sea	Land
1964	18.6	57	
1965	20.4	71	
1966	21.7	81	
1967	23.4	76	
1968	26.3	109	9
1969	29.3	100	25
1970	32.9	102	40
1971	37.1	92	65
1972	39.9	84	87
1973	42.9	90	94
1974	46.7	111	89

Note: July-Dec. 1974, General Cargo imports by sea 91,000 tonnes
Sources: Imports - Sea: NTPA
Land: McDonell (1968-71) BTE estimates (1972-74)
Population - Commonwealth Statistician

GENERAL CARGO SHIPPING IMPORTS TO DARWIN



NOTE: (1) MAINLY OVERSEAS ORIGIN
(2) OTHER GENERAL CARGO
(3) JULY - DECEMBER FIGURES DOUBLED

The rapid increase in the popularity of overland transport compared with shipping services, as shown in Table 2.1, was largely because of the shorter delivery time and the consequent reduced need for large inventories and expensive warehousing.

Warehousing facilities in Darwin are very limited, and Darwin wharves have traditionally been required to perform a warehousing function. By 1965, wharf congestion had reached such a high level that many consignees were prepared to pay higher freight rates to overland transport operators, who could provide them with relatively small consignments of goods at short notice. The land transport industry, assisted by a new generation of reliable heavy vehicles, grew rapidly.

Overland transport is normally faster than sea transport and freight rates vary depending on the size of the consignment and the speed of delivery required. It is less prone to interruption of service due to industrial problems and has the ability to respond to demand at short notice. However, land transport is more costly for many cargoes and it is prone to delays for extended periods due to flooding. Additionally the upgrading and maintenance of long distance, low utilisation, land transport systems are expensive when compared with the upgrading and maintenance of port facilities to service the same freight movement task.

As land transport cannot effectively compete for the west coast traffic, the majority of the overland operators' new business has been gained at the expense of the Australian National Line's relatively infrequent container service from the east coast. This service carried little more cargo into Darwin in 1973-74 than had the Line's break-bulk ships in 1965 (see Diagram 2.1). The Western Australian State Shipping Service, adopting a weekly unitised service, have improved upon their 1965 share of Darwin's interstate transport requirements.

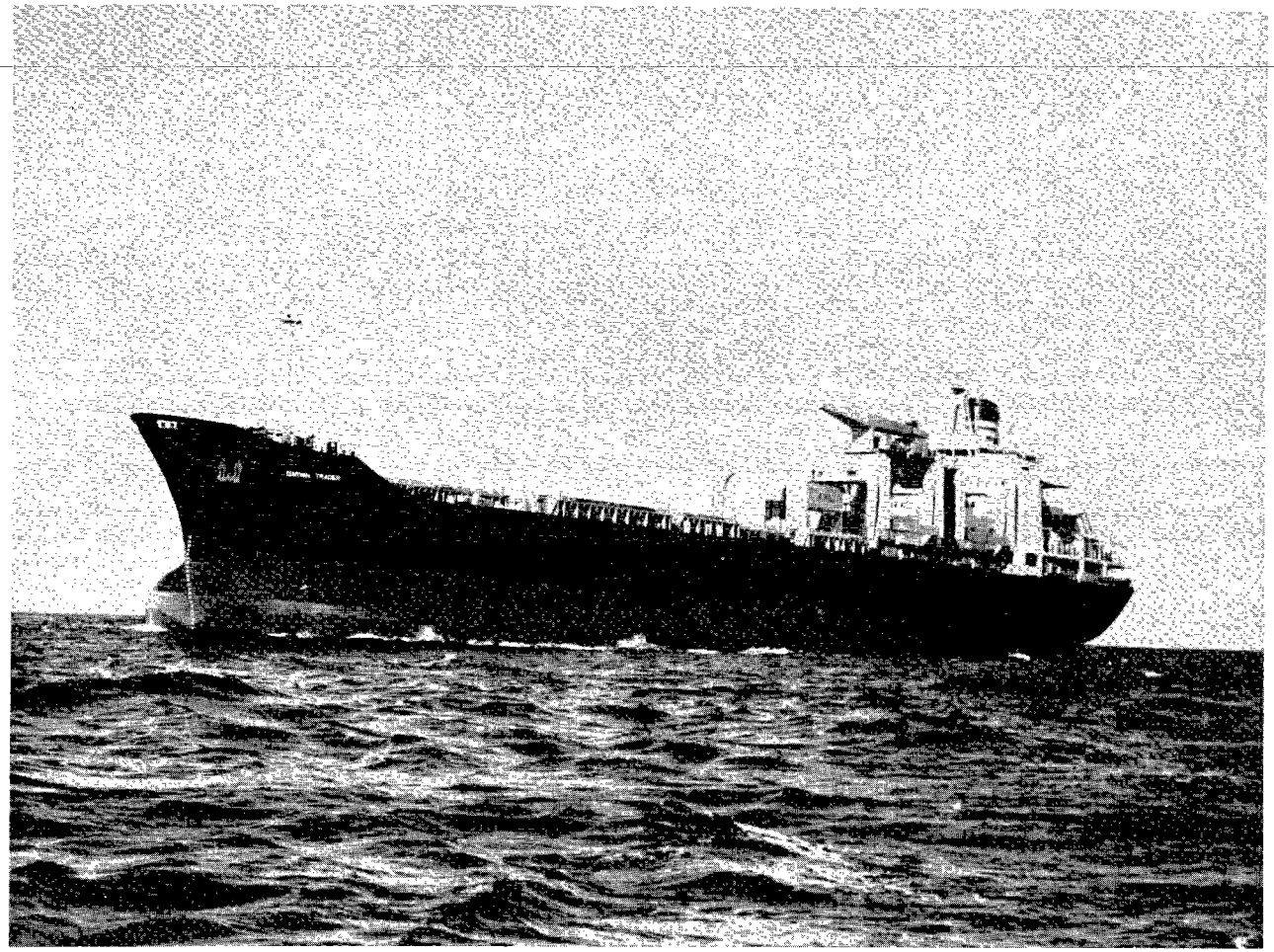
2.4 FUTURE GENERAL CARGO SHIPPING IMPORTS

Prior to the cyclone the annual rate of general cargo imports had reached 180,000 tonnes per annum for a population of 48,000 people. The mid-1975 population of approximately 35,000 had a high percentage of adult males and so the amount of high density cargo, (e.g. processed foods, beer etc) per head of population was also high. The post cyclone population requires a much greater quantity of household goods per head than the population of 1974 and some of this cargo would be most economically imported by sea. Additionally, some reconstruction materials such as timber from overseas, must always come via the Port.

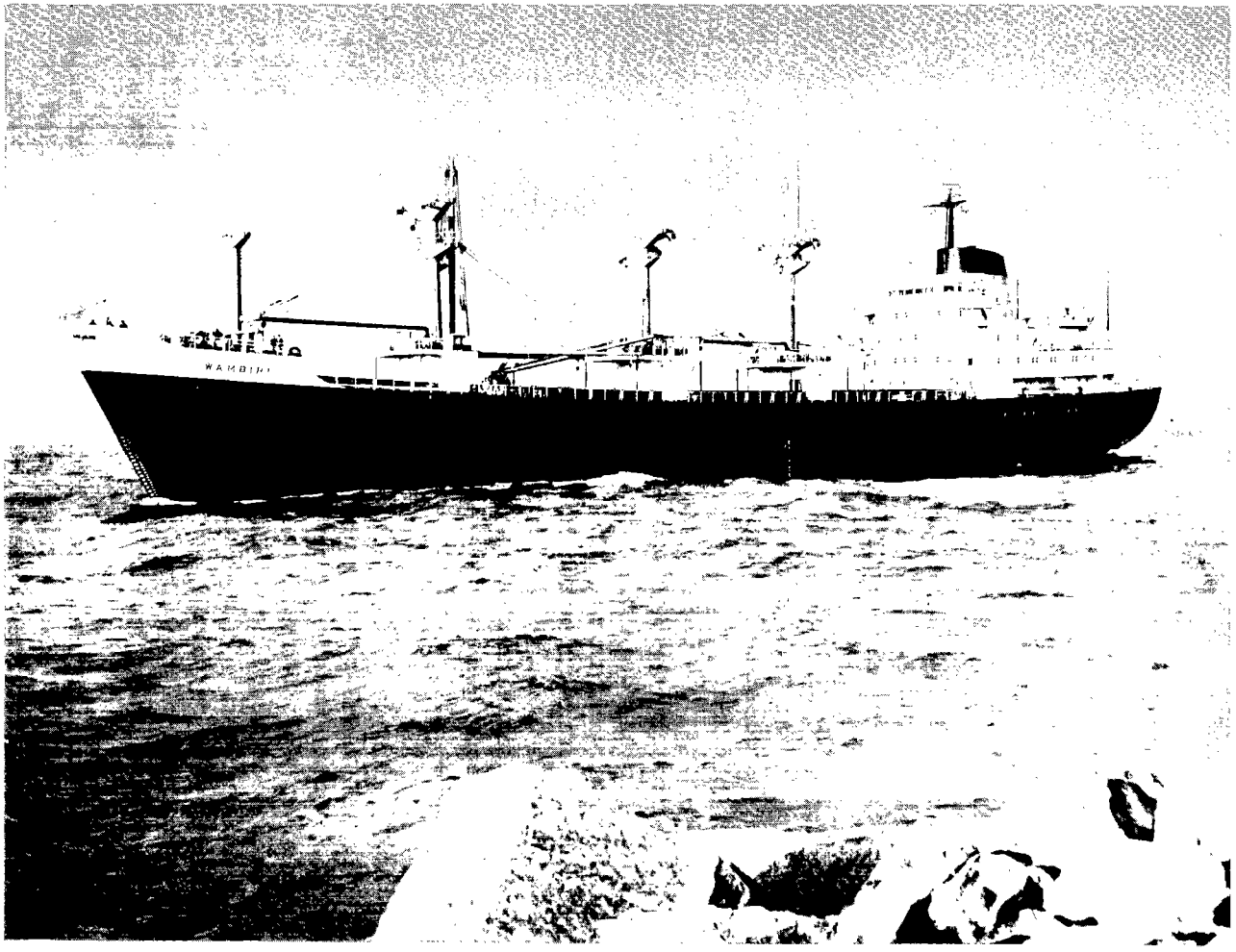
Therefore, neglecting those reconstruction materials which will probably be imported by land unless port facilities are significantly improved, imports of general cargo by sea may be expected to approximate 200,000 tonnes per annum in the immediate future. As Darwin's population returns to pre-cyclone levels and distribution, the average imports per head of population will fall. Thus in the medium term, the total level of this cargo is likely to remain at around 200,000 tonnes p.a. Import trends apparent by September 1975 confirm this estimate. Additionally, reconstruction will increase the short term freight requirements. This matter is discussed further in Chapter 5 and 7.

All overland transport is dependent upon a road system that, at present, includes such flood-prone sections as that around Newcastle Waters. Both 1974 and 1975 saw the roads into Darwin cut by floodwaters for extended periods. However, there is little evidence to suggest that the risk of supply interruptions has deterred consignees from relying upon overland transport from the east coast where it has offered a saving in transport and inventory costs. Consequently the implementation of highway improvement plans is not expected to increase the attractions of overland cargo transport routes.

It is unlikely therefore that the seaborne cargo imported into Darwin from the east coast will be further reduced by competition from overland transport. The west coast shipping service faces very little competition from overland transport and so can be expected to maintain its share of the cargo traffic into Darwin.



ANL cellular vessel *Darwin Trader*



WASSS unit load vessel *Wambiri*

3. EXISTING PORT OPERATIONS

3.1 GENERAL

The layout of the Port of Darwin is shown in Figure 1. Darwin is serviced on a regular basis for general cargo by three shipping lines, namely:

(i) The Australian National Line (ANL), which provides a service for 6.1m ISO container cargo from Melbourne, Sydney and Brisbane.

(ii) The Western Australian State Shipping Service (WASSS), which operates unit load vessels from Fremantle via north west ports to Darwin.

(iii) The Knutsen line, whose *'Bakke'* vessels call at Darwin, Western Australian ports, South East Asia, Japan and the west coast of the USA.

Currently the ANL operates only one ship to Darwin, the 11,900 dwt cellular container vessel, *Darwin Trader*. This vessel, which entered service in mid 1970, was equipped with container handling gantry cranes because no container handling facilities were available in Darwin. At that time, ship-mounted cranes were considered a better financial proposition than shore-based facilities, particularly because of the construction work necessary to strengthen Stokes Hill Wharf to accommodate a crane.

The *Darwin Trader* achieves a discharge rate double that of the unitised WASSS vessels and many times higher than attained by the break-bulk vessels of the early 1960's. However, the cranes were expensive, and costly in terms of ship stability, and the present method of handling at Darwin results in an unloading cycle of about ten minutes, a time considerably longer than the three to four minutes cycle originally planned. Furthermore, the basically cellular structure of the *Darwin Trader* prevents ANL from offering an effective east coast service for non-containerisable cargoes.

Since 1971, WASSS has introduced four unit load ships of approximately 7,000 dwt. These ships replaced the older, conventional vessels for the Fremantle-Pilbara-Kimberley-Darwin service. The unit load ships provide a weekly service from Fremantle and carry cargo in a variety of small containers, in palletised form and in pre-slung units. A small number of 6.1m ISO containers are carried into Darwin by these ships. The round trip for each vessel takes about two weeks.

The *'Bakke'* ships carry unitised and other cargoes, including vehicles from overseas, and take away most of the small volume of non-bulk exports.

Until the introduction of the *Darwin Trader* and the unitised WASSS vessels, general cargo was handled by break-bulk ships requiring extensive periods, often measured in weeks, to discharge their loads. Small ships using Stokes Hill Wharf contributed greatly to the delays in berthing ships and clearing cargo. Although berth occupancy by all vessels reached a level of well over 80 per cent in the period 1968-71, less than half of this usage was due to large cargo or passenger vessels. With the introduction of the container and other unitised services, the time spent in discharging cargo was reduced to a matter of days and this clearly increased the availability of berths with consequent reduction in average ship waiting time.

3.2 STOKES HILL WHARF

3.2.1 Description

Stokes Hill is the main general cargo wharf for Darwin and is used by all the regular shipping lines. Typically 500-3,000 tonnes of cargo are discharged at each visit by vessels other than the *Darwin Trader*. In addition to general cargo, Stokes Hill Wharf is used by a variety of small vessels including Navy patrol ships, tugs, prawners, pearlers and fishing vessels. The small vessels normally use the landward side of the wharf and leave the seaward side free for larger vessels.

The present wharf was opened in 1956 and replaced the old Town Wharf. It originally provided a berth 183 metres in length which was capable of handling the large passenger vessels which berthed at Darwin on occasions. Major extensions at the western end and lesser works at the eastern end have re-shaped the initial structure, making the wharf now 293 metres long and 43 metres wide with additional widening of 6 metres at the western end. It is possible to berth two vessels of the size currently serving Darwin along the south face. The minimum depth of water at the front is 9.6 metres whilst the depth at the rear of the wharf is 4.5 metres. The wharf is connected to the shore by a curved approach about 275 metres in length and 10 metres wide.

3.2.2 Operation - Unitised Cargo

Palletised cargo is moved by 2½ tonne forklift trucks into the transit sheds without undue difficulty. The existing sheds are, at about 1,400 sq metres per berth, too small to allow efficient sorting and stacking (particularly by waterside labour subjected to Darwin's climatic extremes) or to cope with their inevitable use as warehouse space for less urgent cargo.

Other unit loads are less easily handled and stored. These items (such as timber, prefabricated building elements and reinforcing steel) are most economically transported by sea, and will be most important in the rebuilding of Darwin. The existing port facilities are quite unsuited to the handling of such cargoes, due to the space and access restrictions on Stokes Hill Wharf. Any new berth must be designed to allow these cargoes to be easily stored in convenient and accessible locations.

