THE UNITED REPUBLIC OF TANZANIA

PRE-FEASIBILITY STUDY REPORT

ON

NATURAL SODA DEVELOPMENT IN LAKE NATRON AND RELATED TRANSPORTATION FACILITIES

PART III

August 1976

JAPAN INTERNATIONAL COOPERATION AGENCY

PART Ⅲ

REPORT

ON

RELATED TRANSPORTATION FACILITIES

CURRENCY EQUIVALENTS

1 Tanzanian Shilling	=	US$ 0.12	=	Yen 36.7
1 U.S. Dollar	=	Shs 8.16	=	Yen 300

ABBREVIATIONS AND ACRONYMS

MWEM	–	Ministry of Water, Energy and Minerals
Stamico	–	State Mining Corporation
T/Y	–	Metric ton per year
DWT	–	Dead weight ton

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CHAPTER 1: TRANSPORTATION PROBLEMS OF THE PROJECT AND SOME GUIDES FOR IDENTIFYING TRANSPORTATION ALTERNATIVES

The existence of an abundant deposit of natural soda in Lake Natron in Tanzania has been widely known for many years. A number of surveys of the deposit have been made in the past in an attempt to develop these valuable natural resources. Development, however, has not been realized because of the difficulties in exploitating and processing the natural soda, and the lack of transportation facilities from the Lake area to adjacent transportation terminals.

In addition, the following problems are pointed out:

(1) The soda ash has to be transported over a long distance, due to the location of Lake Natron which is situated 600-km inland from the Indian Ocean coast.

(2) The transportation of soda ash is limited in its capacity to cover the costs for construction of transportation infrastructure because the volume of soda ash transported is restricted by the market condition of soda ash to the medium scale of 500,000 – 1,000,000 t/yr.

(3) The transportation of the soda ash requires specialized vehicles and storage facilities, which are not able to be used for transport of other commodities due to the nature of soda ash.

(4) The fact that the ex-plant cost of soda ash occupies a considerable part of the expected FOB price as shown in the Part II, reduces the project's capacity to bear the transportation costs.

(5) As the refinery plant is to be operated on a continuous basis, the transportation facilities have to provide their service without long period of forced outage.

Therefore, the soda ash transportation has to satisfy the following basic requirements:

(1) Transportation costs must be as cheap as possible.

(2) Transportation must be reliable.

(3) The quality of soda ash must not be deteriorated in transit.

Port Facility:

In this pre-feasibility study, almost all the soda ash to be developed is considered as exports to the world market. Consequently, port facilities suitable for soda ash exports are required.

Such ports must have specialized storage and loading facilities to handle the soda ash. As several ocean ports exist along the Indian Ocean coast, an export port for soda ash is selected on the basis of studies of possibilities of development and/or improvement of port facilities in each ocean port.

Inland Transportation:

Many combinations of transportation mode are possible link Lake Natron and the selected port.

In the area between Lake Natron and the nearby transportation terminal, Arusha, there are no reliable transportation facilities like roads and railways. Therefore, it is necessary to develop new transportation facilities in this area. The facilities possible include road, railway, rope-way, and pipelines.

From Arusha to the ocean ports, a railway system and road networks exist, both considered to be serviceable for soda ash transportation. These systems, however, have some limitations in their transportation capacities at present e.g. a vehicle limitation in the road networks, and an insufficiency of train control systems and of the number of sidings in the railway system. The transportation study in this area is to be carried out taking into consideration the maximum utilization of the existing transportation facilities.

For roads and railways which seem to be prospective inland transportation facilities, the following points are taken into account:

(1) The construction costs of a new road are much cheaper than that of a new railway.

(2) The operation and maintenance costs of transportation by railway are much cheaper than transportation by road, and the railway has advantages in that it conserves valuable petroleum.

(3) Railway transportation is economical in the transportation of a large volume over long distances.

Assessment:

The search for the best means of transportation of exports and the above-mentioned sectors of transport, various transportation alternatives with different combination of transportation modes are identified and their technical feasibilities are assessed, namely the nature and degree of technical difficulties encountered and the uncertainties involved are examined. In the estimation of the costs involved in such transportation alternatives, whether costs for construction and/or improvement of facilities and operation and maintenance of them, such technical difficulties and uncertainties are fully reflected. In the costs of transportation of soda ash, a minimal cost analysis is made between the different combinations of transportation mode based upon the minimal costs of a technically and economically viable mode of transport. In this assessment, external effects generated by the development of soda ash transportation facilities are taken into account as much as possible.

CHAPTER 2 BASIS FOR COMPUTING FINANCIAL AND ECONOMIC COSTS OF THE PROJECT

2-1 Expenses Related to This Project

In order to conduct cost-benefit analyses of this project, it is necessary to ascertain the costs of this project. To do that, we have used the 'incremental costs' principle. Under this principle, the costs that would have been necessary even if there had not been this project are not considered project costs. On the other hand, all costs that are necessary for this project and which probably would not have been necessary if this project did not exist are considered as costs of the project. For example, costs related to construction of the new railway from Lake Natron to Arusha are considered as project costs because if there had been no project there would have been no need for the railway, even in the future. Other examples are certain harbor-related costs. Improvement costs needed to handle a future increase in general freight (e.g., costs for dredging to deepen the inner harbor to 10 m) are not considered as costs related to this project but all extra (incremental) costs of dredging to deepen the harbor beyond a depth of 10 m, will be borne by this project. In the case of the existing railway, the costs of various additional facilities, equipment and so forth that are required to use the line to transport products related to this project should be borne by this project. These include costs for building intermediate stations or sidings to increase the line's capacity, the installation of new signals, the purchase and operation or maintenance of rolling stock, and the construction and operation or maintenance of facilities for trans-shipment of freight between trains and trucks. But costs that would probably occur in the future for normal maintenance or improvement of the transport of people and goods are not considered in this project. (Of course, costs incurred for track and immovable facilities already in existence are not borne by this project.) This 'incremental costs' (marginal costs) principle is applied for the financial and economic analyses. This principle is used not only because it is fitting for economic analyses concerned with the conservation and commitments of economic resources, but also because it is effective for the subsequent financial analyses as well.

If existing railway lines are used for transporting soda ash, the railway authorities will want to know what new cost burdens will emerge and whether revenues from this project will be able to cover the new costs. Using financial analyses methods based on the 'incremental costs' principle will give the railway authorities the information they need. If the new costs are covered by revenues from this project, then the authorities will thus have ascertained that they will suffer no loss as long as the revenues are adequately distributed among participating agencies.

2-2 Estimates of Financial and Economic Costs

Financial evaluation should serve for two basic purposes. First, to see whether revenues from the project can cover all necessary costs; and second, to see whether all the organizations and individuals participating in this project will be able to offset their expenditures in it with their revenues from it. At the present stage, however, it is much too early to conduct a detailed analysis of participants in the project, and we will only review the matter of whether or not the project over-all will be able to balance its expenditures with its revenues.

The method of computation used to help in this review is as follows. Total costs are computed by using actual prices that will be paid for each cost item. As, in Tanzania, the price of products and the cost of labor for services are officially fixed nationally or by region, those official figures are used. For imported items not listed on official price lists, the CIF price in foreign currency at the port of entry is converted into the local currency at the official exchange rate and added to it is the cost of inland transport to the site where the item is to be used. Prices are generally calculated at end-1975 or early 1976 levels, and no later fluctuations are considered. Separate consideration is given to future inflation.

Economic evaluation, on the other hand, is to determine whether in terms of Tanzania's over-all economy this project will contribute or not. This is done by comparing costs and benefits. Costs are the commitments or consumption of resources (including labor) for the project, and benefits are the saving, creation or acquisition of resources. In this sense, tax payments are not considered as actual consumption of resources but as transfer payments. Thus, amounts equivalent to the taxes paid and included in costs must be subtracted from the costs. Also, the true value of the resources to the national economy may not be accurately reflected in the actual prices. For example, if the supply of unskilled labors is excessive and not fully productively employed then their economic contribution will not be as large as the amount of wages actually being paid. In other words, the productive contribution in their old employment which is forgone because of this project ..... their opportunity cost ..... may be lower than the amount of wages paid under the project. In such a case, that labor must be evaluated at a lower amount level than the amount of wages paid. In contracts, imported products may have a higher value to the national economy than the amount computed by converting the foreign currency denominated CIF price into Tanzania currency at the official exchange rate. Where foreign currency is in short supply, making it necessary to impose import restrictions, we can generally make such statements. It is necessary in such a case to evaluate the value of foreign currency higher than the official exchange rate (foreign currency is evaluated by a shadow price). There is also a need in services and goods such as cement, construction and transport -- services and goods which are a combination of imported and domestic services and goods -- to increase the amount according to the ratio of the combination. Based on this view, we use the following shadow factors, which are based on factors suggested by the Government of Tanzania.

— Shadow foreign exchange rate	1.3
— Shadow wage rate for unskilled labor	0.75
— Shadow wage rate for expatriate personnel	0.70
— Shadow price for cement	1.16
— Shadow price for electricity	1.19

CHAPTER 3. PORT STUDY

Introduction

The purpose of investigations for the port sector was to select a site suitable for handling and shipment of soda ash processed and refined in the vicinity of the Lake Natron, and where additional investments are necessary, to estimate construction and operation costs of such facilities. For this purpose, interviews were held mostly at ports of Tanga, Dar es Salaam and Mombasa with personnel concenred from the East African Harbour Corporation, Public Works Departments, National Development Corporation, local engineering consultants with experience in harbors, and other related organizations. Required data and information were collected and field inspections were made. The results of the investigations are briefly described in the following pages and cost estimates are given, based on data collected to date.

3-1 Ports in East African Community

The economies of the three East African Community nations and neighboring landlocked countries are heavily dependent on foreign trade.

The transport system in the East African Community is characterized primarily by the export of primary products, import of machinery, fuel and consumer goods, and domestic distribution. The major cargo flow (in the direction of trunk line transportation) originates in the four ports of Mombasa, Dar es Salaam, Tanga and Mtwara and moves east and westward. The port of Mombasa serves the hinterland embracing Uganda, Kenya, northern Tanzania and Ruanda, while Dar es Salaam handles cargoes to and from the Mtwara's hinterland, the whole of Tanzania except for the Tanga POrt's zone of influence in the north, Zambia, Brundi and eastern Congo. Although South Rhodesia's gaining of sovereignty and the recent closure of Angolan port of Robito have resulted in re-routing cargo traffic to and from Zambia via Dar es Salaam, putting substantial added load on the entire transport system in the East African Community, Zambia and the port of Dar es Salaam have now been linked by an oil pipeline, road and railway.

Given below is the summary of the ports of Mombasa, Dar es Salaam and Tanga (see Fig. 3-1).

3-1-1 Mombasa Port

Mombasa (see Fig. 3-2) is a natural harbor with a vast expanse of water. The approach channel through the port mouth is 12 m deep and poses no navigational problems. The tidal range is 3.8 m at spring tide and the current velocity is 2 knots. The port is well sheltered from waves and swells and has an anchor ground allowing 17 ocean-going vessels with draft up to 10 m to lie at anchor at a time.

This port has a total of 15 deep water wharves (2,700 m in total length) with a

Figure 3-1 Map of East African Ports

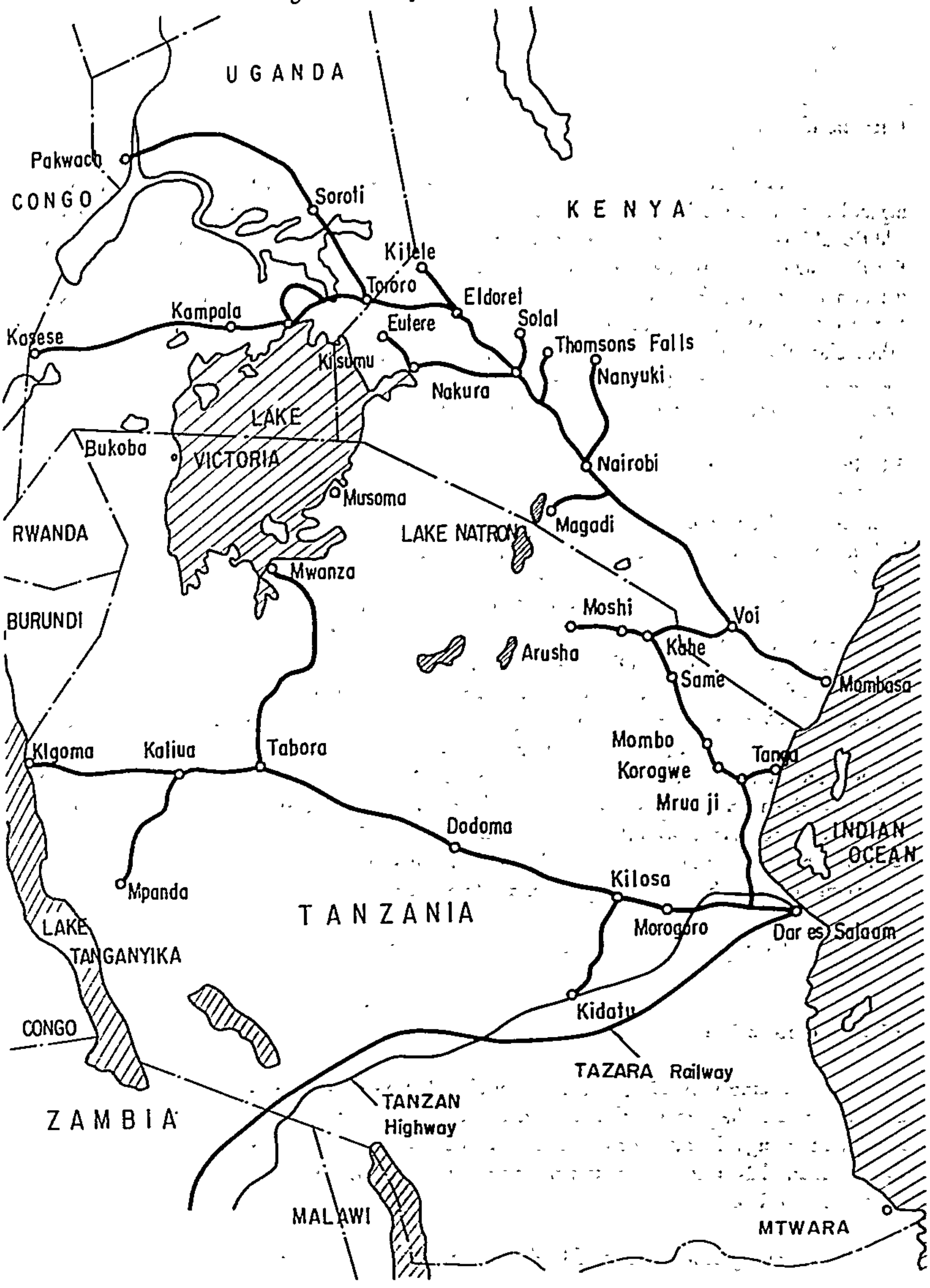
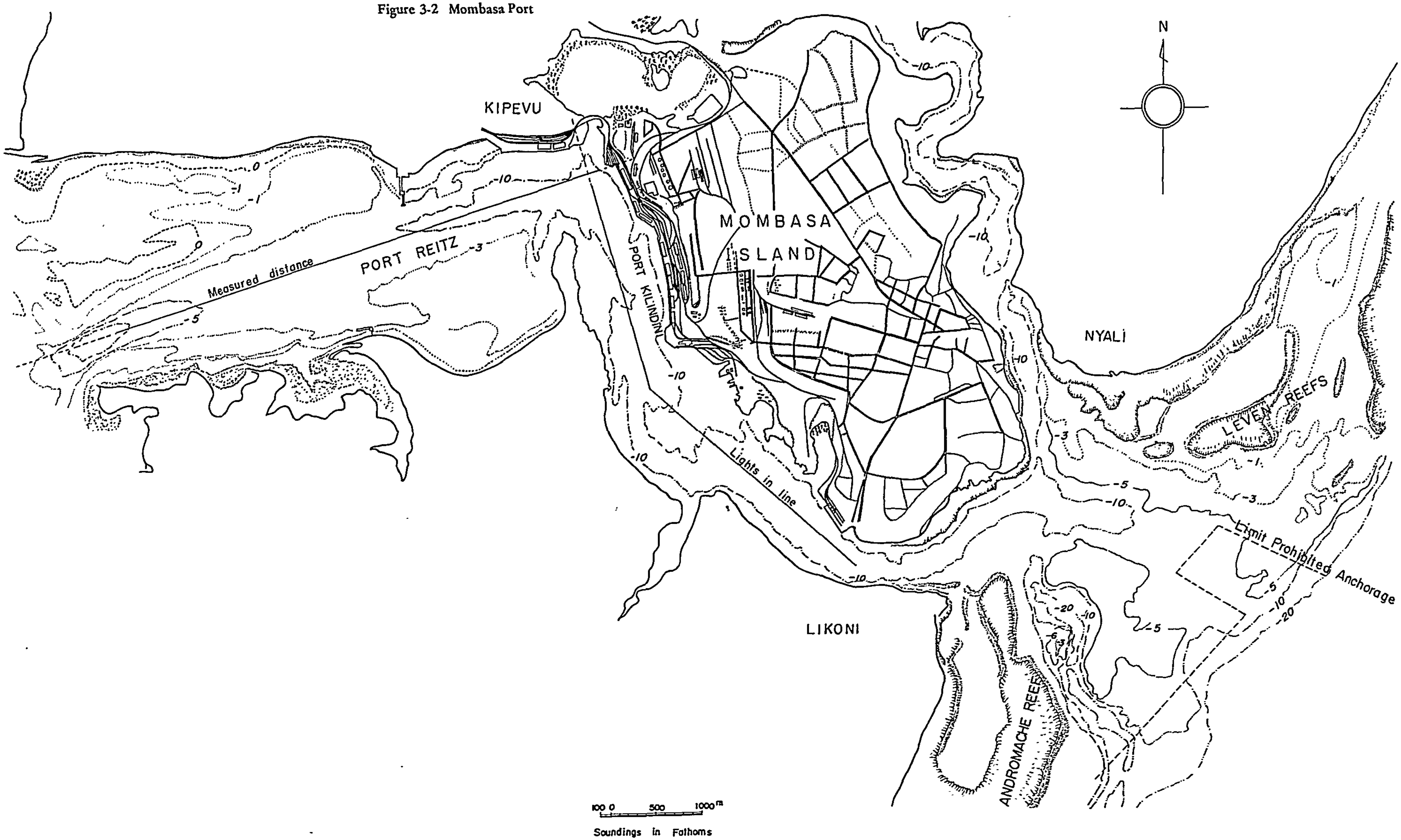


Figure 3-2 Mombasa Port



minimum depth of 10 m alongside. Two of these wharves, No. 16 and No. 17 are 11 m deep alongside so as to be available for serving container ships in future years. Adjoining Berth No. 14 is a 13.4m-deep berth designed to unload 65,000 DWT oil tankers.

There are 14 wharf transit sheds and seven more are located away from the shoreline. These sheds have a total floor area of 143,000 m².

A 412 m long lighterage wharf intervenes between deep water Berth No. 1 and the dockyard. Other port facilities include a bulk cement berth, belt conveyor for bagged soda ash and a pipeline for molasses shipments.

During 1974, the port handled seaborne cargo in a total of 6,800,000 tons including trans-shipments. Of this tonnage, 4,500,000 tons were imports and the remaining 2,300,000 tons exports.

Over the 1969 - 1974 period, the cargo traffic through the port grew at an average annual rate of 5%, the annual growth rate being 7% for imports and 2% for exports. During the same period, minerals and fuel accounted for 71% of the total imports, while the major export items were coffee, tea, lumber, cement, oil and oil products.

In 1974, the average ships waiting time, cargo handling time and turn around time for ocean-going vessels were 2.5, 5.4 and 7.9 days, respectively. The turn around time represents a gain of nearly 1.7 times over that recorded five years back.

3-1-2 Dar es Salaam Port

The port of Dar es Salaam (see Fig. 3-3) consists of an approach channel, about 2.3 km long, through the port mouth and a vast calm inner harbor. The channel is only 128 m wide at its shallowest part, 7.3 m deep, and has a sharp curvature at its junction with the harbor. Because of this curvature the harbor is accessible only to 182 m long twin-screwed ships and 174 m long single-screwed vessels. At night, ships, 147 m or less in length, can reach the harbor when the sea level is below 2.7 m above the datum level. With the tidal range of 3.3 m at spring tide, the harbor is not accessible to tankers at night, however, inner harbor provides an anchorage capable of accommodating five ocean-going ships at a time.

On the west bank of the southern creek in the inner harbor there are 11 deep water wharves (1,466 m in length), of which Berths No. 1 through No. 3 are 9.2 m deep alongside and the rest have a depth of -10 m alongside. Berths No. 7 to No. 11 are so designed as to permit dredging alongside up to -12 m. Construction of two additional berths are planned beyond the existing Berth No. 11 in order to cope with anticipated cargo traffic growth in the next five years.

An outmoded lighterage wharf, transit shed in the rear and access road are presently under repairs. The lighterage wharf is 580 m long. In the Bay of Mjimwema a seaberth and a sub-marine pipeline are provided to serve 100,000 DWT tankers that are not accessible to the inner harbor because of the limited width of the approach channel.

In addition to the 12,000 m^2 transit shed behind the lighterage wharf, there are more sheds having a total floor area of 21,600 m^2 at the rear of Berths No. 1 through No. 8 and Berths No. 10 and No. 11.

In 1974, the port handled a total of 3,700,000 tons of seaborne cargo including trans-shipments. This tonnage includes 2,800,000 tons imports and 850,000 tons exports. Minerals and fuel represented 50% of the total imports, which include food, fertilizers, paper, steel products and automobiles. The average annual cargo growth rate for the 1969 - 1974 period is 11%, with the 15% growth rate for imports far outstripping that 2% for exports. The average turnaround time for ocean-going vessels jumped from 3.5 days per ship in 1969 to 10.62 days per ship in 1974.

3-1-3 Tanga Port

This port (seeFig. 3-4) is not equipped with a deep water wharf. All incoming ships are served by lighters at anchor grounds in the inner and outer harbors for loading/discharging operations. Generally, the port is well protected from open seas, but cargo handling operations are sometimes hampered by swells.

The inner harbor can accommodate seven ships, ranging in draft from 6.3 m to 9.3 m and up set 210 m in length, at a time. The approach channel to the inner harbor is 9 m deep. The outer harbor provides an anchorage-14 m in depth which permits three ships to cast anchor at a time. The inner harbor is also accessible to vessels at night. On the east side of Raska Zone a multi-purpose jetty is in operation to serve a nearby fertilizer plant. The jetty, designed for 20,000 DWT ships, is also capable of receiving ocean-going ships with draft up to 14.5 m. Cargos like bulk phosphate, sulphate and liquid ammonia are handled at the jetty. On the inner harbor there are two lighterage wharves ranging in depth alongside from 2.4 m to 3.0 m and 381 m in total length.

In 1974, the port handled 400,000 tons of ocean cargo, of which 250,000 tons were outbound and 150,000 tons inbound. Imports consisted principally of materials for the fertilizer plant, maize, flour and oil; the major export items were coffee and sisal ropes. The food imports including maize and flour remained almost constant in volume during the 1969 - 1973 period. Obviously, the food imports reflected a temporary Tanzanian Government measure to tide over a food crisis caused by a drought.

Figure 3-3 Dar es Salaam Port

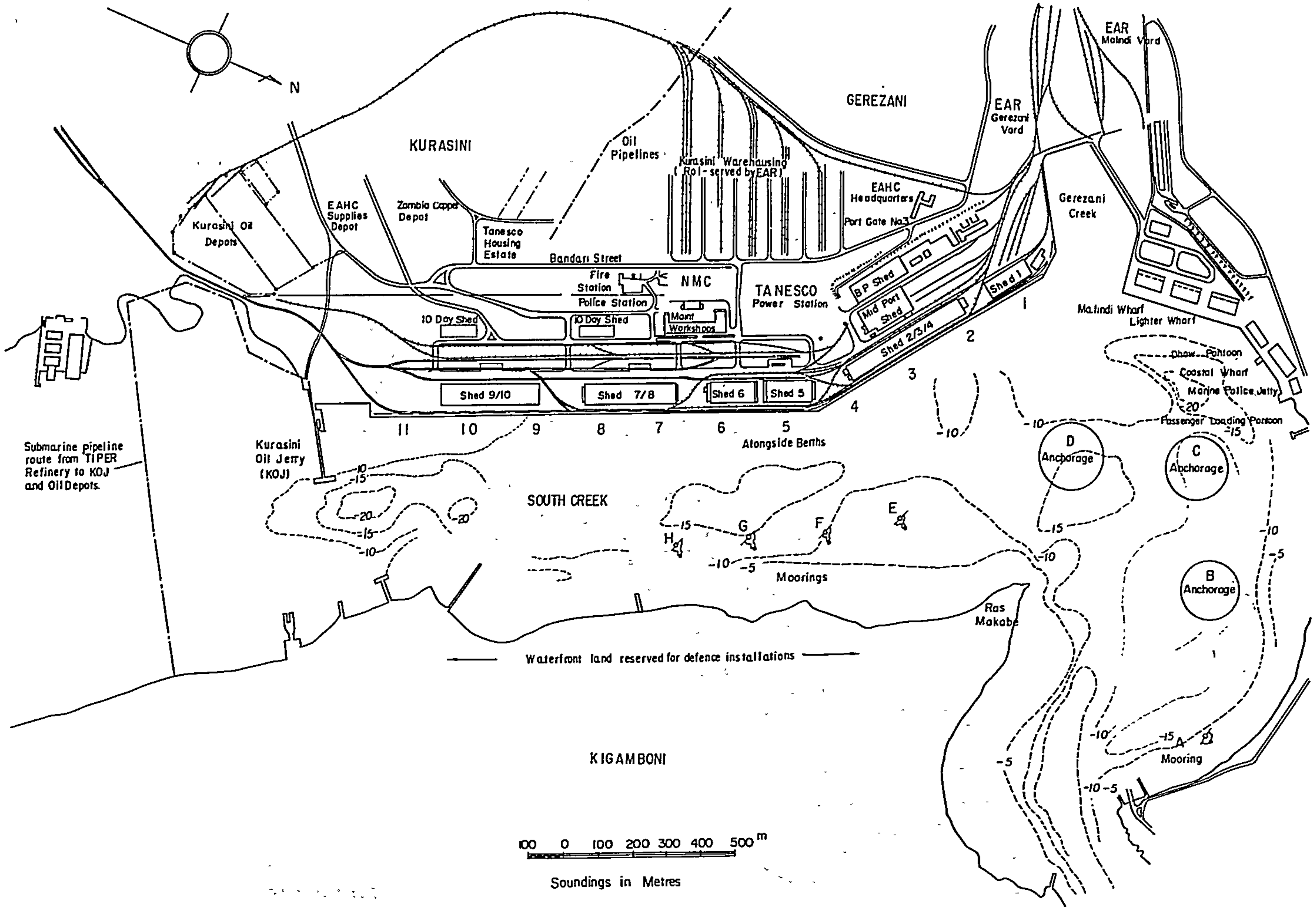


Figure 3-4 Tanga Port

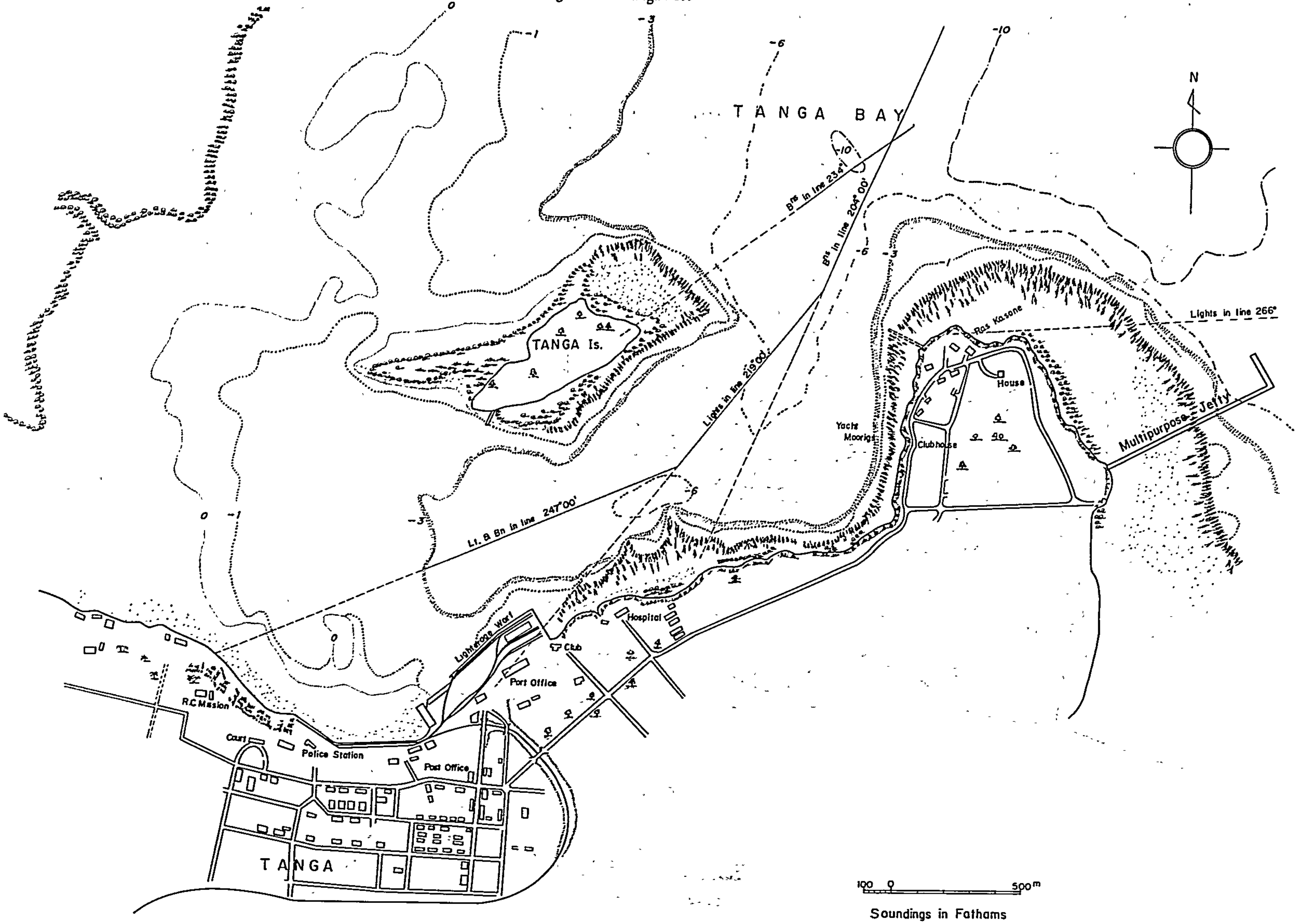


Table 3-1 Ship Arrivals and Cargo Volumes Handled in East African Ports (1974)

Port	Mombasa	Dar es Salaam	Tanga
Number of ship arrivals	1,699	965	357
(Ocean-going vessels)	(736)	(653)	(310)
Net registered tonnage	6,582,107	3,362,356	1,388,404
Cargo volume handled (DWT)			
Total imports	4,464,164	2,841,385	253,053
General cargo	1,280,800	1,143,465	122,455
Fertilizer materials (Tanga)	-	-	104,672
Petroleum and products in bulk	3,183,364	1,697,920	25,926
Total exports	2,311,511	847,692	142,303
General cargo	1,078,411	599,054	142,303
Dry bulk cargo (cement)	640,885	-	-
Molasses (bulk)	51,739	-	-
Petroleum and products in bulk	302,413	223,892	-
Bunker oil	238,063	24,746	-
Total imports/exports	6,775,675	3,689,077	395,356
Trans-shipments	14,100	4,504	196
Total of imports/exports/trans-shipments	6,789,775	3,693,581	395,552

Table 3-2 Principal Commodities Exported and Imported through East African Ports during 1974

Unit: Harbor tons

Port		Mombasa	Dar es Salaam	Tanga
Total Imports		4,319,499	3,218,477	279,548
0	Food	211,916	366,206	57,157
1	Beverages & tobacco	7,319	2,480	-
2	Crude materials inedible except fuel	18,827	17,039	113,975
3	Fuel & lubricant	3,078,081	1,627,900	21,061
4	Oils & fats	47,909	-	19,031
5	Chemicals	203,993	84,673	1,032
6	Manufactured goods classified chiefly by materials	434,238	203,760	16,290
7	Machinery & transport equipment	295,209	177,074	2,866
8	Manufactured articles	22,007	739,425	48,136
9	Other items	-	-	-
Total Exports		2,846,791	946,562	184,991
0	Food	661,309	132,023	51,209
1	Beverages & tobacco	-	27,894	-
2	Crude materials inedible except fuel	465,363	519,576	110,065
3	Fuel & lubricant	588,790	190,976	-
4	Oils & fats	-	2,058	1,354
5	Chemicals	138,651	-	-
6	Manufactured goods classified chefly by materials	797,159	19,469	21,487
7	Machinery & transport equipment	-	1,198	-
8	Manufactured articles	195,519	53,368	-
9	Other items	-	-	-

Table 3-3 Port Facilities in East African Ports

Port	Mombasa	Dar es Salaam	Tanga
(a) Berths, Wharves, Jetties, etc.			
Deep water berths: No.	15	11	
Total length (m)	2,700	1,466	
Dredged depth (m)	10	10	
Bulk oil jetties: (Tanker Berths) No.	2	1	
Single Buoy Mooring: No.		1	
Bulk Cement Berths: No.	1		
Total length (m)	305		
Cased Oil Wharf: No.	1		
Lighterage and Dhow Wharves: No.	2	4	2
Total length (m)	412	588	381
Handling Points: No.	9	5	9
Explosives Jetty: No.	1		
Multi-purpose Jetty (exclusively serving fertilizer plant): No.			1
(b) Sheds			
Main Quay Transit Sheds: No.	14	8	
Total floor space (m^2)	143,000	63,466	
Back of Port Transit Sheds: No.	6	2	1
Total floor space (m^2)	18,618	16,695	
Lighterage Area Transit Sheds: No.	6	8	9
Total floor space (m^2)	16,250	11,628	21,913
Customs Warehouse: No.		1	
Transit Depots: No.		1 (Ubunga)	
Total floor space (m^2)		24,155	
(c) Stacking Ground			
Main Port Area (m^2)	74,402	93,000	11,334
Transit Depots		20,539	

Table 3-4 Cargo Volumes Handled in Three East African Ports (DWT)

Port / Year	Mombasa			Dar es Salaam			Tanga		
	Imports	Exports	Total	Imports	Exports	Total	Imports	Exports	Total
1969	3,188,284	2,087,139	5,297,467	1,398,034	754,895	2,170,133	54,991	178,573	234,004
1970	3,524,147	2,251,722	5,796,227	1,647,619	808,277	2,463,260	73,457	194,161	270,802
1971	3,968,064	2,369,620	6,365,466	2,018,503	761,974	2,790,025	117,117	171,022	292,281
1972	3,786,373	2,105,656	5,922,475	2,300,881	826,862	3,130,155	109,582	144,633	256,767
1973	4,162,866	2,540,621	6,723,657	2,391,506	820,003	3,213,691	147,953	131,043	280,092
1974	4,464,164	2,311,511	6,789,775	2,841,385	847,692	3,693,581	253,053	142,303	395,552
1974/69	1.39	1.10	1.28	2.032	1.12	1.70	4.6	0.79	1.69
Average Growth Rate (1969-74)	6.8%	1.9%	5.0%	15%	2%	11%	35%	0.05%	11%

Table 3-5 Turnround Time in Three East African Ports (Days)

Turnround Time (*Ships Waiting Time* / Cargo Handling Time

Port / Year	Mombasa			Dar es Salaam			Tanga		
	Waiting	Cargo Handling	Turnround	Waiting	Cargo Handling	Turnround	Waiting	Cargo Handling	Turnround
1969	1.0	3.69	4.69	0.80	2.73	3.53	0.06	1.35	1.41
1970	0.33	3.45	3.78	1.50	3.69	5.19	0.03	1.60	1.63
1971	1.76	4.18	5.94	1.88	5.18	7.06	0.13	1.92	2.05
1972	1.02	3.56	4.58	1.47	4.99	6.46	0.05	1.64	1.69
1973	2.27	4.45	6.72	1.03	4.99	6.02	0.09	2.00	2.09
1974	2.49	5.37	7.86	3.77	6.85	10.62	0.22	3.23	3.45

Table 3-6 Cargo Volume Handled per Berth (ton/year)

Port / Year	Mombasa		Dar es Salaam		Tanga	
	Single Berth	Single Buoy Mooring	Single Berth	Single Buoy Mooring	Single Berth	Single Buoy Mooring
1969	148,770	28,934	209,983	85,773	-	23,890
1970	169,295	23,408	253,627	100,746	-	27,971
1971	161,371	34,844	176,757	39,182	-	29,953
1972	163,348	18,209	148,623	32,971	-	25,702
1973	181,175	22,103	138,642	37,745	-	22,030
1974	146,145	15,259	161,277	31,051	-	23,181

3-2 Characteristics of Soda Ash Cargo and Handling Facilities

3-2-1 Annual volume to be handled

The economic level of soda ash production on the Natron Lake is assumed to be 500,000 to 1,000,000 t/yr.

3-2-2 Method of packing

Soda ash is a granular substance of high moisture-absorptiveness and is easy to solidify when it contains moisture. When stacked high for a time, it is prone to compression under its own weight, solidifying or being pulverized to increase cohesiveness. Normally, soda ash is handled in bulk or in bags. Bagged soda ash will require a transit shed with a total floor area of approximately 15,000 m^2 for loading onto a 10,000-tonner. Suppose the bagged cargo can be transported by a belt conveyor, or on pallets by fork lifts to the wharf for loading onto the carrier by a crane. The belt conveyor method is the faster.

3-2-3 Handling

Usually, bulk soda ash is transported by special tank wagons to the wharf where the wagon floors are opened, discharging the cargo for transport to silos by means of a belt conveyor and bucket elevators. For loading onto a carrier the bulk soda ash is taken out by a belt conveyor from the silo through its bottom and discharged into the hold. To reduce the ship's turnaround time, the loading operation is performed on a round-the-clock basis with a high-capacity conveyor.

3-2-4 Ship size

To save on ocean freight costs, cargo should be in large lots on board as large a vessel as possible. In Japan, grain carriers of 15,000 DWT class are in service between Kawasaki and San

Diego, U.S. West Coast, for hauling soda ash. An unloading terminal capable of handling 30,000 tons of soda ash is currently under construction in Kawasaki on Tokyo Bay.

To accommodate soda ash carriers of 50,000 DWT or larger size, the approach channel to the port must have a minimum depth of 13 m and silo capacity must also be sufficient to store the cargo. In destruction, few ports are capable of handling soda ash carriers of this size. The optimal ship size for the transport of soda ash produced on the Natron Lake should be determined on the basis of a detailed evaluation of various relevant factors, such as the destinations of the cargo. For the purpose of our analysis, ship sizes ranging from 30,000 to 50,000 DWT are assumed.

3-2-5 Silo capacity

An economic level of output and transportation must be maintained, if efficiency is to be achieved in factory production and inland transportation. Soda ash carriers may often be delayed in arrival at the port of loading due to weather conditions. The port should have an adequate storage capacity to insure regular inland transportation of soda ash from the source of supply.

In this report, a soda ash output of 1,000,000 t/yr. and 300 days for overland haulage per annum are assumed for the purpose of our analysis. Further, it is assumed that a 30,000 DWT carrier will be commissioned for the ocean transport of the cargo. Based on these assumptions, the silo capacity that allows for a delay up to 20 days in the ship's arrival will be approximately 100,000 m^3. Assuming an annual production of 500,000 tons, ship size of 15,000 DWT and a similar delay in the ship's arrival, the required silo capacity will be about 50,000 m^3. For our analysis, the silo capacity requirements are assumed to be 100,000 m^3 for production of 1,000,000 t/yr. and 70,000 m^3 for an output of 500,000 t/yr.

3-2-6 Berth requirements

Table 3-7 shows the average ships waiting time required if a deep water wharf is constructed to serve ships ranging in deadweight tonnage from 15,000 to 30,000 DWT assuming soda ash output levels of 1,000,000 and 500,000 t/yr.

Table 3-7 Average Ships Waiting Time

		Case 1	Case 2
1.	Annual Volume Handled (ton)	1,000,000	500,000
2.	Number of Berths	1	1
3.	Ship Size (DWT)	30,000	15,000
4.	Carrying Capacity ξ (ton)	27,000	14,000
5.	Ship Arrivals per Annum	37	35.7
6.	Arrival Rate (ships/day)	0.1014	0.0978
7.	Average Handling Time (day)	3.81	2.46
8.	Service Rate μ (ships served/day)	0.262	0.4068
9.	Berth Occupancy Rate (ζ)	0.3863	0.2404
10.	Average Ships Waiting Time t_q (day)	2.4	0.7779
11.	Average Ships Waiting Time Assuming Constant Service Rate	1.2	0.388

Assumption 1: Queuing of M/M/1 is assumed. From this assumption, the number of ship arrivals during a given period can be obtained by Poisson's distribution formula and the cargo handling time is expressed as exponential distribution.

Assumption 2: A belt conveyor with a capacity of 400 tons/hour (500 tons/hour x 0.8) will be used round the clock in the loading operation. In this case, the average handling time can be determined by the following equation:

$$t_B = \xi / 400 \times 24 + t_d$$

where, t_B: average handling time
ξ: carrying capacity
t_d: time required for pre-entry and pre-departure preparations of ships

In the case of a terminal port, the time required for such preparations is one day.

Note: Ships average waiting time
The average time of M/M/1 can be obtained by the following equation and it will be reduced to one half if the handling time is constant.

$$t_q = t_B \frac{\zeta}{1-\zeta}$$

where, t_q: average waiting time
t_B: average handling time
ζ: berth occupancy degree (= arrival rate/service rate)

Calculations under simplified assumptions:
The average ships waiting time is 1.2 to 2.4 days for an annual output of 1,000,000 tons and 0.38 to 0.7 days for an annual output of 500,000 tons. Here, the berth occupancy rate is 38% and 24%, respectively. From these assumptions, one berth is considered sufficient in both cases to ship soda ash.

3-3 Selection of Port Facility Construction Sites

Six places were examined with a view to selecting a site suitable for handling soda ash:

a. Mombasa Port
b. Dar es Salaam Port
c. Coast of Ras Nyamaku in Mwanbani Bay
d. Multi-purpose Jetty in Tanga Port
e. Inner Harbor of Tanga Port
f. Coast near the Multi-purpose Jetty

Sites a. to d. had to be rejected for further consideration for the following reasons. Thus, sites e. and f. are the most feasible alternatives and cost estimates were made for these sites.

(a) Mombasa Port

As described above, Mombasa Port, with annual total cargo handling of 6.8 million DWT, is the largest port in the East African Community. However, the plan to haul soda ash from the Lake Natron to this port by railway has a problem in respect of its efficiency. It is said that according to recent cases the railway transport capacity between Kenya and Tanzania has deteriorated due to the shortage of wagons. Further, as viewed from the Tanzanian side, the overland transport plan is not advisable because the benefits induced secondarily from the development efforts, including improvement of relevant facilities and increase in employment, will be divided between the two countries.

(b) Dar es Salaam Port

Due to the closure of Angolan port of Labito, Zambian exports and imports are presently passing through Dar es Salaam Port. And, transit cargoes are expected to furtherly increase in volume in the future now that the Tanzam Highway and Tanzam Railway are open between Zambia and Dar es Salaam Port. The port is not operated efficiently at present because stock yard space is inadequate, cargoes for Zambia and other countries are handled at the same berth, and cargoes are handled at slow pace of only about 6 tons per hour per gang (cf. 23 tons per hour per gang at Yokohama Port). If the soda ash berths are to be built in Dar es Salaam Port, the best conceivable sites will be either on the south side of the entrance channel or on the coast facing the high sea. Both of the sites will require, for better communications with the railway terminal and port administration office, a bridge and access road so that the construction cost of the new berth will be made higher as compared with the existing berths. In addition, the distance to be covered by overland transport between the Lake Natron and this port is longer than that between the Lake and Tanga Port by about 40%. This will be another factor raising the cost of transport to Dar es Salaam Port, as compared with Tanga Port.

(c) Coast of Ras Nyamaku in Mwanbani Bay

The Mwanbani Bay is situated at about 8 km south of Tanga Port, and investigations are presently under way on the coast near Ras Nyamaku by the United Nations Development

Program, covering the projection of cargo traffic, and sounding and boring surveys. With the coral reef well developed in the offing, similarly to Tanga Port, the bay is completely sheltered from the effects of waves and swell of the Indian Ocean. The bay satisfies topographical conditions necessary for good natural port; adequate water depths being available because of steep seabed inclination, large vessels can come close to the shore without performing costly dredging operations and a calm and sufficient water area may be secured for the turning of vessels. On the other hand, however, the overland access to the site is hampered by small rivers and all weather roads are not yet completed. At the time of field investigations during the last November dry season, the rivers had to be crossed by canoe and then walking was necessary for more than half an hour to reach the site. With exception of scattered palm forests and small hamlets, the site and its vicinity are generally flat lands covered with shrubs and grasses. As there is no almost change in elevation between the coastline and shore behind as at Tanga Port, there is ample space for constructing transit sheds and storage yards. The site, therefore, appears attractive for constructing port facilities not only for the handling of soda ash but also other types of cargoes. Unless the facilities are built to serve different types of cargoes, the site will not be advisable as the construction costs of port service facilities and overland access will have to be borne by the present project alone. Therefore, the site should be re-examined if necessary on presentation of the results of investigations separately conducted by the UNDP (see Fig. 3-5. Tanga Port and Its Adjacent Area).

(d) Multi-purpose Jetty in Tanga Port

The multi-purpose jetty is located on the outer harbor of Tanga Port facing the Indian Ocean. The depth alongside being 14 m, vessels of 50,000 DWT class and over can be accommodated safely. Phosphate, sulfate, liquid ammonia and other raw materials are presently landed at the jetty for the fertilizer plant at south of the jetty. Cargo handling efficiency at the jetty is extremely low because the access road to the jetty is only one lane wide, trailers can not be freely operated as the crane and hopper take up space on this narrow jetty, and further the crane frequently breaks down. According to the operation records of the jetty in 1974 – tonnage unloaded from the moored vessels – the volume of cargoes handled per day averages 700 tons. The production scale of the fertilizer plant is expected to be expanded in the future. The factory has a plan to increase the production to 120,000 t/yr. by 1978 and ultimately to 300,000 t/yr. in the future. The amount of raw materials to be imported to accomplish the production target and the number of days required for their unloading is as tabulated below.

Table 3-8 Raw Materials to be handled at Multi-purpose Jetty

	Production target - ton/year	Import of raw materials - ton/year	Berth occupancy rate - days
1978	120,000	211,765	302
(Future)	300,000	529,000	756

From this, it would appear impossible for the jetty to handle one million tons of soda ash as well even if the cargo handling efficiency of the jetty was increased by the improvement of existing facilities and rationalization of handling operations.

(e) Inner Harbor of Tanga Bay

The inner harbor of Tanga Port is completely free from any swell or waves and no noticeable current is observed. The maximum water depth in the bay is approximately 8.0 m. Layers of sandy soil and clay are formed alternately in the sea bed soil. According to available soil data, there is no ultra-soft clay or rock outcrop in the area. Although it has been said that mud is flowing out from the swampland at the innermost part of the bay and is pended in certain water areas, and the shallow water at west of the lighterage wharf is chiefly attributable to reposition of this mud, recent site investigations revealed that except for small rivers emptying into the bay, there is no major source of sand drift. So, sand drift will not constitute any major problem for the maintenance of channel in the future. Thus, the plan to construct large ship berths along the face line of the existing wharf is promising for the following reasons:

i) The operation and management of port activities, such as cargo handling, weighing and customs inspection may be centralized by arranging the lighterage wharf and quaywall closely each other. Such arrangement will also result in improving the effectiveness of investment on the soda ash berth by allowing handling other types of cargoes whenever the berth is unoccupied.

ii) There is an ample space to construct an additional berth which would become necessary to handle the increasing amount of cargoes other than soda ash in the future. The berth may be built on the east coast-line if an adequate space was reserved beforehand for the access road between the quaywall and silos.

iii) Since the new facilities are planned at an area adjacent to the existing harbor, they will require practically no additional investment for the construction of road and railway or for the services, such as water and power supply and telephones.