3.2.3 Operation - ISO Freight Containers

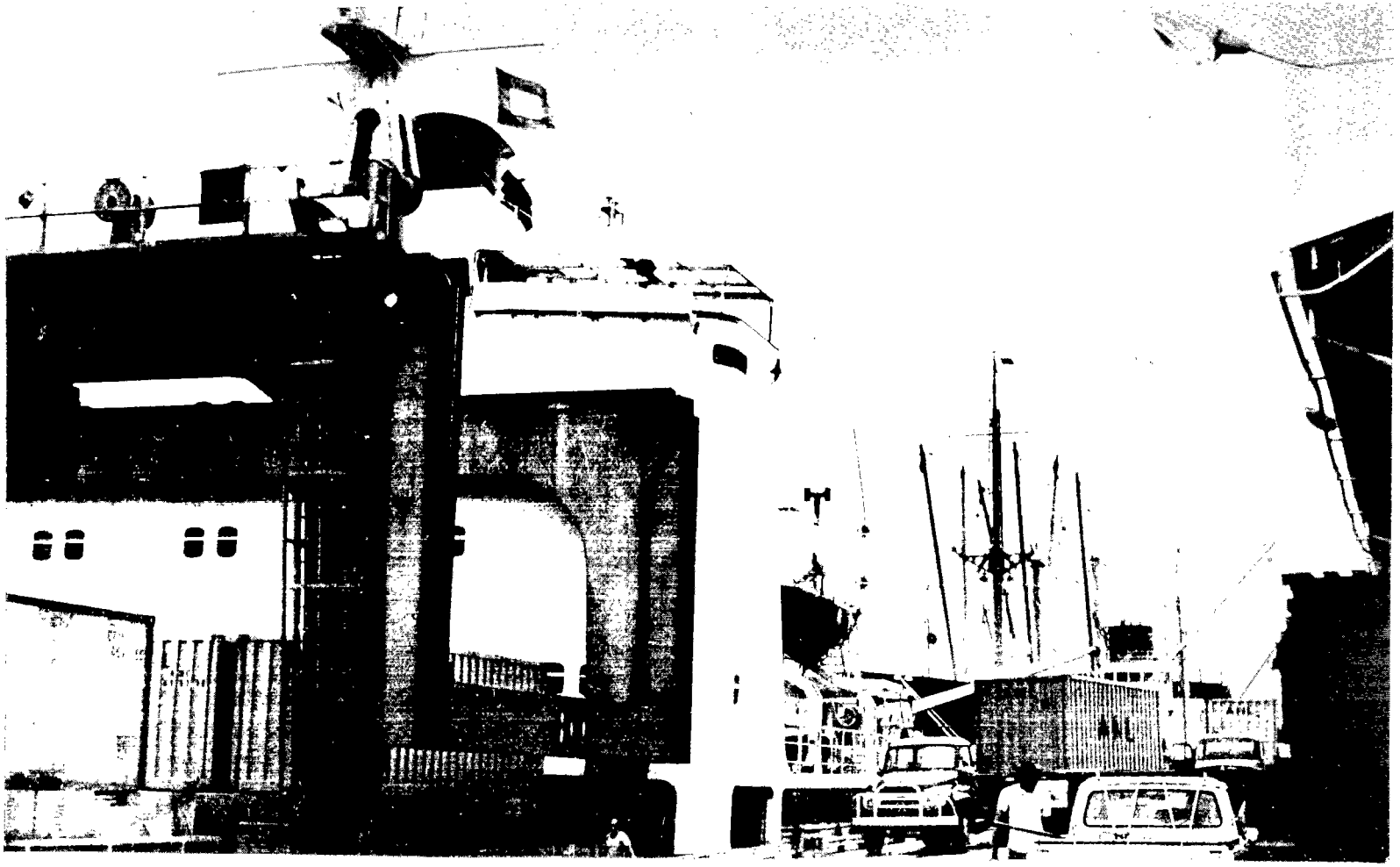
Containers from the *Darwin Trader* are transferred directly between ship's cranes and flatbed articulated road vehicles, ten of which (hired from a local contractor) carry empty and full containers between the wharf and the ANL terminal when the *Darwin Trader* is in port. Typically, in March 1974, 390 truck-hours were spent on this task, unloading about 4,700 tonnes of cargo.

Such a direct transfer is not easy, with the high lift and uncertain operation of the ship's cranes and the congested state of the Stokes Hill Wharf. Therefore the trucks are generally manoeuvred into position under the ship's gantries; even so, crane time is wasted on this manoeuvre and a surplus of trucks provided to ensure that the cranes are not delayed by containers waiting uncollected on the wharf. The use of a conventional forklift truck on the wharf would provide a considerable increase in efficiency. The forklift would first serve the ship's cranes and later, at leisure, transfer containers to trucks for the trip to the ANL terminal or to those consignees receiving full container loads. A similar method of operation, using a side-loading forklift truck, commonly handles the relatively small number of ISO containers discharged by WASSS vessels. Were this method to be adopted for east coast container operations it would require more space than is currently available on Stokes Hill Wharf.

3.2.4 Operation - Timber

Most timber is received bundled in lots of between 1 and 10 tonnes, and is handled by ship's gear over Stokes Hill and Fort Hill Wharves. Timber from overseas is allowed to be moved to quarantine storage, at timber merchants' premises or at the Department of Health's yard at Dinah Beach, without restriction.

Certain small timber ships, when discharging at low tides, find the reduced height of the rear face of Stokes Hill



Dawin Trader - Stokes Hill Wharf, gantry cranes in folded position, December 1974

Wharf an advantage in that it permits their derricks to be used more easily, and thus generally berth at the landward side of Transit Shed B.

Wherever it be discharged, the volume (often 3,000 tonnes) of a timber consignment causes severe handling and storage problems. At the western end of Stokes Hill Wharf there is nowhere to conveniently put bundles of timber. Stevedores, their first duty being to service the ship, are forced to place bundles wherever they can find space for them. Timber so dispersed creates considerable inconvenience to all users of the wharf for some time afterwards while it is sorted for collection by consignees.

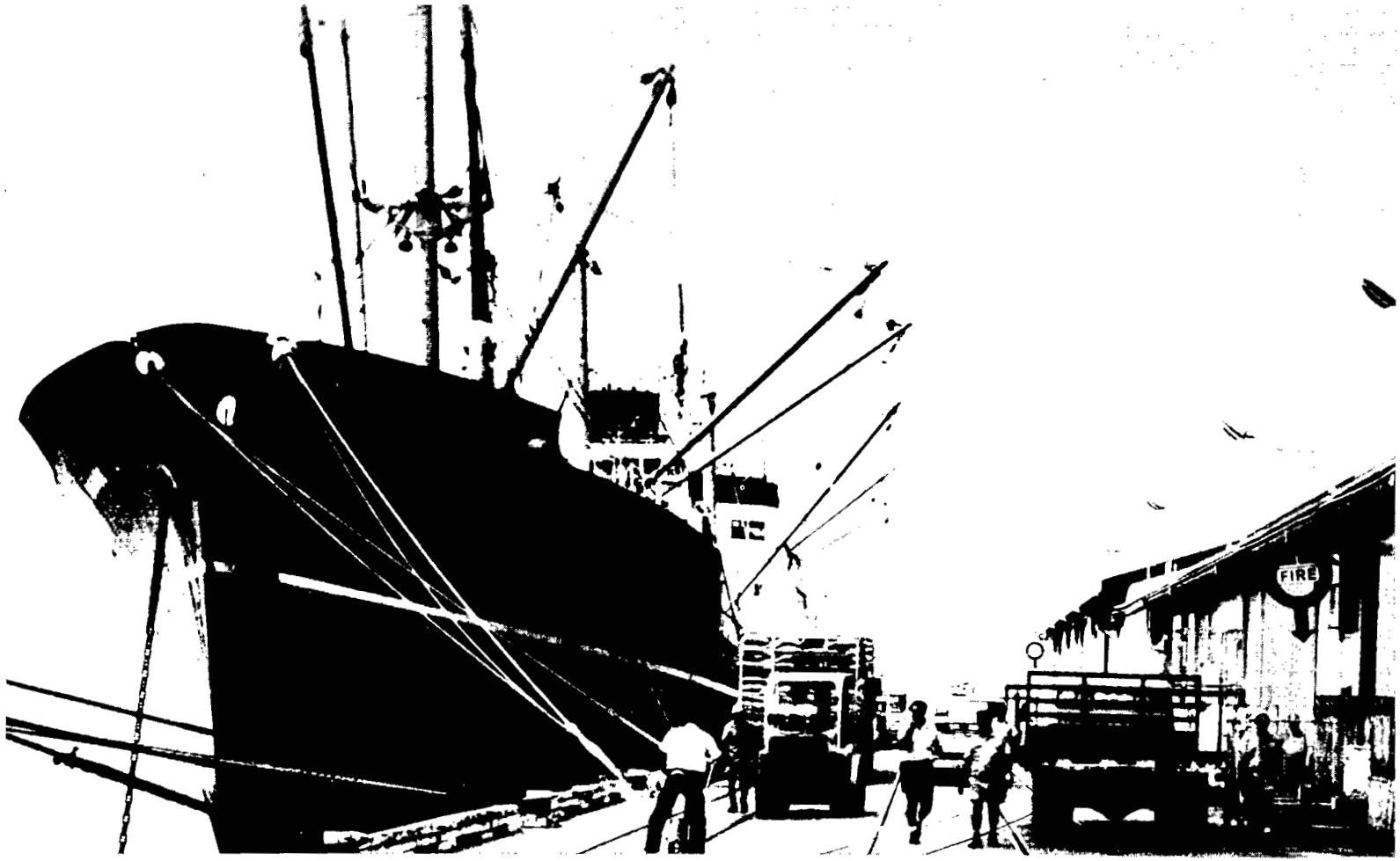
The shortage of open storage area often forces the storage of timber in Stokes Hill Wharf transit sheds. This is a difficult and annoying manoeuvre for waterside workers, who must pass from a narrow apron through shed doors usually narrower than the length of the bundles they are carrying on forklift trucks. It is also an unacceptable waste of the limited available shed space. The difficulties involved in subsequently sorting and removing timber from the sheds are considerable, as is the inconvenience caused to those seeking access to other cargoes.

3.2.5 Limitations

Difficulties occur in operating Stokes Hill Wharf due to access limitations, a shortage of storage space and the limited load bearing capacity of the deck.

A limitation to the operation of the wharf is its 12 metre apron width, front and rear. This is inadequate for the efficient handling of the quantity and type of general cargo now arriving in Darwin as:

- cargo not easily fitted into the transit sheds (e.g. timber) cannot be stored on the apron without causing severe congestion;
- the use on the apron of ISO container handling equipment disrupts all other activities;
- movement of cargo, particularly lengthy items, along the face of the wharf is impossible without severely inconveniencing ship unloading operations. The open storage area at the eastern end of the wharf is thus effectively inaccessible for ships using the western berth;



STOKES HILL WHARF - seaward face, unitised cargo handling operation, December 1974

road vehicle movements along the landward side of the wharf (e.g. when attempting to pick up cargo) are impeded by the operation of vehicles and equipment serving the small commercial vessels moored on this side of the wharf.

More fundamental is the absence of adequate open storage facilities adjacent to the berth face. The existing area of about 1600m^2 created by eastward extension of the wharf is inadequate for the traffic handled by the eastern berth and, as described earlier, is often effectively inaccessible for vessels using the western berths of Stokes Hill Wharf.

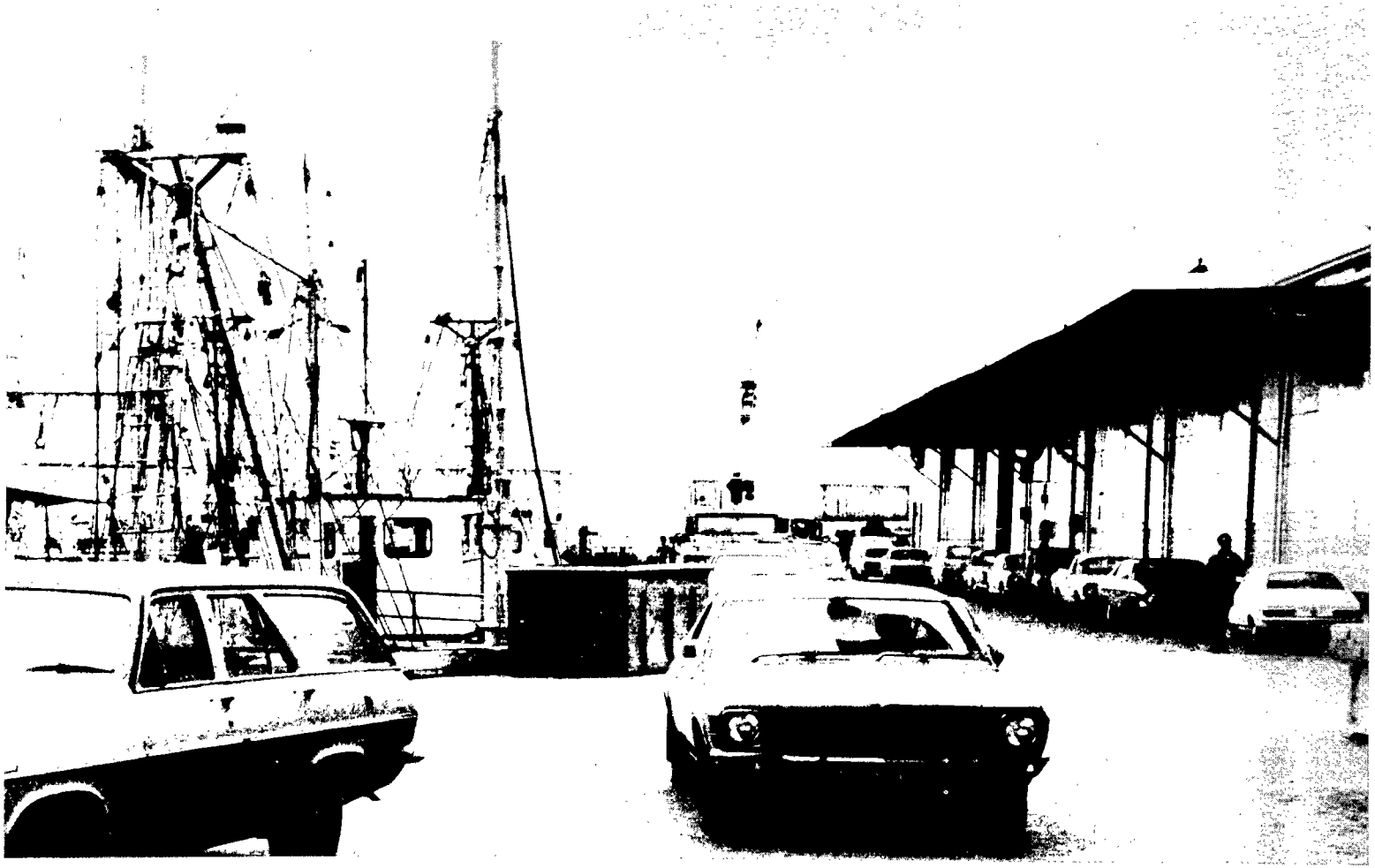
A further difficulty arises because of the large distance between the wharf and the on-shore storage facilities. This distance of nearly 800m necessitates a relatively large fleet of vehicles to clear cargo from the wharf as vessels are discharged.

The latter problem can be seen alternatively as an absence of adequate storage facilities adjacent to the wharf. The present gross area of the wharf is 13,000m^2, excluding the approach jetty. The area consists of access roads and wharf apron of 8,000m^2, offices and amenities of 530m^2, shed storage of 2,870m^2 and open storage of 1,600m^2. The shed storage, at 1,400m^2 per berth, is too small, not only for efficient everyday operation, but also for adequate undercover working space for periods of hot or wet weather.[5] The storage situation is worsened by some consignees using the space in the sheds for warehouse purposes rather than for short term, in-transit storage.

The wharf and approach are also severely handicapped by the strength of the decking. The original parts of the wharf, including the approach parts of the eastern end and the central area around shed A, are now nearly 20 years old (see Figure 2). The original timber deck has been replaced by concrete, but many of the original timber beams remain. Consequently, the deck is not suitable for heavy concentrated wheel loads and is being damaged by the 20 tonne capacity side-loading forklift truck now in operation. The deck strength limitation prevents the use of the front-loading forklift truck, in common use elsewhere for handling 6.1m ISO containers, because of the greater wheel loads involved.

3.2.6 Possible Improvements

In planning any substantial alterations to Stokes Hill Wharf the following factors would need to be considered:



STOKES HILL WHARF - landward face, small ships operation, December 1974

(i) Repairs to or replacement of parts of the support structure, and repair or strengthening of the deck where necessary. In August 1975 these matters were currently under investigation by the NTPA.

(ii) Confirmation of the expected structural life of the wharf.

(iii) Improvements to methods of collecting and removing cargo from the wharf. This could necessitate widening of the aprons to facilitate movement.

(iv) Possible major extension of the wharf to provide more satisfactory amounts of open storage space.

(v) Removal of some or all of the small ship operations to an alternative location in order to reduce overall congestion and simplify the variety of services.

(vi) Allocation of adequate transit shed space for despatch and receiving operations.

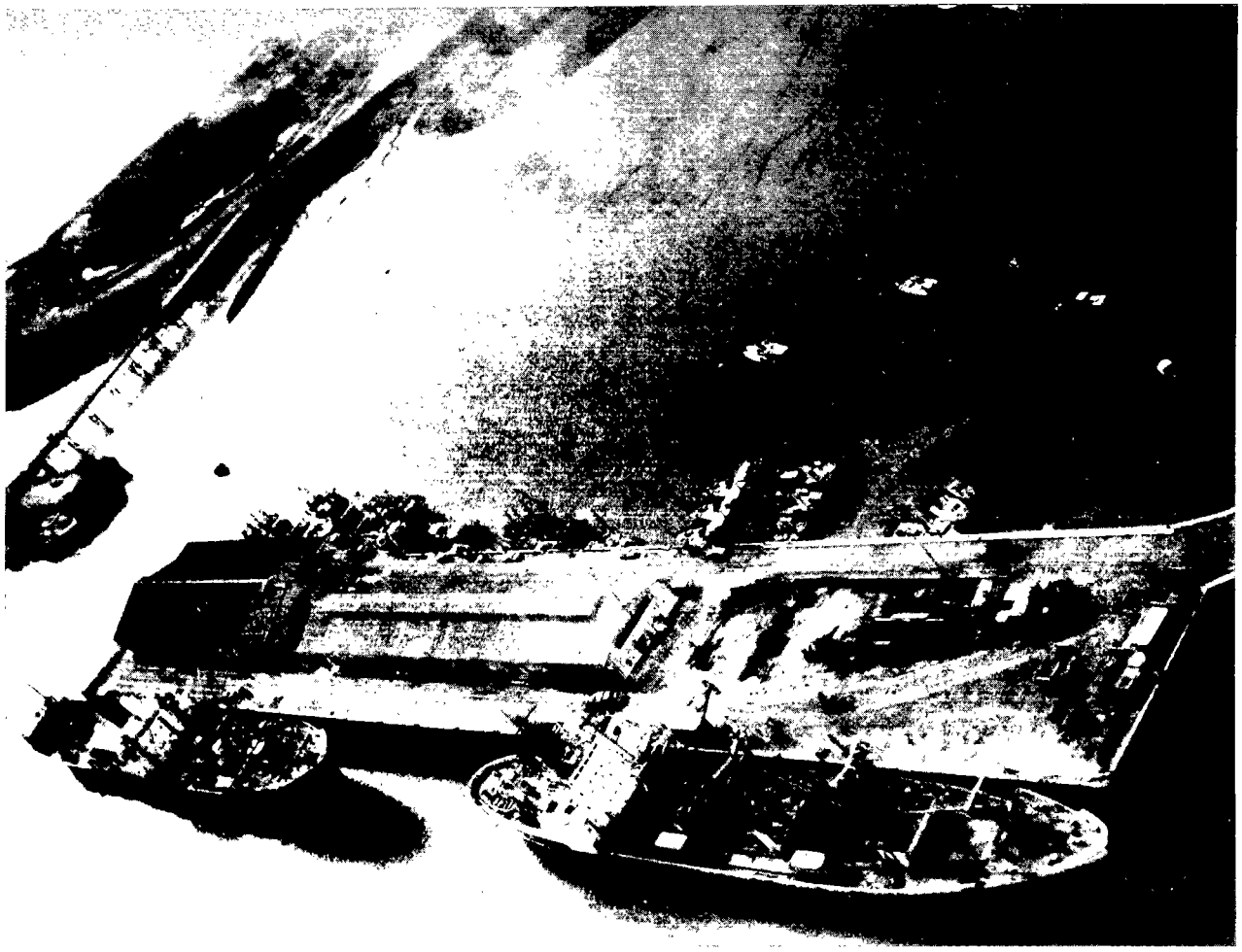
3.3 FORT HILL WHARF

3.3.1 Description

This wharf, which is located on the eastern side of Fort Hill, is a small T-head structure approximately 107 metres long and 15 metres wide. It is reached by an approach jetty approximately 150 metres long and 6 metres in width. Minimum depth alongside is approximately 7 metres. The wharf, despite major reconditioning in 1957, is nearing the end of its structural life due to extensive corrosion of the bracing system and support piling. Doubts have been expressed as to its ability to withstand accidental overloads imposed during berthing, loads which would normally be within the design limits.

3.3.2 Operation and Limitations

The wharf is too small for use by the 5,000 to 10,000 tonne general cargo vessels serving Darwin, and is therefore generally used as berthage for small ships such as prawning vessels and drilling rig tenders. White oil, black oil and cement pipelines are terminated on the wharf, which is accordingly also



STOKES HILL WHARF - showing open storage area on right hand side, low tide, December 1974

used by small tankers; however, oil discharging facilities are also provided on the Iron Ore Wharf, which serves as Darwin's main tanker berth.

Other vessels, such as small timber ships, have berthed at Fort Hill when space at Stokes Hill Wharf was unavailable. The space and access limitations of the wharf make this an inefficient operation, judged unsatisfactory and undesirable by all involved.

While the wharf continues to have some use for small vessels, the lack of structural soundness must raise the inevitable question of replacement in the near future. The bulk cement discharge facility could be readily moved, at little cost, to another wharf, probably the Iron Ore Wharf.

3.4 IRON ORE WHARF

3.4.1 Description

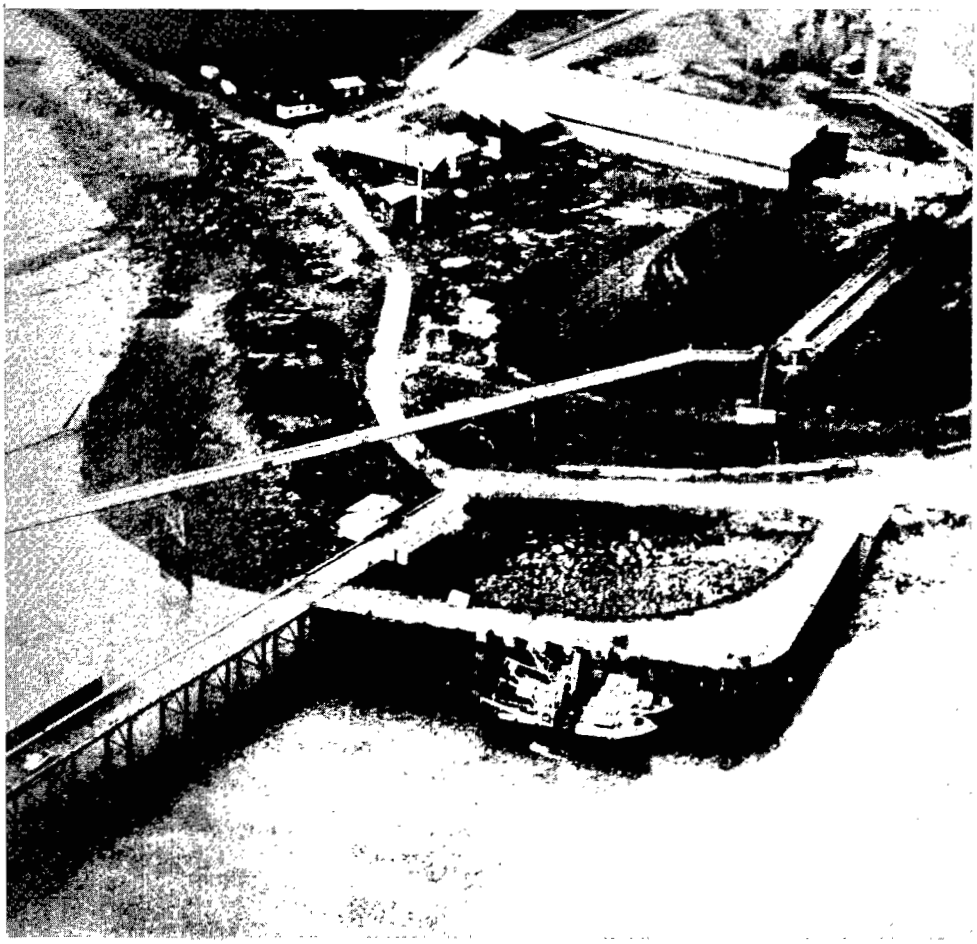
This piled structure, to the south-west of Fort Hill, was constructed in 1967 to handle the bulk export of iron ore. The wharf comprises a narrow 17 metre wide deck, approximately 140 metres long, primarily designed to carry an iron ore shiploader. The deck is reached by an approach approximately 6 metres wide and 160 metres long. Minimum depth of water alongside is 11.6 metres. The wharf is in sound condition apart from some damage to the approach which occurred during the cyclone.

3.4.2 Operation and Limitations

With the cessation of iron ore exports from the Port of Darwin, the wharf continues to give profitable service as Darwin's tanker berth. Replacement of oil lines and associated equipment would allow the berth to handle bulk petroleum products at rates many times those of 1974, should this be required within the lifetime of the facilities. The wharf is too small to allow the efficient discharge of general cargo.

3.5 BOOM WHARF

This is a small L-shaped wharf 70 metres long and 9 metres wide, built in 1939-40. It is constructed of reinforced concrete and is in reasonable condition for the modest functions which it is required to perform. Its use is restricted to shallow draft vessels. Berthing is hindered to some extent by its position inshore of, and abutting the approach to, the Iron Ore Wharf.



BOOM WHARF, low tide, December 1974

4. SPECIAL CONSIDERATIONS

4.1 ALTERNATIVE VESSEL TYPES

Improvements in future port operation may arise, not only because of changes in cargo handling methods, but also from the introduction of new types of vessels such as LASH (lighter-aboard-ship) or vehicle deck ships.

LASH ships carry cargo in barges (lighters) which are offloaded by a ship-mounted crane. Some also carry containers in a cellular structure near the bow. These vessels are able to stand off shore to discharge barges. Shore facilities, with wharf-mounted cranes, are required only for unloading the shallow draft barges. In practice LASH vessels are usually brought alongside a wharf at major ports so that provisioning, bunkering and unloading of containerised cargo can be carried out. The wharf requirements are then similar to those for a cellular container ship.

Cellular container ships are generally loaded and discharged by wharf-mounted cranes. A wharfside container handling crane at Darwin would improve cargo handling on the present vessels as well as providing an opportunity for other cellular vessels, without ship-mounted cranes, to service the port. The investment in a wharfside container handling crane has not been warranted in Darwin in past years as it would have required a substantial rebuilding of Stokes Hill Wharf to support such a crane. However, when building a new wharf it costs very little extra to make provision for a future crane installation. Such an installation may be justified with a change in vessel type serving Darwin.

Vehicle-deck vessels are presently operating with notable efficiency on Australia's east coast and may in time be adopted for the service to Darwin. The vehicle deck vessel derives its efficiency from the speed with which forklift trucks and/or articulated vehicles can load or unload cargo via a ramp to shore. Generally therefore, port facilities provide a large open storage area immediately adjacent to the ramp where cargo, which is not necessarily containerised, may be rapidly deposited. Broadly, a vehicle deck service might be expected to combine the versatility of the WASSS unitised service with a rate of cargo discharge surpassing that of the cellular *Darwin Trader*. The long term east coast shipping requirements of Darwin may therefore be fulfilled by vehicle-deck, rather than cellular vessels. It is understood that the technical problems of building a loading ramp to cope with Darwin's 8 metre tides can be overcome at a cost comparable to that of equipping a berth with modern, high speed, container lifting equipment.

Whether or not a vehicle deck or cellular service is provided ultimately, efficient handling requires that adequate and convenient manoeuvring and storage space for cargo handling exists immediately adjacent to the berth.

4.2 CARGO HANDLING REQUIREMENTS

4.2.1 General

The wharf facilities in Darwin are required to provide, in the most economic manner:

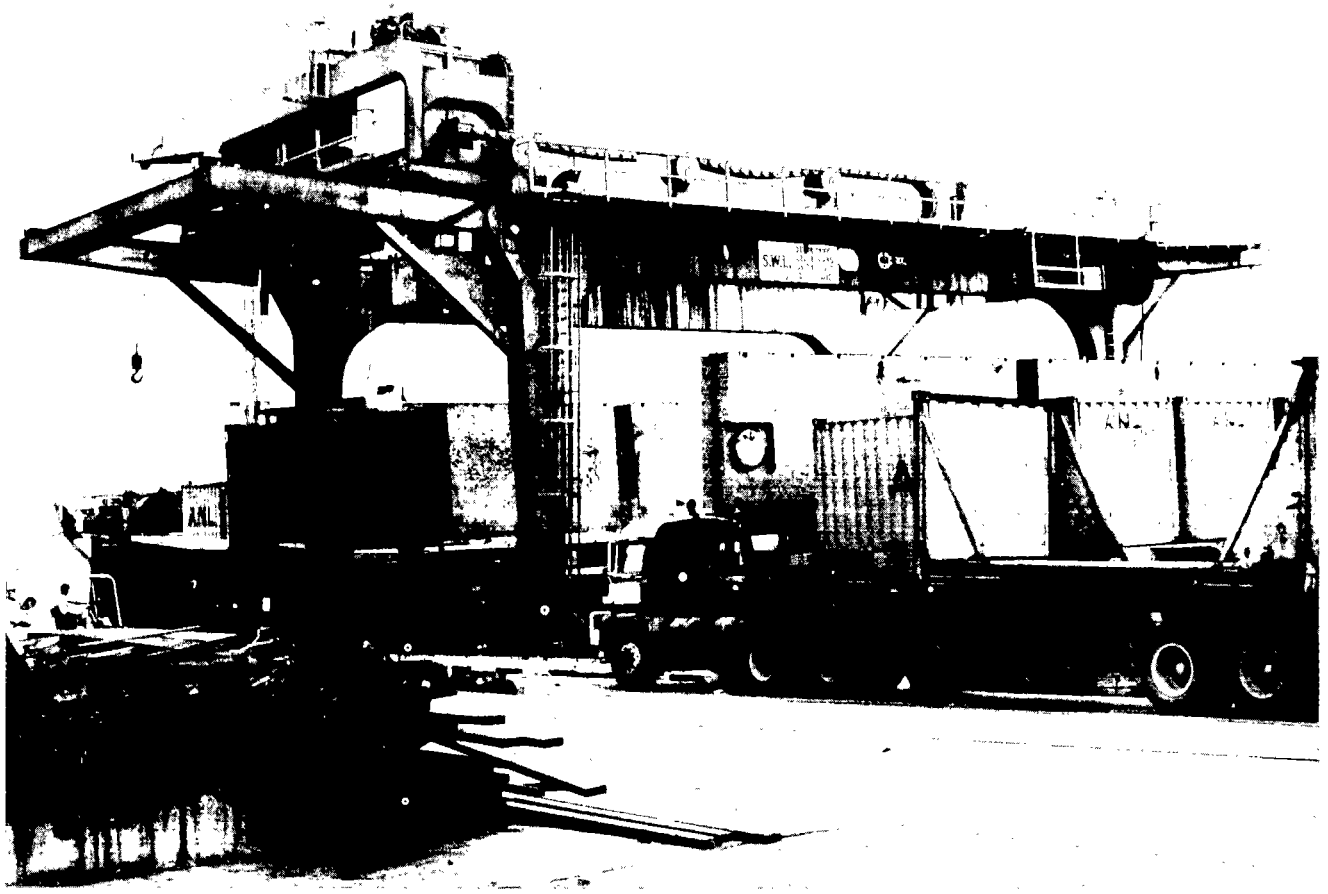
- rapid turnround of ships;
- efficient movement of containerised and unitised cargo through the terminal with minimal delays;
- rapid turnround of road vehicles delivering and collecting cargo; and
- storage space for in-transit and short term storage of cargo.

4.2.2 Container Handling

Containers unloaded by the *Darwin Trader* (maximum capacity 278) would be most economically handled at the wharf, and in adjacent storage areas, by mobile equipment. In the Darwin situation front loading forklift trucks are preferred for container handling where mobile equipment is needed.