(f) Coast near the Existing Multi-purpose Jetty

This site is also protected from waves by the presence of offshore coral reef. Water depths of about 12 m are available at about 600 m from the shoreline. The elevation of existing seabed on which causeway and road jetty are to be aligned over the distance of 600 m exceed for the most part the level of low water springs or about 6 m. Therefore, it will be possible to select a structurally inexpensive type and the amount of dredging will be very small. It would be desirable if the face line of new jetty may be adapted to conform to that of the existing jetty, taking into account the furrow of vessels berthed and unberthed. It would also be advisable to construct the new wharf on the south side of the existing one, in order to separate trailer traffic between the existing jetty and fertilizer plant and the transport carrying soda ash.

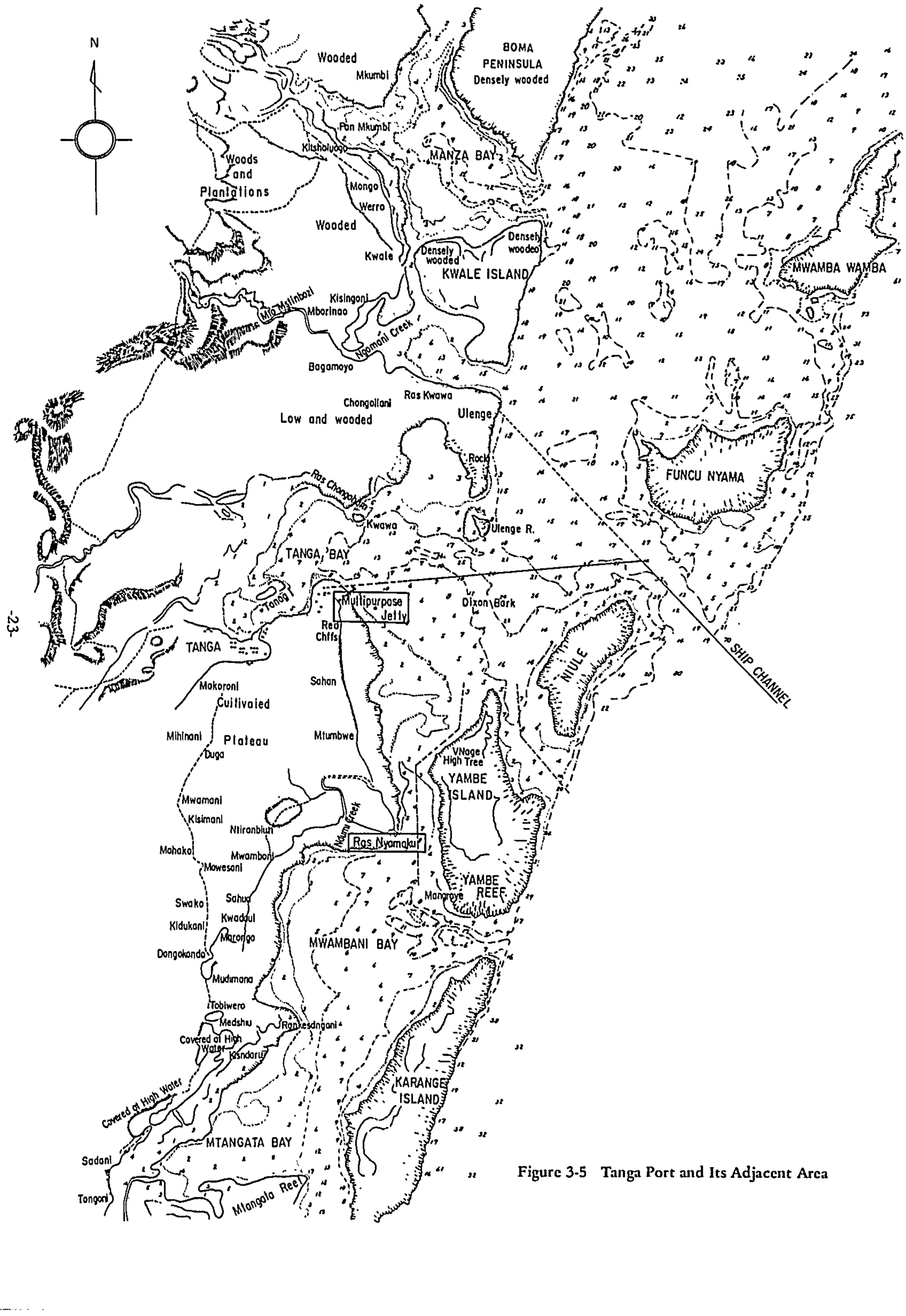


Figure 3-5 Tanga Port and Its Adjacent Area

3-4 Port Facility Plans

3-4-1 Outline of the plans

To obtain a basis for calculating costs of construction and operation of the soda ash handling berth, the facility layout plan was worked out for the two sites (Inner Harbor of Tanga Port and Coast near the Multi-purpose Jetty) which have been dealt with in the preceding chapter. The plan is based on the following conditions (see Fig. 6. Port Facility Layout Plan).

Table 3-9. Proposed Alternatives for Port Facilities

Sites	Soda Ash Production	Size of Vessels	Number of Berth
e	1,000,000 t/yr.	30,000 DWT	1
e	500,000	15,000	1
f	1,000,000	30,000	1

3-4-2 Storage and loading facilities of soda ash

As described in Paragraph 2-5, the necessary minimum amount of soda ash to be stored corresponding to the production scale was determined to be 100,000 cu.m. and 70,000 cu.m. for the production of 1,000,000 t/yr. and 500,000 t/yr., respectively. Although 500 ton/hour capacity is adopted for loading into vessels, two units of loaders with 250 ton/hour capacity are planned instead of using a 500 ton/hour loader, in case it breaks down (see Fig. 7. Plan for Silo and Related Facilities). All the silo and related facilities will be of electrically driven types. The following number of personnel will have to be assigned for the operation and maintenance of these facilities:

Table 3-10 Personnel to be assigned to Silo and Related Facilities

Type of Personnel Required	Soda Ash Production (t/yr.)	
	500,000	1,000,000
Manager	1	1
Secretary	1	1
Clerks	3	3
Maintenance Engineer	2	2
Foreman	4	4
Equipment Operator	16	18
Common Laborer	32	40
Forklift Operator	4	7
Foreign Instructor	6	6
Total	69	82

Foreign instructors are intended for the transfer of technology necessary for the maintenance and operation of these facilities to Tanzanian staff. A period of two years should be sufficient for this purpose after the commencement of operation. As ancillary facilities to the plant, an administration block and quarters for the employees will be necessary.

3-4-3 Facility plan for the Tanga Port Inner Harbor Site (site 'e')

(1) Layout plan of port facilities

The site is located at the inner harbor of Tanga Port. The plan calls for the construction of a soda ash handling berth on the extended line of the existing lighterage wharf. The plan consists of two cases; for production of 500,000 t/yr. and for 1,000,000 t/yr.

i) Soda production – 500,000 t/yr.

It is assumed in this case that vessels to serve for will be of 15,000 DWT class and the facilities consist of quaywall, revetment, reclamation works, silos, etc. The dock railway sidings to haul soda ash to the silo will be extended from the existing ones. However, due to the unavailability of site to receive and inspect the incoming soda ash wagons, the water area in front of the existing marshalling yard at the innermost part of the bay will be reclaimed. The plan further calls for dredging the minimum necessary area to the depth of 10 m for the berthing and unberthing of fully laden 15,000 DWT carriers which will draw waters of 9.5 m (see Fig. 3-8. Plan for site 'e', 500,000 t/yr.)

ii) Soda production – 1,000,000 t/yr.

The facility layout plan has been worked out at the same location with the case 'i') above, using the same idea except for the size of vessels which was increased to 30,000 DWT class (see Fig. 9. Plan for Site 'e', 1,000,000 t/yr.)

(2) Design conditions

In order to calculate approximate costs of construction of the above described port facilities, basic design was prepared of the quaywall which is most important of all the facilities. Shown below are the design conditions adopted for the quaywall.

i) Tide level

H.H.W.S.	±3.90 m
M.L.W.S.	±0.00 m (Works Datum)

ii) Crown Height of Quaywall

H.H.W.S. + 3.90 m + 1.00 m = +4.90 m

Figure 3-6 Layout Plan of Port Facility

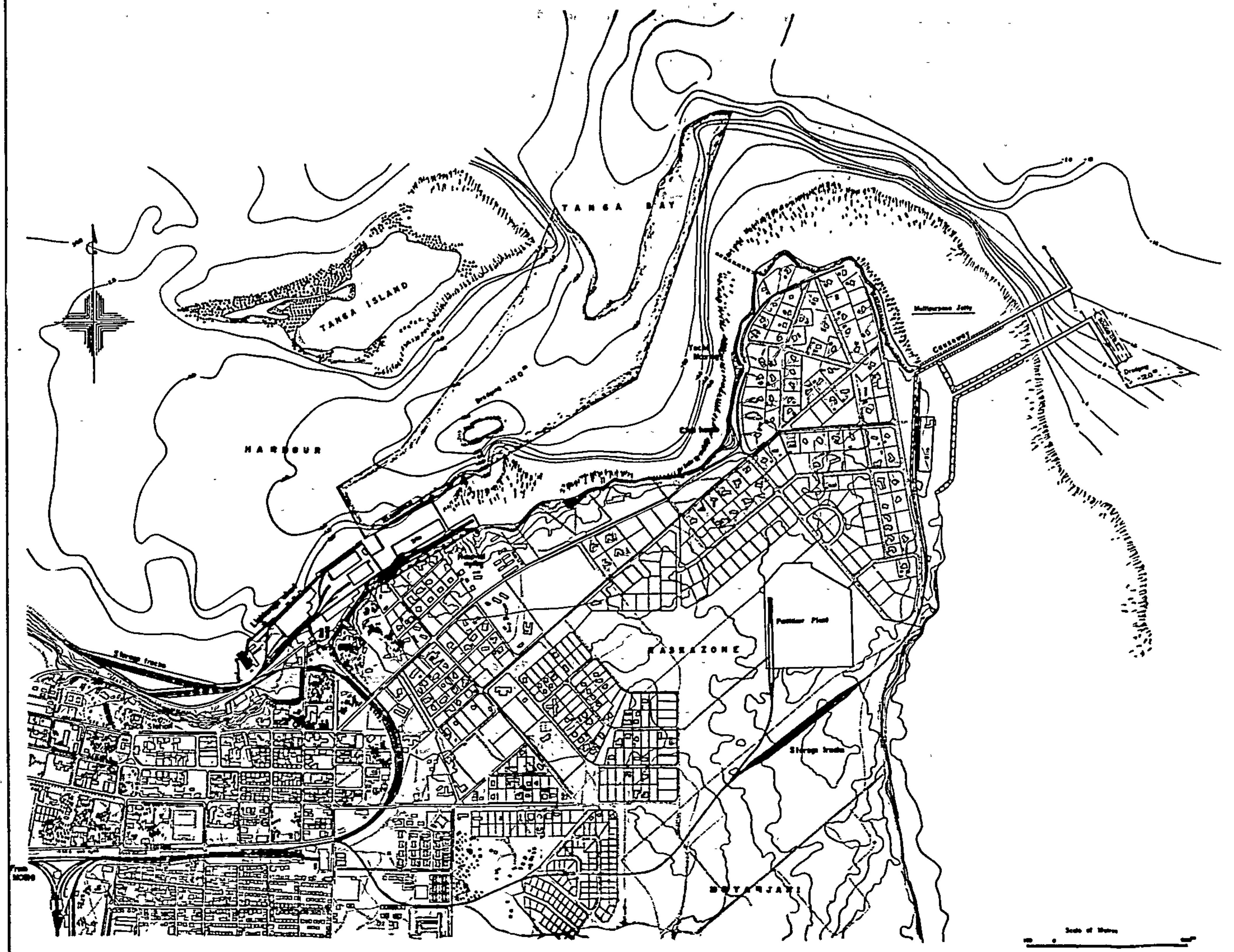


Figure 3-7 Plan for Silo and Related Facilities

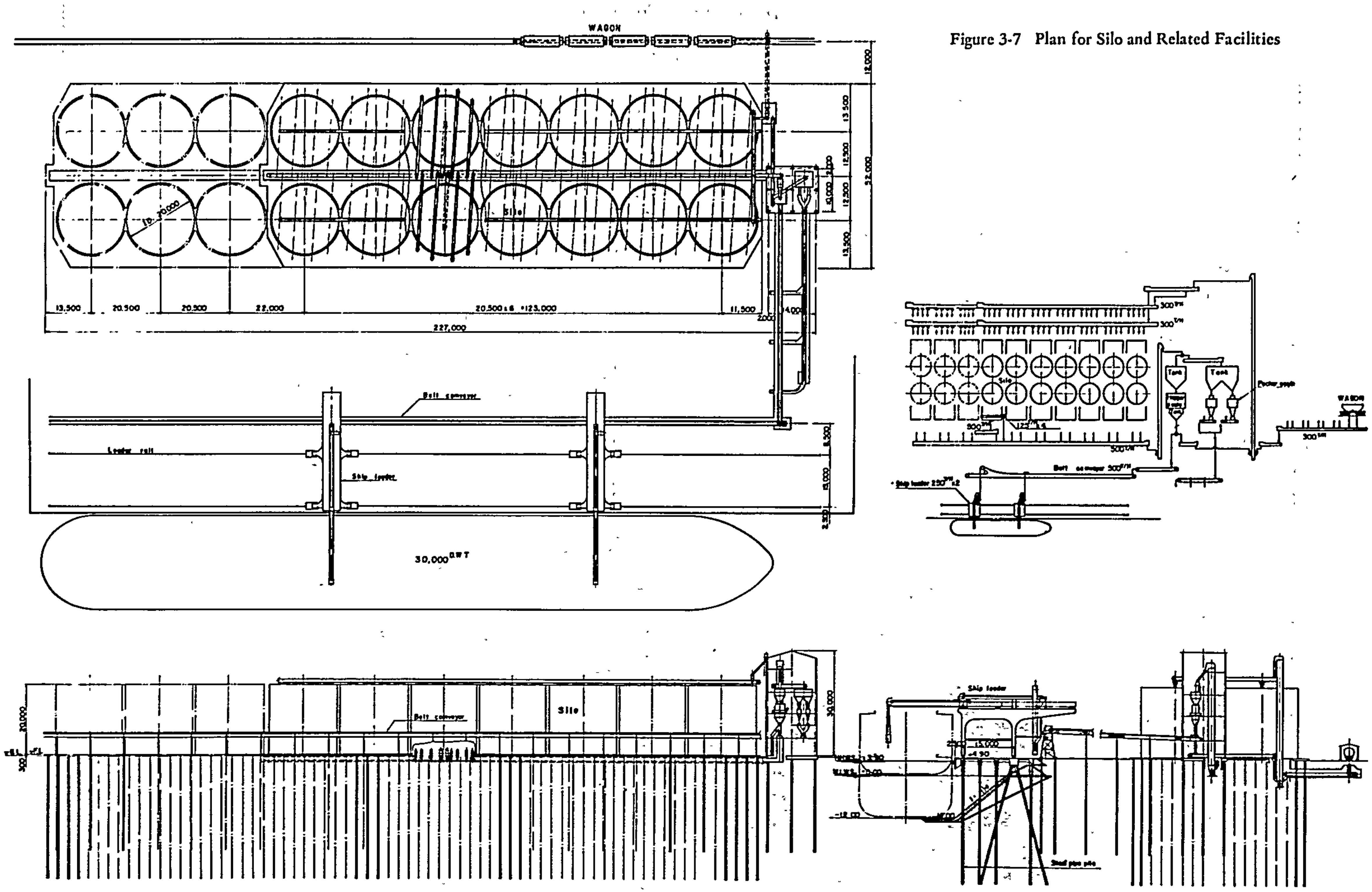


Figure 3-8 Plan for Site 'e', 500,000 t/yr.

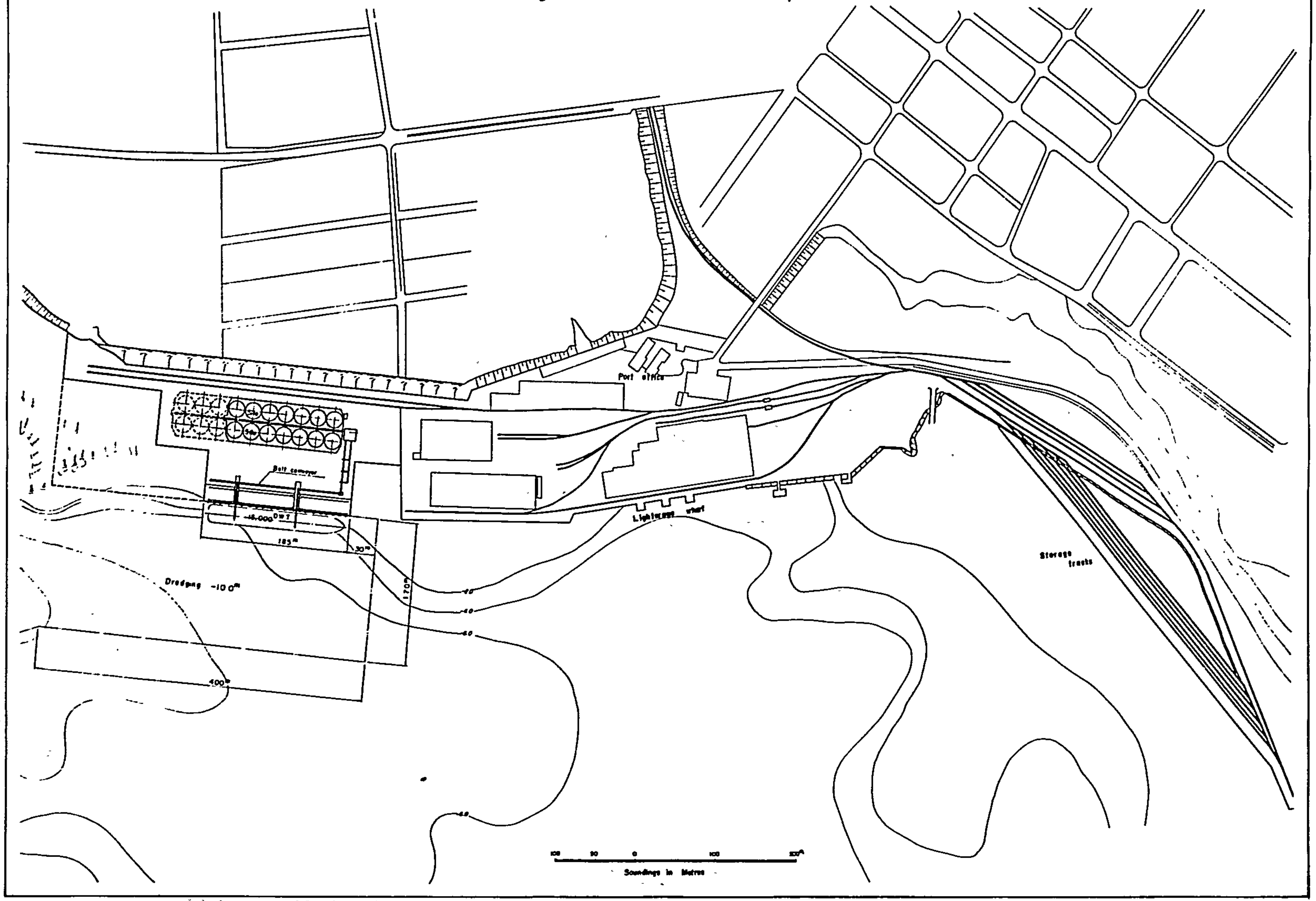
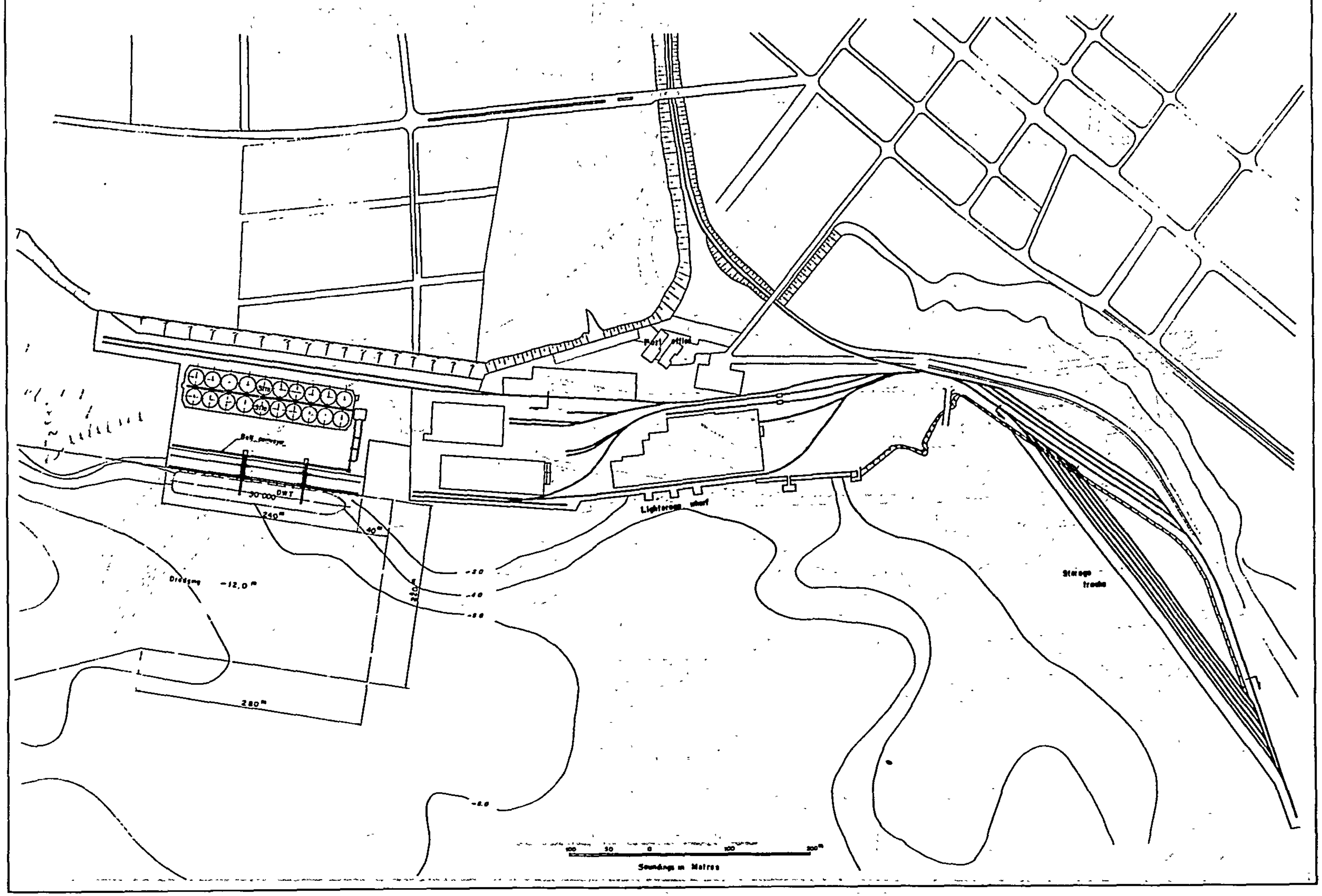


Figure 3-9 Plan for Site 'e', 1,000,000 t/yr.



iii) Load factors

Surcharge	q = 700 lbs. per sq. ft.
Weight of loaders	W = 180 tons per unit
Vehicular load	T – 20

iv) Design seismic coefficient

$k_h = k_v = 0$

v) Soil conditions

From data obtained at the site, the soil conditions are assumed to be as follows:

S.B. to -10.0 m	Sand layer	N = 3	$\phi = 25°$	$\gamma' = 1.0\ t/m^3$
-10.0 m to -20.0 m	Clay layer	N = 2 – 3	$C = 5.0\ t/m^2$	$\gamma' = 0.7\ t/m^3$
-20.0 m to -25.0 m	Sand layer	N = 15	$\phi = 30°$	$\gamma' = 1.0\ t/m^3$
below -25.0 m	Sand layer	N = 25	$\phi = 35°$	$\gamma' = 1.0\ t/m^3$

Given below are conditions applicable specifically to respective size of vessels to be accommodated:

i) When the vessel is of 15,000 DWT

Size of vessel

Length	L = 165 m
Breadth	B = 21.6 m
Height	H = 13.0 m
Full draft	D = 9.5 m

Berth

Unit length	185 m
Depth alongside	-10.0 m

ii) When the vessel is of 30,000 DWT

Size of vessel

Length	L =	215 m
Breadth	B =	26.5 m
Height	H =	16.7 m
Full draft	D =	11.2 m

Berth

Unit length	240 m
Depth alongside	-12.0 m

(3) Structure of quaywall

Based upon design conditions stated above, the preliminary design was prepared of the quaywall. Although the sheet pile type, gravity type, relieving platform type, etc. are conceivable for the type of the quaywall, the relieving platform type was adopted considering the topography and soil conditions of the site and the easiness of construction works.

Design work of the selected type consisted primarily of the decision on the shape and size of piers comprising main members, with the shape of their coping determined according to our experiences of similar structures in the past.

The basic concept used in the design calculation was to have the impact and traction of the vessels, lateral force working on rails when the loader is in operation and all other lateral loads including soil pressure from behind supported by coupled piles and to have the vertical loads, such as dead load, surcharge and weight of loaders supported by vertical and coupled piles.

As a counter-measure to corrosion of steel pipe piles used for the piers, the thickness of the pipe was increased in an amount commensurate with the planned service period. For the section above M.L.W.S. level, the concrete lining will be done for the additional precaution. (See Fig. 3-10. Berth Structure at Site 'e', 500,000 t/yr. and Fig. 3-11. Berth Structure at Site "e", 1,000,000 t/yr.)

(4) Construction method and program

i) Construction method

Unlike general civil works, the majority of harbor works are carried out at sea and under water. For that reason, the main stay of construction machinery to be mobilised to the site will comprise various floating plant, such as dredgers, floating pile drivers, tug boats, pontoons, diving boats and floating concrete mixers. Very little of this equipment is available at the site

Figure 3-10 Berth Structure at Site 'c', 500,000 t/yr.

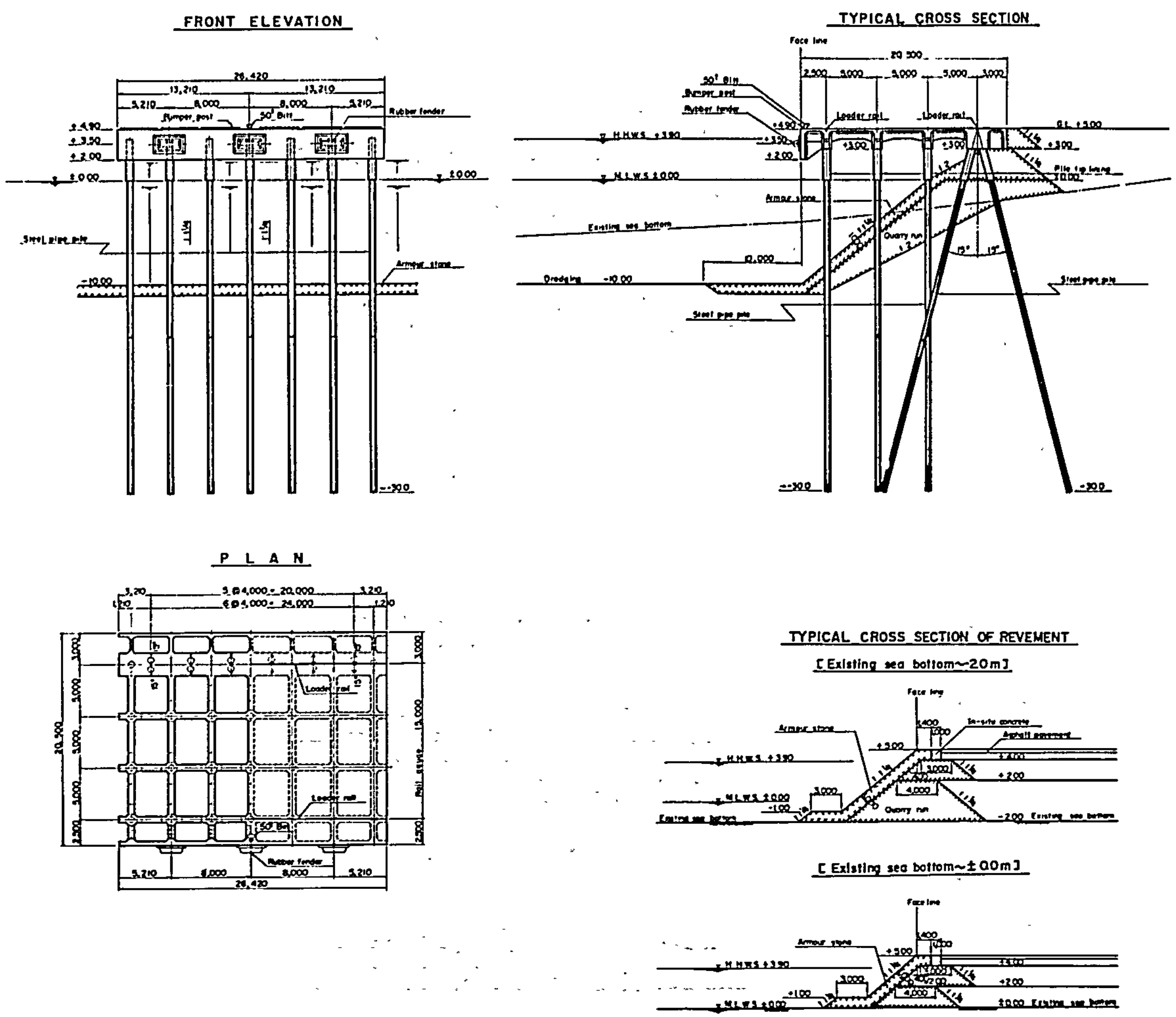
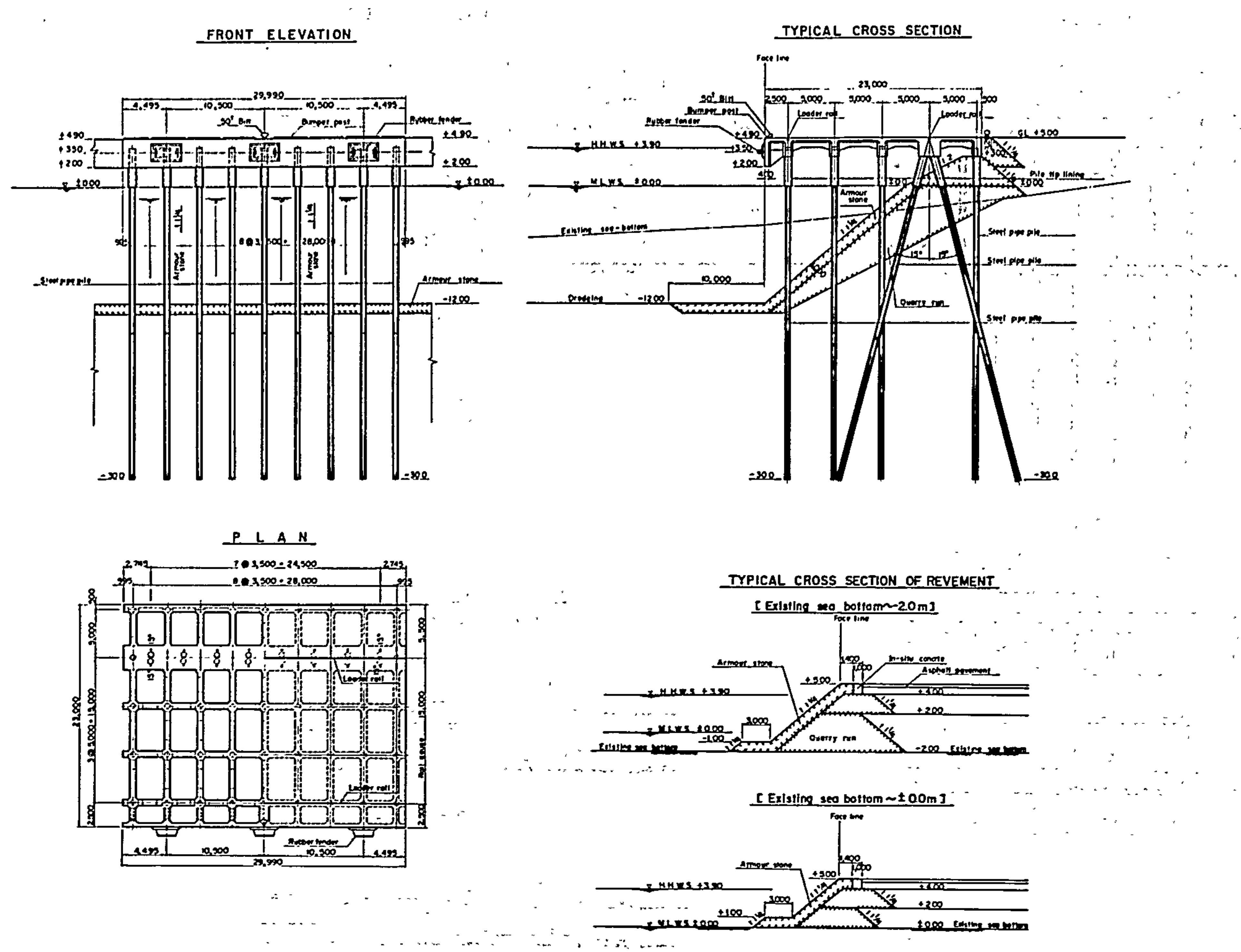


Figure 3-11 Berth Structure at Site 'e', 1,000,000 t/yr.



so that all these crafts will have to be towed from abroad. Similarly, the crews to operate these crafts will have to be experienced expatriate personnel.

In both cases of production scale of 500,000 t/yr. and 1,000,000 t/yr., the dredging operations at the site 'e' will be performed by use of suction hopper dredgers. Assuming that the dredged materials will be mostly silt and clay unsuitable for reclamation works, an area north of the Tanga Island was chosen as its dumping site. Discharge pipes will have to be extended from the dredgers to the dumping site. Part of the pipes will be laid on seabed in order not to disturb cargo handling operations at the lighterage wharf.

Steel pipe piles for the pier of the relieving platform will be sunk by a floating pile driver equipped with a large capacity hammer.

For the concrete capping, shored frameworks shall first be erected, reinforcing bars be assembled in them, then freshly mixed concrete will be poured from the floating mixer.

The underwater slope below the relieving platform will be covered by rubble for their protection. The rubble stones will be obtained from a quarry about 10 km west of Tanga.

The revetment will be built by a method similar to that used for the under water slope of the platform.

As for the reclamation works, the existing shore slope will be excavated by power shovels, then levelled by bulldozers and if more materials are needed, the quarry run will be hauled by tipping lorries.

Foundation piles of silos and beltconveyors will be driven by driving equipment on shore. The foundation concrete of the silo will be placed by use of the floating concrete mixer.

The engineering consultants in charge of investigations and design will have to be engaged to supervise the works throughout its entire period.

ii) Construction program

A study of execution program of respective work has revealed that both plans of soda ash production of 500,000 t/yr. and 1,000,000 t/yr. would take a total of five years before they are completed; a year for investigations, another year for design and award of contractors and three years for works execution. (See Fig. 3-12. Construction Programme at Site 'e', 500,000 t/yr. and Fig. 3-13. Construction Programme at Site 'e', 1,000,000 t/yr.)

(5) Cost estimate

In principle, the cost estimate should be made after completion of a design structurally suitable for soil conditions of load supporting layers of the selected site, using unit prices reflecting price level at the time of tendering and also taking into account recent cases of execution of similar nature.

The estimated costs now being submitted are based on the quantity obtained from the preliminary design which is prepared on soil conditions assumed from data of the existing lighterage wharf, multiplying unit prices prevailing at February 1976. Therefore, the costs should be re-examined and revised according to the results of soil investigations to be performed during the preliminary and detailed designs.

Of the materials to be imported for the works, those which may be used by other projects, such as reinforcing bars and guard rails, were assumed to bear 30% of CIF Tanga price as tax and items other than those to be exempt of taxation. It is also assumed that all the floating plant and construction machinery brought into Tanga for the purpose of works execution will be free of taxation.

Estimated construction costs by production scale and type of works are as shown in Table 11 below:

Table 3-11 Estimated Construction Costs at Site c

Unit: Tanzanian Shillings

Type of Works	Production Scale	
	500,000 t/yr.	1,000,000 t/yr.
Preliminaries	4,375,000	4,375,000
Quay Wall	20,628,600	31,068,700
-2 m Revetment	2,182,500	1,746,000
-0 m Revetment	4,648,000	4,564,000
Dredging		52,977,330
Excavation	958,500	958,500
Reclamation	8,108,100	8,316,000
Paving of Open Storage	338,916	364,490
Silo	156,698,600	200,564,500
Office, silo	1,224,405	1,477,060
Staff Quarters, silo	10,106,200	10,106,200
Railway Sidings	4,665,240	4,665,240
Sub-total	213,934,061	321,183,020
Investigations	4,720,000	4,720,000
Design	8,176,000	9,273,100
Supervision	8,508,000	8,508,000
Sub-total	21,404,000	22,501,100
Total	235,338,061	343,684,120
Contingency	23,533,939	34,368,880
Grand Total	258,872,000	378,053,000

Figure 3-12 Construction Programme for Site 'e', 500,000 t/yr.

Type of works	Description	Quantity
Preparatory works	Preparatory works Complete	1 lot
-10 m quay wall	Removal of existing foundation	32,200 m^3
	Driving of vertical steel pipe pile	161 Nos.
	Driving of battere steel pipe pile	84 Nos.
	Dumping of quarry run	16,471 m^3
	Rough leveling of quarry run mound	3,255 m^2
	Covering by armour stone	10,766 m^3
	Leveling of armour stone	6,069 m^2
	Concrete lining of pile tip	245 Nos
	Timbering	21,032^5 m^3
	Concrete capping	2,985^5 m^3
	Steel reinforcement	328^4 t
	Stone backfill	1,085 m^3
	50 ton bitt	7 Nos.
	Metal fixture of bumper post	42 Nos.
	Loader rail	369.^{9} m
	Rubber fender	21 Nos.
-2 m revetment	Dumping of quarry run	15,275 m^3
	Rough leveling of quarry run mound	3,150 m^2
	Covering by armour stone	4,400 m^3
	Leveling of armour stone	3,900 m^2
	In-situ concrete	250 m^3
±0 m revetment	Dumping of quarry run	25,896 m^3
	Rough leveling of quarry run mound	7,802 m^2
	Covering by armour stone	11,371 m^3
	Leveling of armour stone	10.292 m^2
	In-situ concrete	830 m^3
Dredging to -10 m	By suction hopper dredger	632,300 m^3
Excavation	Excavation	67,500 m^3
Reclamation	Reclamation	131,600 m^3
	Reclamation	79,000 m^3
Paving of open storage	Paving of open storage	16,532^5 m^2
Foundation work of silo	Driving of steel pipe pile	1,244 Nos.
	Placing of cobblestone	3,920 m^3
	Concreting	15,385 m^3
	Steel reinforcement	1,077 t
Building foundation	Driving of steel pipe pile	9 Nos.
Belt conveyor	Driving of H pile	34 Nos.
Silo & related Facilities	Silo & related facilities	1 lot
	Office	315 m^2
	Staff's quarters	2,600 m^2
Railway siding	Railway siding	1 lot
Construction supervision	Construction supervision	3 yr.

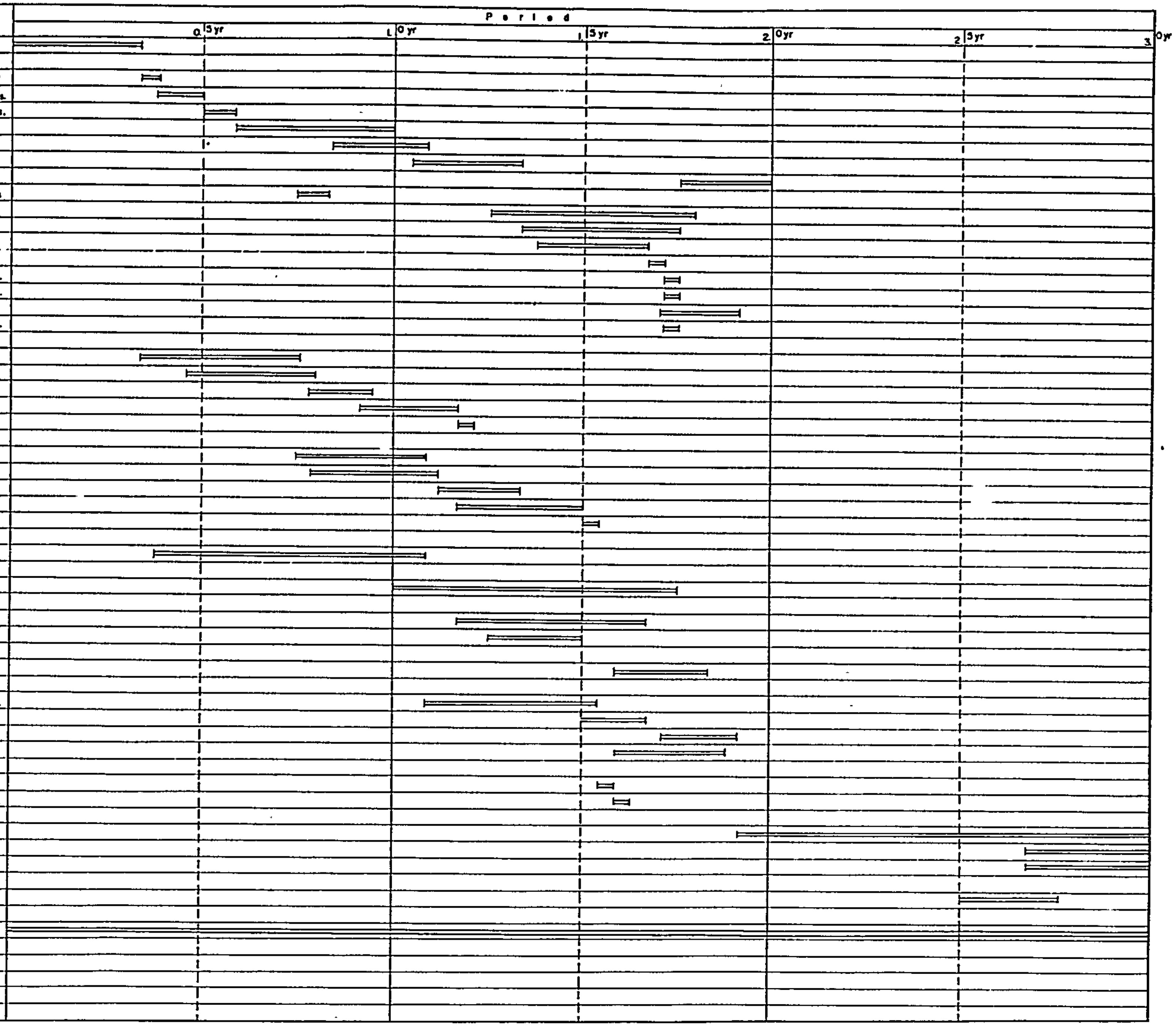
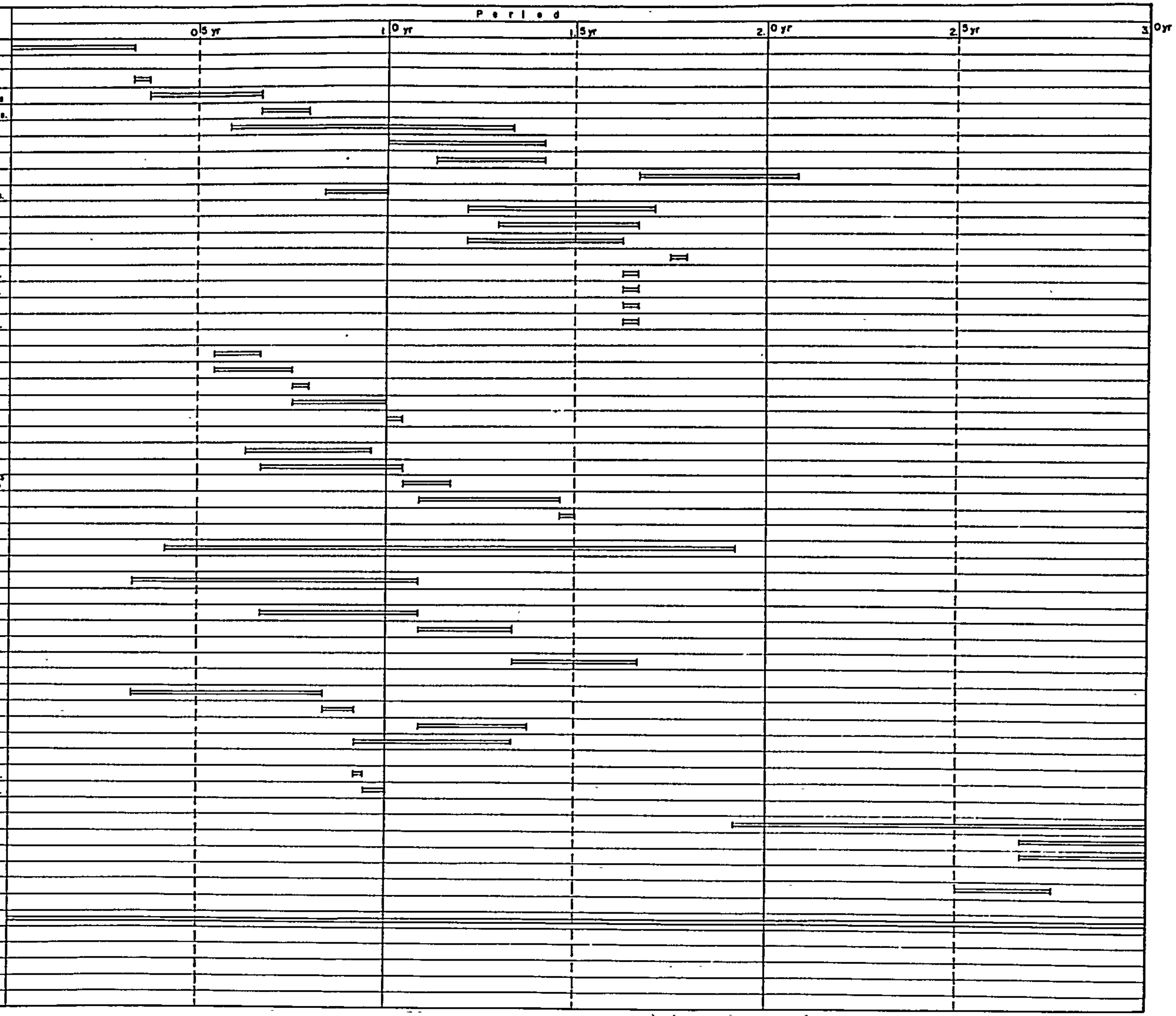


Figure 3-13 Construction Programme for Site 'c', 1,000,000 t/yr.