Ideally the wharf apron should back on to an open storage area for containers. Containers deposited on the apron by a ship's crane or wharf crane can then be transferred by mobile equipment directly to the storage area. A clear apron width, not including through traffic roads, of at least 18m is preferred for container handling where ships' cranes are used and at least 30m is needed where the crane is mounted on the apron. If the storage area is remote from the wharf face, as is the case with the existing Stokes Hill Wharf, a truck and trailer combination can be used to transport containers to the storage area. Where mobile container equipment cannot be used on the wharf, the slower system of directly loading trucks with the ship's cranes must be used.

Mobile equipment for loading and unloading vehicle-deck ships should be able to operate directly between the ship and the storage area.



Dawin Trader - Stokes Hill Wharf, gantry cranes loading empty containers, December 1974

4.2.3 Unitised Cargo Handling

Unitised cargo, consisting of palletised loads of dry and refrigerated goods, building materials etc, pre-slung or strapped units and small containers of up to approximately 2m x 2m x 2m, comprises a significant proportion of the freight handled at Darwin. This type of load form often requires the provision of transit shed accommodation for weather protection and security. Incoming cargo deposited on the wharf by ship's cranes can then be transferred to intermediate storage in the transit sheds, or where appropriate to an outdoor storage area, by forklift trucks. Cargo can be later loaded by forklift trucks on to road vehicles for despatch to consignees.

Where the transit shed is remote from the wharf face, a truck and trailer system would be used to transport cargo from wharf to shed.

In locating the shed it is important to have a short and unimpeded access for forklift operation from the ship to the shed and to have easy access for road vehicles to collect the cargo, generally from the opposite side of the shed to the ship operation. Much unitised cargo is suitable for stacking two and three loads high. A total allowance, including aisles, of $1m^2$/tonne of goods is adequate for storage. In Darwin the size of transit shed accommodation needed is dependent principally on the tonnage discharged as there is little outgoing cargo.

4.3 CONSIGNEE REQUIREMENTS

From an examination of the present operation of the Port of Darwin, it is clear that the following user requirements are pre-requisites for successful future operation:

(i) A rapid, regular and frequent service. Since the value of general goods in an ISO 6.1m container typically varies from $8,000 to $50,000 any unnecessary delay in transit can raise costs to the consignee in the form of interest charges by approximately $20 to $140 for each week's delay in delivery. More importantly, however, delays resulting from an irregular service which, for instance, may vary between four and five weeks, will force the consignee to maintain a stock inventory some 25% higher than would be the case if he could rely on a four week service. To maintain this high inventory level adds directly to the costs of a consignee and forms a substantial proportion of his total operating expenses.

(ii) A versatile service. Whereas the *Darwin Trader* is designed for carrying containers it is ill-equipped to handle many forms of non-containerised cargo. On the other hand, non-containerised cargo is easily handled by the WASSS ships.

It is understood that ANL are forced to refuse a significant proportion of Darwin-bound cargo offered to them because the cargo is unsuitable for efficient handling by the *Darwin Trader*. ANL's vehicle deck vessels could readily provide the kind of versatile service envisaged for Darwin if suitable ramp facilities were available. This may be possible in the future.

It would also be desirable that any new service should permit small consignments to be imported without excessive consolidation or de-consolidation delays.

(iii) Adequate storage and access facilities. Sufficient space, both open and covered, is needed in the vicinity of the wharves so that ship loading and unloading can proceed undisturbed and without impediment from the tallying, sorting, customs and despatch operations. Likewise there should be a well laid out internal movement system for road vehicles as well as loading facilities for road vehicles which would allow consignments to be picked up without undue delay. It would also be necessary to provide warehousing space, at a fee which reflects the cost of provision, for items which are not collected promptly.

4.4 WATERSIDE AMENITIES

The McDonell Report emphasised the importance of the attitudes to new methods and working conditions adopted by waterside labour on the overall efficiency and reliability of port operation.[8] Although the standard of amenities provided was not an issue for dispute in pre-cyclone Darwin and therefore was not an important factor in shipping delays, it is difficult to ignore the fact that poor amenities could lead to future disputes.

At present, differing standards of amenities are provided at the various wharves around Darwin, with Stokes Hill being the best equipped. Ideally, a main wharf in more or less constant use should include a locker room, ablutions area, mess room, canteen facility and first-aid room. These facilities need to be close to the main areas of activity, within say 100 metres, if they are to function adequately in their support role. In a climate such as Darwin's, it would also be desirable to provide a more than usual amount of under cover work area to shelter workers from the extremes of weather.

Car parking provisions for the regular workforce, visitors and service vehicles are also an important requirement. At present there is a car park off the access road to Stokes Hill Wharf, but it is some 500 metres away from the wharf. Couriers and short period visitors are tempted to drive onto the wharf and thus mix with the cargo handling operations. It would be preferable for car parking to be close to the offices and amenities, but kept out of the way of wharf operations.

The layout and location of internal roads, aisles and work areas are important for the safety of personnel as much as for efficiency. The layout should reflect the need to avoid conflicts between corridors of movement and stationary work areas, thereby protecting workers from moving vehicles and equipment.

4.5 STRATEGIC REQUIREMENTS

Being the principal port of the north coast of Australia, Darwin has an important strategic role. At present, the Navy deploys a small force of coastal patrol boats, chiefly to police fishing activity in territorial waters. This force needs a facility to refuel, provision and arm ships, as well as a place for routine maintenance and minor repairs. These operations are best performed in an area away from the general commercial operations. Previous studies have suggested that appropriate facilities should be provided in association with the small ships' development in Frances Bay.

The Army, on the other hand, requires that port facilities should be capable of handling items of heavy equipment and prefers that a large open storage area be close to the wharf face. The wheel loading of such equipment does not exceed that of a front loading, container handling, forklift truck.

4.6 CYCLONE PROTECTION

The direct effects of cyclone *Tracy* on the port were limited to demolition of or damage to all of the sheds and offices

in the harbour area, and a certain amount of erosion of the foreshore. Fendering on the Iron Ore Wharf was damaged by wave action.

Most of the damage to wharf structures and their approaches was caused by pontoons and small vessels which had broken free from their moorings. Drifting vessels caused relatively serious damage to the approach jetties of all three major wharves. Both the Stokes Hill and Iron Ore wharves were themselves slightly damaged but their ship-berthing facilities were not significantly compromised.

In emergency situations, such as those created by cyclones, it is of course vital that basic facilities such as the port should remain essentially intact so as to be available for relief work. Because of this need, design standards will need to be more stringent than would be the case in less cyclone-prone areas.

4.7 SMALL SHIPS

Up to the end of 1974, the large number of small ships, notably prawning vessels and oil rig tenders, were causing considerable problems in port management. In fact, this problem has been highlighted in many of the studies of port operations stretching back over the last seven years. In particular, the McDonell Report of 1972 gave the construction of a small ships facility as its first priority for achieving port improvement.[8] There have been numerous proposals for development of such a small ships facility, with the bulk of opinion favouring a location in Frances Bay. Such a location offers more protection from wind and wave action but more importantly, it enables the Stokes Bay area to be reserved for large commercial vessels. This separation of activities would provide clear advantages not only by reducing congestion, but also by ensuring more appropriate facilities for each class of vessel.

The loss of small ships caused by cyclone *Tracy* emphasises their vulnerability under these conditions. On the day before the cyclone, Captain Noble estimates that there were 44 vessels in the Stokes Bay area and 8 more in Frances Bay.[14] Of the total, 5 were undamaged, 22 suffered damage of varying degree, 17 were wrecked or sunk and 8 were in unknown condition or missing after the cyclone.

Although it is difficult to predict when these vessels will again be using the Port in their pre-cyclone numbers, it is accepted that some form of small ship facility must ultimately be provided in Port Darwin.

4.8 EAST ARM PORT DEVELOPMENT

The possible future establishment of a power station and associated industrial development at East Arm would probably be accompanied by the construction of port facilities at this site for the import and/or export of bulk materials. This does not conflict with the continued development of general cargo facilities in Stokes Bay.

5. RECONSTRUCTION

5.1 THE TASK

An adequate port would be a significant aid in the post-cyclone reconstruction of Darwin. This chapter estimates the tonnage which could usefully be brought in by sea.

Based on the Northern Territory Housing Commission's estimates and other figures mentioned by the Cities Commission in their report, it is estimated that about 53% of all houses in Darwin were effectively destroyed and about 7% remained intact. Of the balance of 40% which were damaged, it has been assumed that 20% of their original building content will need to be replaced to fully recondition the houses. Thus the repair to damaged houses can be represented as the complete construction of 8% of all houses. In total, therefore, the repair and reconstruction effort amounts to about 60% of all houses existing before the cyclone, estimated at 15,000; this is equivalent to the complete reconstruction of 9,000 houses. To this figure should be added an allowance for damage to retail, office and industrial buildings, amounting to the equivalent of an additional 500 houses. Thus a total of 9,500 houses has been taken as a guide figure.

The type and amount of building materials to be brought in will vary with the method of construction. An average of 40 tonnes of material per house would require 380,000 tonnes of building material and components to be imported for reconstruction. Additional materials may also be required for the repair of public utility services. The total amount may well be in the vicinity of 450,000 tonnes. This does not include furnishings or domestic appliances, and is in addition to the level of imports required to sustain Darwin under normal conditions.

5.2 IMPLICATIONS

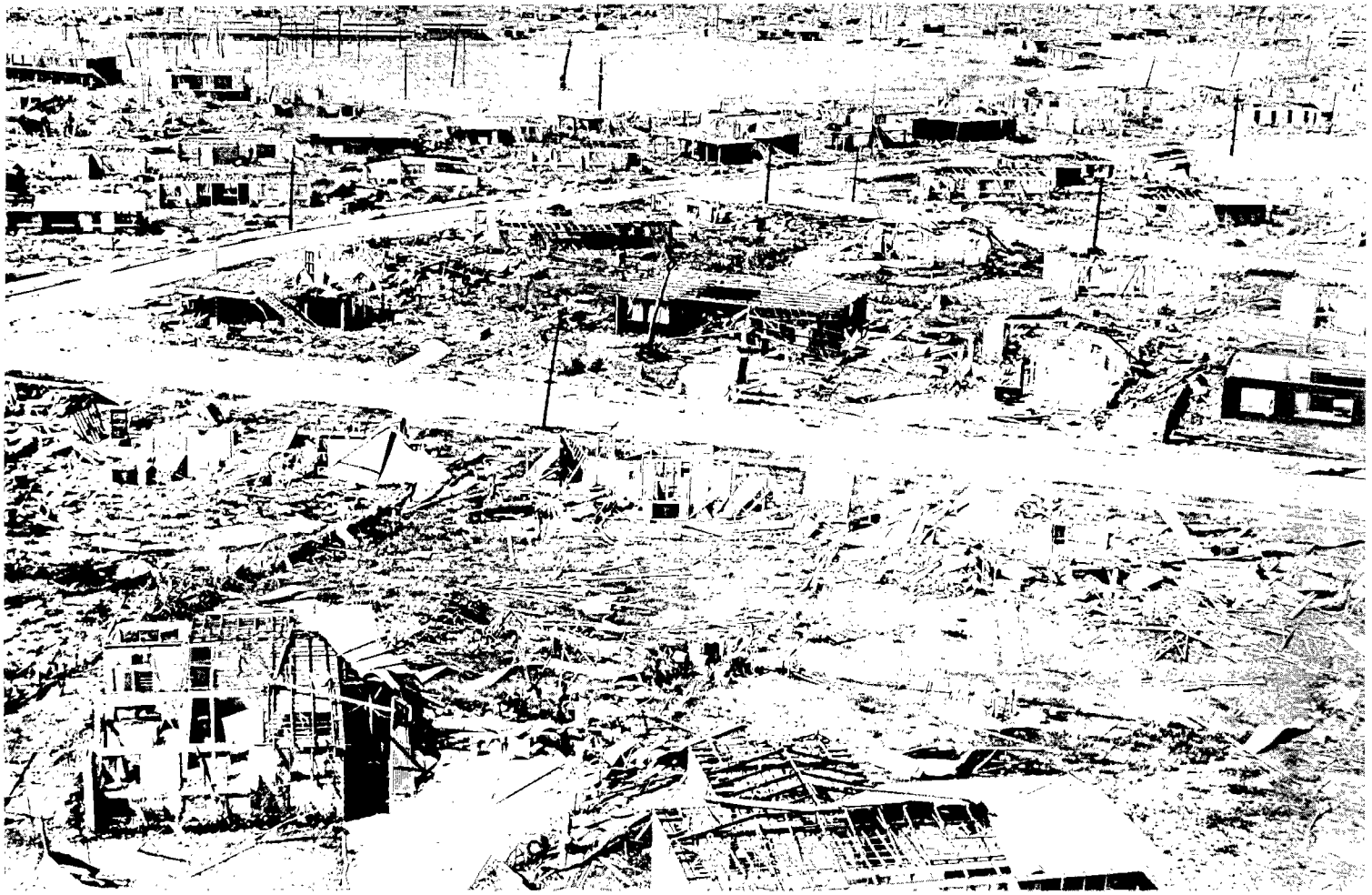
Practically all of the building material required for Darwin has to be imported. Most of this is of relatively low cost, for example, $20/tonne for bricks to $400/tonne for water pipes ex works. Compared to these prices the cost of freight is high. Typical rates from Sydney are $50-$60/tonne by sea, and from $120/tonne upwards by overland transport. Corresponding rates from Queensland ports, or overland from Adelaide, would be somewhat lower. For large volume contracts, overland hauliers may be able to offer lower rates. However, a differential of at least $20/tonne between sea and road transport could be expected to apply to these high density items.

Of the 450,000 tonnes of materials for reconstruction, between 50% and 70% would come from the eastern states and would

be open to competition between sea and land transport. Taking 270,000 tonnes at a saving of $20/tonne yields a potential transport cost reduction of about $5.4 million if sea transport is used to the maximum extent. Consignors from overseas and Western Australia do not have an effective choice of transport mode.

If a period of 6 years is assumed for reconstruction, the rate of associated imports would be 75,000 tonnes per annum. However, the nature of many building materials in terms of size, would cause increasing operational difficulties on the present Stokes Hill Wharf with consequent increases in costs. As the reconstruction proceeds, the population will rise, causing an increase in gross levels of imports. Unless substantial improvements are made to the Port, an even larger share of imports would be freighted overland, at the cost penalty indicated.

It is important that port improvements be completed as soon as possible if they are to be considered as an aid to reconstruction. The shortest period for practical completion for a new berth, for example, is about 15 months if the project were treated as urgent.



Cyclone destruction, January 1975

6. IMPROVEMENT OPTIONS

6.1 GENERAL

The space and access limitations of the existing Stokes Hill Wharf, together with the limited scale of operation of most Darwin consignees, have defeated previous attempts to have non-containerised cargo removed from the wharf by consignees quickly enough to eliminate wharf congestion.

Efficient port facilities will allow the rapid placement of discharged cargo into storage without prejudicing access to this cargo at a later stage. They are also required to accommodate a user requirement for medium-term storage. Congestion of the two berths on Stokes Hill Wharf currently prevents either of these requirements from being satisfied; four improvement options are offered in this Section.

Option A, requiring minimal capital expenditure, seeks to eliminate wharf congestion by immediately transferring discharged cargo to a shore-based storage and sorting facility. Option B, also based upon the exclusive use of Stokes Hill Wharf, aims to reduce congestion by the expansion of the wharf structure itself. Option C is designed to greatly reduce congestion on Stokes Hill Wharf by adding to the wharf apron and by operating it as a single large-berth berth only with the addition of a new berth at Fort Hill. Option D involves the construction of a new berth at Fort Hill with no modification to Stokes Hill Wharf.

It should be noted that all options require the continued use of the existing Stokes Hill Wharf to some extent. The structural condition of the wharf has been described previously. Repair, maintenance and strengthening work is currently being investigated by the NTPA. The remaining useful life of the structure is not certain, but it is unlikely to exceed the 22 years assumed for the economic evaluation without major reconstruction.

6.2 OPTION A

Improvement Option A, (see Figure 5) considers the possibility of establishing a shore-based storage facility, with a fleet of vehicles transporting cargo to and from the wharf. Container shed No.2 may serve as a basis for the shore-based storage area. The transit sheds on Stokes Hill Wharf are not required in this situation, and would therefore be removed to provide sufficient space on the wharf for vehicle loading operations. The wharf is at present composed of decking at two separate heights, with transverse ramps connecting these levels. The ramps would be re-positioned to provide a continuous high-level working

area and to allow an independent traffic circulation pattern for each main berth. The lower (landward) level would be retained for small vessel operation. The offices and amenities could be re-built to occupy a minimum area. If required, the roof of shed A could be retained to provide cover for personnel and equipment.