Type of works	Description	Quantity
Preparatory works	Preparatory works complete	1 lot
-12 m quay wall	Removal of existing foundation	62,720 m^3
	Driving of vertical steel pipe pile	304 Nos
	Driving of battere steel pipe pile	128 Nos.
	Dumping of quarry run	26,296 m^3
	Rough leveling of quarry run mound	4,992 m^2
	Covering by armour stone	14,584 m^3
	Leveling of armour stone	8,016 m^2
	Concrete lining of pile tip	432 Nos.
	Timbering	30,250 m^3
	Concrete capping	4,483 m^3
	Steel reinforcement	493 t
	Stone backfill	2,496 m^3
	50 ton bitt	8 Nos.
	Metal fixture of bumper post	64 Nos.
	Loader rail	480 m
	Rubber fender	24 Nos.
-2 m revetment	Dumping of quarry run	12,220 m^3
	Rough leveling of quarry run mound	2,520 m^2
	Covering by armour stone	3,520 m^3
	Leveling of armour stone	3,120 m^2
	In-situ concrete	200 m^3
±0m revetment	Dumping of quarry run	25,428 m^3
	Rough leveling of quarry run mound	7,661 m^2
	Covering by armour stone	11,165.5 m^3
	Leveling of armour stone	10,106 m^2
	In-situ concrete	815 m^3
Dredging to -12m	By suction hopper dredger	2,068,000 m^3
Excavation	Excavation	67,500 m^3
Reclamation	Reclamation	137,000 m^3
	Reclamation	79,000 m^3
Paving of open storage	Paving of open storage	17,780 m^2
Foundation work of silo	Driving of steel pipe pile	1,244 Nos.
	Placing of cobblestone	3,970 m^3
	Concreting	20,905 m^3
	Steel reinforcement	1,463 t
Building foundation	Driving of steel pipe pile	9 Nos.
Belt conveyor	Driving of H pile	34 Nos.
Silo & related Facilities	Silo & related facilites	1 lot
	Office	380 m^2
	Staff's quarters	2,600 m^2
Railway siding	Railway siding	1 lot
Construction supervision	Construction supervision	3 yr.



The reason for excluding dredging costs from the production scale 500,000 t/yr. is that to handle general cargoes increasing in future any port equivalent in size to the present Tanga Port, whichever that may be, would have to have channels and berths of 10 m and thus they should be incurred by public funds. Following the same idea, the dredging cost to 10 m are excluded from the case of production scale 1,000,000 t/yr. and only the discrepancy between 10 m and 12 m is included in the cost.

3-4-4 Facility plan for the Tanga Port Outer Harbor Site (site 'f')

(1) Layout plan of port facilities

This site is located on the coast of Tanga Port's outer harbor. It is planned to construct port facilities at the south side of the existing multipurpose jetty, to handle 1,000,000 t/yr. of soda ash.

To accommodate 30,000 DWT carriers, the facilities will primarily consist of a main pier, gangways and access road and be supplemented by reclamation works, silos, open storage and railway sidings.

A new land lot will be created by excavating part of the shoreline and tipping resultant materials into adjoining waters. Silos and related facilities will be built in a way similar to that adopted at the other site. The railway sidings to the silo will be branched out from the sidings to the existing fertilizer plant, with storage tracks installed in the vicinity of the junction point.

To berth and unberth safely a fully laden 30,000 DWT vessel drawing waters of 11.2 m, a necessary minimal area will be dredged to 12 m depth (See Fig. 3-14. Plan for Site 'f', 1,000,000 t/yr.)

(2) Design conditions

Design conditions for the Site 'f' are similar to those used for Site 'e', except for soil conditions, which were assumed as follows from data obtained during preliminary investigations for the existing multi-purpose jetty.

S.B. to -17.0 m	Clay layer	N = 0 – 1	C = 2.0 t/m^2	γ' = 0.5 t/m^3
-17.0 m to -22.0 m	Sand layer	N = 5	ϕ = 25°	γ' = 0.8 t/m^3
-22.0 m to -32.0 m	Hard clay layer	N = 5 – 10	C = 10.0 t/m^2	γ' = 0.8 t/m^3
below -32.0 m	Sand layer	N = 25	ϕ = 35°	γ' = 1.0 t/m^3

(3) Structure of major facilities

Based on the design conditions mentioned above, preliminary designs were prepared of the main pier, gangways and ship mooring dolphins which comprise major facilities.

As for the structural type, the jetty type similar to the existing multi-purpose jetty was adopted, being considered to be best suited for the purpose.

The basic concept for the preliminary design is identical to that adopted for Site 'e'. (See Fig. 3-15. Berth Structure at Site 'f', 1,000,000 t/yr.)

(4) Construction method and program

i) Construction method

The fundamentals of construction method, are different from what has been described in Paragraph 4-3-4, i) above.

As the dredging requirements are smaller than at Site 'e', the operation will be performed by the combined use of a grab type dredger and self-propelled hopper barges. The grab type dredger can be converted to the floating crane by replacing certain attachments. Dredged materials will be dumped at the area north of Tanga Island.

ii) Construction program

A study of execution program of respective work revealed that it would take a total of five years; a year for investigations, another year for design and award of contracts and three years for execution of works. (See Fig. 3-16. Construction Program at Site 'f', 1,000,000 t/yr.)

(5) Cost estimate

Employing the method similar to that described in Paragraph 3-4-5 for Site 'e', the construction costs at Site 'f' were estimated. Shown below are breakdown of the costs by types of works.

Figure 3-14 Plan for Site 'f', 1,000,000 t/yr.

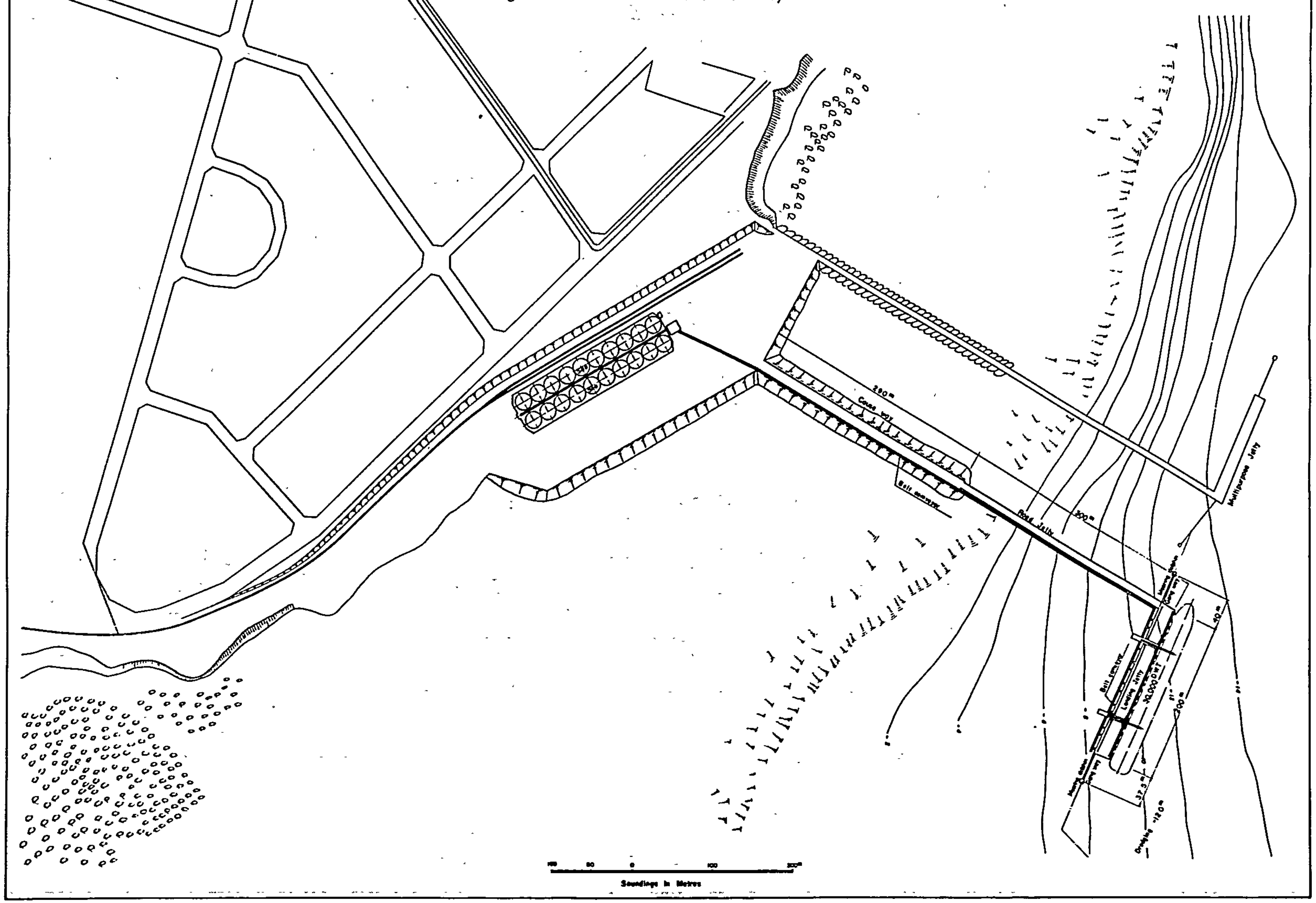


Figure 3-15 Berth Structure at Site "f", 1,000,000 t/yr.

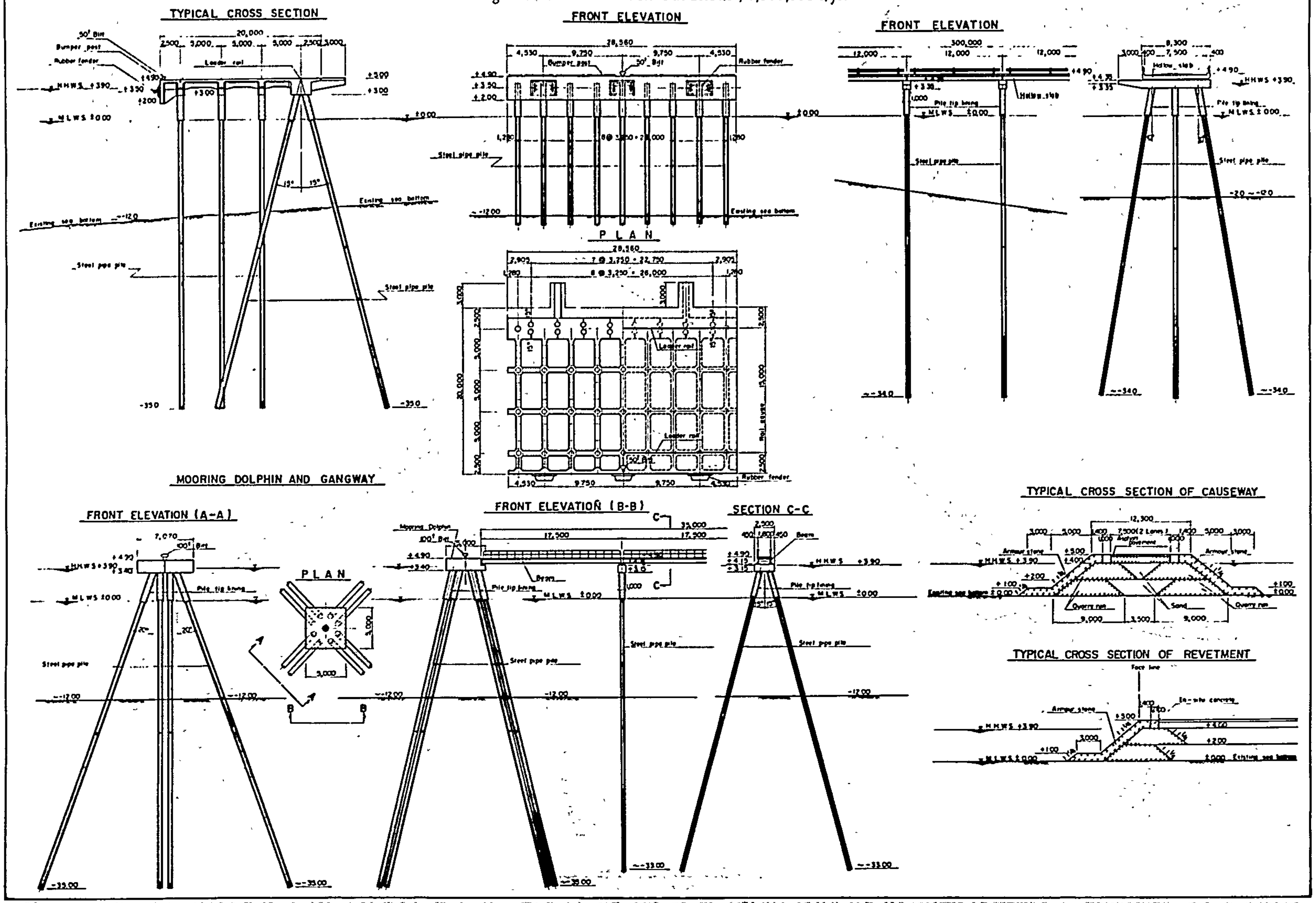


Figure 3-16 Construction Programme for Site 'f', 1,000,000 t/yr.

Type of works	Description	Quantity
		1 lot
Preparatory works	Preparatory works complete	
Landing jetty	Driving, vertical steel pipe pile	203 Nos
	Driving, batter steel pipe pile	112 Nos.
	Pile tip lining	315 Nos.
	Timbeing	21,775 6 m^3
	Capping concrete	3,314 2 m^3
	Reinforcement	364 6 t
	Bitt, 50 tons	7 Nos
	Bumper post	56 Nos.
	Ladder rail	399 8 m
	Rubber fender	21 Nos.
Road jetty	Driving, vertical steel pipe pile	26 Nos.
	Driving, batter steel pipe pile	52 Nos
	Pile tip lining	78 Nos.
	Timbering	3,630 9 m^3
	Capping concrete	195 m^3
	Reinforcement	195 t
	Hollow slab	300 Nos
	Concrete, filling	271 m^3
	Concrete, foot transverse members	75 m^3
	Concrete, pavement	197 m^3
	Guard rail	600 m
Mooring dolphin	Steel pipe pile	16 Nos
	Pile tip lining	16 Nos
	Timbering	480 m^2
	Capping concrete	75 m^3
	Reinforcement	75 t
	Bitt, 100 tons	2 Nos
Pier for gangway	Steel pipe pile	4 Nos
	Pile tip lining	4 Nos.
	Timbering	25 6 m^3
	Concrete	10 m^3
	Reinforcement	1 t
Gangway	Construction and erection	1 lot
Cause way	Quarry run	18,096 m^3
	Leveling, quarry run	5,452 m^2
	Armour stone	7,946 m^3
	Leveling, armour stone	7,192 m^2
	Banking	6,766 m^3
	Gravel, subbase	2,610 m^3
	Concrete, in-site	580 m^3
	Asphalt pavement	2 175 m^2
	Guard rail	580 m
Revetment, ± 0 m	Quarry run	15,912 m^3
	Leveling, quarry run	4,794 m^2
	Armour stone	6,987 m^3
	Leveling, armour stone	6,324 m^3
	Concrete, in-situ	510 m^2
Dredging, -12 m	Grab dredger	92,400 m^3
Excavation	Excavation	114,600 m^3
Reclamation	Reclamation	11,000 m^3
Paving, open storage	Paving, open storage	43,175 m^2
Foundation, silo	Steel pipe pile	1,244 Nos.
	Placing of cobblestone	3,970 m^3
	Concrete	20,905 m^3
	Reinforcement	1,463 4 t
Foundation, building	Steel pipe pile	9 Nos.
	Steel member, H shaped	34 Nos
Site equipment	Site equipment	1 lot
	Office	480 m^2
	Staff quarters	2,600 m^2
	Railway siding	1 lot
Construction supervision	Construction supervision	3 yr

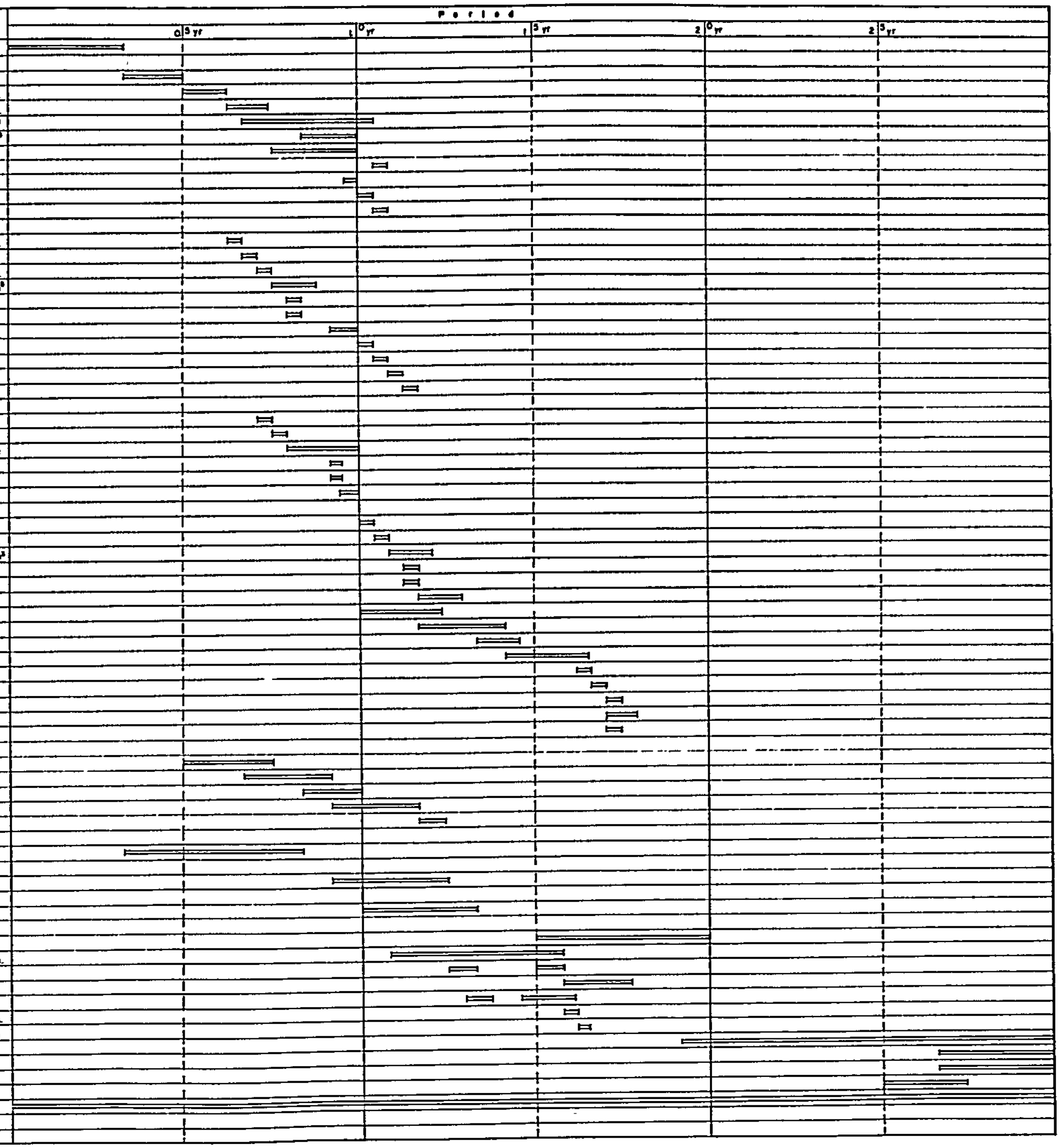


Table 3-12 Estimated Construction Costs at Site 'f'

Unit: Tanzanian Shillings

Type of Works	Amount
Preliminaries	4,375,000
Landing Jetty	19,031,200
Road Jetty	7,100,000
Mooring Dolphins	794,000
Pedestrian Bridge	436,900
Causeway	3,992,300
-0 m Revetment	2,856,000
Dredging	6,163,000
Excavation	1,627,320
Reclamation	423,500
Paving of Open Storage	885,087
Silo	200,546,500
Office, Silo	1,477,060
Staff Quarters, Silo	10,106,200
Railway Sidings	5,075,470
Sub-total	264,907,537
Investigations	3,428,500
Design	9,273,100
Supervision	8,508,000
Sub-total	21,209,600
Total	286,117,137
Contingency	28,611,863
Grand Total	314,729,000

3-4-5 Operation and maintenance costs of alternative plan

Each alternative plan includes following costs for the maintenance of respective facilities:

Quaywall and revetment	0.2% of construction cost, per year
Paving of open storage	5.0% of construction cost, per year
Silo and railway sidings	3.0% of construction cost, per year

The costs of personnel assigned for the operation and maintenance of silo and related facilities and the power rate of the silo are incorporated in the estimate as the costs of operation. The foregoings are shown in the following table.

Table 3-13 Operation and Maintenance Costs of Alternative Plans

Unit: Tanzanian Shillings

Operations and Maintenance Costs	Alternative Plan		
	Site 'e'		Site 'f'
	500,000 t/yr.	1,000,000 t/yr.	
First 2 years	7,386,000	3,960,200	8,992,200
After 3rd year	4,452,000	6,026,200	6,058,200

The operation costs of the railway sidings are excluded as they will be covered in the report of the Railway Sector. Costs and charges levied to incoming vessels, such as pilotage, docking charge, tonnage dues and dues for various port services are also excluded from the operation costs as they should be covered by the ship's freight rate.

3-4-6 Distribution of financial costs by year

The distribution of financial costs of each alternative based upon respective construction program is as shown in Table 14 below.

Table 3-14 Distribution of Financial Costs by Year

Unit: Tanzanian Shillings

Year	Alternative Plan		
	Site 'e'		Site 'f'
	500,000 t/yr.	1,000,000 t/yr.	
1	5,192,003	5,192,006	3,771,352
2	8,993,605	10,200,423	10,200,415
3	25,445,943	92,264,815	45,440,588
4	84,624,345	97,135,560	81,778,310
5	134,616,104	173,260,196	173,538,335
6	7,386,000	8,960,200	8,992,200
7	7,386,000	8,960,200	8,992,200
8	4,452,000	6,026,200	6,058,200
9	4,452,000	6,026,200	6,058,200
10			
11			
12	Ditto	Ditto	Ditto

3-4-7 Economic costs and their distribution by year

The approximate costs of construction, operation and maintenance described in Paragraphs 4-3-5, 4-4-5 and 4-5 are financial costs of the project.

The economic costs of the project were obtained, excluding tax on imports which was included in the process of calculation of the financial costs and using the shadow price and shadow wage as quoted below:

Foreign exchange portion	1.3
Local currency portion	1.0
Cement	1.16
Electricity	1.19
Skilled labor	1.0
Unskilled labor	0.75
Expatriate personnel	0.70

Similarly to the annual distribution of financial costs, the distribution of economic costs by year are shown in Table 15.

Table 3-15 Distribution of Economic Costs by Year

Unit: U. S. Dollars

Year	Alternative Plan		
	Site 'e'		Site 'f'
	500,000 t/yr.	1,000,000 t/yr.	
1	595,401	595,401	432,487
2	1,102,514	1,250,678	1,250,678
3	2,833,420	10,816,722	5,235,557
4	9,559,781	10,871,332	9,142,522
5	15,476,457	20,077,142	20,124,020
6	758,753	940,696	943,707
7	758,753	940,696	943,707
8	506,753	688,696	691,707
9	506,753	688,696	691,707
10	↓	↓	↓
11			
12	Ditto	Ditto	Ditto
⟨	↓	↓	↓

3-5 Impacts of the Project on Tanga Port Area

For the production of 1,000,000 t/yr. of soda ash, approximately 200,000 t/yr. of crude oil will have to be supplied to the processing plant. Present import of petroleum being approximately 20,000 t/yr., the related facilities to be expanded to handle increasing amounts of crude oil in future. In the vicinity of Tanga, there are steel bar processing plants and they have plans to establish factories to manufacture cement and to process sisal. As the hinterland covers relatively densely populated areas, such as Arusha, Moshi and Lushto, the industrialization of these areas will be dependent on new construction of additional port facilities.

Both of the cases 2 and 3 are located close to residential areas and the coast of inner harbor is presently utilized for bathing resort and boarding area of yachts. Consequently, should port facilities and marshalling yard be constructed in the area, it will be necessary, on entering into the implementation stage, to adjust and modify the present plan of land/water area utilization with the project.

3-6 Terms of Reference for Feasibility Study

3-6-1 Object of study

The proposed feasibility study will establish the economic and technical viability of expanding the Tanga Port's loading facilities for soda ash shipments from the supply source on the east shore of the Natron Lake, and will prepare a layout plan of the required facilities and an estimate of the costs of construction and operation.

3-6-2 Details of study

To achieve the objects as defined in 6-1 above, the Consultant shall undertake the following investigations and studies:

(1) Collection and compilation of available data on weather and sea conditions

(a) Meteorological data

It is necessary to obtain the records of meteorological observations in the areas adjoining the port, including the Tanga Bay and Bempa Strait. The required observation records shall include the following:

i) Wind direction and velocity observed three to four times a day during the past year, in order to determine the frequency of wave occurrences in the proposed site for the construction of the required loading facilities.

ii) Annual maximum wind velocity, its direction and daily weather maps up to two days prior to the day of the maximum wind velocity.

These data must be extracted from the wind observation records for the last 10 years, in order to facilitate the determination of the design waves for rough weather which will vitally affect the structural designs.

iii) Monthly observation records of atmospheric temperature, humidity, rainfall and the number of rainy days per annum during the last 10 years.

(b) Data on sea conditions

It is necessary to obtain the records of tidal observations in the port in recent years, which will include the following:

i) Records of tidal observations made in the port continuously for a minimum period of three months, in order to establish the relationship among the working datum line, chart datum and bench mark.
A harmonic analysis of these records shall be effected to obtain harmonic constants, thereby determining the necessary tide levels.

ii) Where it is not practicable due to the lack of the necessary facilities to obtain observation records as specified in i) above, the Consultant shall install such facilities at an appropriate location in the site to get the required data. The automatic tide gauge to be employed for this purpose shall be Fuess type capable of one-month winding (manufactured by Kyowa Shoko K.K., Tokyo).

(2) Topographical survey and sounding at proposed site

(a) Topographical survey

The Consultant shall carry out a planimetric survey of the proposed site, including the shoreline and existing structures, to prepare a plan on 1/1,000 scale.

(b) Traverse survey

The Consultant shall carry out a traverse survey of the area indicated in Fig. 3-17, at a line interval of 20 m. The standard interval between survey points shall be 2 m, but in unforeseen differences in elevations, the survey shall be carried out accordingly.

(c) Sounding

The Consultant shall carry out a sounding of the area indicated in Fig. 3-17, at a line interval of 20 m using a survey boat equipped with an echo sounder.

Readings on the recording paper on the echo sounder shall be taken every 10 cm for each 20 m of sounding. In unexpected differences in depths, the readings shall be taken accordingly. The sounding results shall be presented on a 1/1,000 scale map.

(3) Soil investigation

(a) Core boring

Core borings shall be undertaken at the locations indicated in Fig. 3-17 to determine the foundation soil conditions for the major structures to be constructed.

For sandy soil, standard penetration tests shall be carried out every 2 m of boring to obtain N values. Soil specimens extracted shall be put to a mechanical analysis.

For silty or clayey soil, a thin-wall type sampler shall be used to obtain undisturbed specimens from each 2 m of boring. These specimens shall be put to uniaxial compression tests and consolidation tests to determine their mechanical properties. In addition, a series of physical tests shall be conducted to establish grain size distribution, plastic limit, liquid limit, natural water content and specific weight.

The primary object of these soil tests is to determine the mechanical properties of undisturbed specimens from silt or clay layers. It is imperative, therefore, to avoid disturbances to the specimens obtained.

(b) Jet boring

Jet borings shall be undertaken at the locations indicated in Fig. 3-17 to determine the properties of the material to be dredged, so that the selection of the optimal type of dredging equipment for construction purposes may be facilitated.

(4) Corrosion test

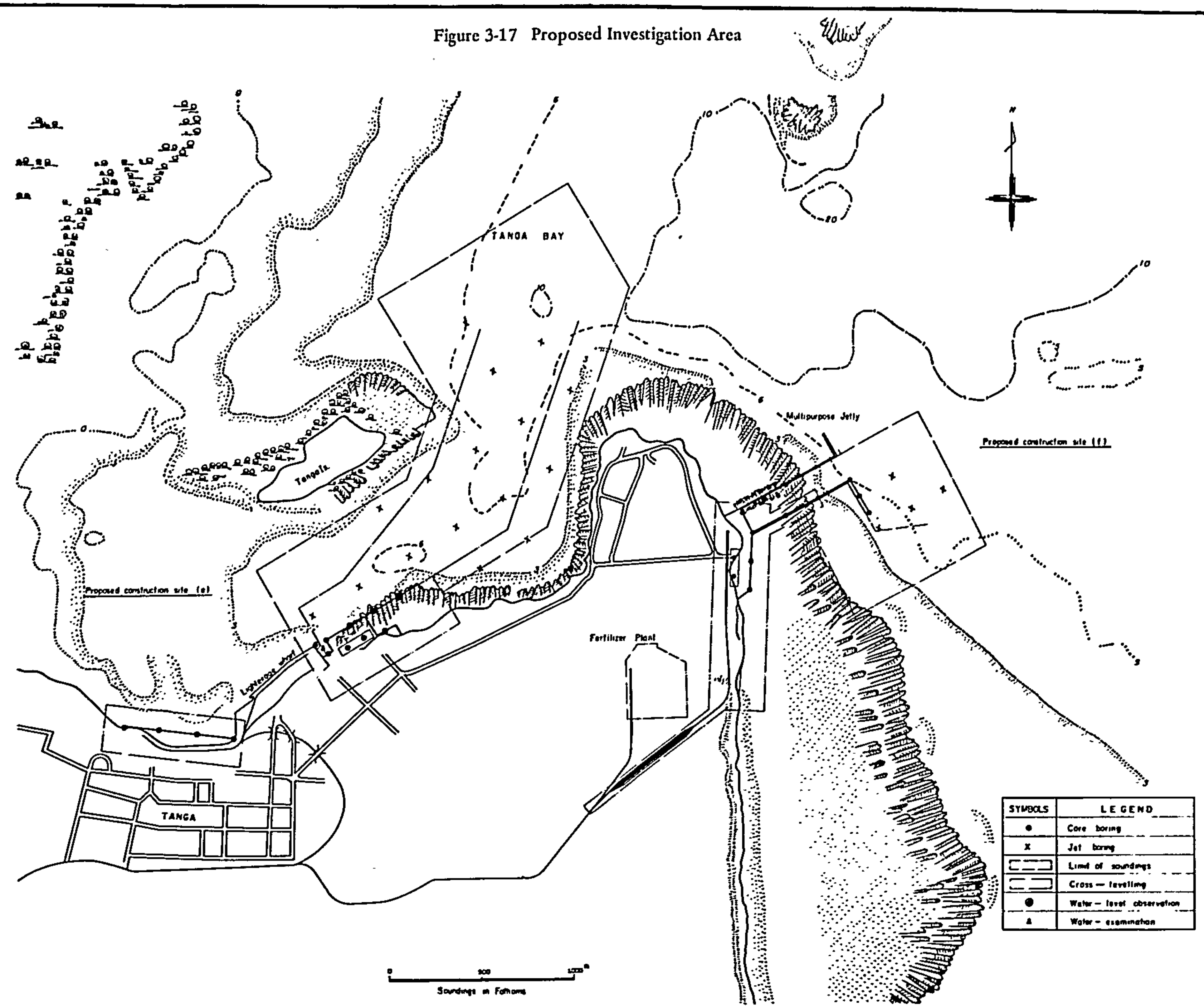
In a corrosion test to help determine the adequate type of steel members for the proposed port structures, a piece of steel, whose weight has been measured up to four places of decimals, shall be kept in the sea water for a period over three months. At the end of this period, the steel piece shall be taken ashore and derusted and the amount of corrosion shall be measured.

The data from this test will be helpful in selecting the optimal type of steel members for the proposed port structures.

(5) Cargo flow survey in Tanga Port's Hinterland

The Consultant shall undertake a survey of cargo movements in the hinterland of the Tanga Port, taking into consideration various industrial development projects proposed by the Tanzanian Government for the area. It is necessary to determine the share of soda ash shipments in the construction cost of the proposed loading facilities, based on the percentage of this cargo in the total annual volume of all cargoes to be handled by the port in future years.

Figure 3-17 Proposed Investigation Area



(6) Conditions for construction and structural design

(a) Conditions for construction

The Consultant shall investigate the types, prices, costs and places of origin of materials, equipment and labor force which can be procured locally for the construction works, so that these data may be utilized for preparing an estimate of the construction costs.

(b) Conditions for structural design

The Consultant shall obtain the design criteria established by the East African Harbor Corporation or their equivalent.

(7) Planning for loading facilities

The Consultant shall determine the optimal number of required berths by constructing a simulation model of shipping traffic in the port, based on the analysis of such factors as ship size and type (liner, tramp, etc.) disclosed by an operation survey on soda ash carriers to be undertaken taking into account the results of a pertinent market survey which has been conducted separately by a special Japanese team.

The Consultant shall also evaluate the optimal silo capacity and loader capacity required, on the basis of the deadweight capacity of incoming vessels and the volume of soda ash shipments transported by rail. The Consultant shall then proceed to prepare a plan for designing the necessary loading facilities which will satisfy all conditions stated above and will be technically feasible.

(8) Preliminary structural design

The Consultant shall prepare alternative designs of the proposed wharves and revetments, based on the soil, sea and loading conditions, evaluate the costs and period of construction works and select the optimal structural types from the standpoint of safety and economy.

(9) Evaluation of technical and economic justifications

The Consultant shall prepare an estimate of the costs of construction, maintenance and operation of the proposed loading facilities, in respect of the technically acceptable plans and shall also make a detailed evaluation of the financial and economic costs.

CHAPTER 4 RAILWAY TRANSPORTATION STUDY

4-1 Outline of Soda Ash Transportation Planning

4-1-1 Aim of planning

The aim of planning as considered in this chapter is to transport as far as Tanga Port soda ash extracted from Lake Natron in the train for soda ash 'more safely', 'less expensively' and 'more punctually'. For this purpose, an effective transport system, comprising of the most effective utilization of the existing Arusha-Tanga railway and construction of a railway line or a road between Arusha and Lake Natron is to be established.

The initial investment for the construction work and rolling stock for the railway is tremendous. Additional operation costs including traffic, maintenance and depreciation costs are a considerable amount. Accordingly, in cases where the amount transported is relatively small, these affect the transport costs seriously. On the contrary, in the case of transport of great quantities, less expensive rail transport is possible as compared with other forms of transport.

The production scales of 250,000, 500,000 and 1,000,000 t/yr., respectively, are taken as the alternative production scales of soda ash. In the cases of 500,000 and 1,000,000 t/yr. traffic, in addition to the new road plus the existing railway route, the combined transportation by both the new railway and the existing railway routes are taken into consideration. While the case of 250,000 t/yr. production is not taken up as the objective of the new railway construction after due consideration of the traffic capacity of soda ash. In this case, the full amount will be carried by the new road and the existing railway. In this way, the most effective transport route will be chosen among various alternatives thus far studied. The improvement of the existing railway in relation to the soda ash traffic to be added to the current tonnage is also studied.

The procedure of railway transport planning is indicated in Fig. 4-1. The technical and economic study of the new road construction is described in the following chapter.

4-1-2 Fundamental features of alternative plans

For the soda ash transport of the combinations of the routes indicated in Fig. 4-2 are to be studied. The decision whether the entire transport will be made by railway or a part thereof by road transport shall be decided after due consideration of the total sum of transport costs.

Figure 4-1 Procedure of Railway Transport Planning

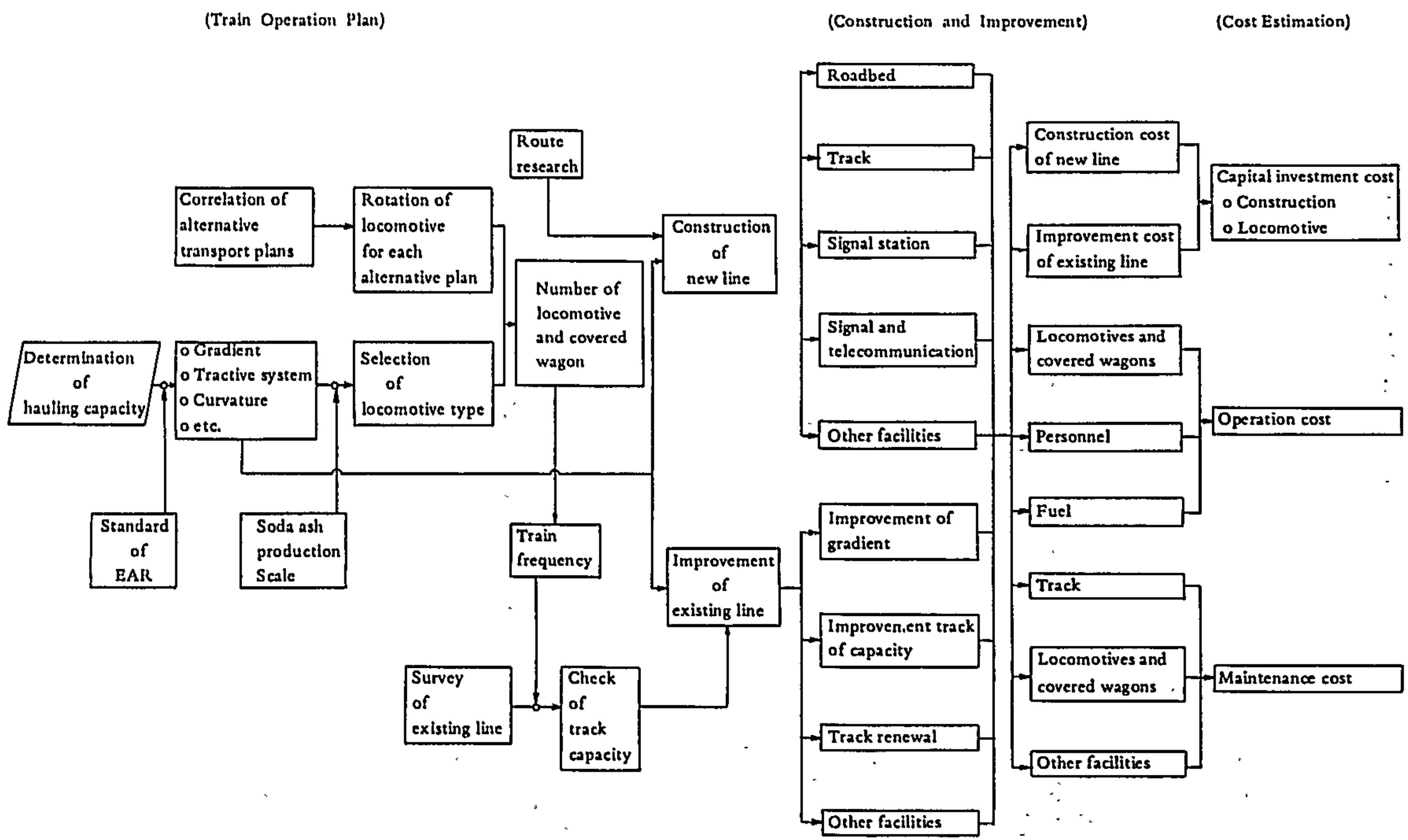
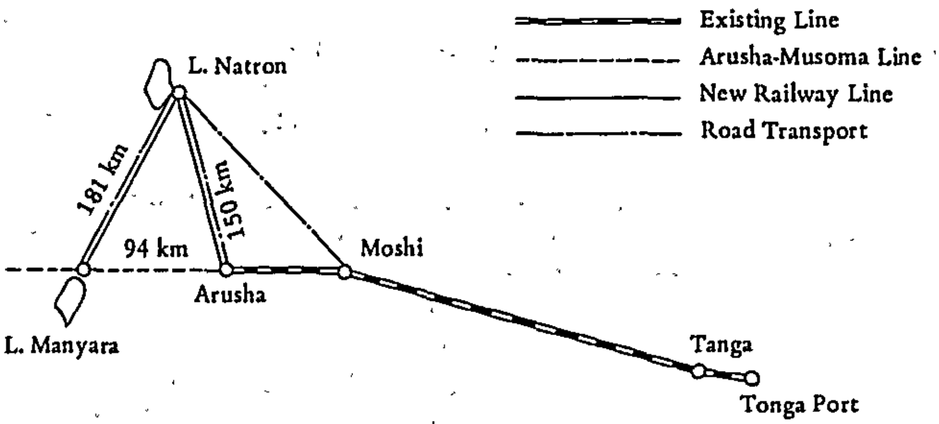


Figure 4-2 Schematic Route of Transporting Soda Ash



(1) *Route 1 (500,000 or 1,000,000 ton transport)*

L. Natron ---- Arusha ---- Tanga ---- Tanga Port

New Railway	Existing Railway	Littoral Railway	
(150 km)	(436 km)	(3 km)	(Total 589 km)

This route will transport soda ash by the train all the way, between Lake Natron and Tanga Port. In this case, a new line is to be constructed connecting Lake Natron and Arusha directly over the shortest distance in accordance with the various conditions of train operations. The existing lines will be utilized for the section between Arusha and Tanga. Since the increase of transport demand is for the primary products, the future growth in the traffic volume in general is like wise expected on the existing line. Studies shall be made on whether the line capacity is sufficient or not, in cases where the soda ash traffic is added to the increased traffic volume. If the rechecking of the capacity proves that it is insufficient, signal stations with crossing facilities will have to be added. The improvement will be made on the gradient sections of the existing line where the shortage of locomotive tractive force may be caused by operating the train carrying soda ash. The sections where the supporting power of track proves likely to be insufficient, will be strengthened.

It is assumed that in the section between Arusha and Moshi, the existing laterite roadbed will be replaced by crushed stone before the present project is commenced, based on the rehabilitation program of the East African Railway Corporation (EAR). In the current alignment, a train from Arusha to Tanga requires the switch-back operation at Moshi Station which is the starting point of the Arusha Branch Line. To make it more efficient, a short-cut line is to be installed so that the train for soda ash bypasses Moshi Station.

(2) Route 2 (500,000 or 1,000,000 ton transport)

L. Natron --- L. Manyara --- Arusha --- Tanga --- Tanga Port

New Railway	Planned Railway	Existing Railway	Littoral Railway	
(181 km)	(94 km)	(436 km)	(3 km)	(Total 714 km)

The train for soda ash will be operated over the entire length of the route as in the case of Route 1, but this route is proposed as an alternative plan in which the new line between Arusha and Lake Natron has a different alignment.

Because this route is about 1.8 times the length of Route 1 between Arusha and Lake Natron, higher costs are required for construction, rolling stock, train operation and maintenance. The realization of this alternative route is subject to the conditions that the EAR-planned Arusha–Musoma Line will already have been completed before the present project is initiated. When soda ash is to be transported, the train can be operated on the Lake Manyara–Arusha section of the Arusha–Musoma Line without involving additional construction costs.

The same degree of improvement is required for the existing line between Arusha and Tanga.

(3) Route 3 (250,000, 500,000 and 1,000,000 ton transport)

L. Natron --- L. Manyara --- Arusha --- Tanga --- Tanga Port

Road	Planned Railway	Existing Railway	Littoral Railway
	(94 km)	(436 km)	(3 km)

(Total length of Railway: 533 km)

This route is a system for the transport for soda ash between Lake Manyara and Tanga. It is assumed that the section between Lake Manyara and Arusha can be utilized for the Arusha–Musome Line as in Route 2. The partial improvement on existing line between Arusha and Tanga is the same as in Route 1. In order to load soda ash, it shall be necessary to provide the industrial sidings with loading facilities at Lake Manyara Station.

(4) Route 4 (250,000, 500,000 and 1,000,000 ton transport)

L. Natron --- Arusha --- Tanga --- Tanga Port

Road	Existing Railway	Littoral Railway	
	(436 km)	(3 km)	(Total length of Railway: 439 km)

In case of this route, the existing railway between Arusha and Tanga is utilized for transport of soda ash by the train. The new industrial sidings and loading facilities will be newly provided at Arusha. Besides, the partial improvement on the existing line will be the same as in Route 1.

(5) Route 5 (250,000, 500,000 and 1,000,000 ton transport)

L. Natron ––– Moshi ––– Tanga ––– Tanga Port

Road	Existing Railway (351 km)	Littoral Railway (3 km)	(Total length of Railway: 354 km)

In this plan the section between Moshi and Tanga of the existing railway is used for transporting soda ash by the train. In this case the section mentioned above will be partially improved. The improvement items are the same as in the case of Route 1. In regard to soda ash loading, the industrial sidings with loading facilities will be newly installed at the Arusha side of Moshi Station. The facilities will be entirely the same as the case of those planned at Lake Manyara *or Arusha Station.*

4-2 Current Situation of Railway Transport

4-2-1 *General description*

The EAR is endeavoring to implement the 1973/76 Investment Program aiming at increasing rail's competitiveness with road traffic, including transport efficiency and stable financial status. For these purposes, the EAR's program consists of (1) improvement of track, *(2) rehabilitation of rolling stock, (3) dieselization*, and (4) training of employees. Current conditions of railway traffic is shown in Fig. 4-3.

4-2-2 Transport situation on the Tanga Line

The *passenger and goods traffic volume* on the Tanga Line in recent years is as shown in Table 4-1, where the overall traffic amount shows a rather constant tendency. But, the fact that such tendency exists in railway transport, as compared with that of road transport, is ascribed to the low-grade transport service resulting from antiquated facilities, superannuated vehicles as well as the increase of number of idle vehicles caused by the shortage of repair parts, etc.

The tonnage of goods transport passing between major stations in 1973 is graphically shown in Fig. 4-4.