No attempt would be made to load vehicles directly from ships' cranes, since this would considerably slow down the rate of discharge of cargo. Wharf operations would follow their present pattern, therefore, except that waterside labour would use forklift trucks to stack cargo onto trucks rather than into transit sheds. Savings in stevedoring costs at the wharf, and in ship discharging time, would result from the reduction in wharf congestion.

Vehicles would be unloaded by additional staff at a new land-based sorting and storage facility, where operations could proceed without the restrictions accompanying use of wharf-based facilities. Consignees would benefit from being thus afforded quick and reliable access to their cargo.

6.3 OPTION B

Option B (see Figure 6) would require staged construction in order to maintain one operational berth at Stokes Hill Wharf. This option has been evaluated as it continues the tradition of the past in meeting all new requirements by extending Stokes Hill Wharf. It would be extremely difficult to implement this option during the reconstruction period without major inconvenience to the operation of the Port.

Option B satisfies the cargo handling requirements by increasing the width of the southern face of the wharf by 18m and by adding 13m to most of the northern face. An additional open storage area 40m x 75m is added to the western end of the wharf apron to provide a separate open storage area for the western berth. The increased area will reduce congestion on the wharf and permit the allocation of a clear roadway around the wharf for through traffic. This option will not add to the available transit shed space. The present operational methods described in Chapter 3.2.2 will continue to be used except that the western berth will have its own adjacent storage area.

Container operations would have to continue in their present fashion due to the restricted wharf area; any future service by vehicle deck vessels would be similarly dependent upon the use of shore-based storage facilities and would thereby sacrifice much of its potential reduction in handling costs and/or vessel discharge time.

6.4 OPTION C

Option C (see Figure 7) proposes the construction of a new land-backed berth at Fort Hill (see Chapter 6.6) which would operate in conjunction with a slightly extended Stokes Hill Wharf functioning as a single berth.

Construction of the new berth would have to be completed before modifications could be made to Stokes Hill Wharf. The modifications could be staged so that one Stokes Hill berth is always operational. However, any modification work would be inconvenient during the major phases of Darwin's reconstruction.

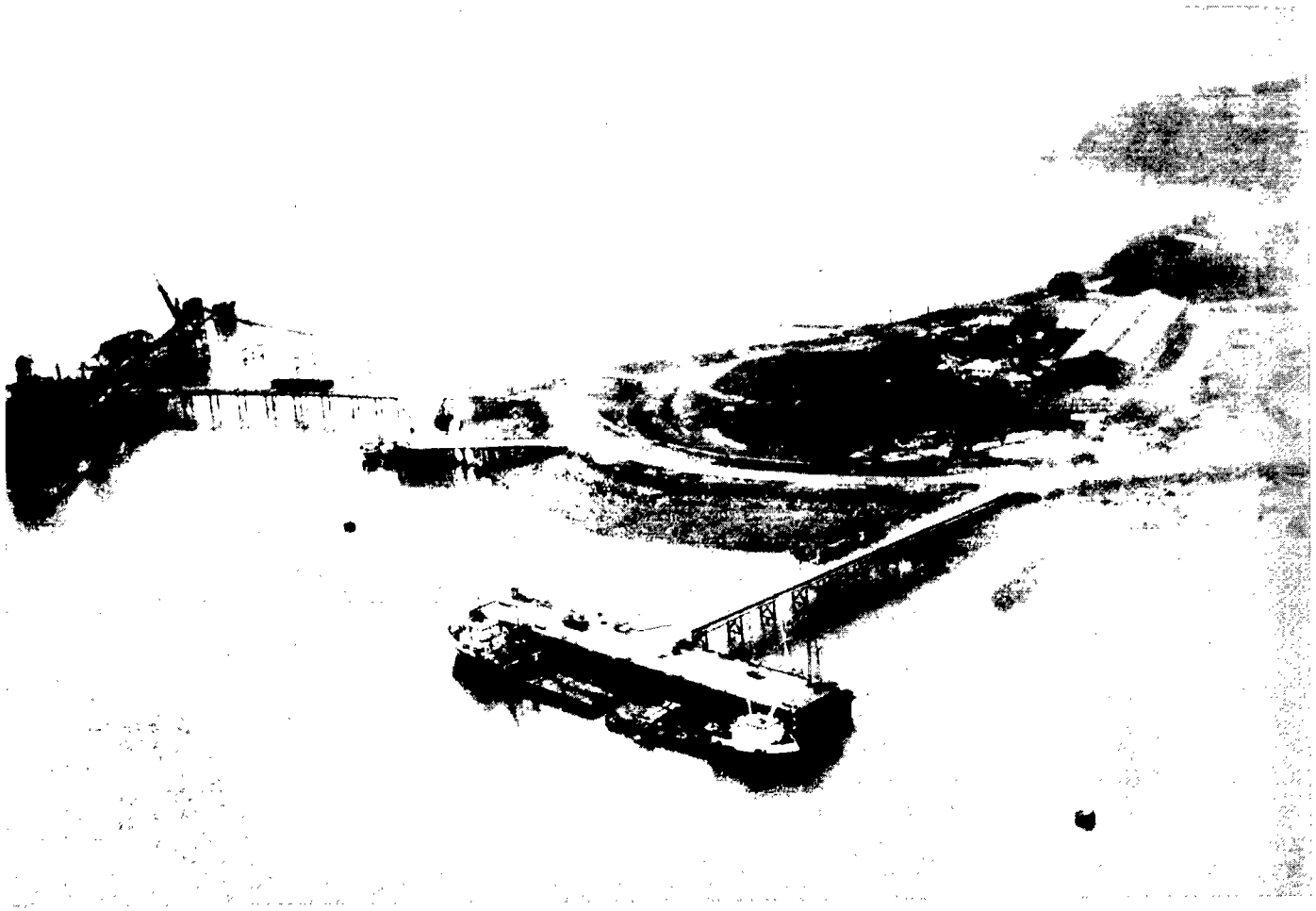
6.5 OPTION D

Option D (see Figure 8) is the same as Option C without the modification to Stokes Hill Wharf. Benefits of the new Fort Hill berth are unchanged but some handling difficulties will still occur on Stokes Hill Wharf and therefore stevedoring cost savings in this area will be reduced.

6.6 PROPOSED BERTH AT FORT HILL (as in Option C and Option D)

The dredged, island berth at Fort Hill West proposed by the Commonwealth Department of Works in 1970 (see Figure 3) offers adequate general cargo handling facilities, and a good seaward approach, but cannot offer the operational advantages of a land-backed berth at Fort Hill along the lines of Maunsell's alternative proposal' (see Figure 2). Fort Hill, particularly with the iron ore stockpile likely to be removed, offers the most economical and convenient site for such a berth, and will allow the future development of other berths eastwards across Stokes Bay to eventually join (or replace) Stokes Hill Wharf.

The new wharf, situated between the existing Iron Ore and Stokes Hill wharves, is the closest that a berth can be placed to the present shore while maintaining the given depth of water of 10 metres. To avoid undue difficulties in berthing ships, the face of the wharf has been positioned far enough off shore to be roughly in line with existing structures and provides at least 11m of water alongside. Proximity to the shore is necessary if the desirable type of along-shore wharf is to be built at a reasonable cost. Wharves connected to shore by access jetties of limited width are invariably subject to operational restrictions.



FORT HILL - proposed site for new berth, low tide, December 1974

The alignment shown for the berth was chosen as being the least likely to cause difficulties from tidal currents during the berthing of ships. The location of the wharf allows continuing access to the Boom Wharf and the in-shore face of Stokes Hill Wharf.

The proposed structure has a gross working area of over 24,000m^2, of which about one half is formed by reclamation in shallow water and the remainder by a piled deck. The reclaimed area does not extend far from the shore partly for reasons of cost and partly to avoid unnecessary amounts of scouring or silting that could arise from changes in the hydraulic regime.

Although the berth has been shown without specialised handling facilities, it is probable that cranage and/or a vehicle deck ramp will be necessary to handle future shipping types and the bulk imports required by the uranium industry (see Annex B). The land-backing provided will be adequate for these activities, and the extra equipment will cost no more than approximately $2 million at 1975 prices. An area of approximately 28,000m^2 at Fort Hill, partly used at present for an iron ore stockpile, is available for expansion of the berth's storage and service facilities.

The wharf apron at 160m is long enough to accommodate ships of the size currently serving Darwin. Should the Port need to regularly serve larger ships this may be simply accommodated by installing a dolphin. At 30m the apron is wide enough to install a large, wharfside, container handling crane if required in the future. Provision should be made in the design of the structure for the later installation of such a crane.

The layout, as illustrated, shows a transit shed of 4,000m^2 where unitised cargo can be sorted, stored and loaded onto road vehicles. Amenities and administrative facilities can be provided in the shed, which is large enough to accommodate up to 3,500 tonnes of cargo with good access. At the rear of the transit shed, on reclaimed land, is the open storage area for containers, cargo suitable for outside storage and a car park. The open storage area is accessible from the wharf apron via access roads 21m wide on either side of the transit shed, and is readily accessible from the shore.

The optimum shape and placement of the transit shed plus the layout of the outside storage area is, of necessity, a compromise between that which is best for general cargo handling and that which is best for container handling. Figure 7 illustrates what this Bureau believes to be the best of the many possible compromises.

7. ECONOMIC EVALUATION

7.1 METHOD AND ASSUMPTIONS

In Chapter 6, four development options were put forward as a means of improving Darwin's port facilities.

For the economic evaluation of the schemes, it has been assumed that the pre-cyclone condition and operation of Stokes Hill Wharf will be the base case for comparing the benefits and costs arising from each option. This is appropriate since Stokes Hill Wharf will be restored to this condition regardless of which option is adopted.

Two cases have been evaluated.

(i) A cargo throughput of 200,000 tonnes p.a. including all overseas and most west coast reconstruction material.

(ii) A cargo throughput of 225,000 tonnes p.a. up to 1980 and 200,000 tonnes p.a. up to 1997 (see Chapter 2.4). The 225,000 tonnes includes an additional 25,000 tonnes p.a. of reconstruction materials. This is considered to be the likely share of east coast cargo which would be handled by an improved port. Without the improved port the goods would be carried overland at a cost penalty of at least $20/tonne door-to-door. This cost would be saved by adopting any of the development options and is therefore considered as an added benefit.

Discounted cash flow evaluation has been used in the analysis, reducing all benefits and costs to present values. The net present value method and benefit-cost ratios are used to rank the options. The assumptions made in the analysis are outlined below:

(i) No major reconstruction of the existing structure of Stokes Hill Wharf will be necessary before 1997. This period of time was accepted as the time base for the economic analysis.

(ii) For Option A, capital would be spent in 1976 and the first full year of benefits would be 1977.

(iii) For Option B, equal amounts of capital would be spent on 1976 and 1977 and the first full year of benefits would be 1978.

(iv) For Option C, capital for the new Fort Hill Wharf would be spent in 1976 and benefits would commence in 1977. For Stokes Hill Wharf capital would be spent in 1977 and the first full year of benefits would be 1978.

(v) For Option D, capital would be outlaid in 1976 and the first full year of benefits would be 1977.

(vi) Maintenance costs were assumed to be similar for all options and not significantly different from those likely to be incurred in the absence of port improvements. They have not been included.

It should be noted that:

(i) All estimates of costs and benefits were made in 1975 dollars.

(ii) Discount rates of 7% and 10% have been used.

(iii) Benefits and costs have been discounted to 1975.

7.2 CAPITAL COSTS

Estimates of the capital costs associated with each of the improvements are summarised in Table 7.1.

Details of construction cost estimates are given in Annex C.

7.3 QUANTIFIABLE BENEFITS

7.3.1 General

Estimates of the quantifiable benefits attributable to each of the four options described in Chapter 6 are shown in this chapter. They are summarised in Table 7.2.

Adoption of any of the four proposals will provide direct benefits by simplifying handling operations and reducing wharf congestion.

TABLE 7.1

ESTIMATED CAPITAL COSTS OF PORT IMPROVEMENT OPTIONS

($ MILLION)

Capital Cost Component	OPTION A (Direct Transfer)	OPTION B (Stokes Hill Only)	OPTION C (Stokes Hill & Fort Hill)	OPTION D (Fort Hill Only)
Extension to Stokes Hill Wharf	(not required)	5.8	2.7	(not required)
Removal of wharf sheds	0.7	(not required)	(not required)	(not required)
Rebuilding of amenities etc.				
New Storage site (land)	0.5 (remote from wharf)	(not required)	2.1 (reclaimed)	2.1 (reclaimed)
New shed & amenities	0.8	(not required)	0.4	0.4
New piled wharf	(not required)	(not required)	5.1	5.1
Essential additional handling equipment	0.7	(not required)	(not required)	(not required)
Establishment etc. (5% capital cost)	0.1	0.3	0.5	0.4
TOTAL CAPITAL COST	2.8	6.1	10.8	8.0
DISCOUNTED at 7% to 1975	2.6	5.5	9.9	7.5
DISCOUNTED at 10% to 1975	2.5	5.3	9.6	7.3

NOTE: All costs expressed in 1975 dollars

7.3.2 Transport Savings to Consignees

Under normal conditions prior to the cyclone, congested wharves required consignees' vehicles to often queue for considerable periods while attempting to collect cargo. Improved facilities may be assumed to reduce this waiting time by an average of at least one hour ('pessimistic') or as much as two ('medium') or three ('optimistic') hours, with each vehicle carrying 10 tonnes and having a resource cost of $12.00 per hour inclusive of its driver.

Savings:	Optimistic	$3.60/tonne
	Medium	$2.40/tonne
	Pessimistic	$1.20/tonne

7.3.3 Inventory Savings to Consignees

By permitting the storage of cargo in a rational and accessible manner, port improvements may reduce the waiting time of consignees by a mean time of three days for 40%, 70% or 100% of their cargo. Mean cargo value of $400 per tonne (note that timber is worth $150, galvanised pipe $400 and seaborne grocery items $1,000 approximately per tonne), and inventory costs at 15% per annum are assumed.

Savings:	Optimistic	$0.50/tonne
	Medium	$0.35/tonne
	Pessimistic	$0.20/tonne

7.3.4 Reduction of Wharfside Stevedoring Costs

By eliminating delays and multiple-handlings due to congestion, stevedoring costs on the wharf will be reduced. Option C is estimated to give the greatest savings of 15%, 25% or 35% in these costs. Lesser savings of 10%, 20% or 30% are estimated for Option D as handling difficulties will still occur on Stokes Hill Wharf despite the reduced usage. Options A and B are estimated to yield savings of nil, 10% and 20% as Option A would operate with reduced efficiency during the wet season and Option B would require that appreciable additional effort be given to organisation within a relatively limited storage area on Stokes Hill Wharf. Existing mean costs are taken as $5 per tonne discharged.

Savings:	A and B -	Optimistic	$1.00/tonne
		Medium	$0.50/tonne
		Pessimistic	Nil
	C -	Optimistic	$1.75/tonne
		Medium	$1.25/tonne
		Pessimistic	$0.75/tonne

D -	Optimistic	$1.50/tonne
	Medium	$1.00/tonne
	Pessimistic	$0.50/tonne

7.3.5 Reduction of Ship Discharging Time

It may be expected that the improved facilities will result in decreased discharge times. At present an average vessel takes three days to discharge 2,000 tonnes and costs accrue at the rate of $4,000 per day. It is anticipated that in optimistic circumstances, one day will be saved by 75 per cent of vessels, whilst this percentage will decline to 50 per cent and 25 per cent for medium and pessimistic conditions.

Savings:	Optimistic	$1.50/tonne
	Medium	$1.00/tonne
	Pessimistic	$0.50/tonne

7.3.6 Additional Transport Costs to Stevedores

Costs will be incurred in the provision of vehicles and drivers to transport cargo to the remote storage site in Option A. Thirteen vehicles each carrying an average of 10 tonnes are assumed to service a ship, with a 90 minute average cycle time per truck. This yields a handling rate (tonnes per truck-hour) approximately 50% lower than that obtained during existing short-haul container operations serving the *Darwin Trader* where vehicles each carry 6.1m containers and loading and unloading are each single operations. This case is therefore taken as a 'Medium' estimate; 'Optimistic' and 'Pessimistic' estimates are based on a cycle time of 75 minutes and 105 minutes respectively. Vehicles are estimated to have a resource cost of $12.00 per hour, including drivers.

Additional Cost:	Optimistic	$1.50/tonne
	Medium	$1.80/tonne
	Pessimistic	$2.10/tonne

7.3.7 Additional Handling Costs to Stevedores

Additional staff will be required for the remote storage area required by Option A. Overall rates of 5, 6 or 7 tonnes per gross man-hour are estimated for the operations of unloading trucks and sorting and stacking cargo. These are approximately double the mean rate obtained during the discharge of containerised and unitised cargo from WASSS and ANL vessels in Darwin as the operation

would be much simpler and would be carried out in an uncongested area. An overall cost of $10 per gross man-hour is assumed.

Additional Cost:	Optimistic	$1.45/tonne
	Medium	$1.65/tonne
	Pessimistic	$2.00/tonne

7.3.8 Additional Handling & Transport Costs to Consignees

An estimate must be made of the cost to consignees of providing the warehousing function denied to them by the adoption of Option B. It may be taken to be 25%, 33% or 50% of the 'Medium' estimate of the cost of providing vehicles and staff for the more comprehensive removal and storage service required by Option A (see 7.3.6 and 7.3.7) plus the cost of providing alternative warehouse space.

Additional Cost:	Optimistic	$0.90/tonne
	Medium	$1.15/tonne
	Pessimistic	$1.70/tonne

7.4 BENEFITS DURING RECONSTRUCTION

Construction of key port improvements could be regarded as part of the reconstruction programme. For example, the cost of the proposed Fort Hill Wharf of $8 million is equivalent to the cost of constructing 167 houses at $48,000 each, a small proportion of the expected programme of 1500-2000 units per annum.

All of the improvement options would increase the efficiency and capacity of the Port to some extent. It is therefore assumed that the improvements, if implemented, would cause imports of reconstruction materials to be diverted from overland transport. The resulting annual benefit can be assessed using the savings of $20/tonne as stated in Chapter 5.2. For example if the entire 270,000 tonnes which may be freighted either by land or sea were to all go by sea to an improved port then the savings would amount to $5.4 million. The cost of the new berth at Fort Hill would be largely recouped on the savings in reconstruction costs alone.

Table 7.3 lists the benefits, in two separate sections, which an improved port would apply to reconstruction imports. Firstly it lists benefits applied to those imports which will always come by sea. It then lists the benefits which would apply if approximately half of the cargo which has a land transport option were to be attracted to the sea mode because of the improved port.

TABLE 7.2 - ESTIMATED QUANTIFIABLE BENEFITS

	OPTIONS											
	A Direct Transfer			B Stokes Hill Only			C Stokes Hill & Fort Hill			D Fort Hill Only		
Status of Estimates **	O	M	P	O	M	P	O	M	P	O	M	P
Benefits	($ per tonne)											
Transport savings to consignees	3.60	2.40	1.20	3.60	2.40	1.20	3.60	2.40	1.20	3.60	2.40	1.20
Inventory savings to consignees	0.50	0.35	0.20	0.50	0.35	0.20	0.50	0.35	0.20	0.50	0.35	0.20
Reduction of wharfside stevedoring costs	1.00	0.50	-	1.00	0.50	-	1.75	1.25	0.75	1.50	1.00	0.50
Reduction of ship discharging time	1.50	1.00	0.50	1.50	1.00	0.50	1.50	1.00	0.50	1.50	1.00	0.50
Additional Operating Costs												
Additional transport costs to stevedores	1.50	1.80	2.10	(not applicable)			(not applicable)			(not applicable)		
Additional handling costs to stevedores	1.45	1.65	2.00	(not applicable)			(not applicable)			(not applicable)		
Additional handling and transport costs to consignees	(not applicable)			0.90	1.15	1.70	(not applicable)			(not applicable)		
Net Benefit (negative value signifies net cost)	3.65	0.80	-2.20	5.70	3.10	0.20	7.35	5.00	2.65	7.10	4.75	2.40
Present value of Net Benefits ($M)	($M)											
(i) Earned on 200,000 tonnes p.a. to 1997 — 7%	7.4	1.6	-4.5	10.5	5.7	0.4	14.9	10.1	5.4	14.4	9.6	4.9
(i) Earned on 200,000 tonnes p.a. to 1997 — 10%	5.7	1.3	-3.5	8.0	4.4	0.3	11.6	7.9	4.2	11.2	7.5	3.8
(ii) Earned on 225,000 tonnes to 1980 then 220,000 tonnes to 1997 — 7%	7.7	1.7	-4.7	10.9	5.9	0.4	15.3	10.4	5.4	14.9	10.0	5.0
(ii) Earned on 225,000 tonnes to 1980 then 220,000 tonnes to 1997 — 10%	6.0	1.3	-3.7	8.3	4.7	0.3	12.1	8.2	4.3	11.7	7.8	3.9

** O = Optimistic Estimate, M = Medium Estimate, P = Pessimistic Estimate

7.5 NON-QUANTIFIABLE BENEFITS

7.5.1 General

Chapters 7.3 and 7.4 have outlined the quantifiable benefits associated with the provision of a new berth at Fort Hill. Such a berth would, however, have other benefits to which no financial value could usefully be ascribed. These benefits would include a reduction in the vulnerability of the Port to future cyclones, an improved strategic value of the Port and a great improvement in the capability of the Port to handle new types of vessels and all foreseeable types of cargo handling equipment.

7.5.2 Vulnerability to Future Cyclones

Development Options A and B both concentrate general cargo handling operations at Stokes Hill Wharf, and are therefore no less vulnerable to future cyclones than were port facilities in 1974. Options C and D provide, in the proposed Fort Hill Wharf, a general cargo berth independent of a vulnerable approach jetty such as that at Stokes Hill Wharf. The new Fort Hill Wharf, closely associated with an appreciable length of foreshore for reasons of materials handling efficiency, may reasonably be expected to survive a future cyclone with minimal damage and thus be available for the immediate discharge of relief material.

7.5.3 Accommodation of Strategic Requirements

A new wharf, as in Options C and D, would be better able to handle large and heavy loads. The form of construction proposed is less vulnerable to attack or sabotage than the long access jetty of Stokes Hill Wharf. The presence of two separate wharf structures is a further safeguard in this respect.

7.5.4 Adaptability To Future Vessel Types

The construction of a new wharf has advantages over modifications to the existing wharf. Not only is more space and a better layout gained, giving flexibility of wharf operation, but the new structure can easily be made sufficiently strong to handle all foreseeable types of cargo handling equipment. The location of the proposed wharf at Fort Hill provides about one metre additional depth of water, thus permitting larger vessels to berth there than at Stokes Hill Wharf. Additionally, the type of berth proposed could be readily adopted to accommodate either vehicle deck ships or those cellular container ships which are not self unloading.

7.5.5 Wet Weather Operation

Approximately 1.5 metres of torrential rain falls annually upon Darwin through the five month wet season. Cargo handling operations are inevitably carried out with reduced efficiency under these conditions, and the relatively complex handling and transport operations required for Option A may be expected to suffer most during the 'wet'.

7.6 SUMMARY OF ECONOMIC EVALUATION

Table 7.3 provides a summary of the economic evaluation of the four development options.

Based on a throughput of 200,000 tonnes p.a. and using the medium estimates of benefits and costs, Option D is the only option which is economically viable at discount rates of both 7% and 10%, giving net present values of $2.6m and $0.5m respectively. Options B and C are viable at 7% discount rate only, using the medium estimates, and yield net present values of $0.2m and $0.7m respectively. The superiority of Option D is maintained when pessimistic and optimistic estimates of benefits and costs are considered.

For the medium estimates of benefits and costs Option D has the highest benefit-cost ratio of 1.4 at 7% discount rate and 1.1 at 10% discount rate. Option C is the next highest.

As mentioned previously an improved port could be expected to attract approximately 25,000 tonnes p.a. of the reconstruction imports which could be brought by either land or sea.

When the additional 25,000 tonnes p.a. of reconstruction materials to 1980 are also considered, the case for Option D is clearer. For the medium estimates the net present value of the project increases to $4.6m at 7% discount rate and to $2.2m at 10% discount rate. The benefit-cost ratio is 1.6 at 7% and 1.3 at 10%, considerably higher than the other options.

When the non-quantifiable benefits are also taken into account, Option D, at a capital cost of $8m offers the highest benefit to the community.

TABLE 7.3 - COMPARISON OF DEVELOPMENT OPTIONS

	OPTIONS							
	A Direct Transfer		B Stokes Hill Only		C Fort Hill & Stokes Hill		D Fort Hill Only	
Discount Rate	7%	10%	7%	10%	7%	10%	7%	10%
Capital Cost ($m)	2.6	2.5	5.5	5.3	9.9	9.6	7.5	7.3
Residual Value ($m)	0.1	0.1	0	0	0.5	0.3	0.5	0.3
				200,000 TONNES P.A.				
Benefits ($m)								
Optimistic	7.4	5.7	10.5	8.0	14.9	11.6	14.4	11.2
Medium	1.6	1.3	5.7	4.4	10.1	7.9	9.6	7.5
Pessimistic	-4.5	-3.5	0.4	0.3	5.4	4.2	4.9	3.8
Net Present Value of Project ($m)								
Optimistic	4.9	3.3	5.0	2.7	5.5	2.3	7.4	4.2
Medium	-0.9	-1.1	0.2	-0.9	0.7	-1.4	2.6	0.5
Pessimistic	-7.0	-5.9	-5.1	-5.0	-4.0	-5.1	-2.1	-3.7
Benefit - Cost Ratio (medium estimates)	0.7	0.6	1.0	0.8	1.1	0.9	1.4	1.1

Benefits ($m)			200,000 TONNES P.A. PLUS 25,000 TONNES P.A. RECONSTRUCTION MATERIAL					
Optimistic	7.7	6.0	10.9	8.3	15.3	12.1	14.9	11.7
Medium	1.7	1.3	5.9	4.7	10.4	8.2	10.0	7.8
Pessimistic	-4.7	-3.7	0.4	0.3	5.4	4.3	5.0	3.9
Line Haul Savings on 25,000 tonnes p.a. at $20/tonne	1.6	1.4	1.1	1.0	1.6	1.4	1.6	1.4
Net Present Value of Project ($m)								
Optimistic	6.8	5.0	6.5	4.0	7.5	4.2	9.5	6.1
Medium	0.8	0.3	1.5	0.4	2.6	0.3	4.6	2.2
Pessimistic	-5.6	-4.7	-4.0	-4.0	-2.4	-3.6	-0.4	-1.7
Benefit - Cost Ratio (medium estimates)	1.3	1.1	1.3	1.1	1.3	1.0	1.6	1.3
Disruption During Construction	Minor		Major		Moderate		Nil	
Additional Berth Capacity for Reconstruction	No		No		Yes		Yes	
Vulnerability to Future Cyclones Chap.7.5.1	Unchanged		Unchanged		Reduced		Reduced	
Disruption During Wet Weather	Increased		Unchanged		Reduced		Reduced	
Accommodation of Strategic Requirements Chap.7.5.2	Unchanged		Unchanged		Increased		Increased	
Adaptability to New Vessels Chap.7.5.3	Unchanged		Unchanged		Increased		Increased	

NOTES: 1. Benefit-Cost Ratio is: (Benefit + Residual Value) ÷ Capital Cost
2. All monetary values have been discounted to 1975.

REFERENCES

1. Feasibility Study on the Development of Port and Harbour Facilities in the Darwin Region, Economic and Technical Data (Canberra, June 1968).

2. Maunsell & Partners, Development of Port and Harbour Facilities Darwin, Report for the Department of National Development. (Melbourne, January 1969).

3. Maunsell & Partners. Darwin Port Study. Short Report on an Additional Port Alternative, Report for the Department of National Development. (Melbourne, July 1969).

4. Commonwealth Department of Works, Development of the Port of Darwin, Northern Territory, Statement of Evidence to Parliamentary Standing Committee on Public Works. September, 1970.

5. Australia. Parliament, Proposed Development of the Port of Darwin, Northern Territory. Minutes of Evidence before the Parliamentary Standing Committee on Public Works (Chairman, Hon. C.R. Kelly), October 1970. (Canberra, 1971).

6. Australia. Parliament, Development of the Port of Darwin, Northern Territory, Report from the Parliamentary Standing Committee on Public Works (Chairman, Hon. C.R. Kelly). Parl. Paper 190. (Canberra, 1970).

7. P.G. Pak-Poy & Associates, Darwin Industrial Port Development. Report for Department of the Interior, (Parkside S.A., September, 1971).

8. Darwin Port Operations, Northern Territory Transport and Consumer Prices, Report of the Commission of Inquiry (Commissioner, G.J. McDonell) on behalf of the Northern Territory Administration. (Sydney, January 1972).

9. K.C. Yong, P.B. Stone, D.N. Foster, Darwin Harbour Model Study. University of New South Wales, Water Research Laboratory Technical Report No. 72/5 (Sydney, May, 1972).

References (Continued)

10. E.McR.Fraser, Port of Darwin Development, - Reassessment of Proposed Development. Internal report Commonwealth Department of Works (May, 1972).

11. Commonwealth Department of Works, Revised Proposals for Development of the Port of Darwin, Northern Territory Report for Parliamentary Standing Committee on Public Works (July, 1972).

12. Development of the Port of Darwin Northern Territory Port Authority Report (Darwin, February, 1973).

13. Cities Commission. Darwin - Planning Guidelines. Report prepared on behalf of the Department of the Northern Territory for the Interim Darwin Reconstruction Commission (Canberra, March, 1975).

14 Captain B.L. Noble, Tropical Cyclone Impact Report - Port Darwin and 'Tracy' Report for the Northern Territory Port Authority (April, 1975).

ANNEX A

HISTORICAL NOTES

	1869	(Reference NTPA)) First wharf constructed
	1887	(Reference Maunsell))
	1894	Proposal for landbacked wharf across Stokes Bay - rejected
	1920	Similar proposals to 1894, also rejected as too expensive
	1939-40	Boom Wharf built
	1945-49	Solid-filled pier proposed to replace war-damaged, timber Stokes Hill - rejected
Nov	1956	Rebuilt Stokes Hill Wharf opened
	1957	Fort Hill Wharf reconditioning completed
	1961	(Reference Maunsell)) Export of live cattle
	1963	(Reference NTPA)) (from Fort Hill Wharf)) discontinued.
Jan	1964	NTPA take control of the Port of Darwin
	1964	Stokes Hill Wharf extended from 600 to 700ft and second transit shed built
	1965	Construction of Iron Ore Wharf and facilities commenced.
	1966	Area near Fort Hill approach leased for Bitumen Plant
Dec	1966	NTPA propose $7.5 million bulk facilities at East Arm
	1967	Iron Ore facilities completed, first shipload departs
	1967	ANL container shed (No.1 shed) built
	1968	Collapse of first sorghum crop
	1968	Area near Fort Hill approach leased to Northern Cement
	1968	Area north of Iron Ore Wharf leased for LPG storage
June	1968	Maunsell commissioned by Dept of National Development
Sept	1968	Maunsell published interim recommendations
Jan	1969	Final Maunsell report published
Jan	1969	Dept of National Development asked Commonwealth Department of Works (CDW) to review Maunsell
Early	1969	Interdepartmental steering committee established
April	1969	CDW published review of Maunsell: wary of East Arm proposal, and Maunsell estimates were too low
July	1969	At request of CDW, Maunsell produced alternative proposal including general cargo at East Arm

ANNEX A (Continued)

Oct	1969	First shipment of Iron Ore fines
July	1970	*Darwin Trader* entered service
Sept	1970	CDW published statement of Evidence to Parliamentary Standing Committee on Public Works (PWC)
Oct	1970	Modified Maunsell report presented by steering committee to PWC. PWC approved this and reported to Parliament
Dec	1970	Parliament endorsed PWC approval
Early	1971	Contracts for No.2 container shed and Frances Bay access road let. No acceptable dredging tenders received.
May	1971	McDonell commissioned by N.T. Administrator to report on Port operations, transport trends and consumer prices
July	1971	Pak-Poy commissioned by Dept of the Interior, to report on industrial development of Darwin to accommodate 200,000 people by 1990.
July	1971	CDW presented 'alternative proposal' to steering committee - this to rebuild Stokes Hill Wharf and delete small ships facility
Sept	1971	Pak-Poy report published
Oct	1971	CDW expanded on their proposal of July 1971
Nov	1971	Frances Creek Iron Mining Company (FIMCO) advised steering committee of financial problems
Nov	1971	Northern Territory Administration committed 190 acres of Frances Bay foreshore to the NTPA
Dec	1971	Acceptable tender for modified dredging scheme received
	1971-72	NTPA extended Stokes Hill Wharf to 960ft
Jan	1972	McDonell report published - drew attention to growth in road transport and cast further doubts on Maunsell's prediction. Recommended construction of small ships facility as first priority
Mar	1972	Steering committee met. Tipperary sorghum and Mt Bundy Iron Ore had collapsed. Proposed deferment of East Arm and new piled Fort Hill West Wharf, but much internal disagreement
	1972	No.2 container shed completed by NTPA

ANNEX A (Continued)

	1972	CDW published a revised 'Statement of Evidence' to PWC, proposing piled Fort Hill West and reduced Frances Bay small ships facilities
Late	1972	Change of Government. Dept of Northern Territory replaced Northern Territory Administration
May	1973	NTPA published report, as requested by the Minister for the Northern Territory - (Hon. K. Enderby)
Aug	1974	Duty-free port proposal published by Action Committee
Dec	1974	Cyclone *Tracy*.