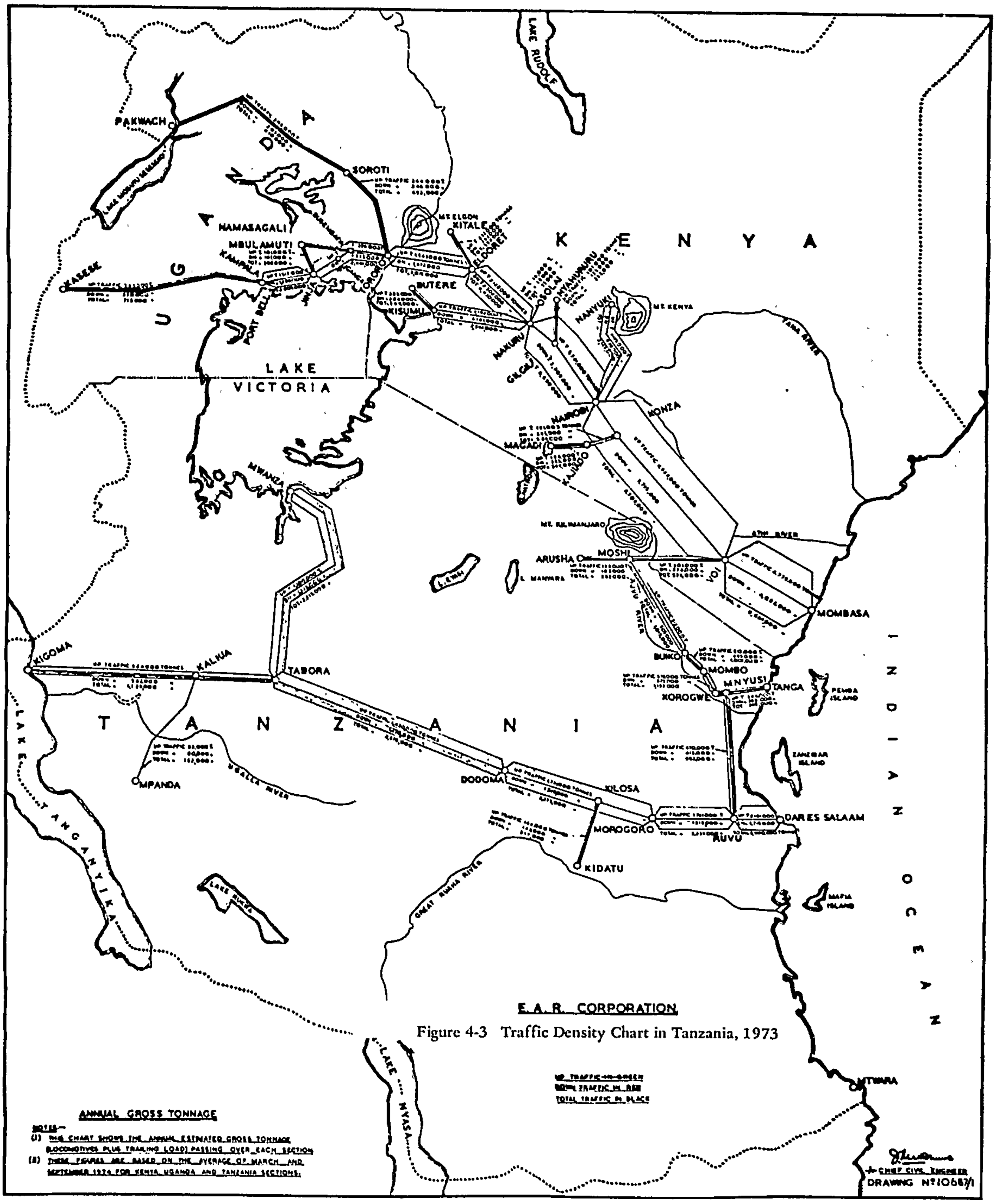


Figure 4-3 Traffic Density Chart in Tanzania, 1973

Figure 4-4 Tonnage between Major Stations

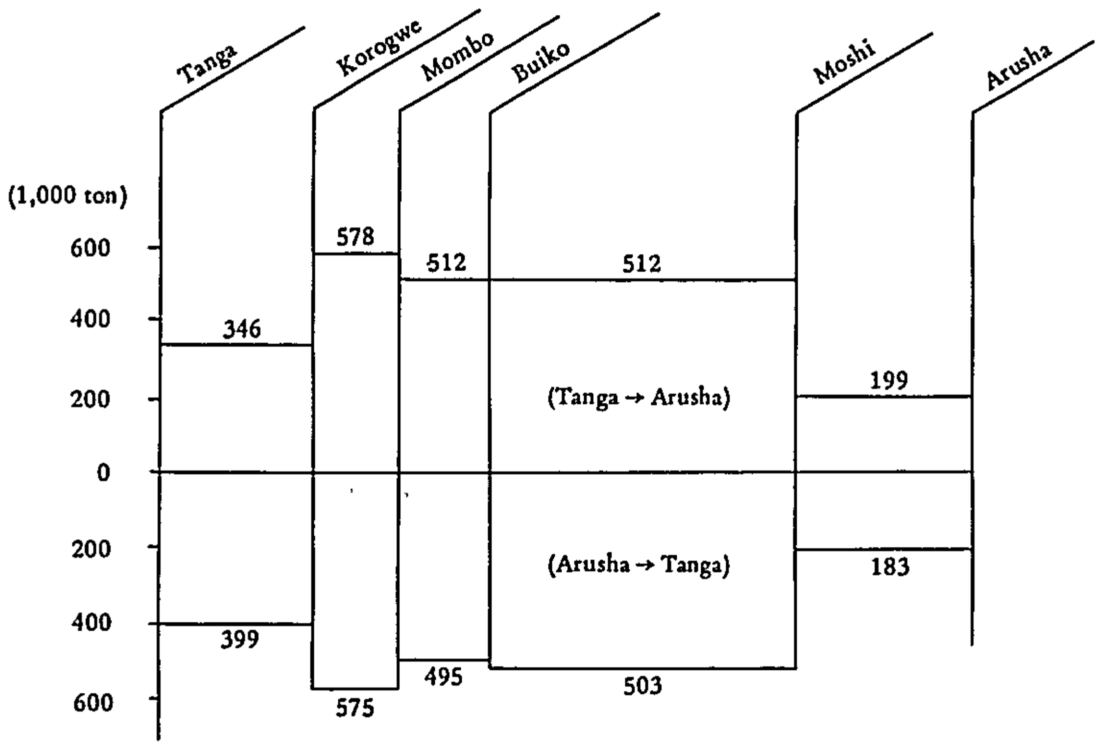


Table 4-1 Traffic Volume Over Tanga Line

Year	Goods (ton)		Total	Passenger (Person)	Passenger (Bus)
	Tanga-Arusha	Arusha-Tanga			
1970	306,547	292,608	599,155	448,381	5,380
1971	350,892	284,115	635,007 (+6)	485,440 (+8)	9,170 (+70)
1972	309,181	302,666	611,847 (-4)	548,720 (+13)	10,622 (+16)
1973	352,044	262,880	614,924 (+1)	614,637 (+12)	16,829 (+58)
1974	250,586	261,056	511,642 (-20)	521,846 (-18)	23,014 (+37)

Note: Figures in parenthesis denote percentage of increase or decrease as compared with the previous year.

The traffic tonnage of major commodities is as shown in the following Table:

Unit: ton

	1970	1971	1972	1973	1974
Coffee	28,464	25,779	39,362	44,554	24,394
Sugar	33,834	29,580	31,938	33,546	22,582
Fertilizer	-	9,586	24,923	35,308	24,959
Timber	8,142	7,911	7,963	9,093	12,385
Sisal	38,890	35,113	26,556	17,828	20,292

4-2-3 Future traffic demand on Tanga Line

It is rather difficult to estimate the future railway traffic volume on Tanga Line as the lowering of transport service in regard to present traffic demand as well as the fact that the major items of the goods transport are the primary products which are susceptible to weather conditions. Provided that the 1973/76 Investment Program and the following railway improvement planning are completely enforced, the tonnage between the major stations given in Table 4-2 is expected.

Table 4-2 Estimated Future Goods Traffic Volume

Unit: ton

	Tanga-Korogwe	Korogwe-Mombo	Mombo-Buiko	Buiko-Moshi	Moshi-Arusha
1974	745,000	1,153,000	1,007,000	1,015,000	382,000
1980	767,000	1,188,000	1,037,000	1,045,000	393,000
1985	790,000	1,223,000	1,068,000	1,078,000	405,000
1990	814,000	1,260,000	1,100,000	1,109,000	417,000

4-3 Train Operation Plan

4-3-1 Type of locomotive and goods wagons

The EAR is promoting dieselization as part of its efforts to improve transport services. The Class 90 diesel locomotive, which is being used in increasing number as the result of the dieselization project, is to be adopted for the locomotives for the trains for soda ash. The principle dimensions of this locomotive are as follows:

Type Class 90

Gauge	1,000	mm
Axle arrangement	1 Co – Co 1	
Length between couplings	16,948	mm
Tare weight	95.9	tons
Weight in working order	101.425	tons
Maximum axle load	13.475	tons
Engine Output	1,840	HP
Rotation	850	rpm
Transmission system	Electric	
Maximum speed	72	km/h
Fuel tank capacity	36,300	max.

The goods wagon for transporting soda ash is the covered wagon as shown in Fig. 4-5. It is a special wagon which is perfectly sealed during transportation of soda ash. The principal dimensions are as follows:

Tare weight	20 tons
Load capacity	30 tons

4-3-2 Study on tractive load of locomotives

According to the EAR's 'Standard Locomotive Load Table', the relationship between gradient and possible tractive load of the Class 90 diesel-electric locomotive is as follows:

Gradient	Tractive Load
1.50%	1,015 tons
1.66	934 *
2.00	760

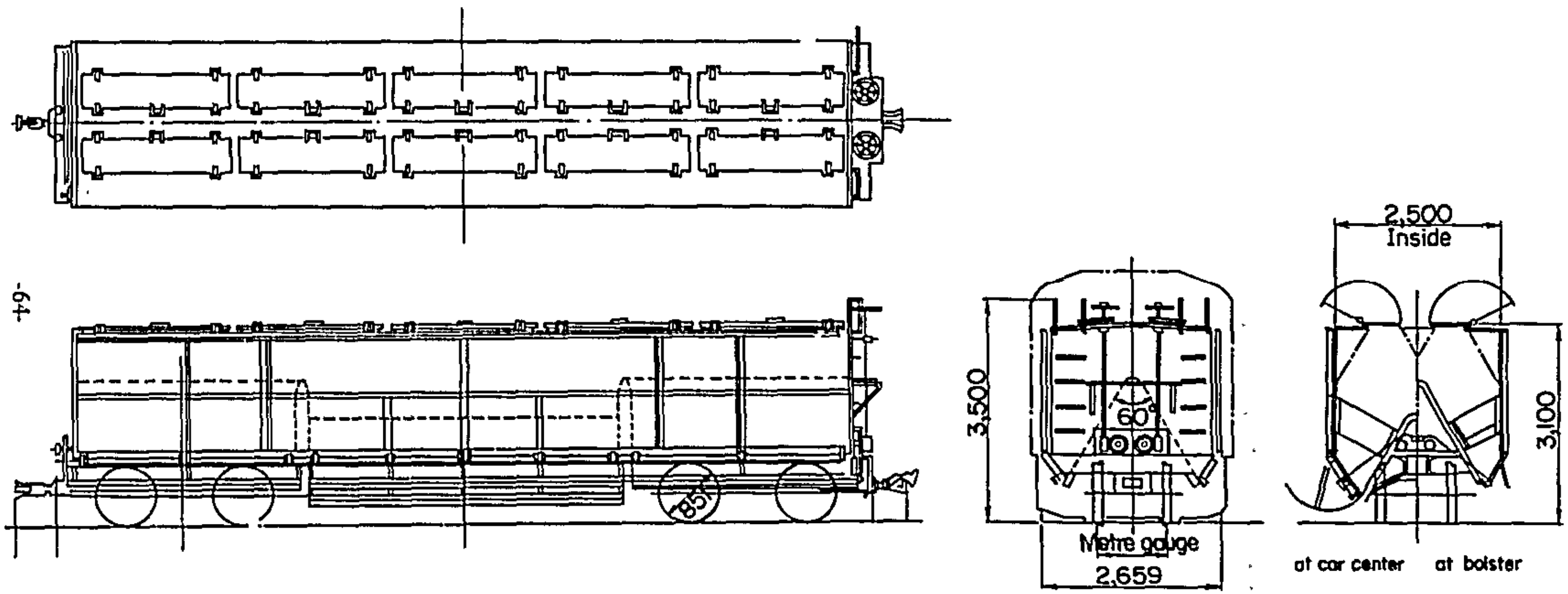
* No figure is available; value is calculated.

If the maximum upgrade towards Tanga Port is specified to be 1.66%, the possible tractive load of the Class 90 locomotive on the entire length is 934 tons. Therefore, the required number of trains for soda ash transport is as follows:

Production scale	1,000,000 ton/yr.	500,000 ton/yr.	250,000 ton/yr.
Daily production	3,300 ton/day	1,670 ton/day	840 ton/day
Required number of train	6 trains/day	3 trains/day	2 trains/day
Tonnage of soda ash per train	550 ton	550 ton	420 ton
Number of wagons per train	19	19	14
Tare weight of train	380 ton	380 ton	280 ton
Loaded weight of train	930 ton	930 ton	700 ton

Note * : Working days are assumed to be 300 days a year.

Figure 4-5 Covered Wagon for Soda Ash



When the steepest gradient of 2.0% or 2.5% is adopted, train operation frequency will increase on account of the lesser possible tractive weight of the locomotive. The additional provision of the signal stations and the overall decrease in transport efficiency will be inevitable. It is not, therefore, recommendable.

4-3-3 Train speed

As present, the average scheduled speed of trains on the Tanga Line is 27.5 km/h, but it is considered that in the future the speed will be increased by some 20%, making the train operation at the speed of 33 km/h possible.

The reasons are that increase of train speed due to dieselization, easing the operation condition through improvement of curves and gradients by implementing 1973/76 Investment Program as well as reducing the loss of time when stopping at stations.

The scheduled train speed between Lake Natron and Tanga Port via Arusha along Route 1, for example, is assessed by the following procedure:

- The scheduled speed of 40 km/h is possible over the section between Arusha and L. Natron where only the exclusive trains for soda ash are operated.
- The scheduled speed between Tang Port and Arusha is to be 33 km/h.
- Based on the above assumptions, the scheduled average speed over the whole section is as follows:

Tanga			
	489 km / 33 km/h	=	13.3030 h
Arusha			
	150 km / 40 km/h	=	3.75
L. Natron			
Total	589 km		17.0530

589 / 17.0530 = approx. 35 km/h

4-3-4 Required number of rolling stock

The required number of rolling stock of the trains for soda ash is determined based on the necessary hours for one round trip for the train, including loading and unloading work at both origin and destination stations.

Required hours other than operation, the fixed hours, is as follows:

Loading of soda ash	2.5 h
Unloading of soda ash	0.5

Train inspection before departure and after arrival — 2.0 h
Shunting and waiting for departure — 9.0

Total — 14.0

The required hour of one round operation of the exclusive train as classified by route is as follows:

Route	Railway Section	Length	Fixed Hour	Operation Hour	Total
Route 1	L. Natron–Tanga Port	589 km	14 h	33.7 h	47.7 h (2.0 days)
Route 2	L. Natron–Tanga Port	714	14	40.8	54.8 (2.3)
Route 3	L. Manyara–Tanga Port	533	14	30.5	44.5 (1.9)
Route 4	Arusha–Tanga Port	439	14	25.1	39.1 (1.6)
Route 5	Moshi–Tanga Port	354	14	19.7	33.7 (1.4)

Based on the required hours for the one round trip, the number of rolling stock necessary for each for the expected route and scale of soda ash production is as shown in Table 4-3. Allowance of the fleet is 20% for the diesel locomotives and 15% for the covered wagons, respectively.

4-4 New Railway Construction Planning

4-4-1 Construction standard

1) Gauge

The track gauge of the new railway is to be one meter which is the same standard as on the Tanga Line.

2) Minimum curve radius

The minimum curve radius of the existing trunk lines of the EAR is 216 m or 8 degrees, but, considering the reduction of the maintenance cost and possibility of passenger train operation, the standard applicable for the new line is to be 300 m or 5° 08'.

3) Steepest gradient

The steepest gradient on the new construction section is to be 1.5%. In view of the

Table 4-3 Required Number of Rolling Stock

Production Scale (tons)	Route	Section	Required Days for Round Trip	Required Locos.	Required Wagons
1,000,000	Route 1	L. Natron–Tanga P.	2.0	6 x 2.0 x 1.2 = 15	12 x 19 x 1.15 = 263
	Route 2	L. Natron–Tanga P.	2.3	6 x 2.3 x 1.2 = 17	14 x 19 x 1.15 = 306
	Route 3	L. Manyara–Tanga P.	1.9	6 x 1.9 x 1.2 = 15	12 x 19 x 1.15 = 263
	Route 4	Arusha–Tanga P.	1.6	6 x 1.6 x 1.2 = 12	10 x 19 x 1.15 = 219
	Route 5	Moshi–Tanga P.	1.4	6 x 1.4 x 1.2 = 11	9 x 19 x 1.15 = 197
500,000	Route 1	L. Natron–Tanga P.	2.0	3 x 2.0 x 1.2 = 8	6 x 19 x 1.15 = 132
	Route 2	L. Natron–Tanga P.	2.3	3 x 2.3 x 1.2 = 9	7 x 19 x 1.15 = 153
	Route 3	L. Manyara–Tanga P.	1.9	3 x 1.9 x 1.2 = 8	6 x 19 x 1.15 = 132
	Route 4	Arusha–Tanga P.	1.6	3 x 1.6 x 1.2 = 6	5 x 19 x 1.15 = 110
	Route 5	Moshi–Tanga P.	1.4	3 x 1.5 x 1.2 = 6	5 x 19 x 1.15 = 110
250,000	Route 3	L. Manyara–Tanga P.	1.9	2 x 1.9 x 1.2 = 5	4 x 14 x 1.15 = 65
	Route 4	Arusha–Tanga P.	1.6	2 x 1.6 x 1.2 = 5	4 x 14 x 1.15 = 65
	Route 5	Moshi–Tanga	1.4	2 x 1.4 x 1.2 = 4	3 x 14 x 1.15 = 49

traction force, 1.66% is justified. However, there is scarcely any difference between the construction cost in case of 1.66% and that of 1.5% upon survey using a map of 150,000 scale. Moreover, considering the case of 1,000 ton traction in future, 1.5% is adopted.

4) Structure and loading gauge

As is indicated in Fig. 4-6, the same standard as that of the EAR is to be adopted.

5) Track structure

The 40 kg/m rail is to be used on the new railway construction section. As present, 29.8 kg/m rail is used between Tanga and Moshi, and 22.5 kg/m rail is laid between Moshi and Arusha. Taking account of the maintenance, increase in speed and traffic volume, 40 kg/m rail is to be adopted.

As for the sleeper, at present, iron sleepers are used. But, as there are some exceedingly corrosive soils, prestressed concrete sleepers should be used for the new line. The number of sleepers is to be 1,360 per kilometer. Crushed stone is to be used as ballast, the thickness of which is to be 15 cm.

6) Earthwork standard

The cross section applicable to embankment and cut is as shown in Fig. 4-7.

7) Signal station

The signal stations are to be located at about 15 km intervals. The relevant location is decided, taking into consideration the crossing situation of the trains for soda ash. The gradient in these signal station yards are supposed to be level or less than 0.25%.

The effective length of the signal station is to be 330 m taking into account the train length of the soda ash train and possibility of passenger traffic service in the future. The length is based on the following data:

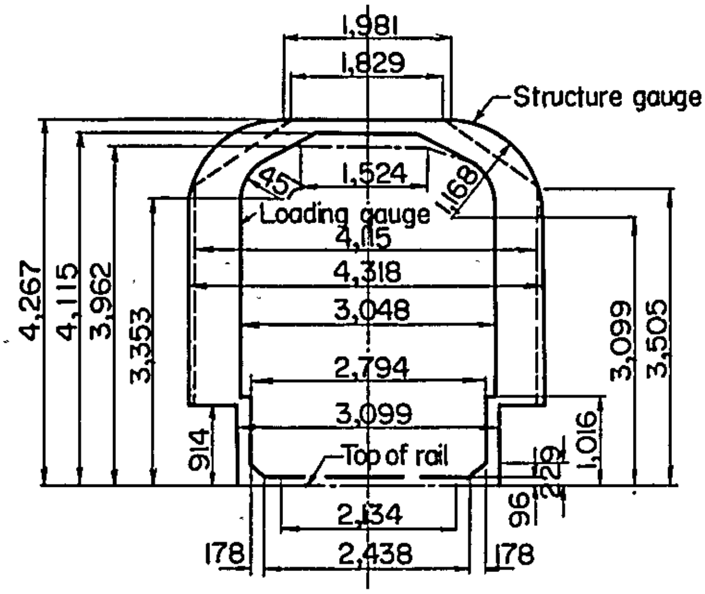
$$\text{Loco.} + \frac{\text{Covered Wagon}}{\text{for Soda Ash}} + \frac{\text{Passenger}}{\text{Coach}} + \frac{\text{Overruning}}{\text{Allowance}} + \frac{\text{Other}}{\text{Allowances}} = \frac{\text{Effective}}{\text{Length}}$$

18 m	12.9m x 19units	20 m	30 m	16.9 m	330 m

8) Signal and safety device

The starting and home signals are to be erected at each signal station. The signals are to be mechanically interlocked with turnouts, which are controlled by manipulation of levers provided at a room in the station main building. However, turnouts in sidings and storage lines are handled on the spot. The block system is to be the tablet system.

Figure 4-6 Structure and Loading Gauge



Tunnel Structure and Loading Gauge

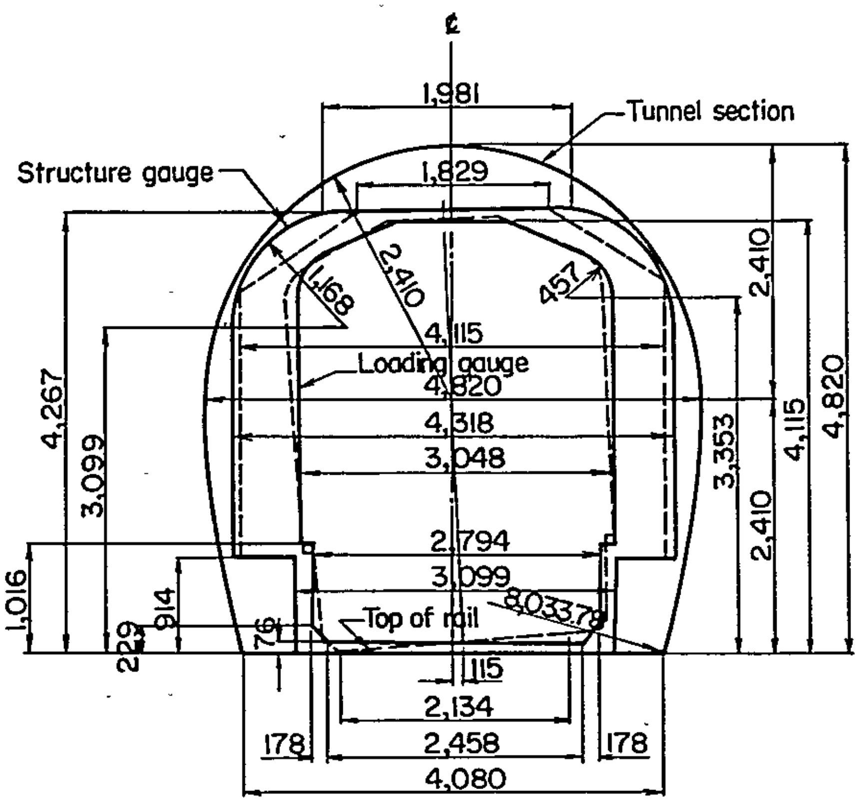
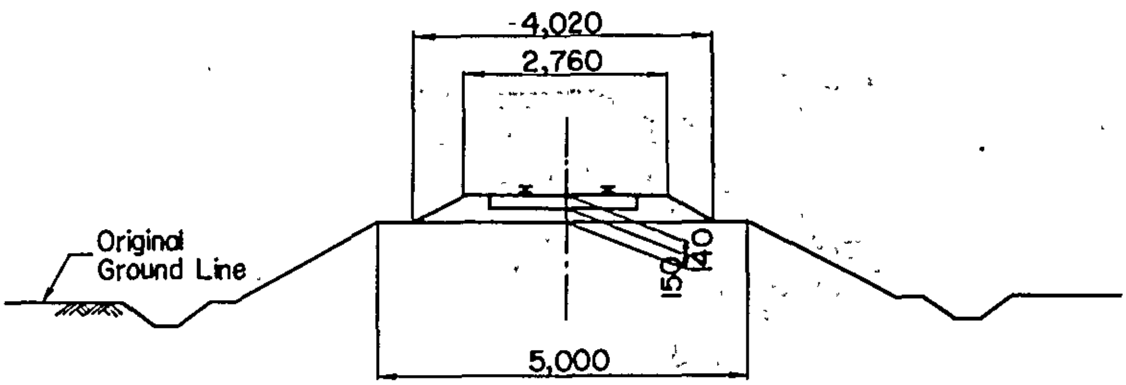
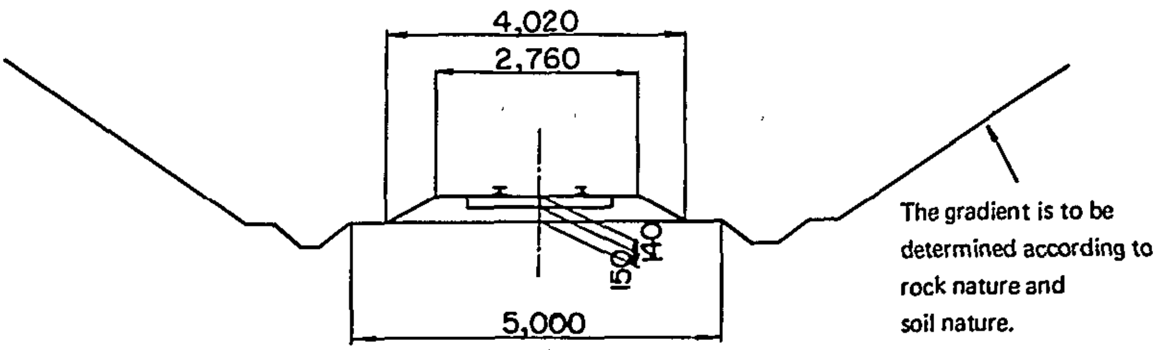


Figure 4-7 Typical Earthwork Section



Cross Section for Embankment



Cross Section for Cut

9) Telecommunications

A telephone system for exclusive use of the railway, with suspension wires, is to be installed.

10) Electric power

As electric power is only used for lighting in the station compounds, it would be obtained from the existing distribution system in the Arusha district. If this is found impossible, a simple diesel generator would be used at each signal station.

11) Station building

The buildings at each signal station are composed of the station main building, in which the station master's office as well as signal and telecommunication office are located, the maintenance building and staff quarters.

4-4-2 Route location

1) Geology

Around the new railway line, alkali basalt rock has erupted repeatedly since the Neogene on the basal rock of Archaean crystalline rocks. The volcanic rocks form a number of volcanic cones including such huge ones as Kilimanjaro, Meru, Ngorongoro and an active volcano, Lengai. Lava with low viscosity which has flown from craters spread widely many times and volcanic clastics are rather few because of the nature of magma. Therefore, the ground other than volcanic cones but including the volcanic slope forms a comparatively even topography. The surface of the volcanic slope and flat land is capped with laterite which is typical residual soil in the savanna region where dry and rainy seasons alternate. The laterite is ordinarily not so conspicuous in thickness and along sharp cliffs basalt is exposed over several meters from the top of cliff. The uppermost part of laterite is fine and soft lateritic soil which is easily scattered by wind in the dry season. It is apt to turn to the muddy road which is difficult to pass in the rainy season, but the portion underneath constitutes a solid and dry substance.

2) Climate

The climate around the route belongs to the typical savanna climate of the central plateau region where alternation of weather conditions prevails and the temperature changes considerably by day and night. The air is cool and the humidity is rather low although the route is in the tropical zone.

There are two rainy seasons, one from March to May and the other, which is less rainy, from November to January. The formers raise crops during the small rainy season. It seldom rains during the dry season. A comparison in the climatic conditions at Moshi and Dar es Salaam is as shown below.

	Average Annual Precipitation (mm)	Average Maximum Temperature (Degree in C)	Average Minimum Temperature (Degree in C)	Average Relative Humidity (%)
Moshi	858	29.7	17.2	75 (09.00) 46 (15.00)
Dar es Salaam	1,125	30.6	20.9	80 (09.00) 60 (15.00)

3) Route location

In selecting the new route, study has been made by locating the rough alignment on the maps, scale of which was 1/500,000. The selected route was studied more precisely on the maps of 1/50,000. The route was modified many times trying to obtain the least construction cost in accordance with the construction standard. After carrying out the field investigation and observation from the plane, two alternative plans have been worked out for the further study.

A route which runs almost in a straight line connecting Arusha with Lake Natron shall cross the volcanic zone around Volcano Maru and Monduli with a tunnel 11km long. A study has been made by which such a long tunnel is not needed, but this line is much longer and alignment is worse, involving difficult execution. Moreover, construction and maintenance costs would be considerably higher than those of the route with tunnel. So the latter route has been abandoned.

The major features of the lines are as given below:

(1) Route 1

Arusha is a plateau city located on the south foot of Mt. Meru at an altitude of 1,350m above sea-level. This city is to the direction of northwest of Tanga Port which faces the Indian Ocean and distance between these two cities is 330km in a straight line, 437km via the existing railway and 410km via road.

Lake Natron is located at NNW of Arusha, 125km away in straight line distance. The northern end of the lake abuts on Kenya border and the altitude of the lake surface is about 600 m from sea level.

The terminal station of the new railway is located on the very gentle slope of the east bank somewhat northerly from the center of Lake Natron which has elongated shape in a nearly north to south direction.

The line runs northward from Arusha along the west side of B104 of the Great North Road, after crossing A104 of the same system. Then the line runs through the col between Volcanoes Meru and Monduly, the height being about 2,000m, by a tunnel of about 11km. After passing through the tunnel, the route separates from the B104 Road, and continues for about 15km keeping its northward direction. Then it turns to the northwest and traverses the great swampy area extending from east to west. Proceeding northwestward along the contour line through the Kisirien hilly land, the line curves along the outside of the Naudo Swamp from its easternmost to northernmost boundary. Then the route goes north along the east slope of Volcano Gelai and turn to the west towards Lake Natron. After reaching Lake Natron, the line goes northward along the shore of the lake for about 5km and finally reaches the terminal. The plan and profile of this route are shown in Figs. 4-8 and 4-9.

Figure 4-8 Plan of New Railway (Route 1)

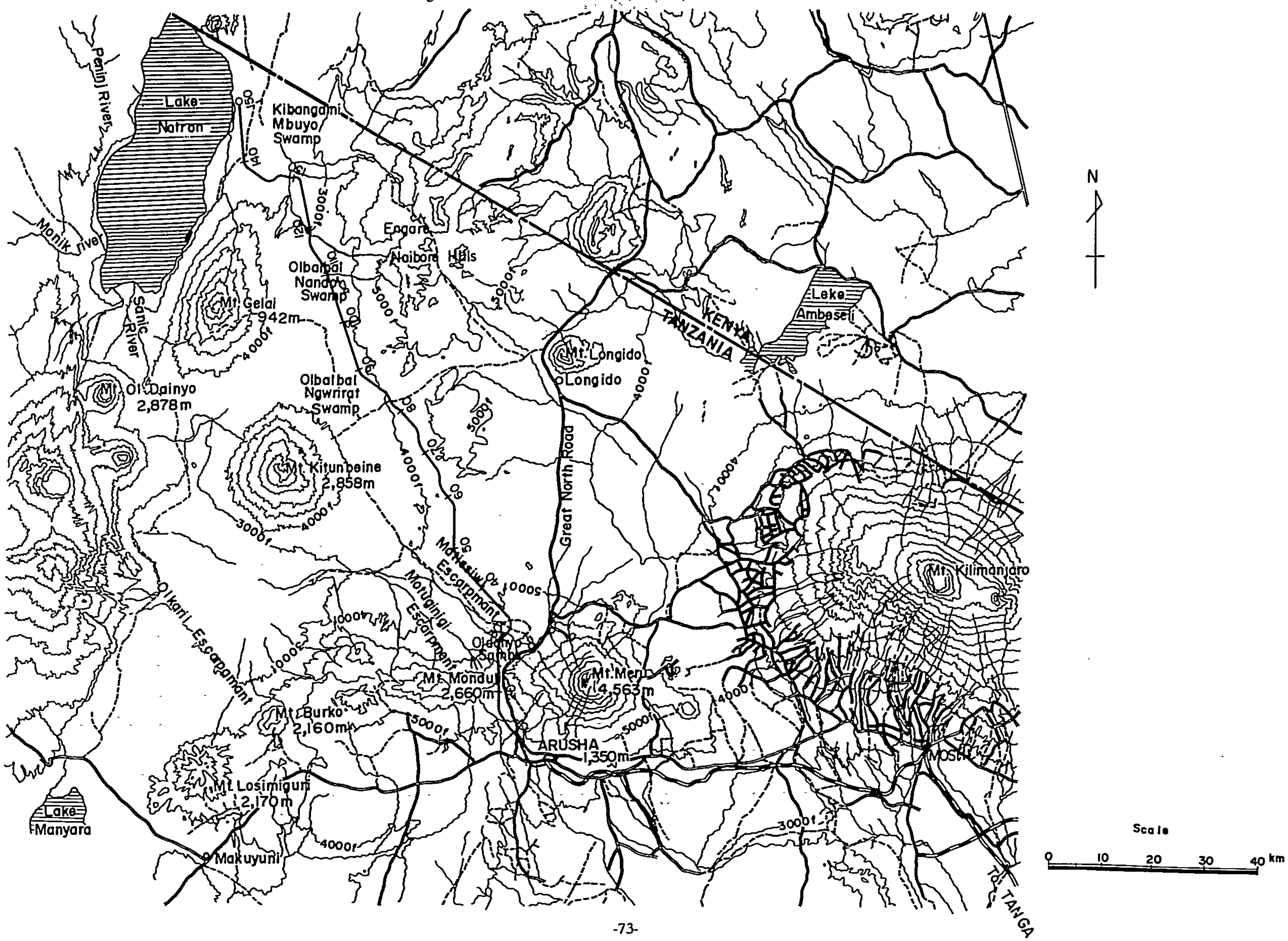
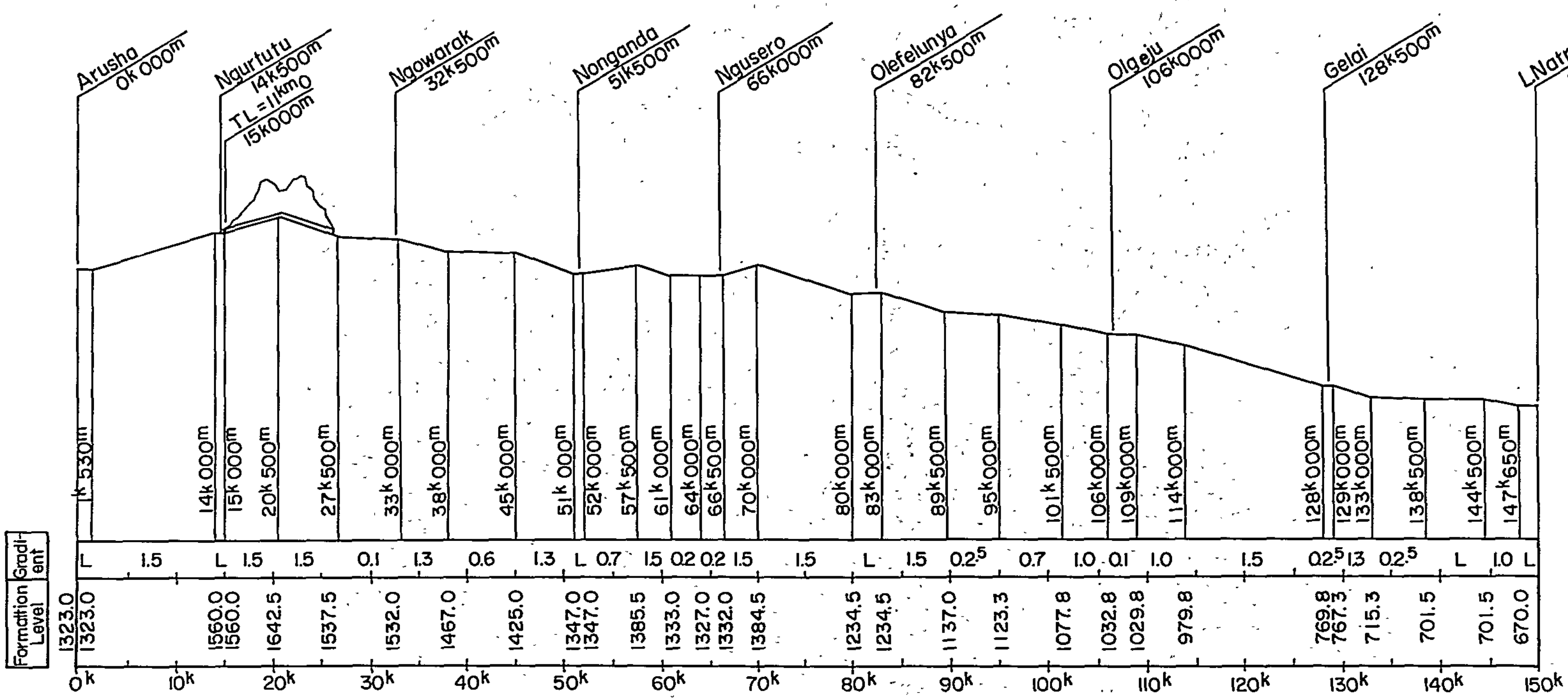


Figure 4-9 Profile of New Railway (Route 1)



(2) Route 2

It is the fundamental condition for Route 2 that the Arusha–Musoma Line, which has been surveyed by the Overseas Technical Cooperation Agency (OTCA), predecessor of the JICA, in 1970, will have been completed before constructing the new railway. According to the OTCA's report, from Arusha along north side of the A104 of the Great North Road, the Arush–Musoma Line will reach Lake Manyara Station, located 95km distant from Arusha. The new railway goes northward after branching off from the Arusha–Musoma Line at Lake Manyara. After passing the eastern foot of Mt. Gelai, it joins the alignment of the Route 1 at about 20km northeast of the summit of Mt. Gelai. Then it reaches Lake Natron along the same alignment as that of Route 1. As this route passes swampy lands for a considerable lengths, there are many problems concerning design and construction as well as train operation and maintenance. The route is relatively level but the route length between Lake Manyara to Lake Natron is about 180km, which means that the length of the new railway construction in case of Route 2 is longer than that of Route 1 by 30km. The construction cost of Route 2 seems to be less expensive since there is no tunnel on this line, but as the additional countermeasures for passing the swamp are required, the overall construction cost is estimated to be almost the same as that for Route 1. Moreover, because the total length of the Arusha–Lake Manyara section of Arusha–Musoma Line and new railway is much longer than that via Route 1, it involves higher costs for rolling stock and operation, thereby making Route 2 rather difficult to be adopted. The plan and profile are as shown in Figs. 4-10 and 4-11, respectively.

4-4-3 Work execution

1) Roadbed

As the required volume of earth for embankment work exceeds the excavated earth obtained from cutting work, the additional soil from pits at nearby hills is necessary. As no information concerning precipitation in the rainy season is available, the definite design of embankment in the swampy land is impossible at this stage. In this report, it is assumed that the height of embankment is two meters from the ground surface, and that there are two big side ditches at both ends. Slopes of cut and embankment should be properly protected according to the soil conditions at each spot.

2) Bridge

There is no big river, but, at Kisirien Hill located east of Mt. Kitumbenine, the new railway crosses many hollows. As these hollows will be severely eroded by rain water coming from the east along the gentle slope in the rainy season, construction of many bridges with span length of 10m to 40m will necessary.

3) Tunnel

As the slopes of the hill, under which a tunnel is constructed, are gentle, open-cut portions are to be provided at both ends before reaching portals. As rocks, assumed to be hard basaltic rocks or schist will be encountered in the tunneling work, the full-surface excavation method is expected to be used, which is illustrated in Fig. 4-12. In relation to the construction period, in addition to the portals, two inclined shafts with length of 1,200m each are necessary. As the locations of shafts are close to the B104 Road in both cases, transportation of materials, equipment, etc. is quite easy. The land around shafts is gentle and installation of facilities for tunnel work is also easily accomplished.

4) Track

Track is extended successively from four bases by mechanical track laying method as shown in the following figure. Track materials are transported to each base via road. The crushed stone for ballasting work over the whole length is supplied from crusher plants located at quarries which are newly constructed at the central and the southern part of Kisirien Hill and rocky mountain near Muriatata.

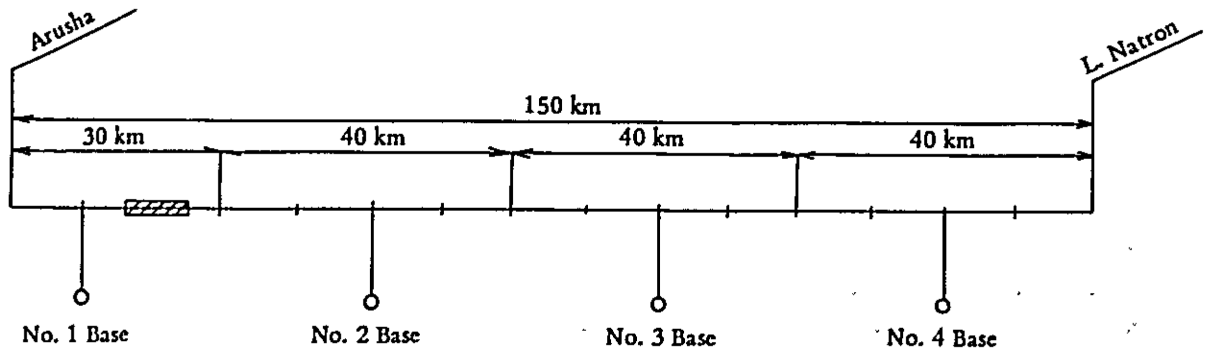


Figure 4-10 Plan of New Railway (Route 2)

Figure 4-11 Profile of New Railway (Route 2)

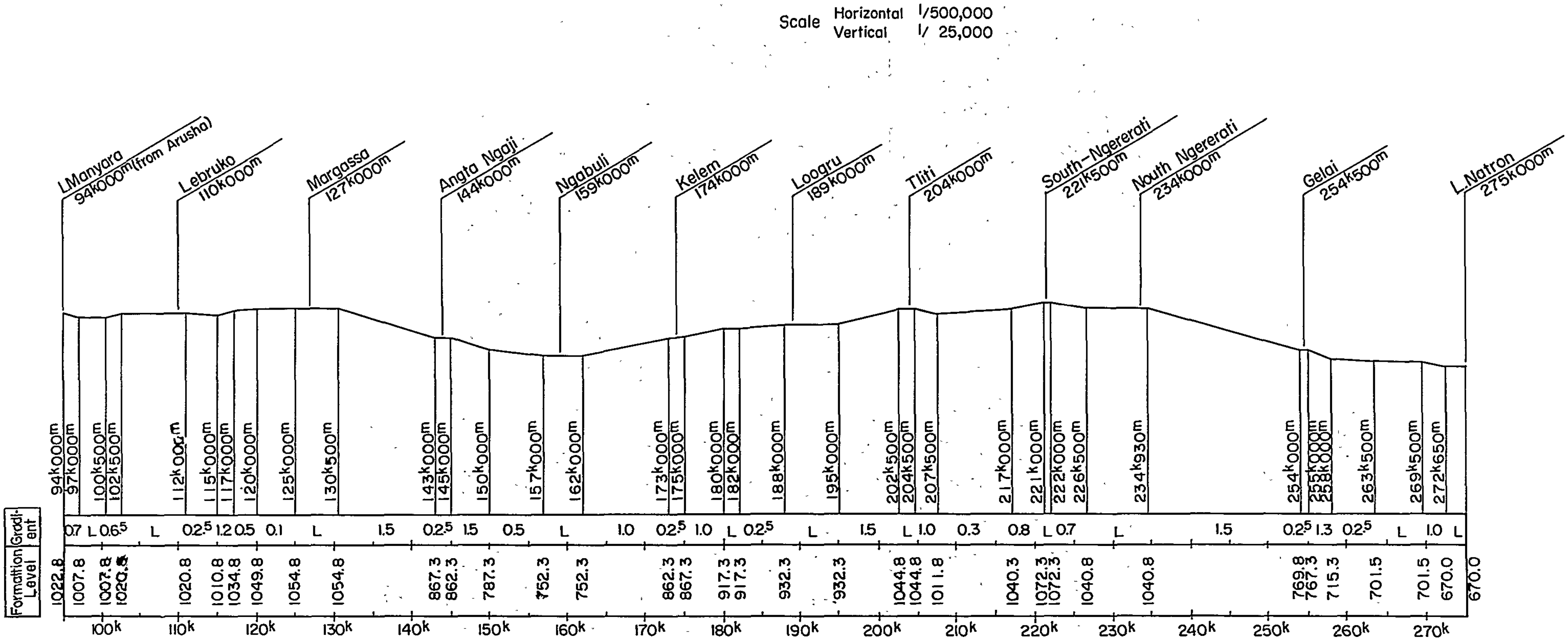
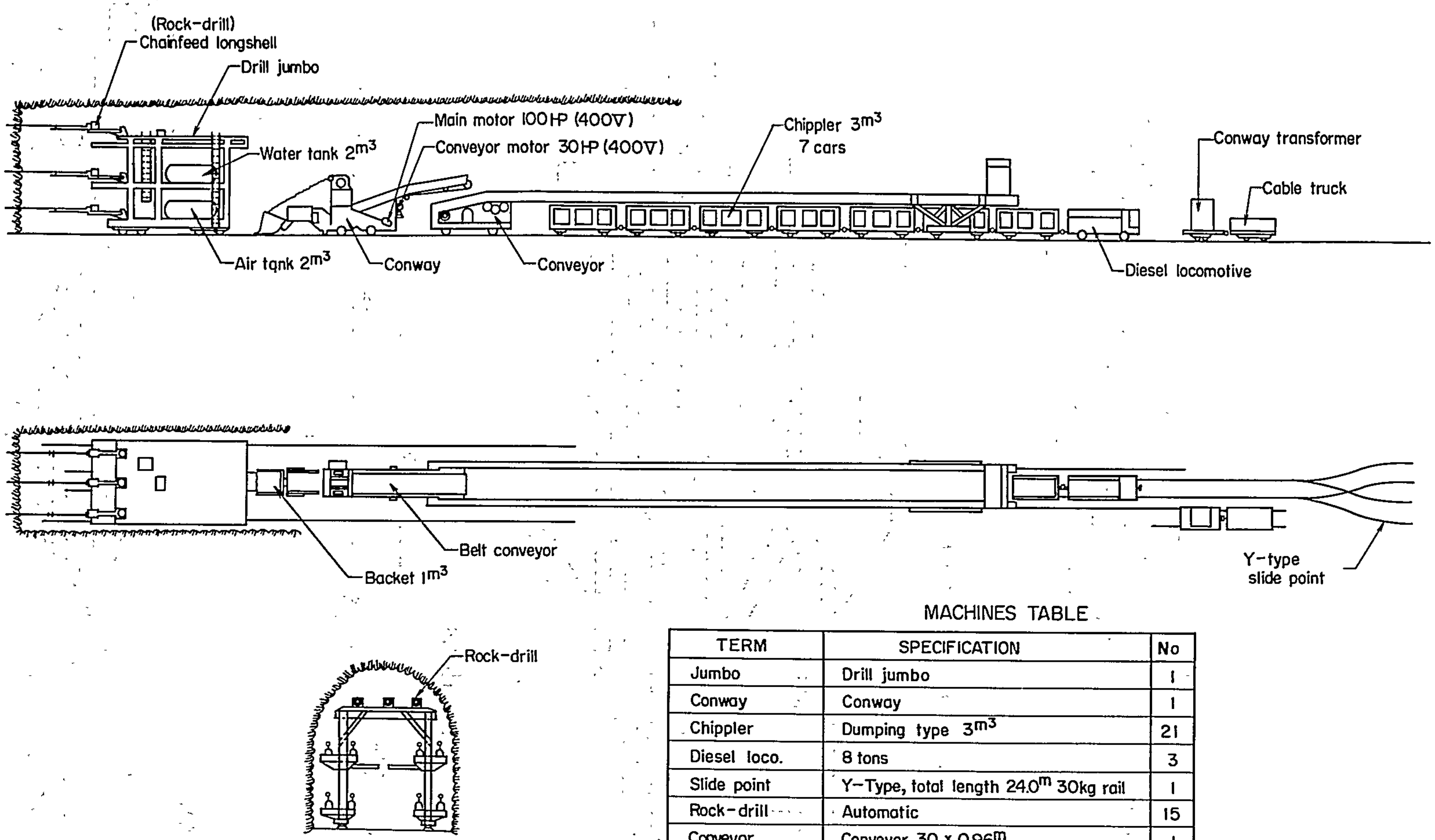


Figure 4-12 Tunnel Excavation Method (Full-Surface Excavation)

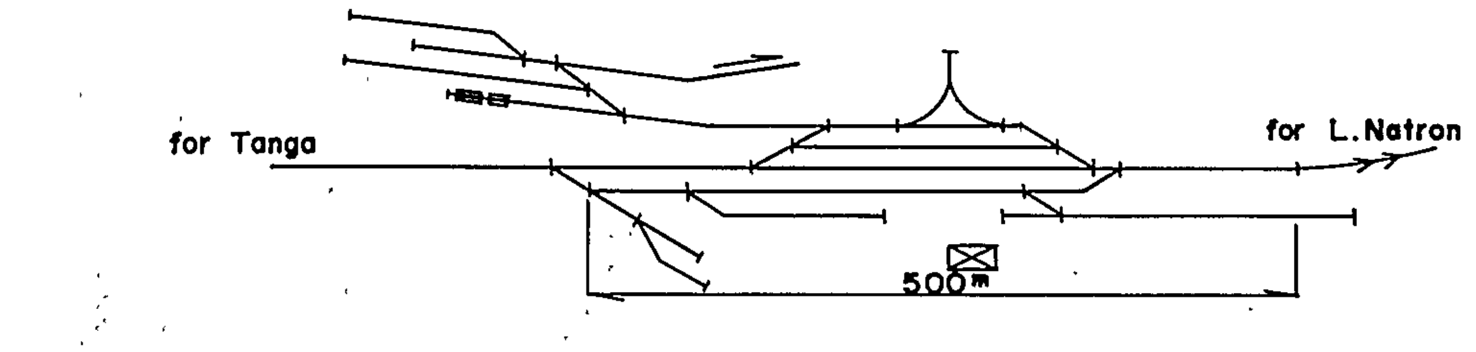


MACHINES TABLE

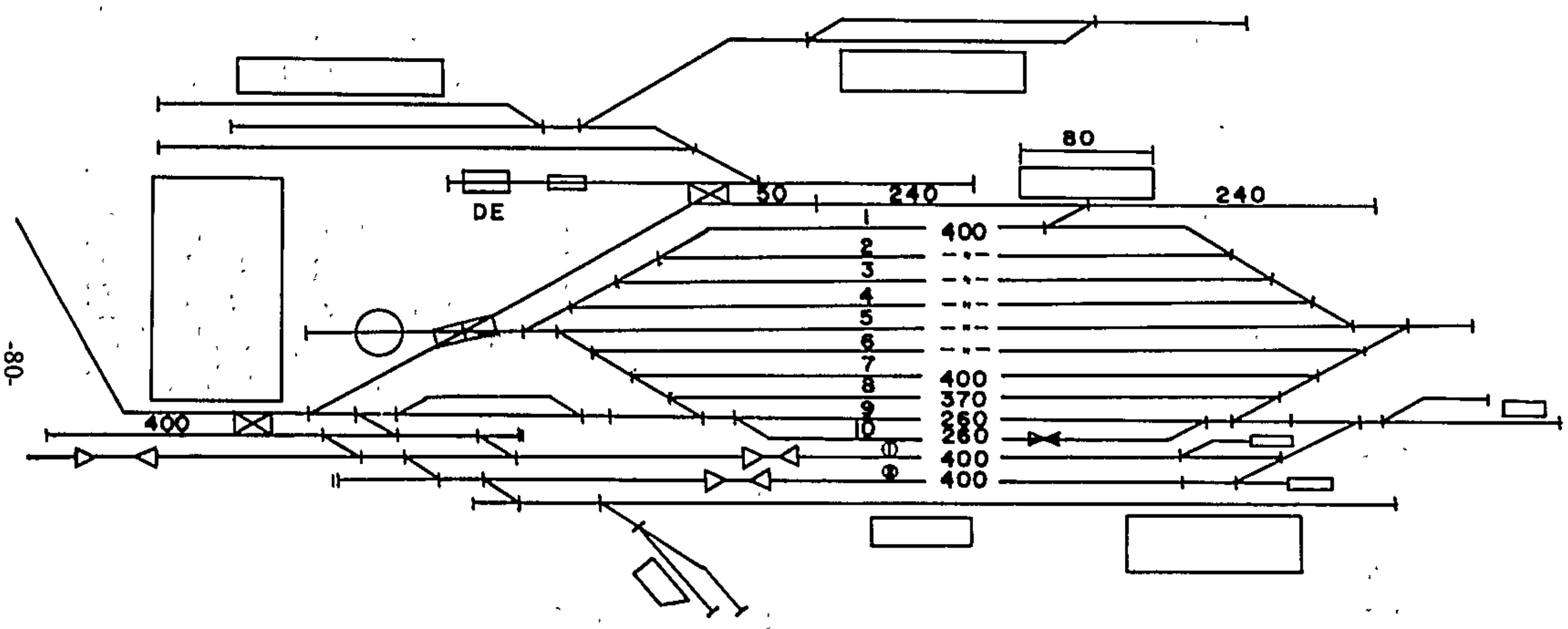
TERM	SPECIFICATION	No
Jumbo	Drill jumbo	1
Conway	Conway	1
Chippler	Dumping type 3^{m3}	21
Diesel loco.	8 tons	3
Slide point	Y-Type, total length 24.0^{m} 30kg rail	1
Rock-drill	Automatic	15
Conveyor	Conveyor 30×0.96^{m}	1
Taper bit	Gauge $44^{m}/m$	
Rod	Dia. $32^{m}/m$, $L=2.7 \sim 3.0^{m}$	
Transformer	Three phase, 3KV, 150KVA	1

4-4-4 Track layout diagram of station

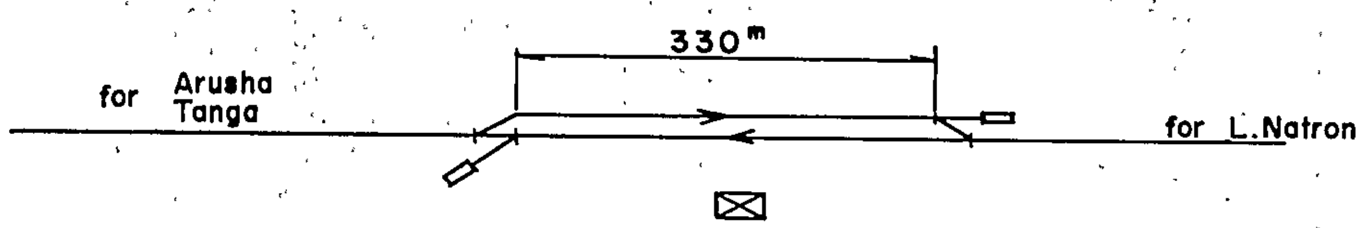
Arusha (Case of Route- 1)



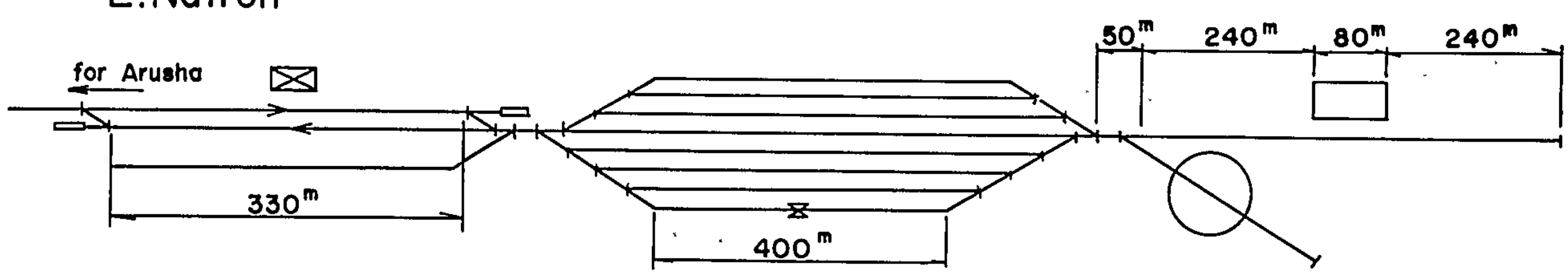
Arusha (Case of Route - 4)



Other signal Stations



L.Natron



4-4-5 Construction cost and maintenance cost

1) Construction cost

The total construction cost of the new line is calculated by adding the costs of each construction item based on the quantities derived from plan and profile. As the EAR has recent experience in railway construction, the unit cost of each item has been established based upon the actual results of road construction in Tanzania and of similar construction works in Japan. The unit construction cost uses prices quoted in December, 1975.