ANNEX B

BULK IMPORTS FOR URANIUM PRODUCTION

It seems certain that uranium deposits known to exist in the Alligator River region of the Northern Territory, about 300km east of Darwin, will be developed in the foreseeable future. Initially, at least, raw materials for processing this ore will have to be imported through Darwin.

The basic requirement for uranium processing is sulphuric acid, with pyrolusite (manganese dioxide) in relatively smaller quantities and limestone for neutralisation of reaction products.

For the treatment of a tonne of ore yielding approximately 3 kilograms of uranium (which we understand to be the yield expected from these ores), around 50 kilograms of sulphuric acid are required. This can be obtained by processing about 16 kilograms of sulphur.

Thus, for every tonne of uranium (or uranium oxide) produced, it will be necessary to import about:

	16 tonnes of sulphuric acid
OR	6 tonnes of sulphur
AND	4½ tonnes of limestone
AND	2 tonnes of pyrolusite

An initial production of 3,000 tonnes of uranium per annum would thus require the importation of about 40,000 tonnes (using sulphur) or 70,000 tonnes (using sulphuric acid) of bulk imports per annum.

It is at present proposed to move these cargoes by road to the production areas, and mining companies would naturally prefer to import sulphur, rather than the acid, to reduce transport costs. Such an operation would involve unloading the dry bulk imports with a grab and holding them at a bulldozed stock-pile before transporting them eastwards.

Stockpile space in the Fort Hill area is readily available, particularly since the presumed demise of the Iron Ore facility. Sulphur, in solid form has, however, been banned from a number of world ports as being dirty, corrosive and a fire hazard. It may be possible to economically import sulphur in liquid (molten) form, or in sealed 20 tonne containers.

ANNEX C

CONSTRUCTION COST ESTIMATES

C.1 BASIS OF CONSTRUCTION COST ESTIMATES

For the purpose of comparison of the options, preliminary estimates of construction cost have been made. Rates for basic items have been used which reflect recent experience in Darwin (May 1975).

The inclusive rates used were:

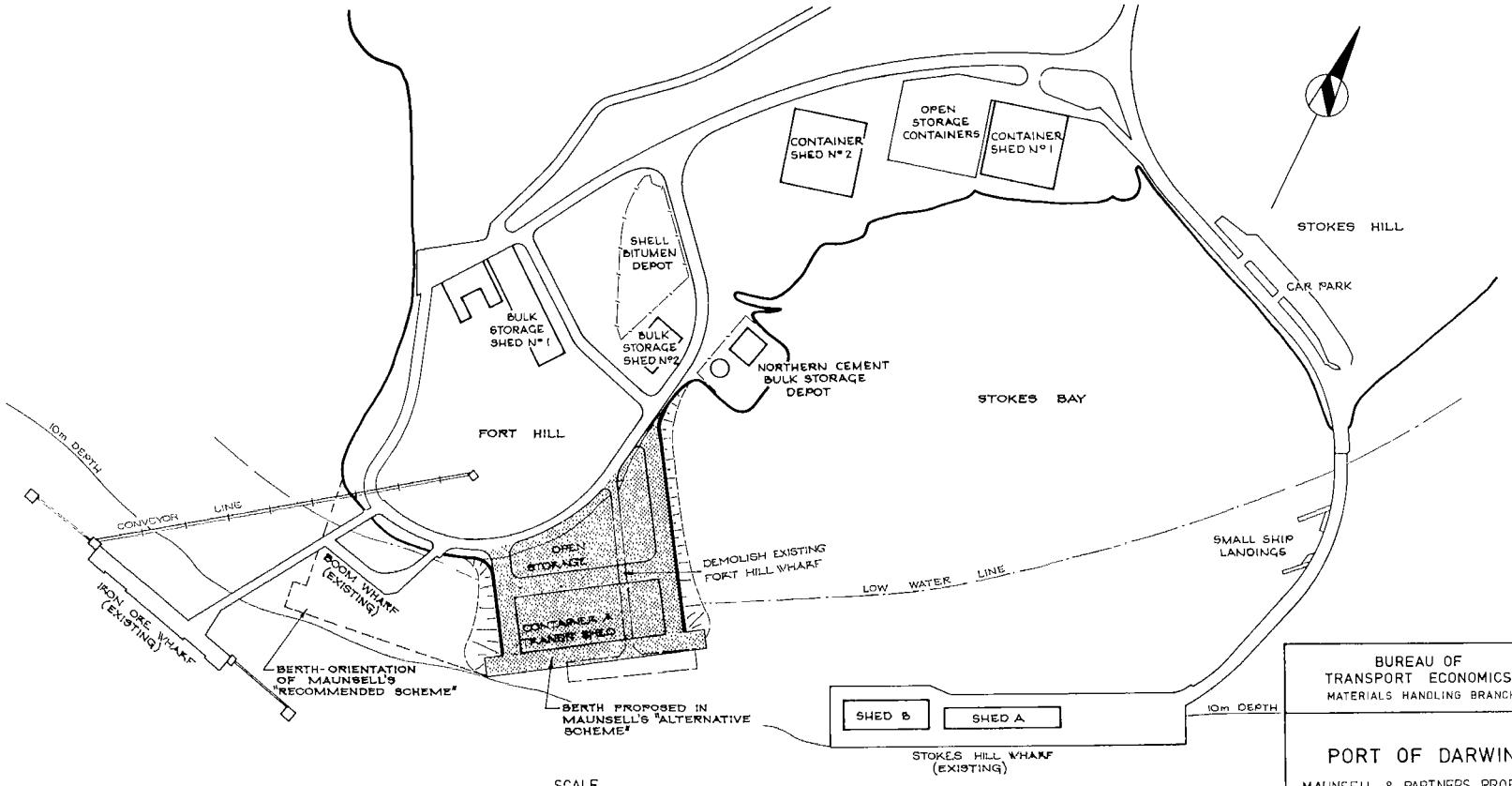
(i)	New piled wharf area, with concrete deck, steel or concrete piles	$\$380/m^2$
(ii)	Berth face, allowance for fendering, bollards, services	\$2,000/m
(iii)	Additional cost associated with the preparation of the edges of the existing wharf for extensions	\$180/m
(iv)	Wharf sheds, gross area	$\$110/m^2$
(v)	Rubble mound reclamation	
	Armour (2 tonne rock)	$\$32/m^2$
	Coarse crushed rock	$\$25/m^3$
	Ordinary fill	$\$5/m^3$
(vi)	Finishes to reclamation	
	Roadways	$\$15/m^2$
	Drainage	\$30/m
	100mm crushed rock surfacing	$\$2/m^2$

C.2 CAPITAL COSTS

For Options B, C and D preliminary quantities of items of construction work were estimated. The appropriate cost of each item was found using the rates given in the above paragraph uniformly for each option. The comparison of quantities and costs is given in Table C.

TABLE C - COST OF CONSTRUCTION WORK

Construction Task and Cost Item	Quantity	Cost ($ Thousands)	
Stokes Hill Wharf Major Extensions (for Option B)			
New Deck Area	11,500m^2		4,370
Berth Face	666m		1,332
Edge Preparation	636m		114
			5,816
Stokes Hill Wharf Minor Extensions (for Option C)			
New Deck Area	4,140m^2		1,573
Berth Face	495m		990
Edge Preparation	495m		89
			2,652
Fort Hill New Wharf (for Options C & D)			
New Piled Berth: Deck Area	12,350m^2	4,693	
Berth Face	180m	360	5,053
Wharf Sheds	4,080m^2		449
Reclaimed Area	12,000m^2		2,084
	130,000m^3		
Demolition of Old Fort Hill Wharf			50
TOTAL			7,636



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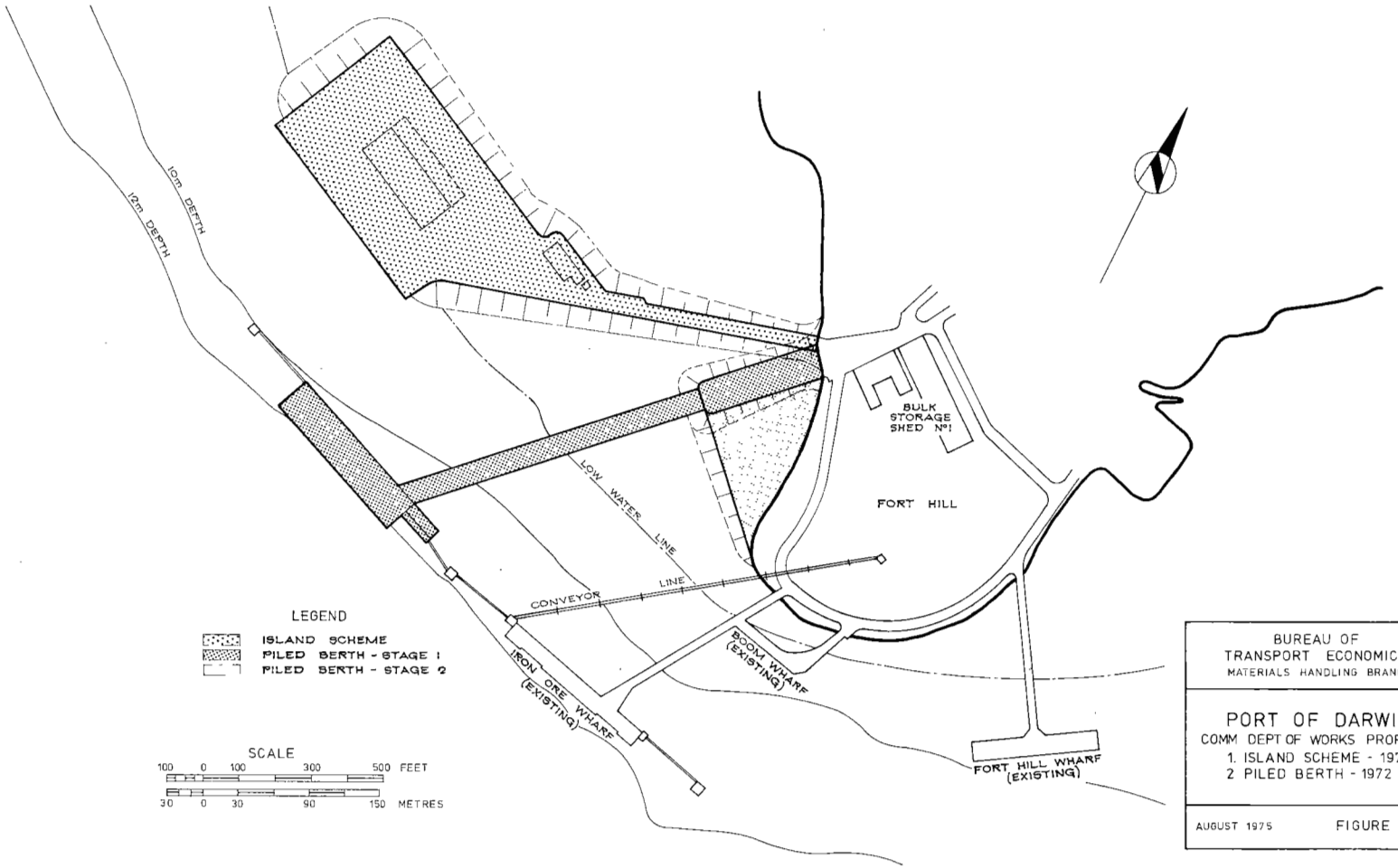
MAUNSELL & PARTNERS PROPOSALS (1968/69)

AUGUST 1975 FIGURE 2



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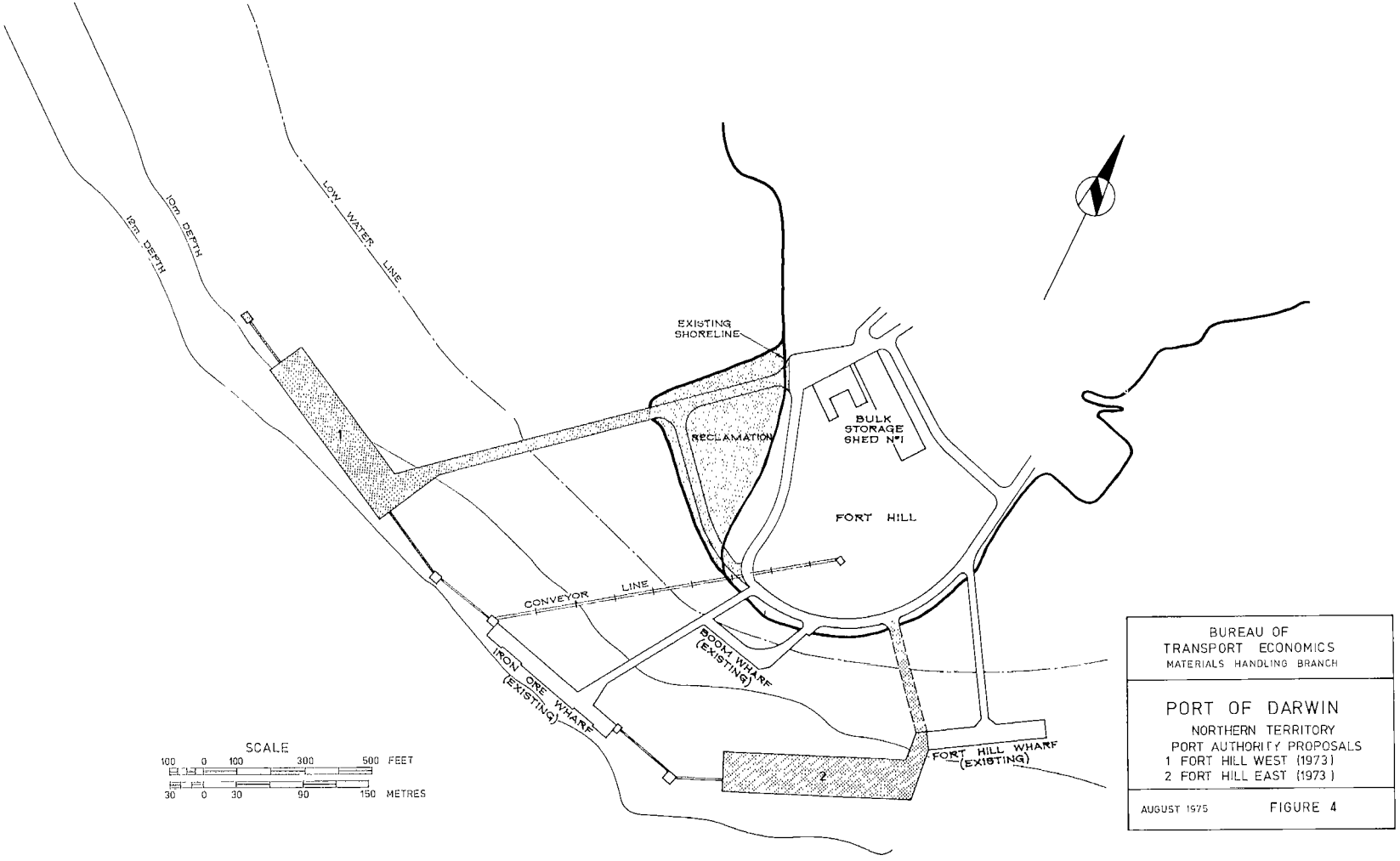
MATERIALS HANDLING BRANCH