The new railway construction cost by the route is as shown in Table 4-4.

Table 4-4 Construction Cost of New Railway by Route

Cost by Item	Financial Cost Route 1	(Tsh 1,000) Route 2	Economic Cost Route 1	(US$ 1,000) Route 2
Material				
F.C.	519,548	493,198	63,667	60,441
D.C.	263,785	315,573	22,355	26,773
Total	783,333	808,771	86,022	87,214
Labor cost				
Skilled	57,838	33,119	5,452	3,122
Unskilled	146,173	154,334	10,335	10,912
Total	204,011	187,453	15,787	14,034
Grand total	987,344	996,224	101,809	101,248
Construction cost per km	6,582	5,504	679	559

Notes: F.C. denotes Foreign Currency
D.C. denotes Domestic Currency

2) Railway maintenance cost

Railway maintenance cost excluding rolling stock maintenance is shown in Table 4-5.

Table 4-5 Maintenance Cost (New Railway Line)

	Financial Cost Route 1	(Tsh 1,000) Route 2	Economic Cost Route 1	(US$ 1,000) Route 2
(1) Maintenance cost per year	11,840	12,989	1,210	1,316
(2) Maintenance cost per km per year	78.9	71.8	8.1	7.3

4-4-6 Construction schedule

The construction schedule of the new railways of the Route 1 is as shown in figure on page 83.

4-4-7 Composite study on the new railway of soda ash project and Arusha-Musoma Line Project

Two alternative railway alignments connecting Lake Natron with the existing line at Arusha for transporting soda ash have been mentioned in preceding paragraphs. In this way, an alignment in case of Route 1 directly connects Lake Natron with Arusha whereas that for Route 2 branches off as far as Lake Natron from a midway station on the proposed line of the Arusha-Musoma Project.

If it is possible to combine these two railway projects in such a way that a railway is constructed between Arusha and Musoma via Lake Natron, it would be theoretically desirable for both projects. This alignment, however, has some technical difficulties and moreover would not be acceptable in view of the costs as mentioned hereinafter.

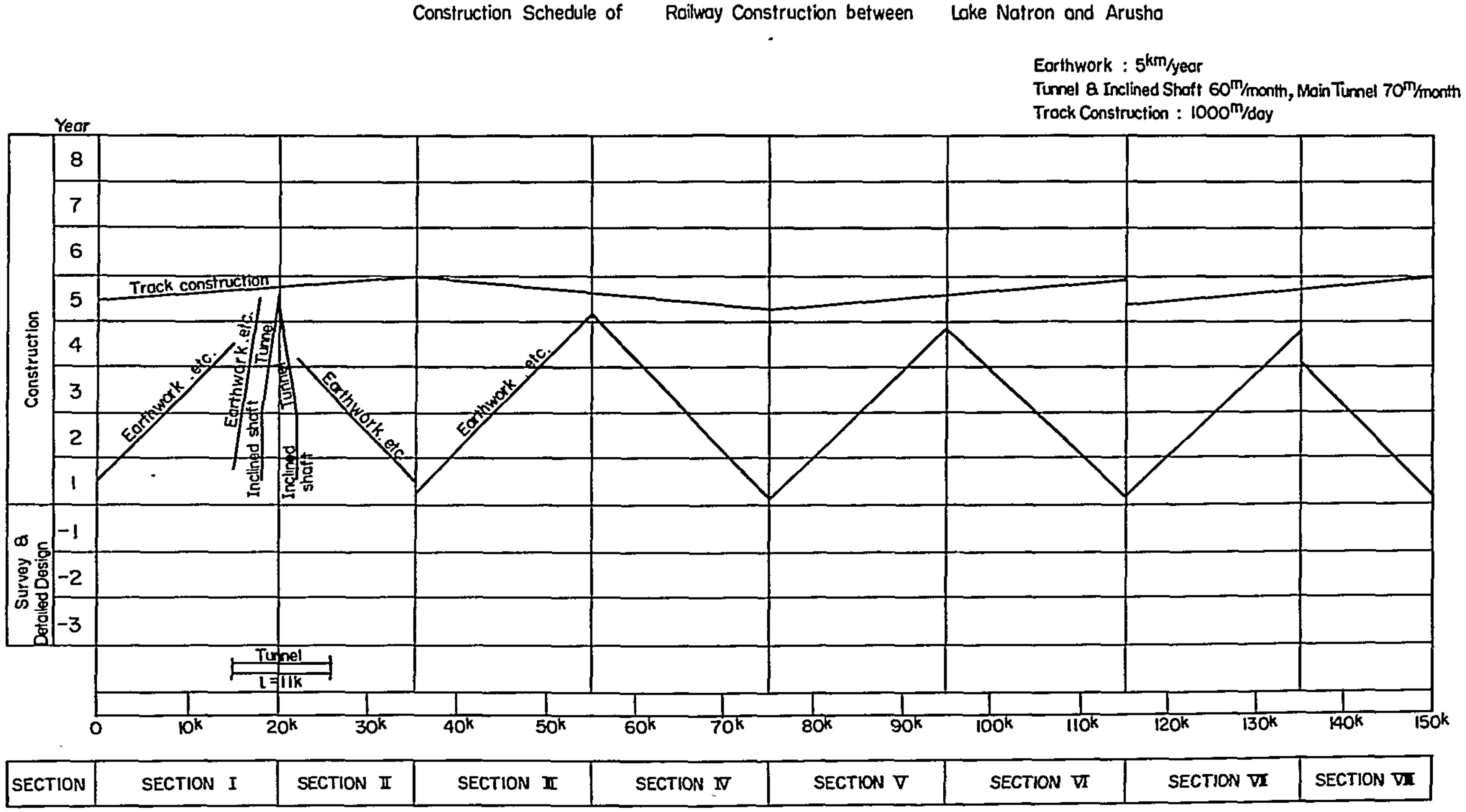
According to the 'Report on Railway Construction Project in Tanzania (Arusha–Musoma)' submitted to the Government of Tanzania by the OTCA, two alternative lines, i.e., the Proposed Line and the Comparative Line, are studied. The relationship among railway routes and Lake Natron is as shown in Fig. 4-13. The two alignments of Arusha–Musoma Line are briefly compared for the section between P_1 and P_2, as follows:

	Proposed Line	Comparative Line
Lowest elevation along line (Elevation & distance from Arusha)	948 m, 105 km	789 m, 140 km
Highest elevation along line (Elevation & distance from Arusha)	1,679 m, 222 km	1,679 m, 295 km
Difference of elevation & distance	731 m, 117 km	890 m, 155 km
Average gradient	6.25 m/km	5.74 m/km
Tunnel length	6.1 km	3.3 km
Route length	190 km	230 km

The Proposed Line is shorter than the Comparative Line but as the former line directly ascends the steep cliffs located in west border of the rift valley, the length of tunnels is longer and average gradient is steeper.

The Comparative Line, besides being longer in distance, passes the foot of Volcano Lengai. This volcano is still active and there are old and new volcanic pyroclastics in the vicinity; its slope therefore is apt to be eroded resulting in the complicated landform. If the Comparative Line is selected for this section of the Arusha-Musoma Line, it may be subject to occasional volcanic activity and, in addition, a number of countermeasures have to be taken for line

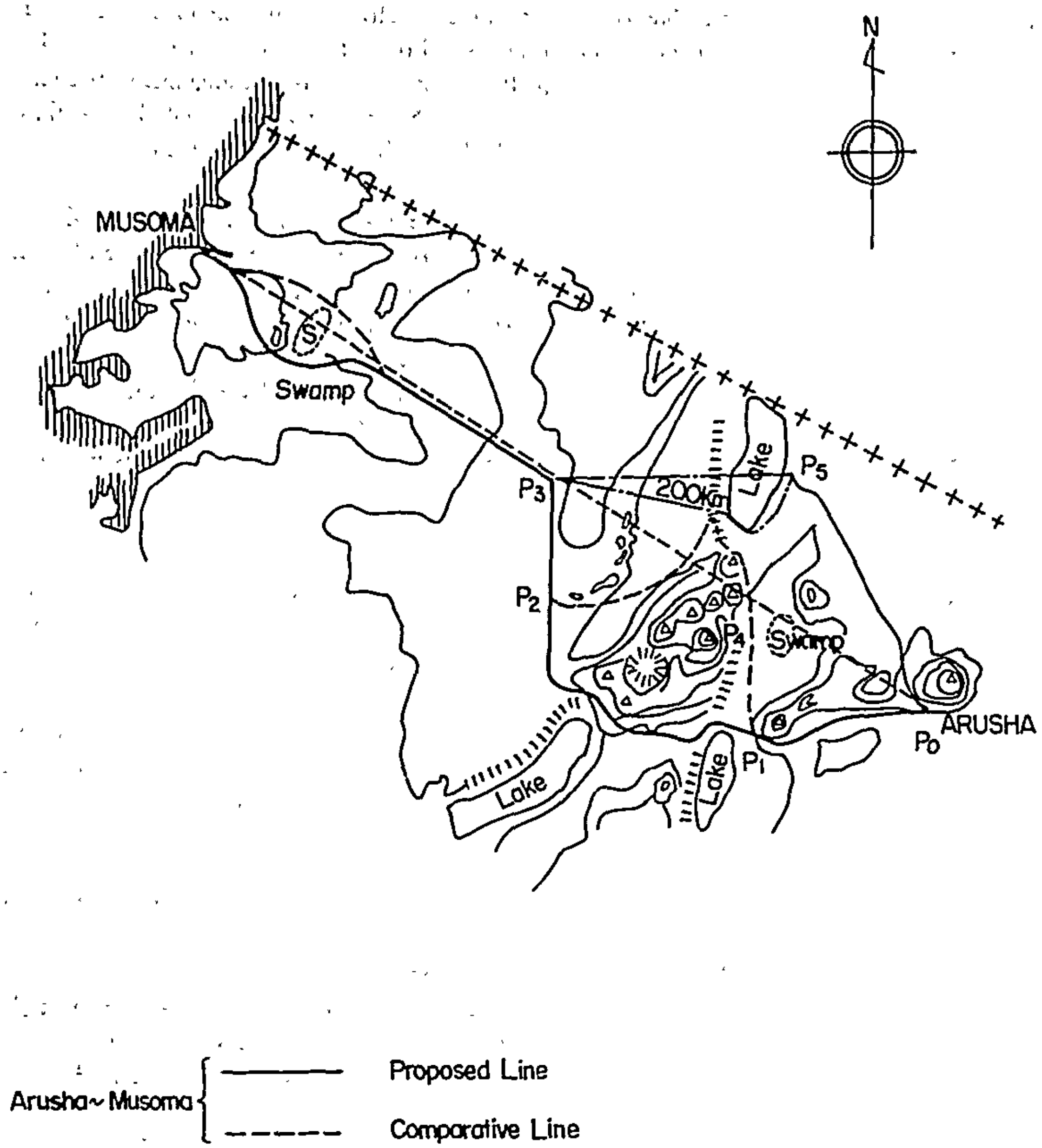
Construction Schedule



Remarks :

1. Mapping along the proposed railway line by means of photogrammetric survey and railway location study thereon; scale of map, being 1 in 500 for around two terminals of Arsha and L.Natron, while 1 in 2,500 for other districts.
2. Geological survey including reconnaissance, test drilling, seismic exploration and soil test. (1 year for items 1 and 2)
3. Route survey including staking along center line, longitudinal and cross leveling, traversing, etc. (1 year)
4. Detailed design, cost estimation, bidding documentation, selection of bidders, contract with the successful, etc. (1 year)

Figure 4-13 Relative Positions of Arusha–Musoma Line



	Arusha ~ Musoma Line								Via L.Natron		
	Proposed Line				Comparative Line				Route -1		
Point	P0	P1	P2	P3	P0	P1	P4	P2	P0	P5	P3
Distance (km)	0	90	280	320	0	90	140	293	0	150	350
Height (m)	1370	1040	1680	1680	1370	1040	789	1680	1370	670	1680

maintenance against erosion on the slopes. More investigations and studies would be necessary to conclude theoretically which line is the best, but, generally speaking, the Proposed Line is superior in view of safety of operation and total expenditure of costs for construction and maintenance, after completion. Moreover, the Proposed Line has better alignment for transportation activity as it would serve for tourists to go to Ngorongoro National Park as well as for transportation of agricultural products from highlands behind Lake Manyara.

The alignment would be considered to be of use for constructing a new railway of Routes 1 or 2 for the Soda Ash Project, which is concurrently to be a part of Arusha-Musoma Line. Thus, the new rialway is extended further from the terminal, namely, P5 in Fig. 4-13 to P3, then again proceeding on to Musoma in Almost straight line by the route planned as original alignment of the Arusha-Musoma Line. In this case, immediately after leaving P5, a bridge over Lake Natron, which might be very difficult because of physical nature of the lake, is necessary. Moreover, a tunnel with length of about 40km is necessary, to pass through the cliff west of Lake Natron, the height of which reaches 600m. Accordingly, it is assessed that this route is not feasible on account of the construction cost.

A route from P5 to a point near P3, going round the south shore of Lake Natron, could be considered. Correlating it with the Comparative Line of Arusha–Musoma Line, this alignment is very far from the crater of Volcano Lengai but it still passes unstable slopes. Since rock of volcanoes in rift valley are of alkali basalt, the flowing lava at the time of eruption is tremendous in quantity and has extraordinary fluidity. So it is deemed that, as in the case of the Comparative Line, this line located in the areas of direct influence from volcanic activity. Therefore, adoption of this line would require solution of further technical problems and it is not proposed in this Report. Even if this route is technically possible the extension is about 30 km longer than the Proposed Line of the Arusha-Musoma Line and, as in the case of the Comparative Line, it may not be used for tourists going to Ngorongoro National Park or for transporting agricultural products produced in the highlands located west of Lake Manyara.

Judging from the foregoing arguments, from both technical and economic viewpoints, it is advisable to adopt the Proposed Line for the Arusha–Musoma Line. Accordingly, the new railway construction of the Soda Ash Project would be planned as an independent project. For this reason, only the new railway alignments in relation to Routes 1 and 2 are studied.

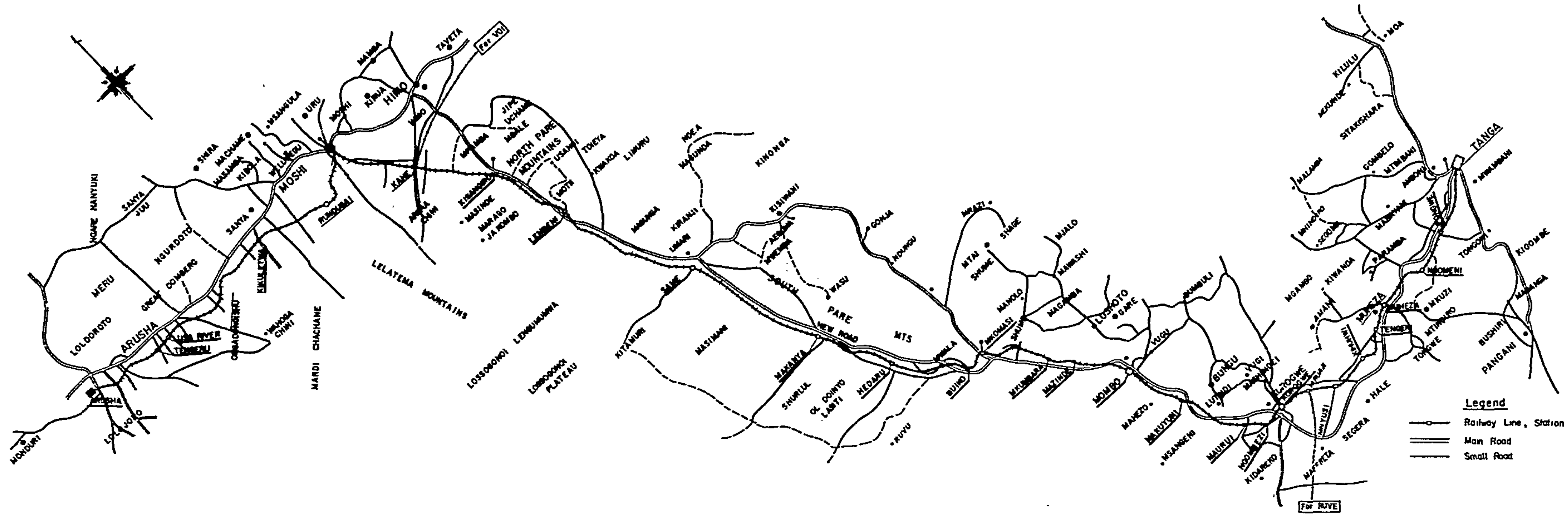
4-5 Improvement of Existing Line

4-5-1 Current status of Tanga Line

The Tanga Line consists of the main line between Tanga and Moshi, and a branch line between Moshi and Arusha as shown in Fig. 4-14.

The route length of the section between Tanga and Moshi is 350.56km with 22 crossing stations. The extension between Moshi and Arusha is 85.27km, over which there are four crossing stations. In addition to the above, a line connecting the Tanga Line with the

Figure 4-14 Sketch Plan of Tanga Line



Scale 1:500,000

Tanzania Central Line and the Kahe Branch Line to go to Voi in Kenya are physically connected with the Tanga Line at Mruazi Junction and Kahe Junction, respectively.

1) Track

The Tanga Line is a single track railway for its entire section and its present status is as follows:

Width of Formation Level:	At embankment	4,572 mm
	At cutting	5,182 mm
Distance between centers of adjoining tracks:		
	At straight section	4,267 mm
Rail:	Tanga–Moshi Section	29.8 kg/m
	Moshi–Arusha Section	22.5 km/m

Ballast:

Tanga–Moshi Section:
Ballast of the main line portion is composed of crushed stone which is of large and uniform size.

Moshi–Arusha Section:
Now it is of laterite ballast, but there is a plan to improve it by replacing it with crushed stone, and replacement work has been begun.

Gradient:

According to the EAR's working time table, the steepest gradient on Tanga Line by section is as follows:

Gradient in UP direction (Tanga → Arusha)	
Tanga–Korogwe	1.5%
Korogwe–Mombo	1.8
Mombo–Mkomasi	1.66
Mkomasi–Buiko	2.0
Buiko–Moshi	1.66
Moshi–Arusha	2.2

Gradient in DOWN direction (Arusha → Tanga)	
Arusha–Moshi–Kahe J.	2.2%
Kahej.–Same	1.25
Same–Buiko	0.57
Buiko–Makuyuni	1.66
Makuyuni–Maurui	2.0
Maurui–Korogwe	1.33
Korogwe–Tanga	1.18

2) **Station**

Distance between crossing stations on Tanga Line is as follows:

Tanga–Pongwe	13.98 km
Pongwe–Ngomeni	10.76
Ngomeni–Muheza	14.18
Muheza–Kihuhwi	15.59
Kihuhwi–Mruazi J.	9.76
Mruazi J.–Mnyusi	4.12
Mnyusi–Korogwe	14.89
Korogwe–Ngombezi	7.76
Ngombezi–Maurui	5.73
Maurui–Makuyuni	16.39
Makuyuni–Mombo	14.89
Mombo–Mazinde	12.67
Mazinde–Mkumbara	6.74
Mkumbara–Mkomasi	19.31
Mkomasi–Buiko	6.64
Buiko–Hedaru	24.64
Hedaru–Makanya	19.31
Makanya–Same	34.60
Same–Lembeni	38.32
Lembeni–Kisangiro	20.02
Kisangiro–Kahe J.	20.02
Kahe J.–Moshi	20.12
Moshi–Kikuletwa	31.68
Kikuletwa–Usu River	30.58
Usu River–Arusha	23.84

The effective length of major stations are as stated below:

Tanga	279 m
Pongwe	195
Ngomeni	280
Muheza	440
Kihuhwi	427
Mnyusi	468
Korogwe	428
Ngombezi	124
Maurui	419
Makuyuni	411
Mombo	421
Mazinde	302
Buiko	401
Hedaru	416

Makanya	447 m
Same	492
Lembeni	423
Kisangiro	422
Kahe J.	628
Moshi	371
Kikuletwa	202
Usu River	272
Arusha	413

The signal at each station consists of only a home signal and no starting signal is erected. Mechanical interlocking between turnout and signal is provided only at Mruazi Junction. There is no facility locking signal and turnout at other stations.

3) Train operation frequency and train speed

According to the EAR's working timetable, the number of trains between major stations is as follows. Some trains are operated daily but others are two to six times a week or only on required days. Some trains are often cancelled. Therefore, the actual number of trains operated is lower than these figures.

Table 4-6 Train Operation Frequency

	Tanga–Arusha	Arusha–Tanga	Total
Tanga			
	5	5	10
Mruazi J.			
	9	9	18 (8) *
Korogwe			
	7	7	14
Mombo			
	6	6	12
Kahe J.			
	11	11	22 (10) **
Moshi			
	1	1	2
Arusha			

Notes: * Trains to and from Dar es Salaam and Wami.
** Trains to and from Voi, which are not operated at present.

The maximum speed permitted between major stations is as follows:

Tanga–Maurui	48 km/h
Maurui–Mkomasi	56
Mkomasi–Buiko	48
Buiko–Lembeni	56
Lembeni–Kisangiro	48
Kisangiro–Moshi	56
Moshi–Arusha	40

The block system for train operation is the tablet system for Tanga–Moshi section and the ticket system for Moshi–Arusha section.

4-5-2 Improvement planning

1) Addition of signal stations

Distances between stations on the Tanga Line are varied. For example, the distance between Makanya and Same is 34.6km and that between Same and Lembeni is 38.3km, which are twice or three times as that of other sections, causing diminished traffic capacity. As a result, in order to increase the traffic capacity required for soda ash transport, it is necessary to add intermediate signal stations over the long sections between stations.

The locations of the added signal stations (see Table 4-7) would be determined according to the circumstances of the traffic volume of soda ash. In cases where the transport of soda ash is 250,000 t/yr., no more signal stations would be necessary, as the soda ash trains would be few in number.

Table 4-7 Location of New Signal Stations

Section	Distance at present	Number of additional signal station	
		Incase of 1,000,000 ton traffic	Incase of 500,000 ton traffic
Maurui–Makuyni	16.39 km	1	-
Mkubara–Mkomasi	19.31	1	-
Buiko–Hedaru	24.64	1	1
Hedaru–Makanya	19.31	1	-
Makanya–Same	34.60	2	1
Same–Lembeni	38.32	2	1
Lembeni–Kisangiro	20.02	1	1
Kisangiro–Kahe J.	20.02	1	1
Kahe J.–Moshi	20.12	1	1
Moshi–Kikuletwa	31.68	1	1
Kikuletwa–Usu River	30.56	1	1
Usu River–Arusha	23.84	1	1
Arusha–L. Manyara	94.00	(3)	(3)
Total		14 (17)	9 (12)

Only one main line and one passing loop with the effective length of 330m are laid at each signal station. As for signals, two units each of home signal and starting signal, totalling four signals, are to be erected and the signals and turnouts are to be mutually locked by means of mechanical interlocking system. As to the block equipment, the tablet system now used in the Tanga Line is to be provided.

2) Track improvement of the Arusha Branch Line

As the track of Arusha Branch Line between Moshi and Arusha, about 85km in length, has laterite ballast, with 22.5 kg/m rails and iron sleepers, the bearing capacity of track is limited and introduction of heavy locomotives of the soda ash trains is almost inconceivable. Accordingly, the rails are to be replaced by the 40 kg/m rails as in the case of the new line between Arusha and Lake Natron, and iron sleepers are to be replaced by prestressed concrete sleepers.

The laterite ballast is to be improved by replacement with crushed stone. The cost of ballast improvement is, however, not taken up in this project as the EAR is now implementing a plan for changing to crushed stone ballast.

3) Improvement of gradient

The sections requiring gradient improvement for reasons of keeping the normal tractive capacity of locomotives are the upgrade sections with gradient of 1.66% or more towards Tanga Port. The sections with such steep gradient are Arusha-Moshi section with 2.2% and Makuyuni–Maurui section with 2.0%.

The upgrade section with the gradient of 1.66% or more towards ARusha does not cause any trouble so far as traffic efficiency is concerned, as the trains for that destination may be operated empty in case of the soda ash trains.

4) Installation of short-cut line at Moshi Station

Moshi Station is the terminal station of the Arusha Branch Line and connection with the Tanga Line is made by the switch-back system. Moshi Station is located on inclined ground and extension of the station compound is very difficult due to this topographical condition. Because of the operational requirements of the scheduled trains, vehicles coming into and going out of the engine depot and goods wagon depot and goods loading and unloading on the limited lines, congestion is occasioned and some difficulties in maintaining good working order are obvious. Without prior improvements, smooth operations in departure and arrival of soda ash trains therefore would be nearly impossible. As soda ash transport is to be by the trains for this exclusive purpose, neither connection and disconnection of wagons at the intermediate stations nor mixed transport by the general goods trains is taken into consideration. In addition, it becomes necessary to improve the traffic efficiency for the soda ash train through reducing the number of stopping stations en route to minimize the loss of time.

For these reasons, installation of the short-cut line as shown in Fig. 4-15 is planned. This is intended for the most effective utilization of the existing facilities of Moshi Station and smooth operation of the soda ash trains. The facilities required are the short-cut line to be newly laid over 3.5km, a crossing signal station with branching out system, and a junction with branching out system only as in the case of Mruazi Junction.

4-5-3 Improvement cost and maintenance cost

1) *Improvement cost*

The kind of improvement work of the existing railway by route is illustrated in Table 4-8.

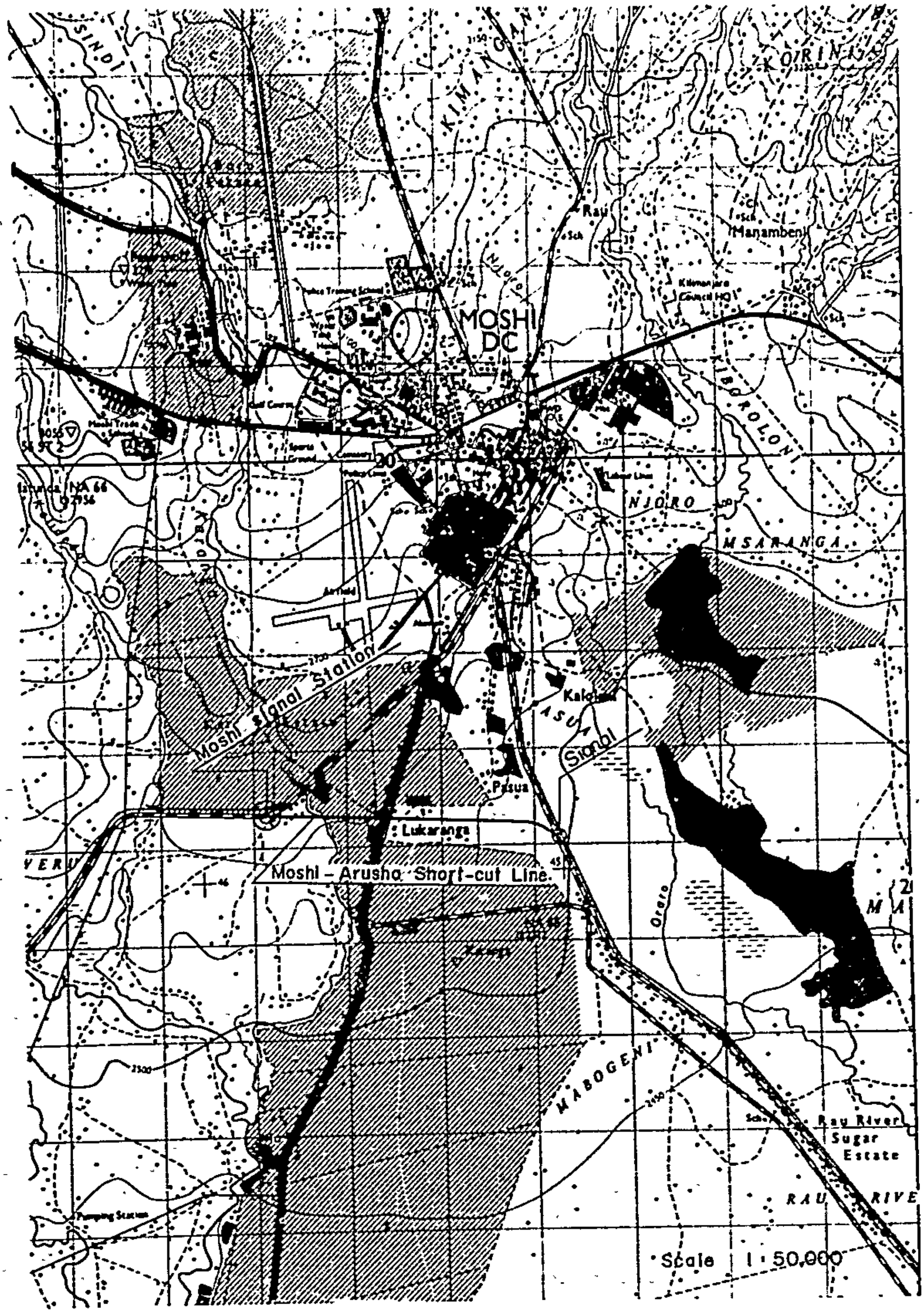
Table 4-8 Improvement Item of Existing Line by Route

Section	Improvement Item	Route 1	Route 2	Route 3	Route 4	Route 5
Tanga–Moshi	Additions of Signal Station					
	11 Stations (1,000,000 ton)	X	X	X	X	X
	6 Stations (500,000 ton)	X	X	X	X	X
	Gradient Improvement	X	X	X	X	X
	Installation of Short-cut Line	X	X	X	X	
	Siding for Loading					X
Moshi–Arusha	*Additions of 3 Signal* Stations	X	X	X	X	
	Gradient Improvement	X	X	X	X	
	Track Improvement	X	X	X	X	
	Sidings for Loading				X	
Arusha–L. Manyara	Additions of 3 Signal Stations		X			
	Sidings for Loading			X		

Notes: 1. As construction cost of loading facility of soda ash is included in the road construction cost, it is not included in the railway improvement cost.

2. The construction cost of the Tanga Littoral Line is included in the port construction cost and not included in the railway improvement cost.

Figure 4-15 Sketch Plan of Short-Cut Line at Moshi Station



The cost for the existing line improvement which is proportionate to soda ash production scale as classified by route is as shown in Table 4-9.

Table 4-9 Cost of Existing Line Improvement

Item	Soda Ash Production Scale	Route 1	Route 2	Route 3	Route 4	Route 5
A. Financial cost	1,000,000 t/yr.	102,841	108,283	108,283	102,841	21,578
(Tsh 1,000)	500,000	93,769	99,211	99,211	93,769	12,506
	250,000	-	-	77,411	77,441	1,620
B. Economic cost	1,000,000 t/yr.	10,192	10,729	10,729	10,192	2,137
(US$ 1,000)	500,000	9,295	9,832	9,832	9,295	1,240
	250,000	-	-	7,684	7,684	166

2) Maintenance cost

Annual maintenance cost according to soda ash production scale as classified by route is as shown in Table 4-10.

Table 4-10 Maintenance Cost (Existing Line)

Item	Soda Ash Production Scale	Route 1	Route 2	Route 3	Route 4	Route 5
A. Financial cost	1,000,000 t/yr.	2,351	2,470	2,470	2,351	444
(Tsh 1,000)	500,000	2,153	2,272	2,272	2,153	247
	250,000	-	-	1,797	1,797	8
B. Economic cost	1,000,000 t/yr.	232	244	244	232	45
(US$ 1,000)	500,000	211	223	223	211	24
	250,000	-	-	177	177	1

4-5-4 Improvement of existing line not included in this project

Goods and passenger transport in Tanzania is chiefly dependent upon the relatively will developed road transport system, and railway transport is playing only a supplementary role. Although some shift from road to rail transport is observed after the oil shock, the diverted amount is negligible due to the low standard of transport service on the existing line.

The cause of insufficient traffic capacity is nothing more than the delay of investment in railway facilities on account of the foreign exchange shortage, as the necessary materials are mostly imported goods. However, even in such a circumstance, the existing line is well maintained showing that all the possible endeavors have been made.

Since the traffic volume of the Tanga Line will be expected to increase annually by 3% or thereabout, even if the demand for soda ash transport is not added, normal investment in facilities for improving track capacity will become necessary in the near future. The required investment will be made for the following items, but as such investment is not directly meant for the soda ash transport, the relative amount is not included in the cost of this project.

1) Extension of effective length in station

To improve the traffic capacity, it is necessary to increase the number of vehicles of each train. The effective length of crossing lines in stations are extremely variable on the Tanga Line. The longer ones are 600m or more, whereas some lines are as short as 120m or thereabout. Under such conditions, crossing of two long trains would be possible only at a limited number of station. It would become difficult to increase the traffic capacity. Therefore, improvement should be made in such a way that each station would have the similar effective length of the crossing lines.

2) Removal of industrial sidings branching from outside of station

Some industrial sidings are laid to workshops and other entities from outside of the station compound. This is the cause of lowering traffic efficiency of the whole route, constituting the constraining factor against the increase of traffic capacity. Moreover, it is dangerous from the standpoint of operational safety. Accordingly, unnecessary sidings should be removed. For necessary ones, signal stations are to be established at the branching spots. If crossing lines are also provided in these signal stations, there would be no problem any more from the viewpoint of the safety of operation. At the same time it would reduce the interval length of stations, thereby helping to increase the traffic capacity.

3) Improvement of signal and safety devices

At present only home signals are erected at crossing stations, but it is necessary to provide starting signals in order to secure the safety on the route ahead. Moreover, the home and starting signals should be mechanically interlocked with turnouts in order to prevent mishandling.

4) Improvement of block system

The block instrument for train operation on the section between Tanga and Moshi is the tablet block system. However, the section between Moshi and Arusha is of the ticket block system depending only upon telephone contact between adjoining stations. This system is quite dangerous when train frequency is increased and improvement by adoption of the tablet system is earnestly recommended.

5) Cruve improvement

Speeding-up is a step toward increasing the transport capacity. For this purpose, a sharply curved line where the train speed is permanently restricted should be avoided.

6) Safety device for level crossing

The Tanga Line has level crossings with trunk road. Some of them have manual crossing barriers to stop the road traffic but most of them only have warning signs. As motor vehicles are operated at high speed along the trunk road, danger will increase at a rapid pace with the increase of train frequency, and at such crossings where traffic is heavy and no counter-measures have yet been adopted crossing barriers operated by watchmen, as is currently practiced at the crossings near the stations, should be employed.

7) Improvement of sleepers

The EAR is using iron sleepers at present. Since iron sleepers are imported, and on account of shortage of foreign exchange, replacement of old sleepers has long been neglected. The results are that majority of them are superannuated. In view of the facts that cement is produced in Tanzania and the prestressed concrete pipes and other similar products are being made, it is desirable to set up a shop to produce prestressed concrete sleepers by requiring the necessary technical know-how.

4-6 Rolling Stock Cost and Operation Cost

4-6-1 Rolling stock cost and maintenance cost

1) Rolling stock cost

The cost items necessary for operation of the exclusive train of soda ash include locomotives, covered wagons and shunting locomotives in loading and unloading sidings for soda ash.

The unit price of imported rolling stock is calculated on a CIF basis at Dar es Salaam at the prices in December, 1975, as stated below:

Locomotive	US$ 650,000
Covered wagon	63,000
Shunting locomotive	600,000

It is estimated that, as for shunting locomotives, two engines each in each yard for loading and unloading, totalling four units in case of 1,000,000 tons transport would be needed, whereas one engine each, totalling two, in cases of 250,000 and 500,000 tons transport, would be needed.

Based on the calculated results of the required number of rolling stock, cost of rolling stock as classified by route is as shown in Table 4-11.

2) Maintenance cost

The maintenance cost of locomotives, wagons and shunting locomotives is stated in Table 4-12.

4-6-2 Operation cost

Operation cost of the soda ash transport for railway portion consists of the following items:

1) Maintenance cost of track and structures for new railway

This cost is mentioned in Table 4-5.

2) Maintenance cost of improved sections for existing line

The maintenance cost for the improved sections financed by the soda ash project is to be shared by this project. The cost is mentioned in Table 4-10.

3) Maintenance cost of rolling stock

The maintenance cost of locomotives, covered wagons and shunting locomotives was mentioned in the last paragraph.

4) Personnel cost of field staff

Personnel cost of train crews and station staff in terms of soda ash production scale and alternative routes is indicated in Table 4-13. As for the maintenance staff, personnel cost is included in items 1), 2) and 3), and is not separately counted.

5) Personnel cost of administrative staff

Personnel costs of administrative office staff including those of directors, administrative staff for operations, traffic, maintenance, general affairs, account, etc., are also mentioned in Table 4-13.

6) Fuel cost

The fuel consumption of the Class 90 locomotive is 5 - 6 liter/km or thereabout as seen from performance data of the EAR. This figure is to be used for the soda ash train.

The price of diesel fuel is Tsh 1.75, wholesale, at Dar es Salaam in December, 1975,

Table 4-11 Rolling Stock Cost

Production Scale (tons)	Route	Financial Cost (Tsh 1,000)				Economic Cost (US$ 1,000)			
		Loco.	Covered Wagon	Shunting Loco.	Total	Loco.	Covered Wagon	Shunting Loco.	Total
1,000,000	1	79,560	135,182	19,584	234,326	9,750	16,566	2,400	28,716
	2	90,168	157,284	19,584	267,036	11,050	19,275	2,400	32,725
	3	79,560	135,182	19,584	234,326	9,750	16,566	2,400	28,716
	4	63,648	112,566	19,584	195,798	7,800	13,795	2,400	23,995
	5	58,344	101,258	19,584	179,186	7,150	12,409	2,400	21,959
500,000	1	42,432	67,848	9,792	120,072	5,200	8,315	1,200	14,715
	2	47,736	78,642	9,792	136,170	5,850	9,638	1,200	16,688
	3	42,432	67,848	9,792	120,072	5,200	8,315	1,200	14,715
	4	31,824	56,540	9,792	98,156	3,900	6,929	1,200	12,029
	5	31,824	56,540	9,792	98,156	3,900	6,929	1,200	12,029
250,000	3	26,520	33,410	9,792	69,722	3,250	4,094	1,200	8,544
	4	26,520	33,410	9,792	69,722	3,250	4,094	1,200	8,544
	5	21,216	25,186	9,792	56,194	2,600	3,087	1,200	6,887

Table 4-12 Maintenance Cost (Rolling Stock)

Production Scale (tons)	Route	Financial Cost (Tsh 1,000)				Economic Cost (US$ 1,000)			
		Loco.	Covered Wagon	Shunting Loco.	Total	Loco.	Covered Wagon	Shunting Loco.	Total
1,000,000	1	6,365	6,759	1,567	14,691	780	828	192	1,800
	2	7,213	7,864	1,567	16,644	884	964	192	2,040
	3	6,365	6,759	1,567	14,691	780	828	192	1,800
	4	5,092	5,628	1,567	12,287	624	690	192	1,506
	5	4,668	5,063	1,567	11,298	572	620	192	1,384
500,000	1	3,395	3,392	783	7,570	416	416	96	928
	2	3,819	3,932	783	8,534	468	482	96	1,046
	3	3,395	3,392	783	7,570	416	416	96	928
	4	2,546	2,827	783	6,156	312	346	96	754
	5	2,546	2,827	783	6,156	312	346	96	754
250,000	3	2,122	1,671	783	4,576	260	205	96	561
	4	2,122	1,671	783	4,576	260	205	96	561
	5	1,697	1,259	783	3,739	208	154	96	458

Table 4-13 Personnel Cost

Production Scale (tons)	Route	Financial Cost (Tsh 1,000)				Economic Cost (US$ 1,000)			Total
		Administrative Staff	Field Staff		Total	Administrative Staff	Field Staff		
			Station Staff	Train Crew			Station Staff	Train Crew	
1,000,000	1	174.0	897.4	828.8	1,900	16.4	84.6	78.1	179
	2	174.0	1,105.8	1,035.8	2,316	16.4	104.2	97.6	218
	3	24.0	645.8	828.8	1,499	2.3	60.9	78.1	141
	4	24.0	552.2	732.2	1,308	2.3	52.1	69.0	123
	5	24.0	458.6	621.8	1,104	2.3	43.2	58.6	104
500,000	1	174.0	703.3	514.6	1,392	16.4	66.3	48.5	131
	2	174.0	921.7	542.2	1,638	16.4	86.9	51.1	154
	3	24.0	489.8	514.6	1,028	2.3	46.2	48.5	97
	4	24.0	396.2	390.4	811	2.3	37.3	31.6	76
	5	24.0	302.6	335.2	662	2.3	28.5	31.6	62
250,000	3	24.0	95.8	359.3	479	2.3	9.0	33.9	45
	4	24.0	95.8	276.5	396	2.3	9.0	26.1	37
	5	24.0	64.6	240.0	329	2.3	6.1	22.6	31

which is applicable for the financial cost. As to the economic cost for fuel, the sales tax and import duty portions are deducted from the wholesale price. The economic cost thereby obtained is Tsh 1.06, of which 90% is foreign exchange:

$$1.06 \times 0.9 = 0.954$$

and 10% is domestic currency:

$$1.06 \times 0.1 = 0.106.$$

For the domestic currency portion, the shadow rate of 1.3 is used, then, the costs are expressed in term of US$ as follows:

$$0.954 / 8.16 = 0.117$$
$$0.106 / (8.16 \times 1.3) = 0.010$$

Total .... 0.127 US$/liter

Based on the above data, the diesel fuel consumption and cost are claculated as shown in Table 4-14.

4-7 Analysis of Railway Transport Cost

4-7-1 Railway transport cost

The cost of transporting soda ash on railway is summarized in Table 4-15. The costs for road and port are separately mentioned.

4-7-2 Comparison of transport cost

Assuming the project life to be 30 years, the transport cost per ton of soda ash on railway only, based on soda ash production scale and the alternative routes, is indicated in Table 4-16.

As the transport cost in Table 4-16 is for railway transport section only and the cost involving road transport shall be added to Route 3 through Route 5. Therefore, it is not advisable to determine the optimum route solely from the said table. However, when reference is made to Route 1 and Route 2, under which the transport at full length between Lake Natron and Tanga Port is by the railway, Route 1 is superior to Route 2. The reasons are as follows:

1. Even though based on the presumption that the Arusha-Musoma Line may be constructed as a separate project, construction cost of which will not be shared by the soda ash project, the cost of new railway construction in the case of Route 2 is nearly the same as that of Route 1. Moreover, construction of the Arusha–Musoma Line is still under the planning stage.

Table 4-14 Fuel Cost

Production Scale (tons)	Route	Section	Length (km)	Consumption (1,000) (liter)	Financial Cost (1.750Tsh/liter)			Economic Cost (0.127US$/liter)		
					Diesel Fuel (Tsh 1,000)	Lubricant (do.)	Total (do.)	Diesel Fuel (US$ 1,000)	Lubricant (do.)	Total (do.)
1,000,000	1	L. Natron–Tanga P.	589	10,602	18,554	3,711	22,265	1,346	269	1,615
	2	L. Natron–Tanga P.	714	12,870	22,523	4,505	27,028	1,634	327	1,961
	3	L. Manyara–Tanga P.	533	9,594	16,790	3,358	20,148	1,218	244	1,462
	4	Arusha–Tanga P.	439	7,902	13,829	2,766	16,595	1,004	201	1,205
	5	Moshi–Tanga P.	354	6,354	11,120	2,224	13,344	807	161	968
500,000	1	L. Natron–Tanga P.	589	5,301	9,277	1,855	11,132	673	135	808
	2	L. Natron–Tanga P.	714	6,426	11,246	2,249	13,495	816	163	979
	3	L. Manyara–Tanga P.	533	4,797	8,395	1,679	10,074	609	122	731
	4	Arusha–Tanga P.	439	3,951	6,914	1,383	8,297	502	100	602
	5	Moshi–Tanga P.	354	3,186	5,576	1,115	6,691	405	81	486
250,000	3	L. Manyara–Tanga P.	533	3,198	5,597	1,119	6,716	406	81	487
	4	Arusha–Tanga P.	439	2,634	4,610	922	5,532	335	67	402
	5	Moshi–Tanga P.	354	2,124	3,717	743	4,460	270	54	324

Note: Consumption Volume = Length x 2 x 300 days (working day) x Number of trains in a day x 5 liters

Table 4-15 Capital Cost and Annual Operation Cost of Railway

Production Scale (tons)	Route	Engineering Fee	Capital Cost			Annual Operation Cost		
			New Railway Construction	Existing Line Improvement	Rolling Stock	Personnel	Fuel	Maintenance
(A) Financial Cost (Tsh 1,000)								
1,000,000	1	54,509	987,344	102,841	234,326	1,900	22,265	28,882
	2	55,225	996,224	108,283	267,036	2,316	27,028	32,103
	3	6,497	-	108,283	234,326	1,499	20,148	17,161
	4	6,170	-	102,841	195,798	1,308	16,595	14,638
	5	1,295	-	21,578	179,186	1,104	13,344	11,742
500,000	1	54,056	987,344	93,769	120,072	1,392	11,132	21,563
	2	54,772	996,224	99,211	136,170	1,638	13,495	23,795
	3	5,953	-	99,211	120,072	1,028	10,074	9,842
	4	5,626	-	93,769	98,156	811	8,297	8,309
	5	750	-	12,506	98,156	662	6,691	6,403
250,000	3	4,646	-	77,411	69,722	479	6,716	6,373
	4	4,646	-	77,411	69,722	396	5,532	6,373
	5	97	-	1,620	56,194	329	4,460	3,747
(B) Economic Cost (US$ 1,000)								
1,000,000	1	6,680	101,809	10,192	28,716	179	1,615	3,242
	2	6,768	101,248	10,729	32,725	218	1,961	3,600
	3	796	-	10,729	28,716	141	1,462	2,044
	4	756	-	10,192	23,995	123	1,205	1,738
	5	159	-	2,137	21,959	104	968	1,429
500,000	1	6,625	101,809	9,295	14,715	131	808	2,349
	2	6,712	101,248	9,832	16,688	154	979	2,585
	3	730	-	9,832	14,715	97	731	1,151
	4	689	-	9,295	12,029	76	602	965
	5	92	-	1,240	12,029	62	486	778
250,000	3	569	-	7,684	8,544	45	487	738
	4	569	-	7,684	8,544	37	402	738
	5	12	-	166	6,887	31	324	459

Table 4-16 Comparison of Transport Cost

Production Scale (tons)	Discount Rate (%)	Route 1	Route 2	Route 3	Route 4	Route 5
(A) Financial Cost per Ton						
		Tsh (US$)	Tsh (US$)	Tsh (US$)	Tsh (US$)	Tsh (US$)
1,000,000	8.5	203.02 (24.88)	216.50 (26.53)	75.05 (9.20)	64.12 (7.86)	47.39 (5.81)
	10.0	227.42 (27.87)	241.56 (29.60)	79.53 (9.75)	68.06 (8.34)	49.80 (6.10)
	12.0	262.87 (32.31)	277.37 (33.99)	85.77 (10.51)	73.54 (9.01)	53.13 (6.51)
500,00	8.5	341.90 (41.90)	358.21 (43.90)	88.18 (10.81)	75.32 (9.23)	50.87 (6.23)
	10.0	386.90 (47.41)	404.93 (49.62)	94.16 (11.54)	80.62 (9.88)	53.53 (6.56)
	12.0	454.48 (55.70)	473.00 (57.97)	102.51 (12.56)	88.01 (10.79)	57.21 (7.01)
250,000	8.5	-	-	166.32 (14.25)	111.26 (13.64)	58.69 (7.19)
	10.0	-	-	124.52 (15.26)	119.46 (14.64)	61.43 (7.53)
	12.0	-	-	135.99 (16.66)	130.93 (16.05)	65.21 (7.99)
(B) Economic Cost per Ton						
		US$ (Tsh)	US$ (Tsh)	US$ (Tsh)	US$ (Tsh)	US$ (Tsh)
1,000,000	10.0	23.70 (193.40)	24.92 (203.37)	8.35 (68.15)	7.15 (58.32)	5.34 (43.58)
	12.0	27.48 (224.23)	28.77 (234.73)	9.06 (73.96)	7.77 (63.40)	5.75 (46.93)
	15.0	33.81 (275.88)	35.20 (287.24)	10.19 (83.18)	8.76 (71.48)	6.37 (51.97)
500,000	10.0	40.38 (329.47)	41.07 (335.11)	9.84 (80.30)	8.40 (68.56)	5.78 (47.15)
	12.0	47.43 (387.06)	48.84 (398.50)	10.78 (87.86)	9.22 (75.21)	6.22 (50.74)
	15.0	59.31 (483.93)	60.81 (496.21)	12.25 (99.92)	10.52 (.85.82)	6.91 (56.40)
250,000	10.0	-	-	12.83 (104.68)	12.51 (102.05)	6.59 (53.75)
	12.0	-	-	14.13 (115.33)	13.76 (112.29)	7.05 (57.50)
	15.0	-	-	19.15 (156.23)	18.77 (153.20)	7.77 (63.44)

Furthermore, if the Arusha–Musoma Line is realized, addition of signal stations between Arusha and Lake Manyara will be required for the added transport of soda ash besides the normal traffic. The cost for signal stations is to be counted in this project. It is found out, therefore, that the cost of existing railway improvement in case of Route 2 will be considerably higher than that of Route 1.

2. As the total extension of railway operation for Route 2 is longer than that for Route 1 by 125 km, the required number of rolling stock for the former exceeds that of the latter.

3. Because of the same reason as the above, costs of maintenance and train operation, including those for train crews, fuel, etc. for Route 2 exceeds to a conspicuous degree those for Route 1.

4-8 Suggestions for the Terms of Reference for the Feasibility Study

In this chapter, statements have been made mainly on the railway portion of each alternative route. These descriptions are the rough results, based on the field studies conducted over a rather short period, made in accordance with the standards for the pre-feasibility study. Therefore, the feasibility study of this project, covering the full extent of investigations and analyses on the various problems, is to be made at the next stage. The following are proposed as terms of reference for the feasibility study on railway transportation.

1) Reviewing this Report, routes for soda ash transport which are based on railway routes and/or railway-road combined routes, are to be chosen for further detailed study.

2) Taking aerial photographs with scale of 1/10,000 along the selected new railway alignment on the maps of 1/50,000, maps of 1/10,000 are to be made by photogrammetric methods. The extension of mapping is a strip of 4km centering on the railway alignment. The railway location is made on maps of 1/10,000. When the location is fixed, maps of 1/2,500 are to be provided by photogrammetric methods from the same aerial photographs. In this case, extension of the mapping is along the route in maps of 1/10,000 with width of one kilometer.

3) Route location on map of 1/2,500
Using maps of 1/2,500, the railway alignment is to be finally determined.

4) Field investigation
The alignment studied on the maps of 1/2,500 is to be checked at the site.
If necessary, modification would be made.

5) Geological investigation
If it is deemed to be necessary, at the time of the site investigation, drilling tests, soil tests, seismic exploration, etc. shall be carried out at the foundation of structures,

tunnels, high embankments, etc.

6) Investigation of the materials and study of construction costs
Investigations are to be made on costs and quantities of available construction materials and equipment, including transportation costs. The unit cost of earthwork, personnel cost, power, as well as capability and efficiency of the Tanzanian laborers and technicians are also to be studied.

7) Data collection and meeting
Date or information is to be collected on the follwing subjects. If any information is found unavailable, conditions to be assumed or other issues are to be decided at meetings with the competent Tanzanian authorities. If necessary, further investigation is to be made.

a) Weather conditions along the new line.

b) Proposed year for constructing the Arusha–Musoma Line and the final alignment.

c) Plan and profile (1/500) of the Tanga–Arusha Line and, improvement and investment plan.

d) Projection of the future traffic over the Arusha–Tanga Line, and such background data as population along the line, and statistics of major commodities transported.

8) Preliminary design and construction cost estimate
According to the investigations and studies mentioned above, design and cost estimates are made according to the normal standard for a feasibility study.

9) Estimation of transport cost.

10) Preparation of terms of reference for the detailed study.

CHAPTER 5 ROAD TRANSPORTATION STUDY

5-1 Roads and Road Transportation in Tanzania

5-1-1 Roads

There are about 33,400 km of roads in Tanzania. However, only about 2,600 km, (8%) are paved and 1,100 km (3%) are engineered gravel. The remainder are un-engineered earth and gravel roads suitable only for dry-weather movement. The average road density is 36 km/ 1,000 km^2, but except for the Tan-Zam highway, most of the engineered roads are located near Dar-es-Salaam and Tanga, and in the Arusha and Lake Victoria areas. The routes of the roads are shown in Fig. 5-1.

5-1-2 Road transportation

Traffic volumes are generally low, averaging well under 50 vpd on most roads as shown in Figure 5-1, and the overall growth rate is estimated at 3 - 4% p.a.

Regarding public haulage, the vast majority (96%) of licensed operators are small, independent carriers, with one to four vehicles, who together account for 68% of the commercial trucking fleet. Cooperative transport companies account for about 18% of the remaining trucking capacity and Government owned companies, about 14%.

Most trucks are of 6-ton capacity, but in recent years there has been a trend toward larger and heavier trucks and buses. Vehicles with capacities of 30 tons or more, and with single axle-loads of well over the 8,200 kg legal limit, have appeared in significant numbers on the Tan-Zam highway and along the coastal road between Chalinze and the Kenya border.

In 1969, the National Transport Corporation was established to develop land, sea and inland waterway, and air transportation means for passengers and goods. So far, four subsidiaries have been formed:

The Dar -es-Salaam Motor Transport Company, Ltd.
The Zambia-Tanzania Road Services Company, Ltd.
The National Road Haulage Company, Ltd., (NRHC)
The Tanzania Coastal Shipping Line, Ltd.

The long-term objective of NRHC is to bear the main responsibility for long-distance road transport. The Haulage rate in November, 1975 was Tsh. 0.55 per ton per running mile for transport of general goods.

5-2 Approach to Road Transportation Study

5-2-1 General approach

In comparison with railway transportation, road transportation is, in general, characterized by the following points:

(i) The operating cost per ton-kilometer of road transportation, including fuel costs, crew wages, maintenance and depreciation of vehicles, is much higher than that of railway transportation.

(ii) The construction cost of roads per unit length is far less than that of railway.

(iii) Road transportation is more economical for haulage of less than 200 - 300 km, than railway transportation.

Taking into consideration the above points and the total haulage distance of about 600 km from Lake Natron to Tanga, the first approach was oriented to a combination of road transportation with the existing Tanga-Arusha railway.

5-2-2 Cost components

Road transportation of soda ash from the Plant at Lake Natron to the nearest adequate railway station was considered to require the following costs:

(i) Construction and maintenance costs for new road(s),

(ii) Improvement and maintenance costs for existing road(s) if any,

(iii) Construction and operation/maintenance costs for transshipment facilities,

(iv) Purchase cost and operation/maintenance costs of vehicles, and

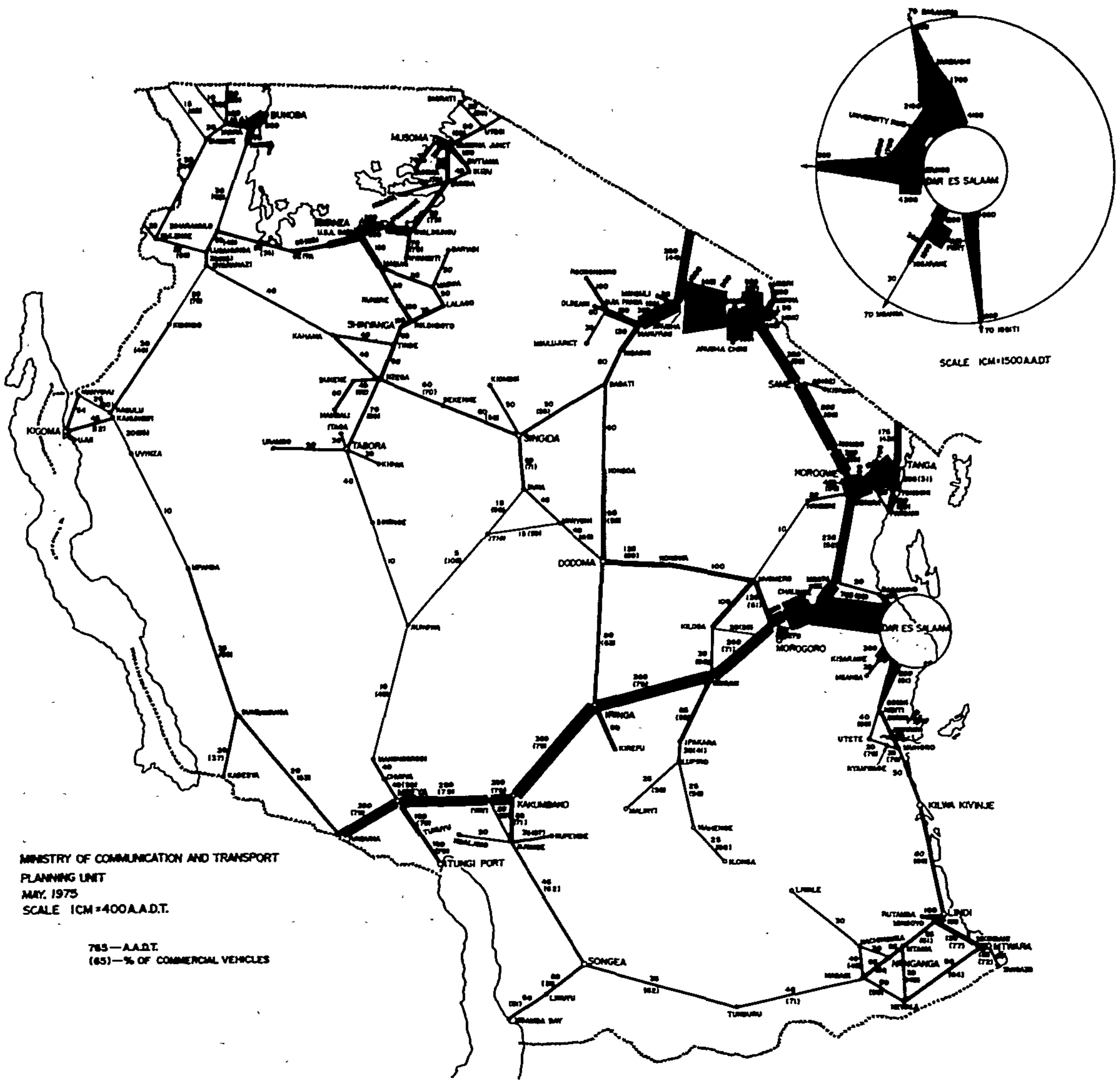
(v) Construction and maintenance costs for a workshop and parking lot.

The construction and operation/maintenance costs of transshipment facilities for loading at the Plant site and for unloading at the port were considered to be included in the Plant costs and the port costs, respectively.

5-3 Existing Roads from Lake Natron to Tanga

The existing roads from Lake Natron to Tanga consist of two completely different sections. One is the section from Lake Natron to Arusha (Longido) and the other from Arusha to Tanga.

Figure 5-1 1974 Road Traffic Volumes



5-3-1 Lake Natron–Arusha (Longido)

To go from Arusha to Lake Natron, one must go up to Longido on the Great North Road, which is in good condition, then turn to west on to a very poor unengineered earth road leading to the east coast of Lake Natron via Kitumibeine and Gelai. It takes about half a day to go to from Arusha to the Lake even in a four-wheel-drive vehicle. Other routes are:

Longido – Engare Naibore – Lake Natron
Oldonyo Sambu – Kitumbeine – Gelai – Lake Natron

These three roads are little more than foot trails and are adequate only for local transportation demands such as supplying consumables to the Masai people living along the roads.

Economic activity there is very limited due to rainfall of less than 400 mm p.a. and only the Masai's stock breeding is worthy of comment. Even in the future, development of the area will be very limited. Therefore, there will be little possibility to construct a road except through this Project.

5-3-2 Arusha–Tanga

The road from Arusha to Tanga via Moshi is called the North Trunk Road and has a 6 m-wide paved surface in good condition. Conditions are as shown in Table 5-1.

Traffic on this road has been increasing at a moderate rate of about 5 - 6% p.a. Because the present traffic volumes are far less than the capacity of these roads, it will be possible to absorb the traffic volume generated by soda ash development without serious congestion, even if traffic on the road grows at a higher rate than previously.

If soda ash transportation is limited to vehicles having smaller single axle-loads than 18,000 lbs. single, there should be no need for structural improvements and additional costs for maintenance would be negligible.

5-4 Volume of Transportation and Vehicle Size

5-4-1 Volume of transportation

Regarding the volume of transportation, three cases, 250,000 tons, 500,000 tons and 1,000,000 tons p.a., were considered. Assuming 300 work days in a year, the average daily transportation volume was calculated as shown below. (on p.115)

Table 5-1 Inventory of Related Roads

	A2-01	A4-04	A4-03	A4-02	A4-01	A1-02
From	Kenyan Border	Dodoma Corner	Moshi	Taveta Junction	Korogwe	Segera
To	Dodoma Corner	Moshi	Taveta Junction	Korogwe	Segera	Tanga
Length (km)	99	85	23	238	21	73
Geometrics						
Base Width (m)	9.0	9.0	9.0	9.0	9.0	8.9
Pavement Width (m)	6.0	6.0	6.0	6.0	6.0	6.0
Terrain	Flat/Rolling	Rolling/Hilly	Flat/Rolling	Flat/Rolling	Rolling/Hilly	Flat/Rolling
Sight Distance (m)	720	340	N.A.	430	300	310
Surface Type	Bitumen	Bitumen	Bitumen	Bitumen	Bitumen	Bitumen
Overall Speed (km/hr.)	67	62	N.A.	67	55	67
AADT (1970)	275	1,000	800	200	300	500
(1974)	250 1,300	900	900 250	300	450 400	700
Traffic Forecast[1]						
1980	390	1,438	1,151	282	412	646
1985	474	1,725	1,380	335	482	735
1990	568	2,068	3,655	398	564	835

1) : From Economic and Engineering Study of the Tanzania Highway.

Average Daily Transportation Volume

Yearly Transportation Volume	Average Daily Transportation Volume
250,000 tons	833 tons
500,000 tons	1,667 tons
1,000,000 tons	3,333 tons

5-4-2 Vehicle size

The following legal limitations on vehicle size are applied in Tanzania:

Legal Limitations on Vehicle Size

'Dimensions and weights of motor vehicles and trailers shall not exceed:

(1)	Overall width	8'–3' (2,514 mm)
(2)	Overall height	14'–6' (4,416 mm)
(3)	Overall length	
	– Single goods vehicle	33' (10,058 mm)
	– Combined vehicle & trailer	50' (15,239 mm)
(4)	Maximum gross weight	
	– Vehicle	22 tons
	– Combined vehicle and trailer	32 tons
(5)	Maximum wheel load	
	– In the case of a single wheel	7,000 lbs. (3,175 kg)
	– In the case of two wheels when the distance between their centers road contacts does not exceed 18 inches	9,000 lbs. (4,082 kg)
(6)	Maximum axle load	
	– In the case of a single axle	18,000 lbs. (8,165 kg)
	– In the case of a group of axles, one of which is not less than 40 inches and not more than 84 inches behind	

the other and both of which collectively carry the load that would normally be carried by a single axle — 32,000 lbs. (14,515 kg)*

Within these limitations, the following sized vehicles were considered suitable for soda ash transportation.

- 9 to Lorry
- 16.5 ton Semi-trailer

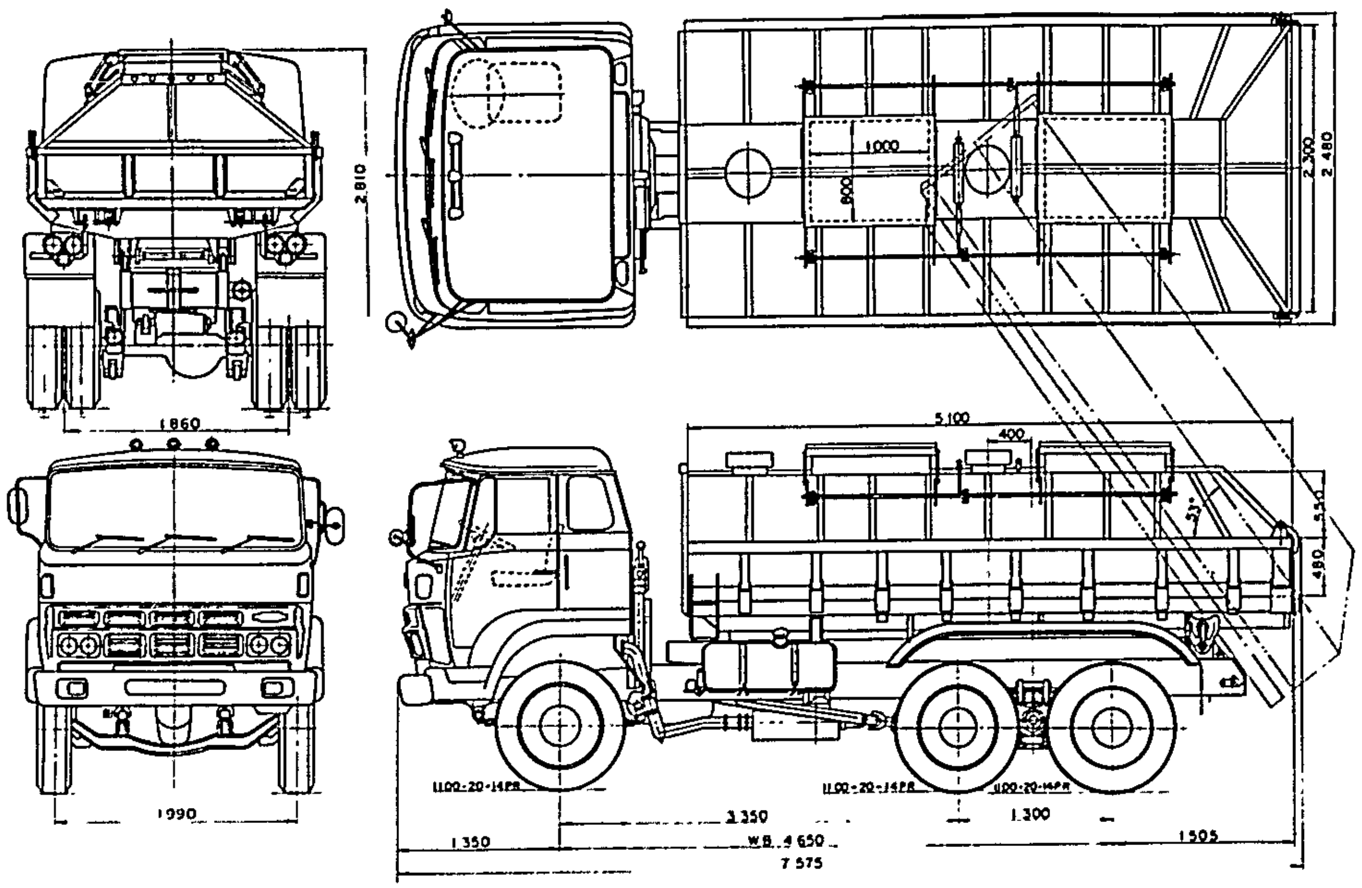
In addition, a 30-ton semi-trailer was also selected in order to clarify the scale merit of vehicles. Roads have to be constructed and/or improved to bear such a large and heavy vehicle, however, the dimensions and weights of the selected vehicles were tentatively assumed as shown in Table 5-2.

Because the soda ash must be kept dry, the vehicle will be provided with a covered container and rear or bottom dumping facilities as shown in Fig. 5-2.

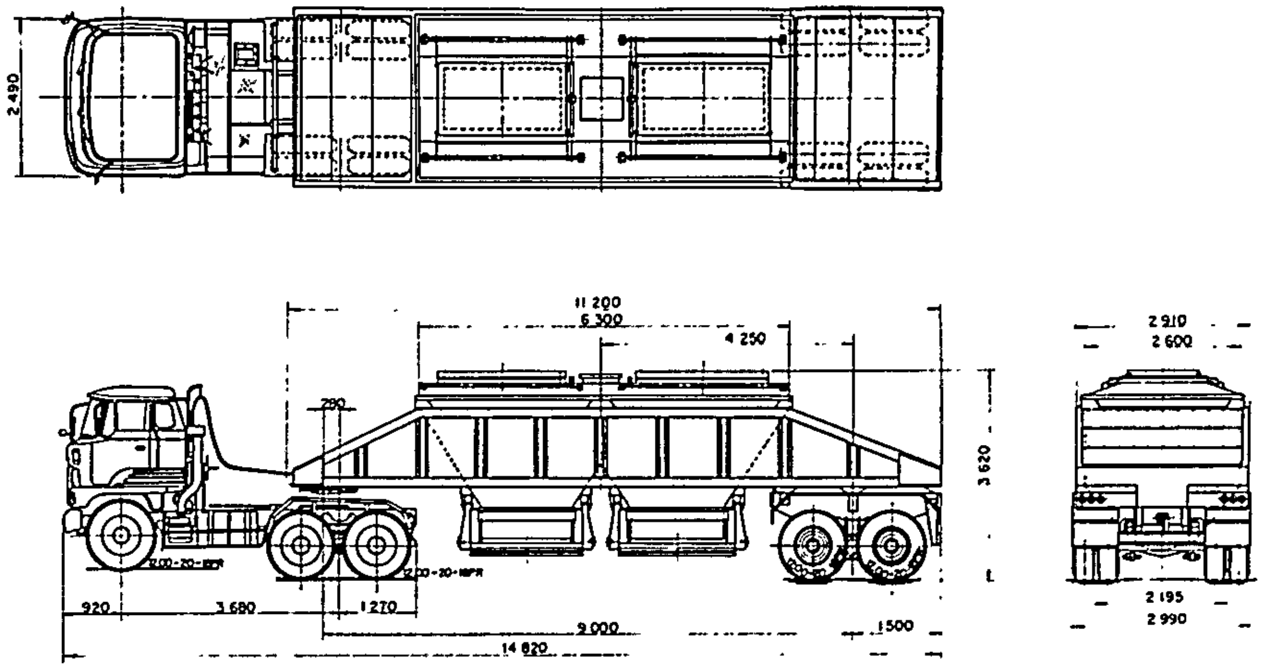
Table 5-2 Dimensions and Weight of Vehicle

Items		Unit	Case 1 9-ton Lorry	Case 2 16.5-ton Semi-trailer	Case 3 30-ton Semi-Trailer
Unloading mechanism			Rear Dump	Bottom Dump	Bottom Dump
Maximum payload		ton	9.0	16.5	30
Tank capacity		m^3	9.6	19.0	32.0
Overall length		mm	7,575	14,820 (Combined)	14,820 (Combined)
Overall width		mm	2,480	2,490	2,910
Overall height		mm	2,810	3,350	3,620
Gross weight		kg	19,635	31,725	49,065
Axle load		kg			
Tractor:	front		5,245	4,035	5,171
	rear		14,390	13,830	20,567
Trailer:	rear		–	13,960	23,320
Tyre size			11.00-20-14	11.00-20-14	12.00-20-18
Maximum power of engine		HP	280	280	350

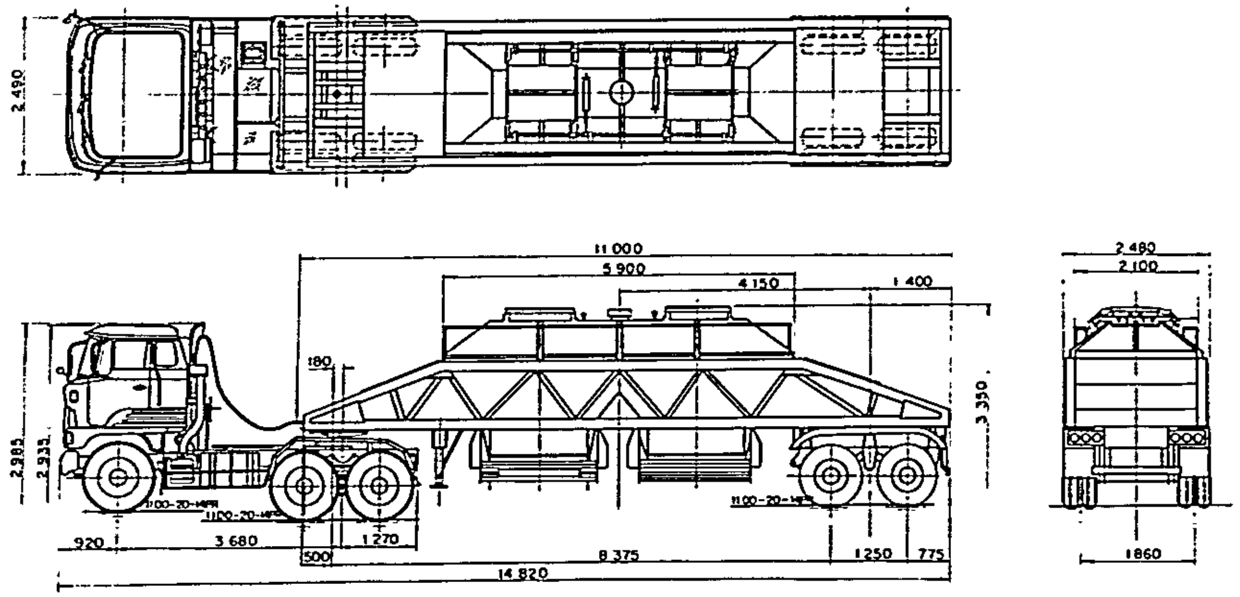
Figure 5-2 Vehicle for Soda Ash Transport



9-TON LORRY



30-TON SEMI-TRAILER



16.5-TON SEMI-TRAILER

5-5 Alternative Points of Transshipment to Railway

5-5-1 Description of alternative points

Considering a combination of roads and railway, the following three railway terminals were found to be alternative points of transshipment:

(i) Arusha station (about 140 km from Lake Natron on a straight line)

(ii) Moshi station (about 180 km from Lake Natron)

(iii) A station to be located on the contemplated Arusha–Musoma railway line (about 140 km from Lake Natron)

Among the three, terminal (ii) and terminal (iii) will become competitive with terminal (i) only if the following conditions are met.

Terminal (ii) : If improvement of the railway between Arusha and Moshi costs an amount large enough to offset supplemental costs for road transportation, including road improvement and vehicle operation from Longido to Moshi; and also if the improvement costs of railway are charged entirely to the Project.

Terminal (iii) : If a substantial portion of the road construction cost from Lake Natron to terminal (iii) is borne by other projects such as regional development, since the construction cost seems higher than that of the road to terminal (i).

These conditions are rather unrealistic and cannot be readily assumed. Therefore, Arusha station (terminal (i)) was selected as a railway terminal in this Report.

5-5-2 Trans-shipment facilities

At Arusha station, trans-shipment facilities will be required for transferring soda ash from motor vehicles to railway cars. Necessary facilities include siloes, conveyer systems, hoppers and shoots.

It was decided that the capacity of storage siloes should be sufficient to store a maximum of one week's worth of transportation volume. The required capacity was estimated as shown below:

Capacity of Storage Silo

	Production Scale (t/yr.)		
	250,000	500,000	1,000,000
Daily Transportation Volume (tons)	833	1,667	3,333
Required Storage Volume	5,000	10,000	20,000
No. of 5,000-ton Silo (nos.)	1	2	4

Financial construction costs for trans-shipment facilities were estimated as shown in Table 5-3, operating and maintenance cost estimates are shown in Table 5-4.

Table 5-3 Financial Construction Costs for Transshipment Facilities

Unit: Tsh. 1,000

	Production Scale (t/yr.)		
	250,000	500,000	1,000,000
Storage Capacity (tons)	5,000	10,000	20,000
1. Silo (1 unit: 5,000-ton capacity)			
(1) Superstructure (steel)	1,350	2,700	5,400
(2) Sub-structure	900	1,800	3,600
2. Converger systems	5,740	8,200	11,480
3. Electric facilities	840	1,200	1,680
4. Related facilities	560	800	1,120
5. Buildings	343	490	686
6. Railway yard	7,652	7,652	11,254
7. Miscellaneous costs	2,433	3,800	5,992
Total cost	19,818	26,642	41,212
(Local currency component)	(8,401)	(10,216)	(15,220)
(Foreign currency component)	(11,417)	(16,426)	(25,992)

Table 5-4 Operating and Maintenance Costs

Unit: Tsh. 1,000

Cost Item	Production Scale (t/yr.)		
	250,000	500,000	1,000,000
1. Maintenance Costs			
(1) Silo, conveyor, etc.	365	570	899
(2) Railway yard	158	158	233
2. Operating Costs			
(1) Electric power	73	131	255
(2) Wages	243	347	486
Total O & M Cost	839	1,206	1,873
(Local Currency Component)	(516)	(731)	(1,139)
(Foreign Currency Component)	(323)	(475)	(734)

5-6 Alternative Routes

5-6-1 Conditions

Conditions in the area between Arusha and Lake Natron are briefly explained below, based on available data and the results of field reconnaissance.

(1) Geography

The Arusha station is located on a plateau at an altitude of about 1,300 - 1,400 m. To the west of this plateau lies the Great Lift Valley, on the floor of which lies Lake Natron, at an elevation of about 600 m. A range of mountains extends from east to west, immediately to the north of the town of Arusha, and includes peaks such as Mt. Meru (4,565 m), Mt. Monousli (2,660 m), Mt. Burko (2,160 m) and Mt. Losimiguri (2,170 m).

On the east side of Lake Natron is Mt. Gelai (2,942 m) and its surrounding range, which make it very difficult to approach the Lake. At the southern end of the Lake is Mt. Ol Donyo Lengai (2,878 m), an active volcano.

The plateau, on which Arusha and Longido are located, extends about 25 - 40 km to the west of the Great North Road. From there, the ground slopes down to the floor of the Valley, with escarpments such as Matissiwi, Matuginigt, and Olkerii.

Some parts of the floor are deposits of sandy silt and subject to inundation during the rainy seasons.

(2) Soil and vegetation

There is insufficient detailed information on soil to judge its physical properties and drainage. However, almost the entire area is covered by brown to dark brown calcareous clay loams (chestnut soils), dark red sandy clay loams (latosolic soils) and black to dark grey clays (grumosolic soils). Although the precipitation in the area is less than 400 mm per annum, traces of water erosion can be observed on the ground surface, particularly at the foots of mountains and escarpments. Therefore, it will be necessary to pay attention to erosion control along the road's route.

Due to the dry and hot climate, the area is sparsely vegetated, and grasslands and dry bush land prevail. Therefore, it will be not so difficult to clear vegetation along the right of way.

5-6-2 Alternative routes

Two different viewpoints were taken into consideration in selecting a road route between Lake Natron and Arusha. One is minimization of the length of new road, through maximum utilization of existing road. The other is minimization of the transportation distance.

From these points of view, two routes were selected on 1 to 50,000 scale topographic maps with a counter line interval of 50 feet.

Route A: Arusha – (Existing Road: 80.4 km) – Longido
– (New Road: 98.2 km) – Lake Natron

Route B: Arusha – (Existing Road: 29.42 km) – Oldonyo Sambu
– (New Road: 124.88 km) – Lake Natron

These routes are shown in Fig. 5-3 and their longitudinal profiles in Fig. 5-4 and Fig. 5-5.

(1) Route A

Route A starts from Arusha station and follows the existing Great North Road up to Longido. Then it generally follows the existing unengineered earth road, which goes through the Engare Naibor Hills. Since the Engare Naibor Hills are small but steep mountains, a considerable amount of earth moving work will be necessary. Beyond the Hills, the route goes down to the floor of the valley, crosses the Kibangaini swamp and reaches the Plant site.

In the Engare Naibor Hills, where water is available and vegetation is thick, a considerable number of Masai raise livestock. If the Project road passes through this area, these people will benefit.

(2) Route B

Route B follows the existing Great North Road up to Oldonyo Sambu and then takes a new route to the west, through the edge of the Matissiwi escarpment. After going down to the floor of the Valley, the route goes on the east sides of the Olbalbal Ngwrirat and Nando Swamps and then crosses the Kibangaini Mbuyo Swamp.

Since this route goes along the swamps' edge, some amount of embankment work will be needed in order to prevent the road from inundation.

Economic activity in the area along the route is very low and has little prospect for the future. Therefore, it was felt that this route would generate few benefits for the region, other than for the Project.

5-7 Costs of Road Construction and Improvement

Since the estimates of road construction and improvement costs were made on the basis of the 1 to 50,000 scale topographic maps, it should be noted that their accuracy is limited.

Figure 5-3 Alignment of Alternative Routes

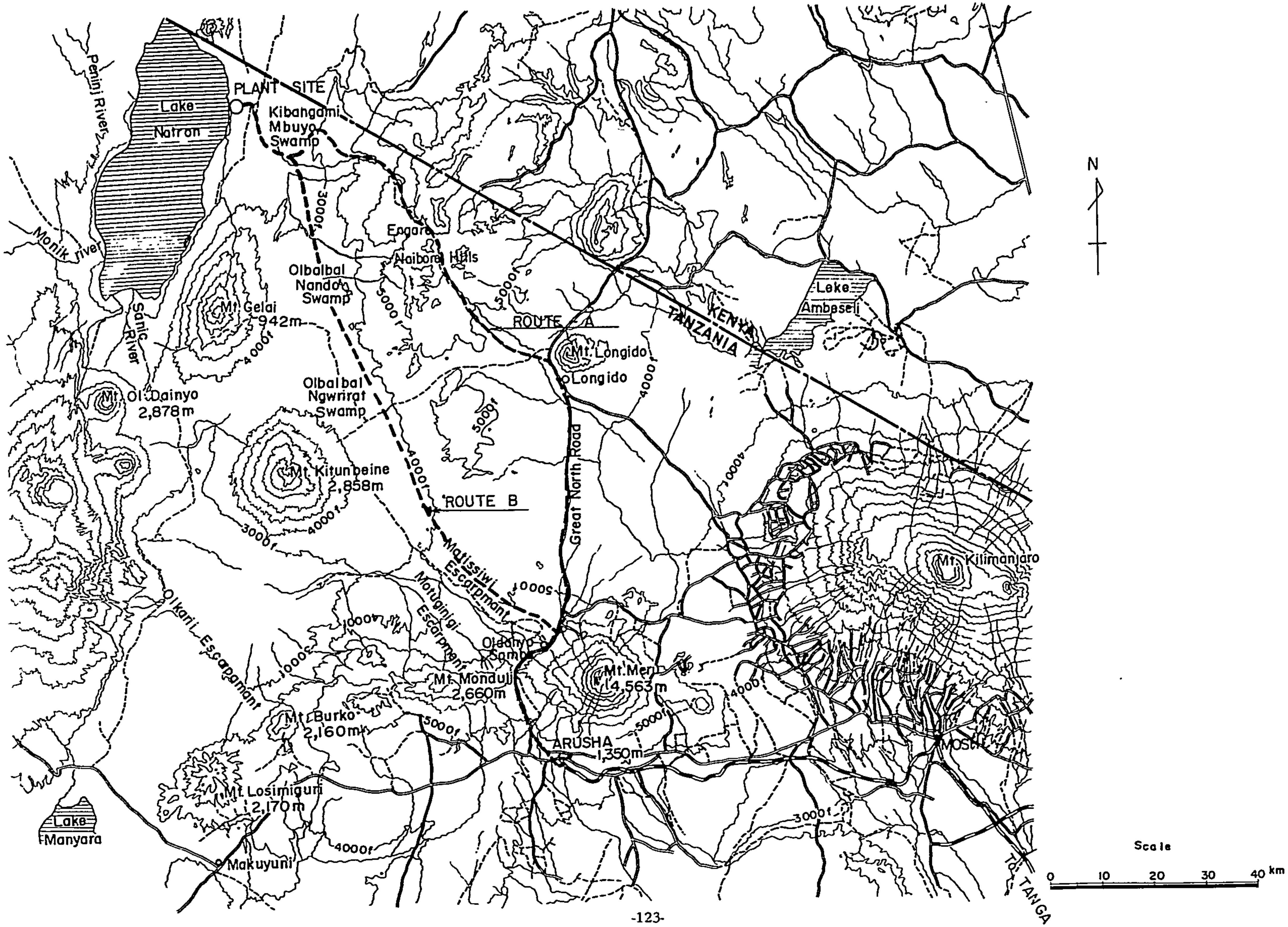


Figure 5-4 Longitudinal Profile Route A

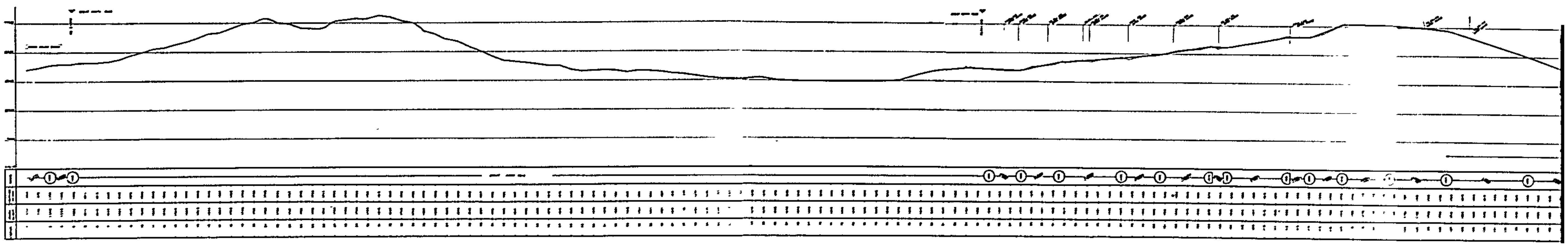


Figure 5-4 Longitudinal Profile Route A

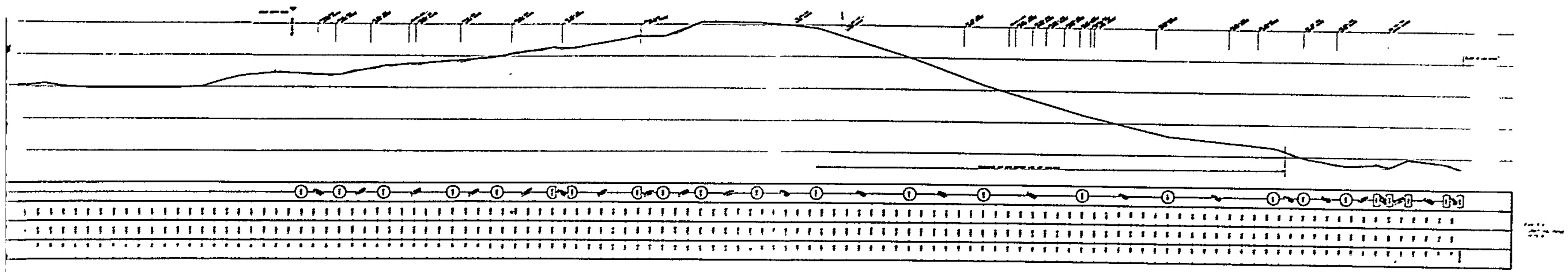


Figure 5-5 Longitudinal Profile Route B

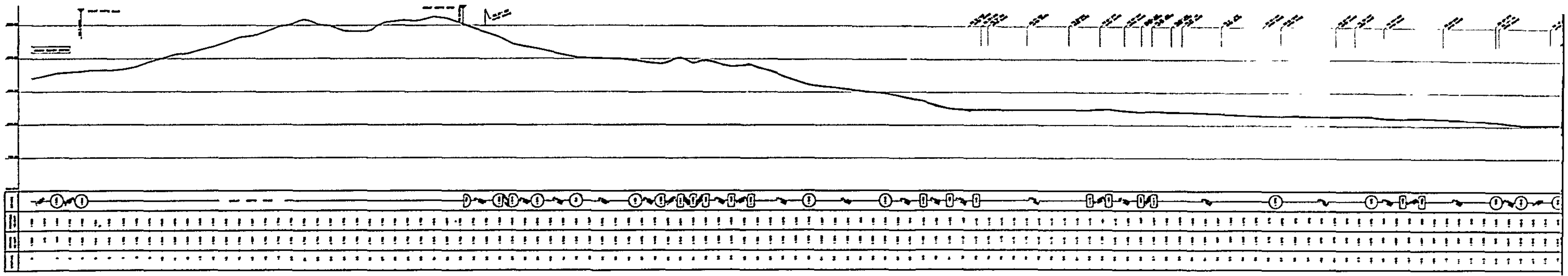
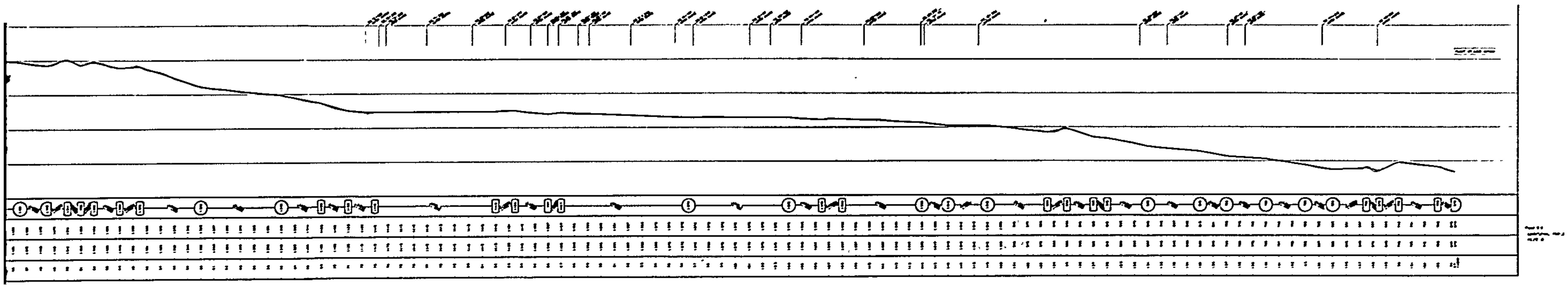


Figure 5-5 Longitudinal Profile Route B



5-7-1 Design of road

Since the soda ash transportation pattern is very regular, even one 3 - 3.6 m wide lane, with an appropriate number of sidings, can bear the traffic, provided that adequate control measures are taken. However, this study is based on a two-lane road.