PORT OF DARWIN

COMM DEPT OF WORKS PROPOSALS
1. ISLAND SCHEME - 1970
2 PILED BERTH - 1972

AUGUST 1975 FIGURE 3



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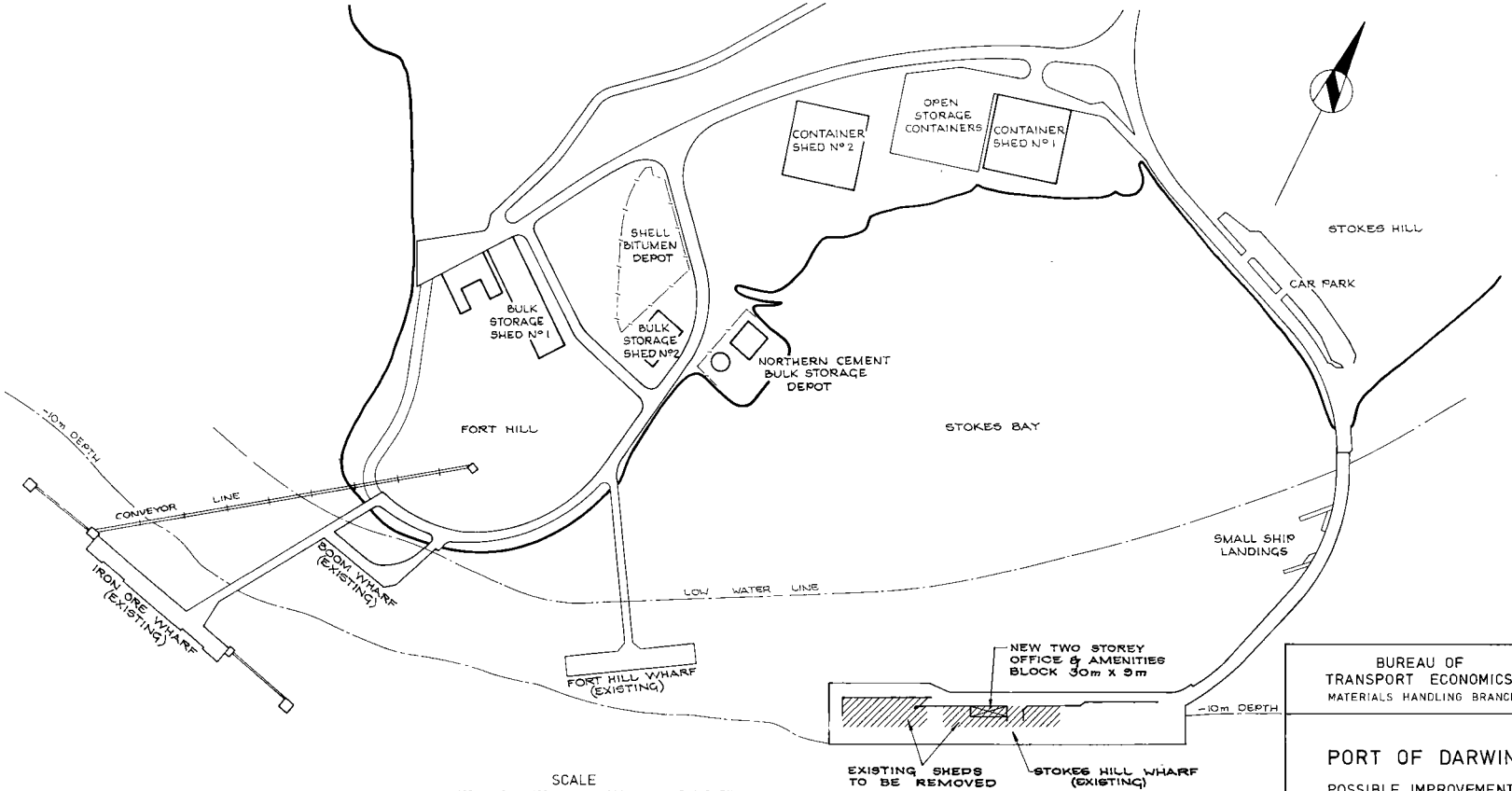
MATERIALS HANDLING BRANCH

PORT OF DARWIN

NORTHERN TERRITORY
PORT AUTHORITY PROPOSALS
1 FORT HILL WEST (1973)
2 FORT HILL EAST (1973)

AUGUST 1975 FIGURE 4



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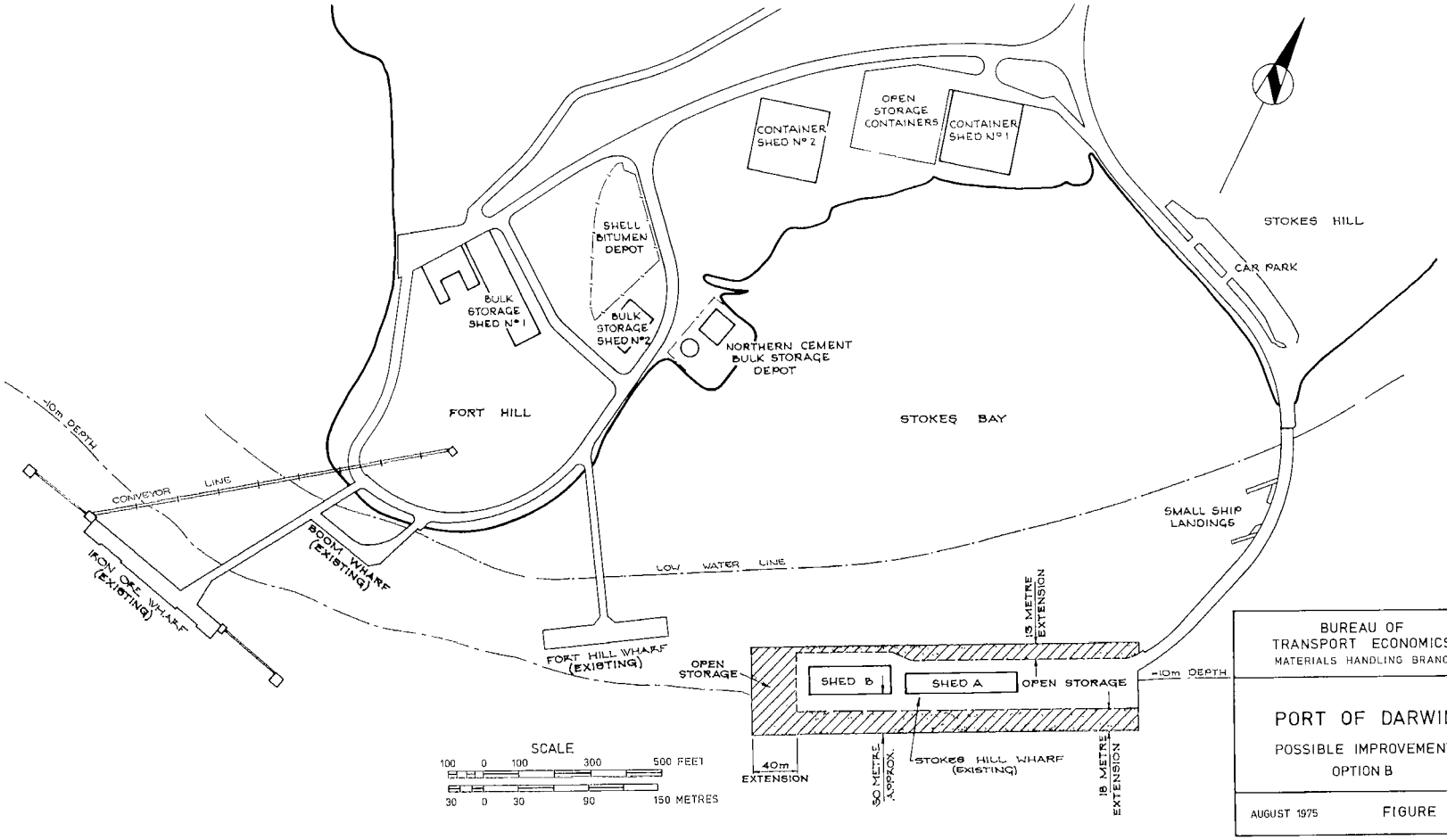
POSSIBLE IMPROVEMENTS
OPTION A

AUGUST 1975 FIGURE 5



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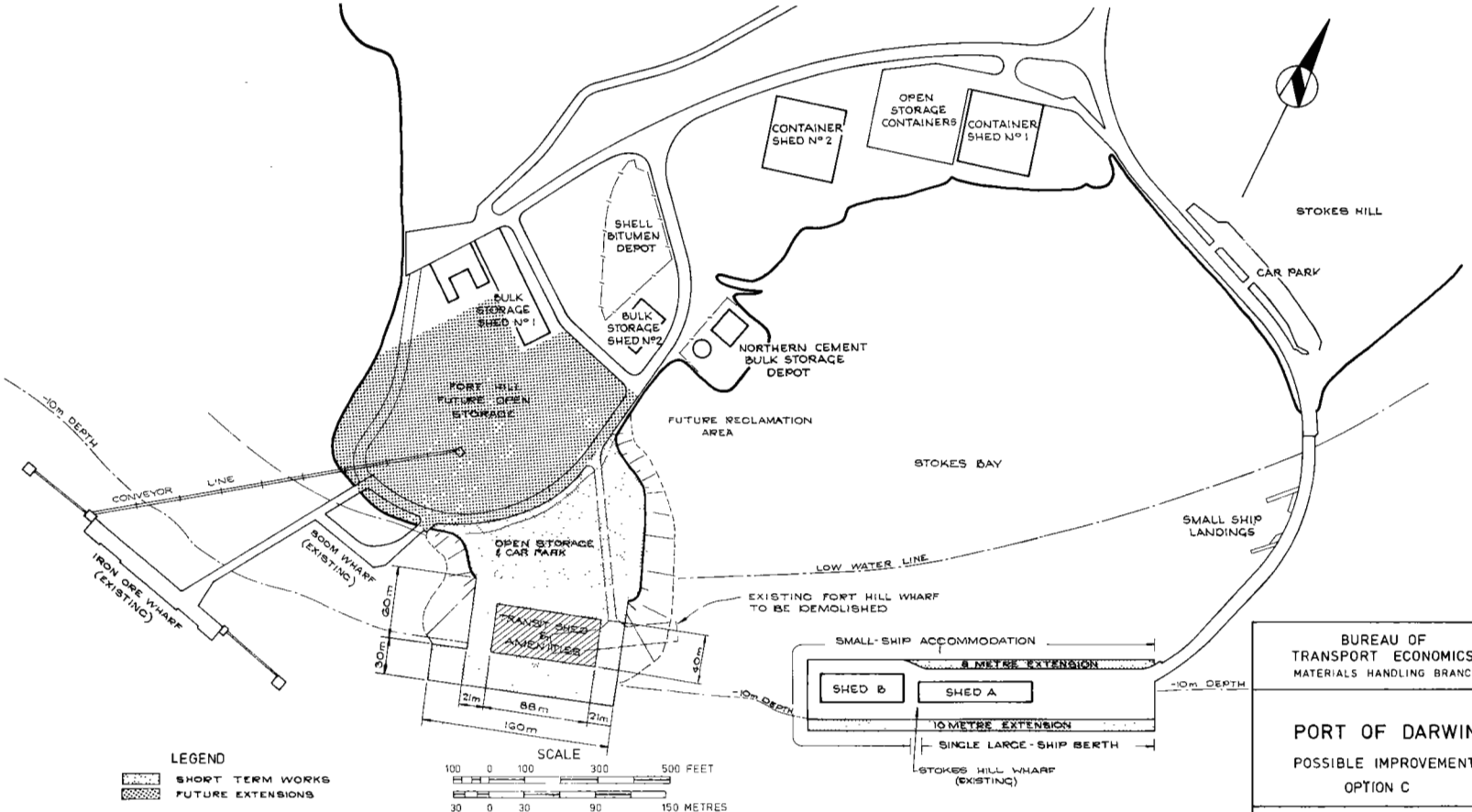
POSSIBLE IMPROVEMENTS
OPTION B

AUGUST 1975 FIGURE 6



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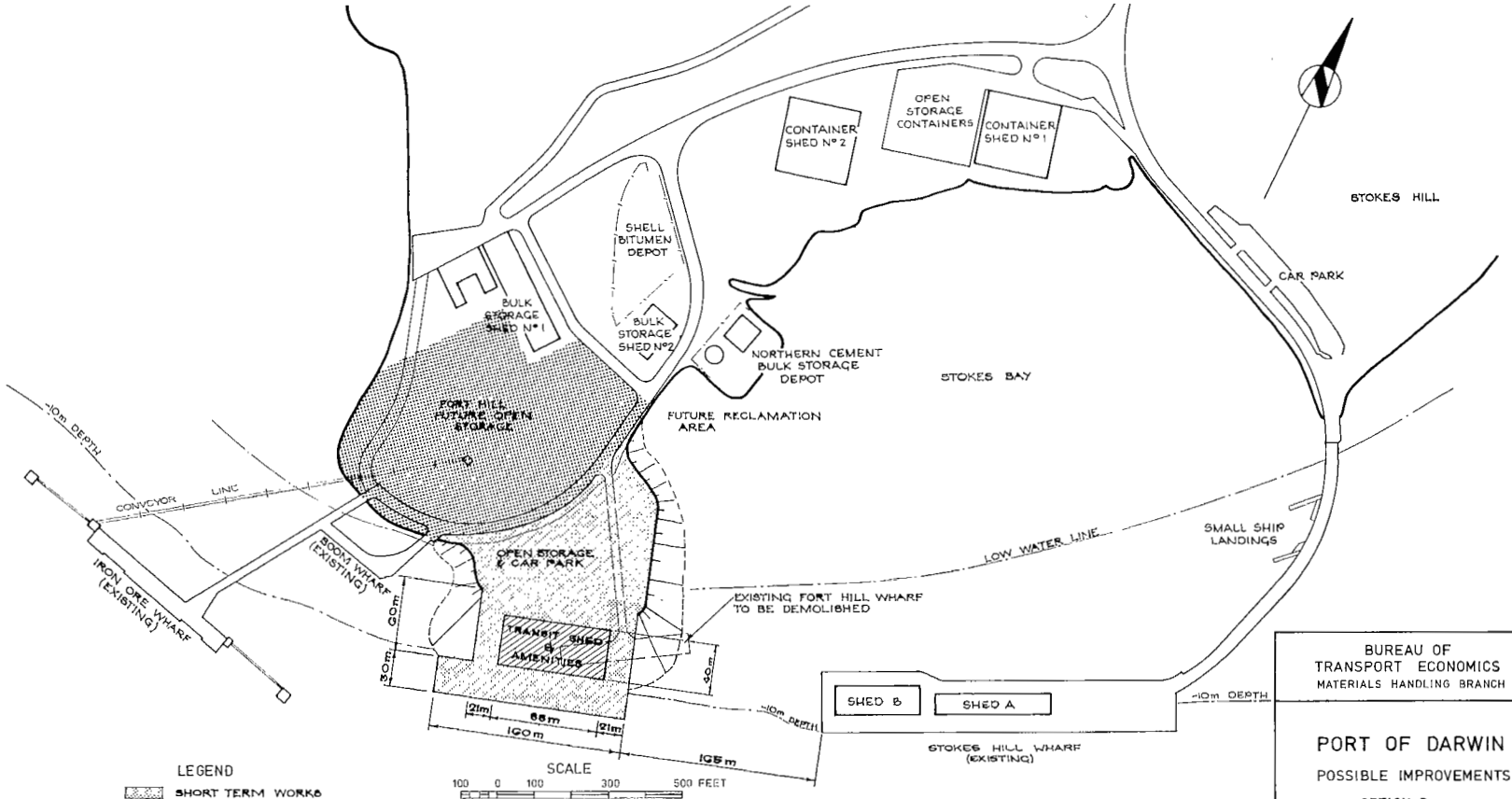
MATERIALS HANDLING BRANCH

PORT OF DARWIN

POSSIBLE IMPROVEMENTS
OPTION C

AUGUST 1975 FIGURE 7



BUREAU OF TRANSPORT ECONOMICS
MATERIALS HANDLING BRANCH

PORT OF DARWIN

POSSIBLE IMPROVEMENTS

OPTION D

AUGUST 1975 FIGURE 8