The geometry of the road was determined in accordance with the 'Geometric Standard Criteria for Rural Roads", taking into account the physical conditions along the routes, the size of vehicle to be employed and operation.

Some major items are as follows:

Major Design Standards

Design speed	80 km/hour
Roadway width	6.0 m for 9-ton lorry and 16.5-ton semi-trailer
	7.2 m for 30-ton semi-trailer
Shoulder width	1.8 m on either side
Maximum grade	5%

The pavement thickness was estimated according to 'A Guide to the Structural Design of Bitumen-Surfaced Roads in Tropical and Sub-tropical Countries (Road Note 31)' in which the cumulative number of standard axles (8,200 kg) and CBR of sub-grade must be assumed.

The cumulative number of standard axles was estimated as shown in Table 5-5 and Table 5-6. Since the results of mechanical soil tests along the proposed route were not available, the CBR of sub-grade was tentatively assumed to be 5%, referring to the design value of T.P.D.F. roads for T.M.A. near Monduri.

The structure of the pavement was determined as follows:

- Wearing ; 50 mm thick asphaltic concrete
- Base ; 150 mm thick
- Sub-base ; Differs according to the cumulative number of standard axle as shown in Table 5-7.

Table 5-5 Equivalent Number of Standard 8,200-kg Axle Load

	9-ton Lorry		16.5-ton Semi-trailer			30-ton Semi-trailer		
			Tractor		Trailer	Tractor		Trailer
	Front Single	Rear Tandem	Front Single	Rear Tandem	Tandem	Front Single	Rear Tandem	Tandem
Axle Load (kg)	5,245	14,390	4,035	13,723	13,960	5,171	20,576	23,327
Equivalence Factor	0.12	1.20	0.03	1.90	1.05	0.12	5.90	11.0
Total per Vehicle		1.32			2.08		17.02	

Table 5-6 Cumulative Number of Standard Axles in 10 Years

Production Scale	9-ton Lorry		16.5-ton Semi-trailer		30-ton Semi-trailer	
	Daily	C.N.	Daily	C.N.	Daily	C.N.
250,000 t/yr.	93	441,936	51	381,888	28	1,715,616
500,000 t/yr.	186	883,872	101	756,288	56	3,431,232
1,000,000 t/yr.	370	1,758,240	202	1,512,576	112	6,862,464

Cumulative Number = Daily Traffic x 300 days x 10 years x 1.2 x Equivalent Number

Table 5-7 Thickness of Sub-base

Production Scale	9-ton Lorry	16.5-ton Semi-trailer	30-ton Semi-trailer
250,000 t/yr.	180 mm	180 mm	260 mm
500,000 t/yr.	220 mm	210 mm	300 mm
1,000,000 t/yr.	260 mm	250 mm	350 mm

5-7-2 Work quantity estimation

Work quantities were estimated under the following headings:

- Clearing
- Earthwork
- Superstructure including sub-base, base, wearing and shoulder construction
- Bridges and culverts
- Drainage work
- Miscellaneous work including line marking and guard rail installation

Clearing

Clearing was estimated for the area within points 10 m from the edge of each shoulder.

Earthwork

Earth quantities were based on typical cross-sections as shown in Fig. 5-6. Application of typical cross-sections to each route was determined using the 1 : 50,000 scale topographical maps as shown in Table 5-8.

Superstructure

Estimates of the area of each pavement layer and shoulder course were based on the pavement design.

Bridges and culverts

Bridges and culverts are shown separately on the longitudinal profiles (Figs. 5-4 and 5-5).

Drainage work

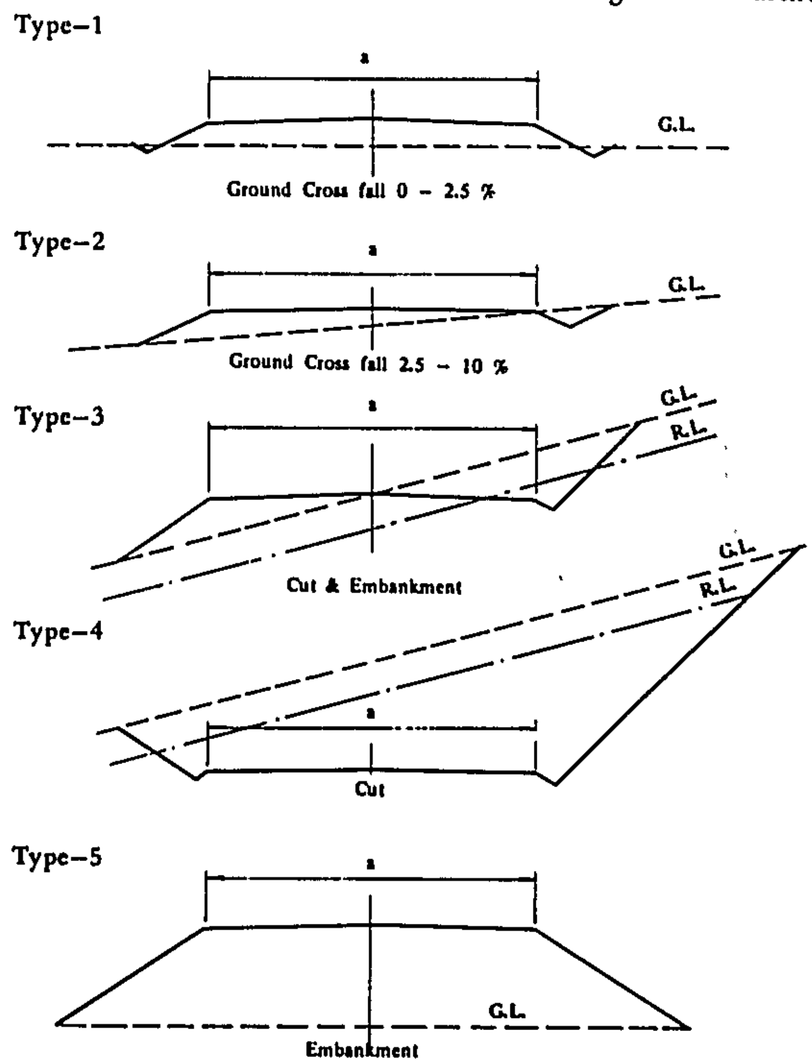
Drainage work consists mainly of shaping side ditches along the entire length of road.

Improvement work was considered to include the following:

- Earthwork for widening 6.0 m roads to 7.2 m
- Construction of additional superstructure of 1.2 m
- Reconstruction of bridges and culverts
- Reconstruction of side ditches

Work quantities were estimated in the same manner as described above.

Figure 5-6 Earthwork Typical Cross-section



Work Volume per meter

Type	a	6–meter 9.6 m	7.2–meter 10.8 m
1.	1. Excavation of top soil (15 cm)	12 m^2	13.5 m^2
	2. Compaction of ground surface	12 m^2	13.5 m^2
	3. Sub grade formation (1 layer=15 cm)	12 m^2 x 3ℓ	13.5 m^2 x 3ℓ
	4. Planting of grass on slopes	2.7 m^2	2.7 m^2
2.	1. Excavation of top soil (15 cm)	12.5 m^2	14 m^2
	2. Compaction of ground surface	12.5 m^2	14 m^2
	3. Sub-grade formation (1 layer=15 cm)	12 m^2 x 3ℓ	13.5 m^2 x 3ℓ
	4. Planting of grass on slopes	2.8 m^2	2.8 m^2
3.	1. Excavation of top soil (15 cm)	18.5 m^2	20 m^2
	2. Excavation of other than (1)	6.4 m^3	7.2 m^3
	3. Excavation in rock	4.1 m^3	4.4 m^3
	4. Compaction of ground surface	8.5 m^2	9.1 m^2
	5. Sub-grade formation (1 layer=15 cm)	17.5 m^2	21 m^2
	6. Planting of grass on slopes	7.5 m^2	7.5 m^2
4.	1. Excavation of top soil (15 cm)	24 m^2	25 m^2
	2. Excavation other than (1)	18.9 m^3	19.8 m^2
	3. Excavation in rock	51.7 m^3	54.7 m^3
	4. Planting of grass on slopes	13.5 m^2	13.5 m^2
5.	1. Excavation of top soil (15 cm)	19 m^2	20.2 m^2
	2. Excavation in borrow	42.9 m^3	46 m^3
	3. Compaction of ground surface	19 m^2	20.2 m^2
	4. Sub-grade formation (1 layer=15 cm)	14.3 m^2 x 20ℓ	15.5 m^2 x 20ℓ
	5. Planting of grass on slopes	11 m^2	11 m^2

Table 5-8 Application of Typical Cross-Sections

Cross-Section	Route A	Route B
Type–1	49.6 km	57.76 km
Type–2	9.3	50.22
Type–3	27.8	7.0
Type–4	11.2	3.4
Type–5	0.3	6.5
Total	98.2	124.88 km

5-7-3 Implementation schedule

Since considerable amounts of equipment and materials will have to be brought in to Lake Natron during the stage of infrastructure construction, as well as for construction of the Plant itself, the road must be completed before any such work can be begun. According to the overall time schedule for Plant construction, the road is to be put into service by the middle of the seventh year.

To satisfy these requirements, the following time schedule was considered necessary:

– Detailed investigation and preparation of final designs and tender documents	18 months
– Tender and tender analysis	6 months
– Construction of road	42 months
Total	64 months

Regarding this estimate, the following points were taken into consideration:

– The time for detailed investigation and preparation of final engineering work does not include the time for aerial mapping, which is scheduled in the feasibility study stage.

– The time for road construction was estimated somewhat long due to the lack of access roads and supporting facilities in the Project area.

A tentative time schedule for road development is given in Fig. 5-7, together with the overall time schedule for the Project.

5-7-4 Construction and Improvement cost estimate

Construction and improvement costs were estimated on the basis of the estimated work quantities and the assumed unit costs. With prices prevailing in the Araska region as reference, major unit cost assumptions are as follows:

	Work Item	Unit	Cost
(1)	Site clearing		Tsh 2,900
(2)	Excavation of top soil 15 cm thick	m^2	2.25
(3)	Excavation other than (1)	m^3	18
(4)	Excavation of rock	m^3	54
(5)	Compaction of ground surface before filling in of embankment	m^3	1.5
(6)	Excavation from stockpile, carried to and spread on every layer to 15 cm thickness	m^2	4
(7)	Excavation in borrow	m^3	18
(8)	Planting of grass on slopes	m^2	2.6
(9)	Sub-base (150 mm thickness)	m^2	15
(10)	Base (150 mm thickness)	m^2	18
(11)	Wearing (50 mm thickness)	m^2	32.8
(12)	Shoulder	m^2	14
(13)	Bridge (6 meter wide)	m	30,000
(14)	Culvert	Place	24,000
(15)	Side ditches	m	6.5

The results of cost estimation are shown in Table 5-9 to Table 5-12.

The economic construction cost was estimated by adjusting transfer payments such as duties and tax, and by dividing the cost into foreign currency components; local currency components, including supply of locally produced materials and equipment and skilled labor; and unskilled labor. The results are shown in Table 5-12.

Figure 5-7 Tentative Time Schedule for Road Development

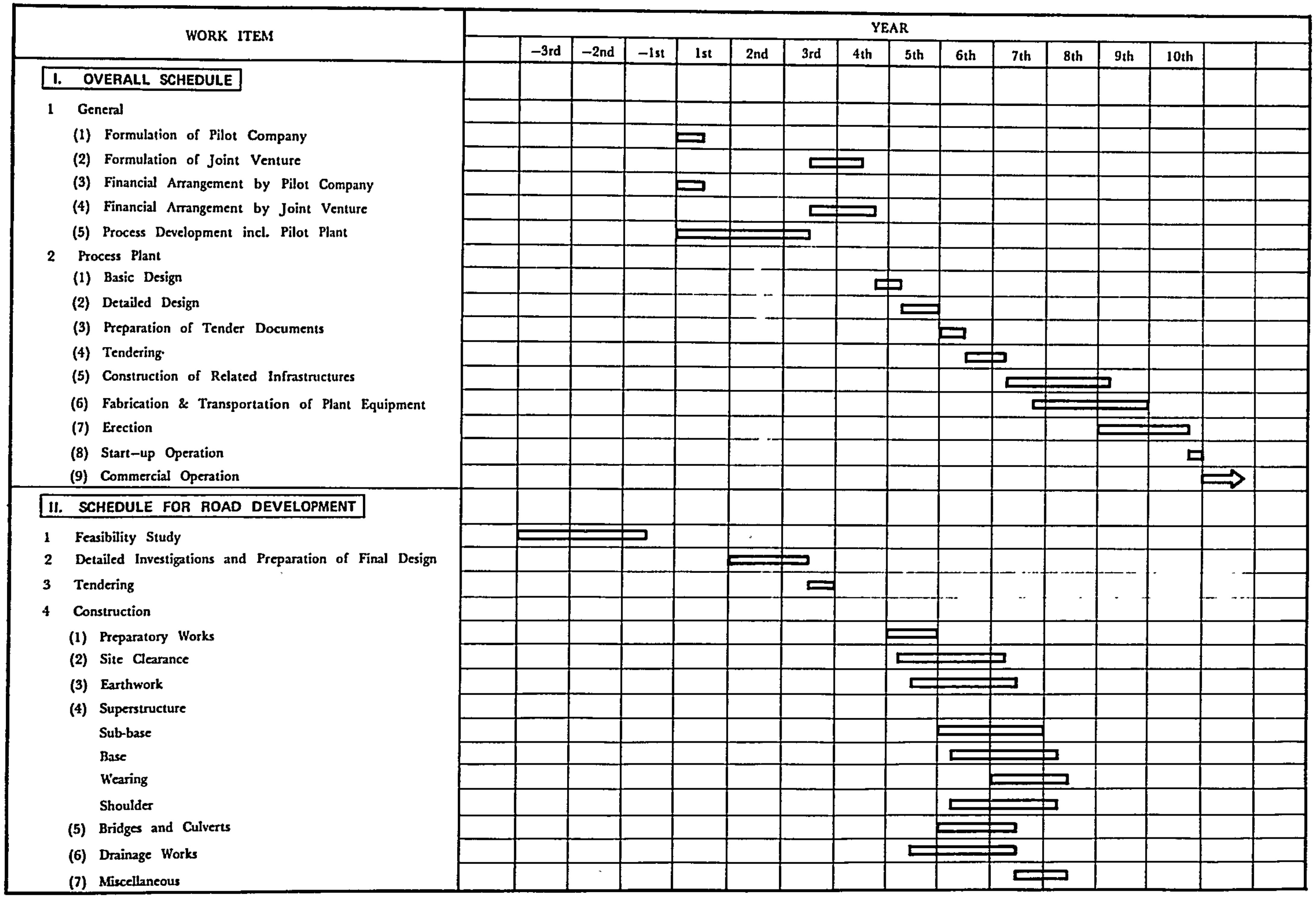


Table 5-9 Financial Construction Cost

- o Production Scale: 250,000 t/yr.
- o Unit: Tsh. 1,000

Work Item	Route A : 178.6km (New 98.2km Im. 80.4km) Vehicle Size			Route B : 154.3km (New 124.88km Im. 29.42km) Vehicle Size			Remarks
	9-ton	16.5-ton	30-ton	9-ton	16.5-ton	30-ton	
1. Preparatory Work	2,000.00	2,000.00	4,000.00	3,000.00	3,000.00	4,000.00	
2. Site Clearance	581.34	581.34	604.91	739.29	739.19	769.26	
3. Earthwork	61,600.09	61,600.09	68,511.66	48,689.91	48,689.91	54,082.71	
4. Superstructure	38,891.04	38,891.04	74,950.53	51,281.04	51,281.04	72,543.83	
5. Bridges and Culverts	4,680.00	4,680.00	6,861.60	6,864.00	6,864.00	8,380.80	
6. Drainage Work	638.30	638.30	1,160.90	811.72	811.72	1,002.95	
7. Miscellaneous Work	2,479.55	2,479.55	4,509.65	3,153.22	3,153.22	3,896.08	
8. Total Direct Cost	110,870.32	110,870.32	160,599.25	114,539.18	114,539.18	144,675.63	
9. Administrative and Engineering Expenses	16,630.55	16,630.55	24,089.89	17,180.88	17,180.88	21,701.34	
10. Contingencies	12,750.09	12,750.09	18.468.91	13,172.00	13,172.00	16,637.70	
11. Total Construction Cost	140,250.96	140,250.96	203,158.05	144,892.06	144,892.06	183,014.67	
12. US$ Equivalent (US$1,000)	17,188	17,188	24,897	17,756	17,756	22,428	

Note: Excluding interest during construction.

Table 5-10 Financial Construction Cost

- o Production Scale: 500,000 t/yr.
- o Unit: Tsh. 1,000

Work Item	Route A : 178.6km (New 98.2km Im. 80.4km)			Route B : 154.3km (New 124.88km Im. 29.42km)			Remarks
	Vehicle Size			Vehicle Size			
	9-ton	16.5-ton	30-ton	9-ton	16.5-ton	30-ton	
1. Preparatory Work	2,000.00	2,000.00	4,000.00	3,000.00	3,000.00	4,000.00	
2. Site Clearance	581.24	581.24	604.91	739.29	739.29	769.26	
3. Earthwork	61,600.09	61,600.09	68,511.66	48,689.91	48,689.91	54,082.71	
4. Superstructure	39,682.74	39,500.04	76,107.52	52,386.56	52,131.44	73,923.00	
5. Bridges and Culverts	4,680.00	4,680.00	6,861.60	6,864.00	6,864.00	8,380.80	
6. Drainage Work	638.30	638.30	1,160.60	811.72	811.72	1,002.95	
7. Miscellaneous Work	2,479.55	2,479.55	4,509.65	3,153.22	3,153.22	3,896.08	
8. Total Direct Cost	111,662.02	111,479.32	161,756.24	115,644.70	115,389.58	146.054.80	
9. Administrative and Engineering Expenses	16,749.30	16,721.90	24,263.44	17,346.71	17,308.44	21,908.22	
10. Contingencies	12,841.13	12,820.12	18,601.97	13,299.14	13,269.80	16,796.30	
11. Total Construction Cost	141,252.45	141,021.34	204,621.65	146,290.55	145,967.82	184,759.32	
12. US$ Equivalent (US$1,000)	17,310	17,282	25,076	17,928	17,888	22,642	

Note: Excluding interest during construction.

Table 5-11 Financial Construction Cost

- o Production Scale: 1,000,000 t/yr.
- o *Unit: Tsh. 1,000*

	Work Item	Route A : 178.6km (New 98.2km Im. 80.4km)			Route B : 154.3km (New 124.88km Im. 29.42km)			Remarks
		Vehicle Size			Vehicle Size			
		9-ton	16.5-ton	30-ton	9-ton	16.5-ton	30-ton	
1.	Preparatory Work	2,000.00	2,000.00	4,000.00	3,000.00	3,000.00	4,000.00	
2.	Site Clearance	581.34	581.34	604.91	739.29	739.29	769.26	
3.	Earthwork	61,600.09	61,600.09	68,511.66	48,689.91	48,689.91	54,082.71	
4.	Superstructure	40,535.34	40,291.74	77,621.43	53,577.12	53,236.96	75,726.53	
5.	Bridges and Culverts	4,680.00	4,680.00	6,861.60	6,864.00	6,864.00	8,380.80	
6.	Drainage Work	638.30	638.30	1,160.90	811.72	811.72	1,002.95	
7.	Miscellaneous Work	2,479.55	2,479.55	4,509.65	3,153.22	3,153.22	3,896.08	
8.	Total Direct Cost	112,514.62	112,271.02	163,270.15	116,835.26	116,495.10	147,858.33	
9.	Administrative and Engineering Expenses	16,877.19	16,840.65	24,490.52	17,525.29	17,474.27	22,178.75	
10.	Contingencies	12,939.18	12,911.17	18,776.07	13,436.06	13,396.94	17,003.71	
11.	Total Construction Cost	142,330.99	142,022.84	206,536.74	147,796.61	147,366.31	187,040.79	
12.	US$ Equivalent (US$1,000)	17,443	17,405	25,311	18,112	18,060	22,922	

Note: Excluding interest during construction.

Table 5-12 Economic Construction Cost

Production Scale (t/yr.)	Route	Vehicle Size	Cost Component		
			Foreign cost US$1,000	Local cost Tsh.1,000	Unskilled labor Tsh.1,000
250,000	A	9-ton	9,629	36,618	13,360
		16.5-ton	9,629	36,618	13,360
		30-ton	14,192	49,720	21,160
	B	9-ton	9,990	36,570	19,948
		16.5-ton	9,990	36,570	19,948
		30-ton	12,763	43,862	19,960
500,000	A	9-ton	9,695	36,818	13,525
		16.5-ton	9,680	36,772	13,487
		30-ton	14,288	50,013	21,402
	B	9-ton	10,080	36,849	20,180
		16.5-ton	10,059	36,785	20,126
		30-ton	14,412	50,396	21,718
1,000,000	A	9-ton	9,764	37,034	13,703
		16.5-ton	9,744	36,972	13,652
		30-ton	14,412	50,396	21,718
	B	9-ton	10,179	37,150	20,428
		16.5-ton	10,150	37,065	20,357
		30-ton	13,025	44,669	20,625

5-7-5 Annual fund requirements

The annual fund requirements were worked out as shown in Table 5-13, in accordance with the previously mentioned implementation schedule.

Table 5-13 Annual Fund Requirements

Production Scale (t/yr.)	Route	Vehicle Size (ton)	Cost[1] Component	Year -9th[2]	-8th[2]	-7th	-6th	-5th	-4th
250,000	A	9	Total	12,974	2,938	22,483	53,547	52,001	12,223
			(Foreign)	(1,140)	(360)	(1,458)	(3,551)	(3,687)	(938)
		16.5	Total	12,974	2,938	22,483	53,547	52,001	12,223
			(Foreign)	(1,100)	(360)	(1,458)	(3,551)	(3,687)	(938)
		30	Total	12,974	2,938	27,386	67,017	84,178	25,577
			(Foreign)	(1,140)	(360)	(1,755)	(4,438)	(6,112)	(1,905)
	B	9	Total	12,974	2,938	19,807	51,039	58,279	15,768
			(Foreign)	(1,140)	(360)	(1,268)	(3,369)	(4,152)	(1,202)
		16.5	Total	12,974	2,938	19,807	51,039	58,279	15,768
			(Foreign)	(1,140)	(360)	(1,268)	(3,369)	(4,152)	(1,202)
		30	Total	12,974	2,938	22,850	60,980	77,111	20,074
			(Foreign)	(1,140)	(360)	(1,457)	(4,041)	(5,564)	(1,700)
500,000	A	9	Total	12,974	2,938	22,504	54,032	52,485	12,234
			(Foreign)	(1,140)	(360)	(1,460)	(3,583)	(3,719)	(939)
		16.5	Total	12,974	2,938	22,499	53,921	53,373	12,231
			(Foreign)	(1,140)	(360)	(1,459)	(3,576)	(3,711)	(939)
		30	Total	12,974	2,938	27,412	67,717	84,893	24,600
			(Foreign)	(1,140)	(360)	(1,757)	(4,483)	(6,160)	(1,907)
	B	9	Total	12,974	2,938	19,832	51,705	58,961	15,787
			(Foreign)	(1,140)	(360)	(1,270)	(3,413)	(4,195)	(1.203)
		16.5	Total	12,974	2,938	19,826	51,556	58,804	15,782
			(Foreign)	(1,140)	(360)	(1,270)	(3,403)	(4,185)	(1,203)
		30	Total	12,974	2,938	22,878	61,814	77,966	22,102
			(Foreign)	(1,140)	(360)	(1,460)	(4,095)	(5,620)	(1,702)
1,000,000	A	9	Total	12,974	2,938	22,526	54,555	53,007	12,246
			(Foreign)	(1,140)	(360)	(1,461)	(3,616)	(3,751)	(940)
		16.5	Total	12,974	2,938	22,520	54,406	52,858	12,242
			(Foreign)	(1,140)	(360)	(1,461)	(3,606)	(3,742)	(939)
		30	Total	12,974	2,938	27,446	68,631	85,829	24,631
			(Foreign)	(1,140)	(360)	(1,759)	(4,542)	(6,220)	(1,907)
	B	9	Total	12,974	2,938	19,859	52,435	59,695	15,808
			(Foreign)	(1,140)	(360)	(1,272)	(3,460)	(4,243)	(1,205)
		16.5	Total	12,974	2,938	19,852	52,228	59,485	15,802
			(Foreign)	(1,140)	(360)	(1,272)	(3,446)	(4,229)	(1,204)
		30	Total	12,974	2,938	22,916	62,906	79,084	22,138
			(Foreign)	(1,140)	(360)	(1,462)	(4,165)	(5,692)	(1,705)

1) : Total Cost is expressed in Tsh. 1,000, Foreign Cost is expressed in US$1,000.

2) : Cost for detailed investigation and preparation of final engineering excluding interest during construction.

5-7-6 Road maintenance costs

Since maintenance of existing roads is performed by the authorities concerned and will continue as present, road maintenance costs to be charged to the Project were only considered for newly constructed roads. Resurfacing costs for improved roads were assumed to be shared equally by the Project's traffic and ordinary traffic.

The unit costs for road maintenance were assumed as follows:

–	Routine maintenance	Tsh. 830/km/year
–	Erosion control and maintenance of ditches and culverts	Tsh. 1,130/km/year
–	Preventive maintenance of roadway	Tsh. 4,860/km/year
–	Resurfacing	Once in 10 years

Based on these assumptions, the maintenance cost for each road was estimated as shown in Table 5-14.

Table 5-14 Road Maintenance Costs

Unit: Tsh. 1,000

Foute		A	B
Route Length (km)	New	98.2	124.88
	Existing	80.4	19.42
– Routine Maintenance		99	104
– Erosion Control and Maintenance of Ditches and Culverts		111	141
– Preventive Maintenance		477	607
Total		687	852
– Resurfacing Cost			
6 m road	New	24,447	30,089
7 m road	New	41,346	41,702
	Existing	(29,337)	(37,307)
	Total	(12,009)	(4,395)

5-8 Vehicle Operation Cost

5-8-1 Operation

To determine the mode of operation, vehicle traveling time and transshipment time, among other factors, must be examined.

Vehicle Traveling Time

Vehicle traveling time is affected by the geometry of the road and the speed of vehicle. The proposed routes have the foolowing gradient composition.

Route	Gradient (%)										
	-5	-4	-3	-2	-1	0	1	2	3	4	5
A	km 2.0	13.0	27.1	13.0	40.0	15.5	28.5	18.0	10.5	9.5	1.5
B	km 2.0	8.82	8.3	38.18	37.0	19.5	18.5	10.5	7.5	1.5	1.5

The speed of vehicle on roads of different gradients was assumed as follows:

Vehicle	Gradient (%)										
	-5	-4	-3	-2	-1	0	1	2	3	4	5
9-ton	30 km/h		50			70			50	30	
16.5-ton	30 km/h		40	60		70		60	40	30	
30-ton	30 km		40	50		70		50	40	30	

Using the above data, one-way vehicle traveling time was calculated as follows:

Route	Distance	Vehicle	Traveling Time	Average Speed
A	178.6 km	9-ton	3.3 hr.	54 km/h
		16.5-ton	3.5	51
		30-ton	3.6	50
B	154.3 km	9-ton	2.5	61
		16.5-ton	2.7	57
		30-ton	2.9	53

Transshipment Time

Transshipment time, including loading and unloading, was estimated at 0.5 hr.

Therefore, the time required for one round trip between Lake Natron and Arusha was estimated as follows:

Route	Vehicle	Time for 1 round trip
A	9-ton	7.1
	16.5-ton	7.5
	30-ton	7.7
B	9-ton	5.5
	16.5-ton	5.9
	30-ton	6.3

Considering the usual system of work time in Tanzania, the frequency of operation for one vehicle was determined to be 2 times a day.

5-8-2 Vehicle operating cost estimate

The following cost components used to estimate vehicle operating cost:

(i) Vehicle cost

(ii) Annual fixed costs

- Wages
- Overhead
- Insurance
- Licence

(iii) Variable cost per operating distance

- Fuel and oil cost
- Tires and tubes
- Maintenance: parts and labor

Cost component estimates were based on the following assumptions:

(1) Vehicle cost

The C.I.F. prices of the vehicles under consideration are based on recent price data obtained from a Japanese maker of similar vehicles.

C.I.F. Price at Dar-es-Salaam Port

Unit: US$

Vehicle	Lorry/Tractor	Trailer	Total
9-ton Lorry	28,000	-	28,000
16.5-ton Semi-trailer	25,670	22,670	48,340
30-ton Semi-trailer	28,500	28,600	57,100

Since no residual value was taken into account after the vehicle's lifetime, which is estimated at 600,000 km for a lorry or tractor, and at 900,000 km for trailer, the above figures were taken as economic vehicle costs. The financial vehicle costs were assumed equal to economic costs, with the expectation that tax exemptions will be granted.

(2) Annual fixed costs

(i) Wages and overhead

Considering the vehicles are larger than those commonly used, the driver's basic monthly salary was assumed at 600 Tsh. The nominal salaries of Tsh. 9,360 p.a. were arrived at by adding the employer's National Provident Fund contribution of 5%, night allowance and other extra payments to the basic salary. The economic cost of the drivers' time was taken at full market rate, reflecting the skilled nature of their occupation.

The number of drivers was estimated by adding an allowance of 20% to the daily frequency of operation, because one operation would take up of a driver's working day. Since loading and unloading are to be carried out by the staff of the transshipment facilities, no trunboys were considered.

Overhead cost was set at 20% of total crew cost.

(ii) Insurance

Reference to other study reports indicates that the following amounts will provide ordinance, third party and comprehensive coverage:

9-ton Lorry	Tsh. 1,110 p.a.
16.5-ton Semi-trailer	Tsh. 1,450 p.a.
30-ton Semi-trailer	Tsh. 1,450 p.a.

Economic costs were assumed to equal financial costs, which seem to reflect the cost of accidents to the economy. For accident costs (premium), the ratio of parts to labor costs was assumed to be 90% and 10%.

(iii) License cost

The present annual licensing fees for commercial goods vehicles in Tanzania are as follows:

Category	Tsh./Year
5 – 10 tons	750
15 – 20 tons	1,500
Over 20 tons	2,000

The license cost, a transfer payment, was included only in the financial vehicle operating cost.

(3) Variable cost per operating distance

To estimate variable cost per operating distance, the annual total vehicle operation distance was calculated as follows:

Annual Total Vehicle Operation Distance

Production Scale	Vehicle Size	Daily Frequency	Route A 183.6 km[L1]	Route B 159.3 km[L2]
t/yr.		Times	x 10^3 km	x 10^3 km
250,000	9-ton	93	10,245	8,889
	16.5-ton	51	5,618	4,875
	30-ton	28	3,084	2,676
500,000	9-ton	186	20,490	17,778
	16.5-ton	101	11,126	9,654
	30-ton	56	6,169	5,352
1,000,000	9-ton	370	40,759	35,365
	16.5-ton	202	22,252	19,307
	30-ton	112	12,338	10,705

L1 Oneway operation distance = Route distance + 5 km

(i) Fuel and oil

Assumptions for fuel and oil consumption rates per kilometer were based on actual data obtained from users of similar vehicles:

Fuel and Oil Consumption Rate

Vehicle	Fuel (Diesel Oil)	Oil (Heavy Vehicle)
9-ton Lorry	0.333 ℓ/km	0.0085 ℓ/km
16.5-ton Semi-trailer	0.500	0.0095
30-ton Semi-trailer	0.833	0.0105

The prices of fuel and oil in December, 1975 were as follows:

Diesel oil	Tsh. 1.88/ℓ
Heavy vehicle engine oil	Tsh. 3.99/ℓ

The following assumptions were made about economic costs:

- Sales tax and import duty were applicable to all items.
- 90% of the total cost is assumed to be the foreign component, the rest local marketing.

Consequently, economic costs were estimated as follows:

			Diesel Oil	Oil
Financial		Tsh./ℓ	1.88	3.99
Sales Tax		Tsh./ℓ	-0.24	-0.27
Import Duty		Tsh./ℓ	-0.45	-0.22
Before Tax and Duty		Tsh./ℓ	1.19	3.50
Economic Cost	Foreign	US$/ℓ	0.131	0.386
	Local	Tsh./ℓ	0.119	0.350

(ii) Tires and tubes

Tires for the vehicles under consideration are as follows:

Tire Size	Vehicle	Lifetime km L1	
		New	Retread
11.00-20-14	9-ton Lorry 16.5-ton Semi-trailer	40,000	20,000
12.00-20-18	30-ton Semi-trailer	44,000	22,000

L1 on bitumen surfaced road

Although the tires are manufactured locally in Arusha, tires of these size are in short supply and are expensive. Therefore, tire costs were estimated on the basis of imports, as follows:

Tire Size	C.I.F.	Duty Tsh. 3.3/kg	Sales Tax 12%	Total	Retread
11.00-20-14	US$ 170				
(65 kg)	Tsh. 1,386	Tsh. 214	Tsh. 192	Tsh. 1,792	Tsh. 272
12.00-20-18	US$ 220				
(90 kg)	Tsh. 1,793	Tsh. 297	Tsh. 251	Tsh. 2,341	Tsh. 272

(iii) Maintenance

On the basis of data obtained from users of similar vehicles in Japan, maintenance rates per kilometer were estimated as follows:

Vehicle	Parts Rate	Labor Rate
9-ton Lorry	Tsh. 0.109/km	0.0030 hr./km
16.5-ton Semi-trailer	Tsh. 0.120/km	0.0032 hr./km
30-ton Semi-trailer	Tsh. 0.130/km	0.0036 hr./km

The labor cost of mechanics was estimated at Tsh. 5.0 per hour.

On the basis of the above assumptions, vehicle operation costs were estimated as shown in Table 5-15 and Table 5-16.

5-8-3 Workshop and parking lot

A workshop and a parking lot, including an operations control office, are required. These facilities will be located near Arusha along the proposed route. Space and cost requirements were estimated as tabulated in Table 5-17.

5-9 Soda Ash Transportation Costs

5-9-1 Route A and Route B

Taking the results of these studies, each cost was integrated into a cash flow table together with the present worth calculations as shown in Table 5-18 and Table 5-19.

The economic transportation cost per unit volume of soda ash from Lake Natron to the railway terminal in Arusha is summarized in Table 5-20.

Table 5-15 Financial Vehicle Operating Costs

Production Scale t/yr.	Route	Vehicle Size	Vehicle Costs						Annual Operation and Maintenance Costs			
			Frequency of Operation	No. of Vehicles	Lorry & Tractor		Trailer		Annual Total Vehicle Operation	Fixed Costs	Variable Costs	Total
					Ave. Lifetime	Cost	Ave. Lifetime	Cost				
		(tons)	(Times/day)		(Years)	(Tsh.1,000)	(Years)	(Tsh.1,000)	(1,000 km)	(Tsh.1,000)	(Tsh.1,000)	(Tsh.1,000)
250,000	A	9	93	56	3.3	12,795	-	-	10,245	1,362	11,556	12,918
		16.5	51	31	3.3	6,493	5.0	5,735	5,618	788	8,937	9,724
		30	28	17	3.3	3,954	5.0	3,967	3,084	441	7,485	7,926
	B	9	93	56	3.8	12,794	-	-	8,889	1,362	10,026	11,389
		16.5	51	31	3.8	6,493	5.8	5,735	4,875	788	7,778	8,565
		30	28	17	3.8	3,954	5.8	3,967	2,676	441	6,606	7,047
500,000	A	9	186	112	3.3	25,590	-	-	20,490	2,724	23,112	25,836
		16.5	101	61	3.3	12,777	5.0	11,284	11,126	1,550	17,752	19,302
		30	56	34	3.3	7,907	5.0	7,935	6,169	882	15,229	16,110
	B	9	186	112	3.8	25,590	-	-	17,778	2,724	20,053	22,777
		16.5	101	61	3.8	12,777	5.8	11,284	9,654	1,550	15,403	16,953
		30	56	34	3.8	7,907	5.8	7,935	5,352	882	13,212	14,094
1,000,000	A	9	370	222	3.3	50,723	-	-	40,759	5,400	45,974	51,374
		16.5	202	122	3.3	25,555	5.0	22,568	22,252	3,083	35,503	38,586
		30	112	68	3.3	15,814	5.0	15,870	12,338	1,746	30,457	32,203
	B	9	370	222	3.8	50,723	-	-	35,365	5,400	36,035	41,435
		16.5	202	122	3.8	25,555	5.8	22,568	19,307	3,083	30,804	33,887
		30	112	68	3.8	15,814	5.8	15,870	10,705	1,746	26,426	28,172

Table 5-16 Economic Vehicle Operating Costs

Production Scale t/yr.	Route	Vehicle Size (tons)	Vehicle Costs: Lorry and Tractor (US$ 1,000)	Vehicle Costs: Trailer (US$ 1,000)	Annual O & M Costs: Foreign Costs (US$ 1,000)	Annual O & M Costs: Local Costs (Tsh. 1,000)
250,000	A	9	1,568	-	915	2,318
		16.5	796	703	700	1,561
		30	484	486	586	1,043
	B	9	1,568	-	795	2,178
		16.5	796	703	607	1,455
		30	484	486	510	940
500,000	A	9	3,136	-	1,830	4,637
		16.5	1,566	1,383	1,385	2,962
		30	969	972	1,172	1,972
	B	9	3,136	-	1,589	4,359
		16.5	1,566	1,383	1,202	2,720
		30	969	972	1,017	1,812
1,000,000	A	9	6,216	-	3,639	9,207
		16.5	3,132	2,766	2,770	5,907
		30	1,938	1,945	2,344	3,925
	B	9	6,216	-	3,162	8,652
		16.5	3,132	2,766	2,406	5,478
		30	1,938	1,945	2,035	3,607

Table 5-17 Workshop and Parking Lot

Production Scale (t/yr.)	250,000			500,000			1,000,000		
Vehicle Size	9-ton	16.5-ton	30-ton	9-ton	16.5-ton	30-ton	9-ton	16.5-ton	30-ton
Number of Vehicles	56	31	17	112	61	34	222	122	68
Space of Vehicle (m^2)	26.4	37.0	43.1	26.4	37.0	43.1	26.4	37.0	43.1
Parking Area (m^2)	4,435	3,441	2,198	8,870	6,771	4,396	17,582	13,542	8,792
Number of Drivers	112	62	34	224	122	68	444	243	135
Office Space (m^2)	560	310	170	1,120	610	340	2,220	1,215	675
Maintenance Shop (m^2)	300	400	450	300	400	450	300	400	450
Cost (x Tsh. 1,000)									
Parking Area	444	344	220	887	677	440	1,758	1,354	879
Office	1,674	927	508	3,349	1,824	1,017	6,638	3,632	2,018
Maintenance Shop	570	760	855	570	760	855	570	760	855
Office Equipment	673	506	409	1,176	775	562	1,991	1,318	862
Maintenance Equipment	550	550	550	550	550	550	550	550	550
Total Cost	3,911	3,087	2,542	6,532	4,586	3,424	11,507	7,614	5,164
Local Component	3,361	2,537	1,992	5,982	4,036	2,874	10,957	7,064	4,614
Foreign Component	550	550	550	550	550	550	550	550	550
Maintenance Cost	223	182	155	354	257	199	603	408	285
Local Component	168	127	100	299	202	144	548	353	230
Foreign Component	55	55	55	55	55	55	55	55	55

Table 5-18 Integrated

		Production Scale 250,000 t/yr.					
		Route A			Route B		
		9-T	16.5-T	30-T	9-T	16.5-T	30-T
	– 10th						
	– 9th	13.0	13.0	13.0	13.0	13.0	13.0
	– 8th	2.9	2.9	2.9	2.9	2.9	2.9
	– 8th	22.5	22.5	27.4	1.98	19.8	22.9
	– 6th	53.5	53.5	67.0	51.0	51.0	61.0
	– 5th	52.0	52.0	84.2	58.3	58.3	77.1
	– 4th	12.2	12.2	25.6	15.8	15.8	20.1
	– 3rd	0.7	0.7	0.7	0.9	0.9	0.9
	– 2nd	0.7	0.7	0.7	0.9	0.9	0.9
	– 1st	35.9	35.9	31.0	37.4	36.0	31.1
	1st	14.7	11.4	9.6	13.3	10.4	8.9
	2nd	14.7	11.4	9.6	13.3	10.4	8.9
	3rd	27.5	17.9	13.6	13.3	10.4	8.9
	4th	14.7	11.4	9.6	26.1	16.9	12.8
	5th	14.7	17.2	13.6	13.3	10.4	8.9
	6th	27.5	17.9	13.6	13.3	16.2	12.9
	7th	14.7	11.4	9.6	13.3	10.4	8.9
	8th	14.7	11.4	9.6	26.1	16.9	12.8
	9th	27.5	17.9	13.6	13.3	10.4	8.9
	10th	39.6	42.1	55.4	43.9	41.0	51.1
	11th	14.7	11.4	9.6	13.3	10.4	8.9
	12th	27.5	17.9	13.6	26.1	22.7	16.8
	13th	14.7	11.4	9.6	13.3	10.4	8.9
	14th	14.7	11.4	9.6	13.3	10.4	8.9
	15th	27.5	23.7	17.5	13.3	10.4	8.9
	16th	14.7	11.4	9.6	26.1	16.9	12.8
	17th	14.7	11.4	9.6	13.3	10.4	8.9
	18th	27.5	17.9	13.6	13.3	16.2	12.9
	19th	14.7	11.4	9.6	13.3	10.4	8.9
	20th	62.8	64.5	77.3	79.9	69.9	76.9
	21st	27.5	17.9	13.6	13.3	10.4	8.9
	22nd	14.7	11.4	9.6	13.3	10.4	8.9
	23rd	14.7	11.4	9.6	13.3	10.4	8.9
	24th	27.5	17.9	13.6	26.1	22.7	16.8
	25th	14.7	17.2	13.6	13.3	10.4	8.9
	26th	14.7	11.4	9.6	13.3	10.4	8.9
	27th	27.5	17.9	13.6	13.3	10.4	8.9
	28th	14.7	11.4	9.6	26.1	16.9	12.8
	29th	14.7	11.4	9.6	13.3	10.4	8.9
	30th	14.7	11.4	9.6	13.3	10.4	8.9
Discount Rate = 8.5%	Total P.W.	494.8	448.4	552.8	515.7	474.1	505.6
	Annual Equivalent	42.4	38.5	47.4	44.2	40.7	43.4
	per ton	169.7	153.8	189.6	176.9	162.6	173.5
Discount Rate = 10%	Total P.W.	528.3	484.6	563.6	514.1	476.2	513.9
	Annual Equivalent	51.0	46.7	54.3	49.6	45.9	49.6
	per ton	203.8	186.9	217.4	198.3	183.7	198.2
Discount Rate = 12%	Total P.W.	531.8	493.7	600.2	513.7	494.3	533.6
	Annual Equivalent	58.9	54.7	66.5	56.9	57.8	59.1
	per ton	235.8	218.9	266.1	227.8	219.2	236.6

Cash Flow (Financial)

Unit: Tsh. 1,000,000

Production Scale 500,000 t/yr.						Production Scale 1,000,000 t/yr.					
Route A			Route B			Route A			Route B		
9-T	16.5-T	30-T	9-T	16.5-T	30-T	9-T	16.5-T	30-T	9-T	16.5-T	30-T
13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
22.5	22.5	27.4	19.8	19.8	22.9	22.5	22.5	27.4	19.9	19.9	22.9
54.0	53.9	67.7	51.7	51.6	61.8	54.6	54.4	68.6	52.4	52.2	62.9
52.5	53.4	84.9	59.0	58.8	78.0	53.0	52.9	85.8	59.7	59.5	79.1
12.2	12.3	24.6	15.8	15.8	22.1	12.2	12.2	24.6	15.8	15.8	22.1
0.7	0.7	0.7	0.9	0.9	0.9	0.7	0.7	0.7	0.9	0.9	0.9
0.7	0.7	0.7	0.9	0.9	0.9	0.7	0.7	0.7	0.9	0.9	0.9
59.5	56.0	45.9	59.6	56.1	46.8	104.1	97.6	78.7	104.3	97.8	78.9
28.1	21.5	18.2	25.2	19.3	16.4	54.5	41.6	35.0	44.8	37.0	31.2
28.1	21.5	18.2	25.2	19.3	16.4	54.5	41.6	35.0	44.8	37.0	31.2
53.7	34.2	26.1	25.2	19.3	16.4	105.3	67.1	50.9	44.8	37.0	31.2
28.1	21.5	18.2	50.8	32.0	24.3	54.5	41.6	35.0	95.5	62.6	47.0
28.1	32.7	26.1	25.2	19.3	16.4	54.5	66.1	50.9	44.8	37.0	31.2
53.7	34.2	26.1	25.2	30.6	24.3	105.3	67.1	50.9	44.8	59.6	47.1
28.1	21.5	18.2	25.2	19.3	16.4	54.5	41.6	35.0	44.8	37.0	31.2
28.1	21.5	18.2	50.8	32.0	24.3	54.5	41.6	35.0	95.5	62.6	47.0
53.7	34.2	26.1	25.2	19.3	16.4	105.3	67.1	50.9	44.8	37.0	31.2
53.0	57.7	68.0	55.8	49.9	58.5	79.5	89.1	92.8	75.3	67.6	73.4
28.1	21.5	18.2	25.2	19.3	16.4	54.5	41.6	35.0	44.8	37.0	31.2
53.7	34.2	26.1	50.8	43.3	32.2	105.3	67.1	50.9	95.5	85.1	62.9
28.1	21.5	18.2	25.2	19.3	16.4	54.5	41.6	35.0	44.8	37.0	31.2
28.1	21.5	18.2	25.2	19.3	16.4	54.5	41.6	35.0	44.8	37.0	31.2
53.7	45.5	34.0	25.2	19.3	16.4	105.3	89.7	66.7	44.8	37.0	31.2
28.1	21.5	18.2	50.8	32.0	24.3	54.5	41.6	35.0	95.5	62.6	47.0
28.1	21.5	18.2	25.2	19.3	16.4	54.5	41.6	35.0	44.8	37.0	31.2
53.7	34.2	26.1	25.2	30.6	24.3	105.3	67.1	50.9	44.8	59.6	47.1
28.1	21.5	18.2	25.2	19.3	16.4	54.5	41.6	35.0	44.8	37.0	31.2
85.7	88.4	97.5	114.0	93.4	96.0	131.7	137.4	138.6	178.3	141.5	135.1
53.7	34.2	26.1	25.2	19.3	16.4	105.3	67.1	50.9	44.8	37.0	31.2
28.1	21.5	18.2	25.2	19.3	16.4	54.5	41.6	35.0	44.8	37.0	31.2
28.1	21.5	18.2	25.2	19.3	16.4	54.5	41.6	35.0	44.8	37.0	31.2
53.7	34.2	26.1	50.8	43.3	32.2	105.3	67.1	50.9	95.5	85.1	62.9
28.1	32.7	26.1	25.2	19.3	16.4	54.5	64.1	50.9	44.8	37.0	31.2
28.1	21.5	18.2	25.2	19.3	16.4	54.5	41.6	35.0	44.8	37.0	31.2
53.7	34.2	26.1	25.2	19.3	16.4	105.3	67.1	50.9	44.8	37.0	31.2
28.1	21.5	18.2	50.8	32.0	24.3	54.5	41.6	35.0	95.5	62.6	47.0
28.1	21.5	18.2	25.2	19.3	16.4	54.5	41.6	35.0	44.8	37.0	31.2
28.1	21.5	18.2	25.2	19.3	16.4	54.5	41.6	35.0	44.8	37.0	31.2
768.5	654.8	687.1	715.9	625.5	632.5	1,213.6	1,008.6	975.7	1,062.6	933.1	879.1
65.9	56.2	58.9	61.4	53.6	54.2	104.1	86.5	83.7	81.9	80.0	75.4
131.9	112.3	117.9	122.8	107.3	108.5	104.1	86.5	83.7	81.9	80.0	75.4
735.9	643.3	685.1	694.0	614.1	629.4	1,141.6	958.3	944.8	1,007.3	891.9	852.7
71.0	62.0	66.1	66.9	59.2	60.7	110.1	92.4	91.1	97.1	86.0	82.2
141.9	124.1	132.1	133.8	118.4	121.4	110.1	92.4	91.1	97.1	86.0	82.2
715.9	642.1	643.7	679.8	612.1	636.1	1,075.2	914.6	923.7	958.5	862.9	839.7
79.4	71.2	71.4	75.4	67.8	70.5	119.2	101.4	102.4	106.2	95.7	93.1
158.7	142.3	142.7	150.7	135.7	141.0	119.2	101.4	102.4	106.2	95.7	93.1

Table 5-19 Integrated

		Production Scale 250,000 t/yr.					
		Route A			Route B		
		9-T	16.5-T	30-T	9-T	16.5-T	30-T
	– 10th						
	– 9th	1.5	1.5	1.5	1.5	1.5	1.5
	– 8th	0.4	0.4	0.4	0.4	0.4	0.4
	– 7th	2.2	2.2	2.7	2.1	2.1	2.3
	– 6th	5.3	5.3	6.6	5.2	5.2	6.0
	– 5th	4.1	4.1	8.5	5.9	5.9	7.8
	– 4th	1.3	1.3	2.5	1.6	1.6	2.3
	– 3rd	0.1	0.1	0.1	0.1	0.1	0.1
	– 2nd	0.1	0.1	0.1	0.1	0.1	0.1
	– 1st	4.1	3.9	3.4	4.1	4.0	3.4
	1st	1.3	1.0	0.8	1.2	0.9	0.8
	2nd	1.3	1.0	0.8	1.2	0.9	0.8
	3rd	2.9	1.8	1.3	1.2	0.9	0.8
	4th	1.3	1.0	0.8	2.8	1.7	1.3
	5th	1.3	1.7	1.3	1.2	0.9	0.8
	6th	2.9	1.8	1.3	1.2	1.6	1.3
	7th	1.3	1.0	0.4	1.2	0.9	0.8
	8th	1.3	1.0	0.4	2.8	1.7	1.3
	9th	2.9	1.8	1.3	1.2	0.9	0.7
	10th	3.9	4.3	5.7	4.4	6.6	5.2
	11th	1.3	1.0	0.8	1.2	0.9	0.8
	12th	2.9	1.8	1.3	2.8	2.4	1.7
	13th	1.3	1.0	0.8	1.2	0.9	0.8
	14th	1.3	1.0	0.8	1.2	0.9	0.8
	15th	2.9	2.5	1.8	1.2	0.9	0.8
	16th	1.3	1.0	0.8	2.8	1.7	1.3
	17th	1.3	1.0	0.8	1.2	0.9	0.8
	18th	2.9	1.8	1.3	1.2	1.6	1.3
	19th	1.3	1.0	0.8	1.2	0.9	0.8
	20th	6.3	6.7	8.0	8.4	7.3	8.0
	21st	2.9	1.8	1.3	1.2	0.9	0.8
	22nd	1.3	1.0	0.8	1.2	0.9	0.8
	23rd	1.3	1.0	0.8	1.2	0.9	0.8
	24th	2.9	1.8	1.3	2.8	2.4	1.7
	25th	1.3	1.7	1.3	1.2	0.9	0.8
	26th	1.3	1.0	0.8	1.2	0.9	0.8
	27th	2.9	1.8	1.3	1.2	0.9	0.8
	28th	1.3	1.0	0.8	2.8	1.7	1.3
	29th	1.3	1.0	0.8	1.2	0.9	0.8
	30th	1.3	1.0	0.8	1.2	0.9	0.8
Discount Rate = 10%	Total P.W.	51.3	48.8	56.6	52.2	49.6	51.8
	Annual Equivalent	5.0	4.7	5.5	5.0	4.8	5.0
	per ton	19.8	18.8	21.8	20.1	19.1	20.0
Discount Rate = 12%	Total P.W.	51.7	49.9	58.9	53.0	50.9	53.9
	Annual Equivalent	5.7	5.5	6.5	5.9	5.6	6.0
	per ton	22.9	22.1	26.1	23.5	22.6	23.9
Discount Rate = 15%	Total P.W.	54.1	53.2	64.2	56.2	54.1	58.6
	Annual Equivalent	7.2	7.0	8.5	7.4	7.2	7.8
	per ton	28.6	28.2	34.0	29.8	28.7	21.1

Cash Flow (Economic)

Unit: US$ 1,000,000

Production Scale 500,000 t/yr.						Production Scale 1,000,000 t/yr.					
Route A			Route B			Route A			Route B		
9-T	16.5-T	30-T	9-T	16.5-T	30-T	9-T	16.5-T	30-T	9-T	16.5-T	30-T
1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
2.2	2.2	2.7	2.1	2.1	2.3	2.2	2.2	2.7	2.1	2.1	2.3
5.4	5.3	6.7	5.3	5.3	5.9	5.4	5.4	6.8	5.4	5.3	6.2
5.3	5.3	8.6	6.0	6.0	7.9	5.3	5.3	8.7	6.1	6.1	8.0
1.3	1.3	2.5	1.6	1.6	2.3	1.3	1.3	2.5	1.6	1.6	2.3
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6.7	6.3	5.3	6.7	6.3	5.2	11.9	11.3	9.0	12.0	11.7	9.0
2.5	1.8	1.6	2.2	1.7	1.4	4.8	3.6	3.0	4.3	3.2	2.7
2.5	1.8	1.6	2.2	1.7	1.4	4.8	3.6	3.0	4.3	3.2	2.7
5.6	3.4	2.5	2.2	1.7	1.4	11.0	6.8	4.9	4.3	3.2	2.7
2.5	1.8	1.6	5.4	3.2	2.4	4.8	3.6	3.0	10.5	6.4	4.6
2.5	3.2	2.5	2.2	1.7	1.4	4.8	6.4	4.9	4.3	3.2	2.7
5.6	3.4	2.5	2.2	3.1	2.4	11.0	6.8	4.9	4.3	6.1	4.6
2.5	1.8	1.6	2.2	1.7	1.4	4.8	3.6	3.0	4.3	3.2	2.7
2.5	1.8	1.6	5.4	3.2	2.4	4.8	3.6	3.0	10.5	6.4	4.6
5.6	3.4	2.5	2.2	1.7	1.4	11.0	6.8	4.9	4.3	3.2	2.7
5.2	5.9	6.9	5.5	4.9	5.9	7.6	9.0	9.4	7.5	6.5	7.1
2.5	1.8	1.6	2.2	1.7	1.4	4.8	3.6	3.0	4.3	3.2	2.7
5.6	3.4	2.5	5.4	4.6	3.3	11.0	6.8	4.9	10.5	9.1	6.6
2.5	1.8	1.6	2.2	1.7	1.4	4.8	3.6	3.0	4.3	3.2	2.7
2.5	1.8	1.6	2.2	1.7	1.4	4.8	3.6	3.0	4.3	3.2	2.7
5.6	4.8	3.5	2.2	1.7	1.4	11.0	9.5	6.9	4.3	3.2	2.7
2.5	1.8	1.6	5.4	3.2	2.4	4.8	3.6	3.0	10.5	6.4	4.6
2.5	1.8	1.6	2.2	1.7	1.4	4.8	3.6	3.0	4.3	3.2	2.7
5.6	3.4	2.5	2.2	3.1	2.4	11.0	6.8	4.9	4.3	6.1	4.6
2.5	1.8	1.6	2.2	1.7	1.4	4.8	3.6	3.0	4.3	3.2	2.7
8.6	9.1	10.2	12.0	9.7	9.9	12.2	14.3	14.4	19.4	14.8	14.1
5.6	3.4	2.5	2.2	1.7	1.4	11.0	6.8	4.9	4.3	3.2	2.7
2.5	1.8	1.6	2.2	1.7	1.4	4.8	3.6	3.0	4.3	3.2	2.7
2.5	1.8	1.6	2.2	1.7	1.4	4.8	3.6	3.0	4.3	3.2	2.7
5.6	3.4	2.5	5.4	4.6	3.3	11.0	6.8	4.9	10.5	9.1	6.6
2.5	3.2	2.5	2.2	1.7	1.4	4.8	6.4	4.9	4.3	3.2	2.7
2.5	1.8	1.6	2.2	1.7	1.4	4.8	3.6	3.0	4.3	3.2	2.7
5.6	3.4	2.5	2.2	1.7	1.4	11.0	6.8	4.9	4.3	3.2	2.7
2.5	1.8	1.6	5.4	3.2	2.4	4.8	3.6	3.0	10.5	6.4	4.6
2.5	1.8	1.6	2.2	1.7	1.4	4.8	3.6	3.0	4.3	3.2	2.7
2.5	1.8	1.6	2.2	1.7	1.4	4.8	3.6	3.0	4.3	3.2	2.7
73.4	63.7	68.8	69.8	61.9	62.1	113.4	95.2	93.0	102.5	89.7	83.8
7.1	6.1	6.6	6.7	6.0	6.0	10.9	9.2	9.0	9.9	8.7	8.1
14.2	12.3	13.3	13.5	11.9	12.0	10.9	9.2	9.0	9.9	8.7	8.1
71.7	63.1	69.8	68.7	62.1	63.2	107.2	91.3	91.4	98.2	87.3	83.0
7.9	7.0	7.7	7.6	6.9	7.0	11.9	10.1	10.1	10.9	9.8	9.2
15.9	14.0	15.5	15.2	13.8	14.0	11.9	10.1	10.1	10.9	9.8	9.2
72.0	64.7	73.7	69.8	64.0	66.6	102.7	89.2	92.6	95.8	85.9	83.9
9.5	8.6	9.8	9.2	8.5	8.8	13.6	11.8	12.3	12.7	11.4	11.1
19.1	17.1	19.5	18.5	16.9	17.6	13.6	11.8	12.3	12.7	11.4	11.1

Table 5-20 Transportation Cost per Unit Volume

Unit: US$ per ton

Production Scale	Route	Vehicle Size	Discount Rate		
			10%	12%	15%
250,000	A	9-ton	19.8	22.9	28.6
		16.5-ton	18.8	22.1	28.2
		30-ton	21.8	26.1	34.0
	B	9-ton	20.1	23.5	29.8
		16.5-ton	19.1	22.6	28.7
		30-ton	20.0	23.9	31.1
500,000	A	9-ton	14.2	15.9	19.1
		16.5-ton	12.3	14.0	17.1
		30-ton	13.3	15.5	19.5
	B	9-ton	13.5	15.2	18.5
		16.5-ton	11.9	13.8	16.9
		30-ton	12.0	14.0	17.6
1,000,000	A	9-ton	10.9	11.9	13.6
		16.5-ton	9.2	10.1	11.8
		30-ton	9.0	10.1	12.3
	B	9-ton	9.9	10.9	12.7
		16.5-ton	8.7	9.8	11.4
		30-ton	8.1	9.2	11.1

Although the differences among the alternative combinations are within the limits allowable at this stage of study, the following points can be noted:

(1) The combinations of route and vehicle selected as optimum for each production scale are:

- 250,000 tons/year: Route A with 16.5-ton semi-trailers
- 500,000 tons/year: Route B with 16.5-ton semi-trailers
- 1,000,000 tons/year: Route B with 30-ton semi-trailers

(2) Use of the largest vehicle will have greater benefits than the figures shown in the table, due to the managerial advantages arising from fewer vehicles and drivers.

(3) A shorter vehicle operating distance is preferable, taking into account the possibility of cost inflation in fuel, wages, and other items.

Taking the above points into consideration, the conbination of development of Route B and use of large vehicles such as 30-ton semi-trailer seems to be recommendable for the production scale more than 500,000 tons per year.

5-9-2 Lake Natron – Longido – Moshi Route

As previously stated, this route becomes competitive only if improvement costs for the railway between Arusha and Moshi are large enough to offset additional road transportation costs from Longido to Moshi and if railway improvement costs are charged entirely to the Project. However these conditions are unlikely, as described in the Railway Transportation Study. The railway transportation cost between Arusha and Moshi is estimated to be quite small. For example, the railway transportation cost between Arusha and Moshi for a production scale of 500,000 tons per year is estimated at US$3.0 per ton (US$10.9 – US$7.9).

The route from Longido to Moshi is about 119.6 km including 54.9 km of existing road, and the total distance from Lake Natron to Moshi via Longido is about 214.2 km. The cost of upgrading the road from Longido to Moshi to a 6 m wide bitumen-surfaced road is estimated at about Tsh. 60 million (production scale: 500,000 tons per year, vehicle: 16.5 ton lorry). The additional road transportation cost was estimated at US$3.4 per ton (road cost: US$2.5 and vehicle operating cost: US$0.9).

Comparing the additional road transportation cost of US$3.4 per ton to the railway transportation cost between Arusha and Moshi presented above, railway transportation is obviously cheaper.

5-9-3 Lake Natron – Lake Manyara Route

The distance from Lake Natron to an appropriate place on the Arusha – Musoma railway line was estimated at about 153.3 km, nearly equal to that of Route B, but the whole length of this route must be newly constructed. Road construction cost was roughly estimated at Tsh. 180,000,000 and the vehicle operating cost was estimated at almost equal to that of Route B.

The area along this route is sparsely populated and the level of economic activity is very low due to the scarcity of natural resources. Therefore, it is considered unrealistic to expect regional development projects which could bear the incremental cost of road construction.

5-9-4 Road transportation to Tanga

The Tanga Post, which was selected as the destination for the soda ash, is located about 440 km from Arusha by road. The vehicle operating cost for read transportation from Lake Natron to Tanga was estimated at US$15.5 per ton for the 16.5-ton semi-trailer. Therefore, the incremental vehicle operating cost between Arusha and Tanga was estimated at US$10.7 per ton, which is comparable to the railway transportation cost of US$10.9 per ton over the same section.

Although this simple cost comparison may give an advantage to road transportation, it must also be considered that such long distance haulage has many problems in areas such as operation and management.

5-10 Suggested Terms of Reference for Further Study on Road Transportation

Since this study is at the pre-feasibility level and contains many uncertainties due to the lack of supporting data such as large-scale topographic maps, soil data, watercourse hydrology data, erosion conditions, etc., further investigation is necessary before making decisions on investment in the Project. The following items are tentatively suggested as Terms of Reference for further studies of road transportation.

1. Objective

The primary objective of the study is to find out the cheapest means for road transport of soda ash from Lake Natron to an appropriate terminal in the existing transportation network, within the limits of sound engineering and socio-economic analysis, after consideration of possible alternatives. This objective is itemized as follows:

- to select routes precisely on large scale topographic maps, based on detailed information concerning topography, geology, soil, hydrology, etc.,
- to prepare feasibility study level designs for the selected road and related structures,
- to estimate construction costs for the road and related structures based on feasibility-level designs and construction programs,
- to estimate vehicle operating cost on the selected route,
- to estimate the transportation cost of soda ash, including road costs and vehicle operation costs,
- to evaluate road transportation financially and economically,
- to prepare a program for detailed investigation and final engineering.

2. Scope of Work

The scope of work for the study of road transportation will include but not necessarily be limited to:

2.1 Field Investigation

(1) To take aerial photographs of 1 : 20,000 scale along a 4 km band following Route A and Route B.

(2) To make topographical maps of 1 : 5,000 scale for Route A and Route B by means of serial photo mapping.

(3) To carry out preliminary soil surveys and testing along Route A and Route B.

(4) To carry out preliminary geological investigations including test drilling at the sites of important structures.

(5) To carry out preliminary construction material surveys and testing.

(6) To carry out meteorological and hydrological surveys.

(7) To carry out surveys of the vegetations and wildlife along the routes.

2.2 Transportation Survey

(1) To carry out a traffic survey along the existing route.

(2) To carry out socio-economic survey along the new and existing routes.

(3) To survey the road haulage system in Tanzania.

(4) To survey the vehicle operating costs prevailing in Tanzania.

2.3 Study and Design

(1) To carry out a comparative study of alternative routes and means of transport with the goal of minimizing the total soda ash transportation cost.

(2) To prepare feasibility study level designs for the selected route and related structures.

(3) To carry out cost estimates concerning the road and vehicle operation, based on the feasibility study level designs.

(4) To carry out financial and economic appraisals of road transport of soda ash.

(5) To prepare a program for detailed investigation and final engineering.

CHAPTER 6 OTHER MEANS OF TRANSPORTATION

6-1 Transportation of Soda Ash by Endless Ropeway

Regarding the transportation of soda ash between Lake Natron and Arusha, a study comparing new railways with an endless ropeway was undertaken. The study assumes a production scale of 1,000,000 tons a year. The results are summarized as follows:

Table 6-1 Capital Cost of Ropeway

Unit: Million Tsh.

Item	Endless Ropeway	New Railway	Note
Construction Cost*	954	1,026	Railway is single track; Endless ropeways are two circuits
Workshop	6	-	For maintenance of 4,500 buckets
Trans-shipment Facility	41	-	For trans-shipment to railway at Arusha
Maintenance Road	24	-	
Power Supply			Installation of Substation, 5,000 kW
Construction Cost*	1,040	1,026	

Note: *; Costs of buckets for endless ropeway and rolling stock required for the railway between Arusha and L. Natron are included. In the latter case, the required figure is calculated proportionally from that for L. Natron to Tanga P.

Table 6-2 Annual Operation Cost of Ropeway

	Operation Cost	Operation Cost per ton
Endless Ropeway	36 million Tsh.	26 Tsh.
Railway	23 million Tsh.	23 Tsh.

As clarified in these tables, the cable ropeway requires such equipment as steel cables, cable towers, buckets, and motors, as well as a workshop for bucket maintenance and other indirect facilities. Therefore, from the viewpoints both of capital costs and operation costs, the endless ropeway compares unfavorably with railway transport. Moreover, there are some technical problems involved with the ropeway, as follows:

(1) The ropeway is a transport facility exclusively for soda ash and cannot be used for other commodities.

(2) A power supply of about 5,000 kW is necessary.

(3) Operation and maintenance require as many as 590 employees. Training and education are necessary for both the unskilled workers and technicians.

(4) To prevent damage during transportation, the bucket must be covered. Therefore, special covered buckets and loading and unloading systems must be designed.

Because of these economic and technical considerations, the ropeway is not recommended for transport along the section between L. Natron and Arusha.

6-2 Transportation of Raw Material Crust by Pipeline System

In this section, the feasibility of transporting raw material crust long-distance through pipelines is considered. This is based on an assumption that the soda ash refining plant will be constructed away from the crust excavation site, for instance in Arusha.

When transporting the raw material crust via pipelines, it is necessary to make the crust into a slurry by mixing it with brine. It is generally accepted that an appropriate ratio of brine to crust is about 7 to 3. Therefore, it is necessary to move 3 tons of slurry to transport 1 ton of crust. This presents the question of whether this method of transport is effective in reducing transport costs.

The crust turned out from Lake Natron is soft and fragile. Therefore, the crust shatters into fine powder during transportation, increasing the viscosity. Table 6-3 shows a result of an experiment on change over time in slurry viscosity when the Natron crust is mixed and stirred with brine taken from the Lake. As shown in this table, the viscosity two hours after mixing is as high as 458 C.P. Unlike slurry transport of coal and water, this method will require a great increase in the electrical power consumption, thereby lowering the operations economic advantage.

Table 6-3 Experimental Data on Slurry Viscosity

	Soda crust and brine	Saturated water solution of sodium carbonate and sesqui-sodium carbonate	Coal and water
Raw solution viscosity	6.28 c.p.	2.42 c.p.	1.00 c.p.
(minutes)			
0	7.67	3.42	1.00
20	-	-	1.35
30	40	137	-
40	-	-	1.56
60	79	152	1.96
90	238	155	-
120	458	163	-

CHAPTER 7 COORDINATED TRANSPORTATION STUDY

From Chapter 3 to Chapter 6 in this report we conducted separate studies by modes of transport for transporting products from the Lake Natron plant to the nearest export port and putting the products aboard ship. In this chapter we consider the transport system comprehensively as one continuous system from origin point to destination (loading aboard ship in port). We want to consider the various transport combinations and to determine which is the optimum alternative.

7-1 Selection of Port Sites and Facilities

As a result of the studies we discussed in Chapter 3, we have selected the following export ports as most desirable for use.

Plan e500: if 500,000 t/yr.: Tanga Port (dredge inner port to 10 m depth) – a sea wall, reclaimed land, silo facilities and other facilities will be constructed or improved. Estimated cost, Tsh. 258,872,000.

Plan e1000: if 1,000,000 t/yr.: Tanga Port (dredge inner harbor to 12 m depth) – same facilities constructed or improved as above but on larger scale. Estimated cost, Tsh. 378,053,000.

Plan f1000: Tanga Port, outer harbor, on the coast in the vicinity of the multipurpose jetty, same facilities as Plan e1000. Estimated cost, 314,729,000.

Note: In the case of 250,000 tons production, same selection of site and same improvement is applicable as the case of 500,000 tons production, namely Plan e500 but with smaller silo facilities.

If Plans e1000 and f1000 are compared, the cost is less for the latter. However, if this project begins on a scale smaller than production of 1,000,000 t/yr. (e.g., 500,000 t/yr.) it may be more economic to start with Plan e500 and to shift later to Plan e1000. Apart from such a phased possibility which is dealt with in Volume 1, we take Plan f1000 as the best alternative for the production of 1,000,000 t/yr., for the purpose of the study in this volume.

7-2 Selection of Transport Methods by Rail and Road

From among the five alternative transport methods which utilize the railway fully or partially, one alternative has been rejected in Section 4. (This one assumes that the Musoma rail line has been built and proposes that a branch line from Lake Manyara to Lake Natron be built so that transport from Lake Natron to Tanga Port by rail alone become possible — See

Section 4). Section 5 has likewise concluded that two other alternatives, one to use truck transport from Lake Natron to Lake Manyara, the Musoma Line from Lake Manyara to Arusha, and the existing Arusha – Tanga Port line, and one to use truck transport from Lake Natron to Moshi and the existing Moshi – Tanga Port line, should both be dropped. (See Section 5, 9-2, and Section 3).

In addition, Section 5 also concludes that the alternative to use truck transport only all the way also should be dropped. (See Section 5, 9-2). Section 6 concludes that the alternative to transport the brine or products by pipeline and ropeway should be dropped. (Section 6, 1 and 2).

There are two remaining alternatives. The first one is to use lorry transport from Lake Natron to Arusha, and the existing rail line from Arusha to Tanga Port. The second one is to use a new rail line from Lake Natron to Arusha and the existing rail line from Arusha to Tanga Port.

Concerning the first alternative (lorry and rail), Route A (through Longido) seems most advantageous for a new Lake Natron–Arusha highway if a 250,000-ton capacity plant is built. On a 500,000-ton or 1,000,000-ton scale, however, Route B seems most advantageous since it is the shortest route.

The most appropriate vehicles for lorry transport would be 16.5 ton trailers for up to a 500,000-ton capacity plant and 30-ton trailers for a 1,000,000-ton capacity plant. Financial and economic analyses in this volume are therefore conducted on that basis. However, in the case of a 500,000-ton or 1,000,000-ton plant, it has been felt in Chapter 5, 9-1, that, considering the possibility of gradually expanding plant output in the future, it would be advantageous to standardize all vehicles and employ only trailers of 30-tons or more. Accordingly, practical alternatives recommendable for implementation would be as follows:

Factory output	Highway	Vehicles used
250,000 t/yr.	Route A	16.5-ton trailers
500,000 t/yr.	Route B	30-ton trailers (or larger trailers)
1,000,000 t/yr.	Route B	30-ton trailers (or larger trailers)

Regarding Plan (2), the investments for new lines are so great that it is absolutely non-economical with production of 250,000 t/yr. Thus, the only studies to be conducted for Plan (2) are for 500,000 t/yr. and 1,000,000 t/yr. For both of these production scales the routes, designs and costs for constructing new lines will all be identical.

7-3 Final Alternatives Chosen and Their Costs Comparison

The final alternatives selected for comparison through the process outlined above are given the following names:

(1) Case RR 250: 250,000 tons; Road Route A; 16.5-ton trailers (Lake Natron – Arusha); railroad (Arusha – Tanga); Port c500.

(2) Case RR 500: 500,000 tons; Road Route B; 16.5-ton trailers (Lake Natron – Arusha); railroad (Arusha – Tanga); Port c500.

(3) Case R 500: 500,000 tons; railroad (Lake Natron – Arusha – Tanga); Port c500.

(4) Case RR 1000: 1,000,000 tons; Road Route B; 30-ton trailers (Lake Natron – Arusha); railroad (Arusha – Tanga); Port f1000.

(5) Case R1000: 1,000,000 tons; railroad (Lake Natron – Arusha – Tanga); Port f1000.

Tables 1 through 10 show annual expenditures of financial costs and economic costs incurred by the construction and operation of necessary facilities/equipment for each of the above alternatives. The tables also show the present values of the financial and economic costs of the five alternatives at the first year of the plant operation and also their annual equivalents in terms of unit cost per ton. By comparing the present values of costs or their annual equivalents with each other, it is possible to identify the relative economic merits of each alternative.

At the 250,000-ton level, the only alternative selected (case RR250) involves a per-ton transportation cost as follows: fiscal cost of \$47.4/ton assuming 8.5% interest; and economic cost of \$47/ton assuming 10% interest. Even at such favorable interest rates, the per-ton transportation cost is fully 60% of the \$80/ton limit set for the product's FOB price at Tanga Port, and thus the economic feasibility of this alternative is considered to be out of the question from the beginning. Final evaluation however, must await a comprehensive evaluation in Volume I. At the 500,000-ton level, the financial cost involved at 8.5% interest is \$30.8/ton in Case RR 500, and \$49.4/ton in Case R 500. Economy of scale makes the 500,000-ton level considerably more advantageous than the 250,000-ton level. However, still insufficient scale in Case R 500 results in costs almost twice as high as costs in Case RR 500. Railway economy requires much larger scale. Consequently, there is little doubt as to the economic superiority of the latter case. Comparison of the economic costs of the same two alternative reveals the same results.

At the 1,000,000-ton level, the per-ton transportation costs are as follows:

Case RR 1000:	\$21.7/ton financial cost at 8.5% interest \$20.1/ton economic cost at 10% interest
Case R 1000:	\$29.5/ton financial cost at 8.5% interest \$28.6/ton economic cost at 10% interest

These figures indicate that: (1) at a production level of 1,000,000 tons, transportion costs incurred by using the optimum transportation method are roughly 25% of the product's price, and are thus not the greatest factor determining the success of the project (the greatest cost factors are expenses involved in construction of plant facilities and in processing); and (2) although the cost difference between Case RR 1000 and Case R 1000 is reduced to approximately $8.0/ton, this difference is still substantial, clearly indicating the economic superiority of the former. Moreover, when interest rates for financial costs and economic costs are raised to 10% and 12%, respectively, the cost difference between Case RR 1000 and Case R 1000 increases to approximately $10/ton. And when these interest rates are further raised to 12% and 15% respectively, the cost difference increases to between $22/ton and $24/ton. As interest rates are raised, the construction of a new railway line, which involves a large initial capital investment and fairly small maintenance and operational costs at later dates, becomes increasingly uneconomic in comparison to construction of a road, which involves a relatively small initial capital investment with larger maintenance and operating costs later.

In conclusion, therefore, given a production level of 1,000,000 tons and interest rates as assumed above, the alternative involving the construction of a railway line is definitely uneconomic, and in order to make it economically feasible, either production must be increased considerably above the 1,000,000-ton level or capital funds at extremely low interest rates must be sought. In this latter case, however, doubt still remains as to whether such funds could not be put to better uses. If this project is to be implemented, therefore, thought should not be given at first to the construction of a railway line. At a later time, however, when certain favorable conditions begin to arise – such as when production becomes stable at a level greater than 1,000,000 tons, and when the economic superiority of road transport declines due to comparative increases in the price of oil – it will still not be too late to positively study and plan the construction of a railway line.

Table 7-1 Financial Costs of Transportation of the Project: Case RR 250

(10⁶ T. Shs.)

Year	Costs											
	Port			Railway			Road			Total		
	C.C.	O.C.	S-t	C.C.	O.C.	S-t	C.C.	O.C.	S-t	C.C.	O.C.	Total
-10												
-9							13		13	13		13
-8							3		3	3		3
-7							22		22	22		22
-6							54		54	54		54
-5	5		5				52		52	57		57
-4	9		9	2		2	12		12	23		23
-3	25		25	3		3		1	1	28	1	29
-2	85		85	46		46		1	1	131	1	132
-1	135		135	101		101	35	1	36	271	1	272
1		7	7		12	12		11	11		30	30
2		7	7						11		30	30
3		4	4				6		17	6	27	33
4									11			27
5							6		17	6		33
6							6		17	6		33
7									11			27
8									11			27
9							6		17	6		33
10							6	36	42	6	52	58
11								11	11		27	27
12							6		17	6		33
13									11			27
14									11			27
15							12		23	12		39
16									11			27
17									11			27
18							6		17	6		33
19									11			27
20				70		82	29	36	65	99	52	151
21				3		9	6	11	17	3	27	30
22						12			11			27
23									11			27
24							6		17	6		33
25							6		17	6		33
26									11			27
27							6		17	6		33
28									11			27
29									11			27
30				35		23			11	35		8
Total	259	126	385	184	360	544	298	383	681	741	869	1,610
P.V. discounted at 8.5%			356			324			448			1,128
Unit costs at I.R.=8.5% (US$/ton)			15.0			13.6			18.8			47.4
P.V. discounted at 10%			358			310			485			1,153
Unit costs at I.R.=10% (US$/ton)			16.9			14.6			22.9			54.4
P.V. discounted at 12%			362			295			494			1,151
Unit costs at I.R.=12% (US$/ton)			19.6			16.0			26.8			62.4

C.C.: Capital Cost
O.C.: O & M Cost
S-t : Sub-total

Table 7-2 Financial Costs of Transportation of the Project: Case R-500

(10⁶ T. Shs.)

Year	Costs											
	Port			Railway			Road			Total		
	C.C.	O.C.	S-t	C.C.	O.C.	S-t	C.C.	O.C.	S-t	C.C.	O.C.	Total
-10												
-9												
-8				8		8				8		8
-7				19		19				19		19
-6				27		27				27		27
-5	5		5	74		74				79		79
-4	9		9	223		223				232		232
-3	25		25	297		297				322		322
-2	85		85	278		278				363		363
-1	135		135	328		328				463		463
1		7	7		34	34					41	41
2		7	7								41	41
3		4	4								38	38
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20				120		154				120		158
21				6		28				6	38	32
22						34						38
23												
24												
25												
26												
27												
28												
29												
30				60		26				60		22
Total	259	126	385	1,308	1,020	2,328				1,567	1,146	2,713
P.V. discounted at 8.5%			356			1,993						2,349
Unit costs at I.R.=8.5% (US$/ton)			7.5			41.9						49.4
P.V. discounted at 10%			358			2,006						2,364
Unit costs at I.R.=10% (US$/ton)			8.5			47.4						55.9
P.V. discounted at 12%			362			2,050						2,412
Unit costs at I.R.=12% (US$/ton)			9.8			55.6						65.4

C.C.: Capital Cost
O.C.: O & M Cost
S-t : Sub-total

Table 7-3 Financial Costs of Transportation of the Project: Case RR 500

(10⁶ T. Shs.)

Year	Costs											
	Port			Railway			Road			Total		
	C.C.	O.C.	S-t	C.C.	O.C.	S-t	C.C.	O.C.	S-t	C.C.	O.C.	Total
-10												
-9							13		13	13		13
-8							3		3	3		3
-7							20		20	20		20
-6							52		52	52		52
-5	5		5				59		59	64		64
-4	9		9	2		2	16		16	27		27
-3	25		25	3		3		1	1	28	1	29
-2	85		85	56		56		1	1	141	1	142
-1	135		135	136		136	55	1	56	326	1	327
1		7	7		17	17		19	19		43	43
2		7	7						19		43	43
3		4	4						19		40	40
4							13		32	13		53
5									19			40
6							11		30	11		51
7									19			40
8							13		32	13		53
9									19			40
10							0	49	49	0	70	70
11								19	19		40	40
12							24		43	24		64
13									19			40
14									19			40
15									19			40
16							13		32	13		53
17									19			40
18							11		30	11		51
19									19			40
20				98		115	44	49	93	142	70	212
21				5		12		19	19	5	40	35
22						17			19			40
23									19			40
24							24		43	24		64
25									19			40
26									19			40
27									19			40
28							13		32	13		53
29									19			40
30				49		32			19	49		9
Total	259	126	385	241	510	751	384	633	1,017	884	1,269	2,153
P.V. discounted at 8.5%			356			439			625			1,420
Unit costs at I.R.=8.5% (US$/ton)			7.5			9.2			13.1			29.8
P.V. discounted at 10%			358			418			614			1,390
Unit costs at I.R.=10% (US$/ton)			8.5			9.9			14.5			32.9
P.V. discounted at 12%			362			397			612			1,371
Unit costs at I.R.=12% (US$/ton)			9.8			10.8			16.6			37.2

C.C.: Capital Cost
O.C.: O & M Cost
S-t : Sub-total

Table 7-4 Financial Costs of Transportation of the Project: Case R 1,000

(10^6 T. Shs.)

Year	Costs											
	Port			Railway			Road			Total		
	C.C.	O.C.	S-t	C.C.	O.C.	S-t	C.C.	O.C.	S-t	C.C.	O.C.	Total
-10												
-9												
-8				8		8				8		8
-7				19		19				19		19
-6				27		27				27		27
-5	4		4	74		74				78		78
-4	10		10	223		223				233		233
-3	45		45	297		297				342		342
-2	82		82	284		284				366		366
-1	174		174	446		446				620		620
1		9	9		53	53					62	62
2		9	9								62	62
3		6	6								59	59
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20				234		287				234		293
21				12		41				12	59	47
22						53						59
23												
24												
25												
26												
27												
28												
29												
30				117		64				117		58
Total	315	186	501	1,483	1,590	3,073				1,798	1,776	3,574
P.V. discounted at 8.5%			439			2,367						2,806
Unit costs at I.R.=8.5% (US$/ton)			4.6			24.9						29.5
P.V. discounted at 10%			440			2,358						2,798
Unit costs at I.R.=10% (US$/ton)			5.2			27.9						33.1
P.V. discounted at 12%			444			2,371						2,815
Unit costs at I.R.=12% (US$/ton)			6.0			32.2						38.2

C.C.: Capital Cost
O.C.: O & M Cost
S-t : Sub-total

Table 7-5 Financial Cost of Transportation of the Project: Case RR 1,000

(10^6 T. Shs.)

Year	Costs											
	Port			Railway			Road			Total		
	C.C.	O.C.	S-t	C.C.	O.C.	S-t	C.C.	O.C.	S-t	C.C.	O.C.	Total
-10												
-9							13		13	13		13
-8							3		3	3		3
-7							23		23	23		23
-6							63		63	63		63
-5	4		4				79		79	83		83
-4	10		10	2		2	22		22	34		34
-3	45		45	4		4		1	1	49	1	50
-2	82		82	62		62		1	1	144	1	145
-1	174		174	237		237	78	1	79	489	1	490
1		9	9		33	33		31	31		73	73
2		9	9						31		73	73
3		6	6						31		70	70
4							16		47	16		86
5									31			70
6							16		47	16		86
7									31			70
8							16		47	16		86
9									31			70
10							0	73	73	0	112	112
11								31	31		70	70
12							32		63	32		102
13									31			70
14									31			70
15									31			70
16							16		47	16		86
17									31			70
18							16		47	16		86
19									31			70
20				196		229	62	73	135	258	112	370
21				10		23		31	31	10	70	60
22						33			31			70
23									31			70
24							32		63	32		102
25									31			70
26									31			70
27									31			70
28							16		47	16		86
29									31			70
30				98		65			31	98		28
Total	315	186	501	393	990	1,383	503	1,017	1,520	1,211	2,193	3,404
P.V. discounted at 8.5%			439			748			879			2,066
Unit costs at I.R.=8.5% (US$/ton)			4.6			7.9			9.2			21.7
P.V. discounted at 10%			440			706			853			1,999
Unit costs at I.R.=10% (US$/ton)			5.2			8.3			10.1			23.6
P.V. discounted at 12%			444			663			840			1,947
Unit costs at I.R.=12% (US$/ton)			6.0			9.0			11.4			26.4

C.C.: Capital Cost
O.C.: O & M Cost
S-t : Sub-total

Table 7-6 Economic Costs of Transportation of the Project: Case RR 250

(10^6 US$)

Year	Costs									Total		
	Port			Railway			Road					
	C.C.	O.C.	S-t	C.C.	O.C.	S-t	C.C.	O.C.	S-t	C.C.	O.C.	Total
-10												
-9							1.5		1.5	1.5		1.5
-8							0.4		0.4	0.4		0.4
-7							2.2		2.2	2.2		2.2
-6							5.3		5.3	5.3		5.3
-5	0.6		0.6				5.2		5.2	5.8		5.8
-4	1.1		1.1	0.2		0.2	1.3		1.3	2.6		2.6
-3	2.8		2.8	0.3		0.3		0.1	0.1	3.1	0.1	3.2
-2	9.6		9.6	4.6		4.6		0.1	0.1	14.2	0.1	14.3
-1	15.5		15.5	11.6		11.6	3.9	0.1	4.0	31.0	0.1	31.1
1		0.8	0.8		1.2	1.2		1.0	1.0		3.0	3.0
2		0.8	0.8						1.0		3.0	3.0
3		0.5	0.5				0.8		1.8	0.8	2.7	3.5
4									1.0			2.7
5							0.7		1.7	0.7		3.4
6							0.8		1.8	0.8		3.5
7									1.0			2.7
8									1.0			2.7
9							0.8		1.8	0.8		3.5
10							0.8	3.6	4.4	0.8	5.3	6.1
11								1.0	1.0		2.7	2.7
12							0.8		1.8	0.8		3.5
13									1.0			2.7
14									1.0			2.7
15							1.5		2.5	1.5		4.2
16									1.0			2.7
17									1.0			2.7
18							0.8		1.8	0.8		3.5
19									1.0			2.7
20				8.5		9.7	3.1	3.6	6.7	11.6	5.3	16.9
21				0.4		0.8	0.8	1.0	1.8	0.4	2.7	3.1
22						1.2			1.0			2.7
23									1.0			2.7
24							0.8		1.8	0.8		3.5
25							0.7		1.7	0.7		3.4
26									1.0			2.7
27							0.8		1.8	0.8		3.5
28									1.0			2.7
29									1.0			2.7
30				4.3		3.1			1.0	4.3		1.6
Total	29.6	15.6	45.2	20.5	36.0	56.5	33.0	35.5	68.5	83.1	87.1	170.2
P.V. discounted at 8.5%			40.7			32.4			48.8			121.9
Unit costs at I.R.=8.5% (US$/ton)			15.7			12.5			18.8			47.0
P.V. discounted at 10%			41.1			31.0			49.9			122.0
Unit costs at I.R.=10% (US$/ton)			18.2			13.8			22.1			54.1
P.V. discounted at 12%			42.2			29.8			53.2			125.2
Unit costs at I.R.=12% (US$/ton)			22.3			15.7			28.1			66.1

C.C.: Capital Cost
O.C.: O & M Cost
S-t : Sub-total

Table 7-7 Economic Costs of Transportation of the Project: Case R 500

(10^6 US$)

Year	Costs: Port C.C.	Port O.C.	Port S-t	Railway C.C.	Railway O.C.	Railway S-t	Road C.C.	Road O.C.	Road S-t	Total C.C.	Total O.C.	Total
-10												
-9												
-8				1.0		1.0				1.0		1.0
-7				2.3		2.3				2.3		2.3
-6				3.3		3.3				3.3		3.3
-5	0.6		0.6	7.6		7.6				8.2		8.2
-4	1.1		1.1	23.0		23.0				24.1		24.1
-3	2.8		2.8	30.6		30.6				33.4		33.4
-2	9.6		9.6	28.5		28.5				38.1		38.1
-1	15.5		15.5	36.0		36.0				51.5		51.5
1		0.8	0.8		3.3	3.3					4.1	4.1
2		0.8	0.8								4.1	4.1
3		0.5	0.5								3.8	3.8
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20				14.7		18.0				14.7		18.5
21				0.7		2.6				0.7		3.1
22						3.3						3.8
23												
24												
25												
26												
27												
28												
29												
30				7.4		4.1				7.4		3.6
Total	29.6	15.6	45.2	138.9	99.0	237.9				168.5	114.6	283.1
P.V. discounted at 8.5%			40.7			209.3						250.0
Unit costs at I.R.=8.5% (US$/ton)			7.8			40.4						48.2
P.V. discounted at 10%			41.1			214.0						255.1
Unit costs at I.R.=10% (US$/ton)			9.1			47.4						56.5
P.V. discounted at 12%			42.2			223.9						266.1
Unit costs at I.R.=12% (US$/ton)			11.2			59.2						70.4

C.C.: Capital Cost
O.C.: O & M Cost
S-t : Sub-total

Table 7-8 Economic Costs of Transportation of the Project: Case RR 500

Case RR 50 (10^{6} US$)

Year	Costs: Port C.C.	Port O.C.	Port S-t	Railway C.C.	Railway O.C.	Railway S-t	Road C.C.	Road O.C.	Road S-t	Total C.C.	Total O.C.	Total
-10												
-9							1.5		1.5	1.5		1.5
-8							0.4		0.4	0.4		0.4
-7							2.1		2.1	2.1		2.1
-6							5.3		5.3	5.3		5.3
-5	0.6		0.6				6.0		6.0	6.6		6.6
-4	1.1		1.1	0.3		0.3	1.6		1.6	3.0		3.0
-3	2.8		2.8	0.4		0.4		0.1	0.1	3.2	0.1	3.3
-2	9.6		9.6	5.6		5.6		0.1	0.1	15.2	0.1	15.3
-1	15.5		15.5	15.7		15.7	6.2	0.1	6.3	37.4	0.1	37.5
1		0.8	0.8		1.6	1.6		1.7	1.7		4.1	4.1
2		0.8	0.8						1.7		4.1	4.1
3		0.5	0.5						1.7		3.8	3.8
4							1.6		3.3	1.6		5.4
5									1.7			3.8
6							1.4		3.1	1.4		5.2
7									1.7			3.8
8							1.6		3.3	1.6		5.4
9									1.7			3.8
10							0.1	4.9	5.0	0.1	7.0	7.1
11								1.7	1.7		3.8	3.8
12							2.9		4.6	2.9		6.7
13									1.7			3.8
14									1.7			3.8
15									1.7			3.8
16							1.6		3.3	1.6		5.4
17									1.7			3.8
18							1.4		3.1	1.4		5.2
19									1.7			3.8
20				12.0		13.6	4.9	4.9	9.8	16.9	7.0	23.9
21				0.6		1.0		1.7	1.7	0.6	3.8	3.2
22						1.6			1.7			3.8
23									1.7			3.8
24							2.9		4.6	2.9		6.7
25									1.7			3.8
26									1.7			3.8
27									1.7			3.8
28							1.6		3.3	1.6		5.4
29									1.7			3.8
30				6.0		4.4			1.7	6.0		2.2
Total	29.6	15.6	45.2	27.4	48.0	75.4	43.1	57.7	100.8	100.1	121.3	221.4
P.V. discounted at 8.5%			40.7			43.6			61.9			146.2
Unit costs at I.R.=8.5% (US$/ton)			7.8			8.4			11.9			28.1
P.V. discounted at 10%			41.1			41.6			62.1			144.8
Unit costs at I.R.=10% (US$/ton)			9.1			9.2			13.8			32.1
P.V. discounted at 12%			42.2			39.7			64.0			145.9
Unit costs at I.R.=12% (US$/ton)			11.2			10.5			16.9			38.6

C.C.: Capital Cost
O.C.: O & M Cost
S-t : Sub-total

Table 7-9 Economic Costs of Transportation of the Project: Case R 1,000

Case R 100 (10⁶ US$)

Year	Port C.C.	Port O.C.	Port S-t	Railway C.C.	Railway O.C.	Railway S-t	Road C.C.	Road O.C.	Road S-t	Total C.C.	Total O.C.	Total
-10												
-9												
-8				1.0		1.0				1.0		1.0
-7				2.3		2.3				2.3		2.3
-6				3.3		3.3				3.3		3.3
-5	0.4		0.4	7.6		7.6				8.0		8.0
-4	1.3		1.3	23.0		23.0				24.3		24.3
-3	5.2		5.2	30.6		30.6				35.8		35.8
-2	9.1		9.1	29.0		29.0				38.1		38.1
-1	20.1		20.1	50.4		50.4				70.5		70.5
1		0.9	0.9		5.0	5.0					5.9	5.9
2		0.9	0.9								5.9	5.9
3		0.7	0.7								5.7	5.7
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20				28.7		33.7				28.7		34.4
21				1.4		3.6				1.4		4.3
22						5.0						5.7
23												
24												
25												
26												
27												
28												
29												
30				14.4		9.4				14.4		8.7
Total	36.1	21.4	57.5	160.1	150.0	310.1				196.2	171.4	367.6
P.V. discounted at 10%			50.3			245.8						296.1
Unit costs at I.R.=10% (US$/ton)			4.9			23.7						28.6
P.V. discounted at 12%			50.8			247.9						298.7
Unit costs at I.R.=12% (US$/ton)			5.6			27.5						33.1
P.V. discounted at 15%			51.9			255.3						307.2
Unit costs at I.R.=15% (US$/ton)			6.9			33.7						40.6

C.C.: Capital Cost
O.C.: O & M Cost
S-t : Sub-total

Table 7-10 Economic Costs of Transportation of the Project: Case RR 1,000

Case RR 100 (10^6 US$)

Year	Port C.C.	Port O.C.	Port S-t	Railway C.C.	Railway O.C.	Railway S-t	Road C.C.	Road O.C.	Road S-t	Total C.C.	Total O.C.	Total
-10												
-9							1.5		1.5	1.5		1.5
-8							0.4		0.4	0.4		0.4
-7							2.3		2.3	2.3		2.3
-6							6.2		6.2	6.2		6.2
-5	0.4		0.4				8.0		8.0	8.4		8.4
-4	1.3		1.3	0.3		0.3	2.3		2.3	3.9		3.9
-3	5.2		5.2	0.5		0.5		0.1	0.1	5.7	0.1	5.8
-2	9.1		9.1	6.1		6.1		0.1	0.1	15.2	0.1	15.3
-1	20.1		20.1	28.1		28.1	9.0	0.1	9.1	57.2	0.1	57.3
1		0.9	0.9		3.1	3.1		2.7	2.7		6.7	6.7
2		0.9	0.9						2.7		6.7	6.7
3		0.7	0.7						2.7		6.5	6.5
4							1.9		4.6	1.9		8.4
5									2.7			6.5
6							1.9		4.6	1.9		8.4
7									2.7			6.5
8							1.9		4.6	1.9		8.4
9									2.7			6.5
10							0.1	7.1	7.2	0.1	10.9	11.0
11								2.7	2.7		6.5	6.5
12							3.9		6.6	3.9		10.4
13									2.7			6.5
14									2.7			6.5
15									2.7			6.5
16							1.9		4.6	1.9		8.4
17									2.7			6.5
18							1.9		4.6	1.9		8.4
19									2.7			6.5
20				24.0		27.1	7.0	7.1	14.1	31.0	10.9	41.9
21				1.2		1.9		2.7	2.7	1.2	6.5	5.3
22						3.1			2.7			6.5
23									2.7			6.5
24							3.9		6.6	3.9		10.4
25									2.7			6.5
26									2.7			6.5
27									2.7			6.5
28							1.9		4.6	1.9		8.4
29									2.7			6.5
30				12.0		8.9			2.7	12.0		5.5
Total	36.1	21.4	57.5	45.8	93.0	138.8	56.0	90.1	146.1	137.9	204.5	342.4
P.V. discounted at 10%			50.3			74.1				83.8		208.2
Unit costs at I.R.=10% (US$/ton)			4.9			7.1				8.1		20.1
P.V. discounted at 12%			50.8			70.1				83.0		203.9
Unit costs at I.R.=12% (US$/ton)			5.6			7.8				9.2		22.6
P.V. discounted at 15%			51.9			66.1				83.9		201.9
Unit costs at I.R.=15% (US$/ton)			6.9			8.7				11.1		26.7

C.C.: Capital Cost
O.C.: O & M Cost
S-t : Sub-total