REPORT

ON

THE SURVEY FOR IRON ORE LOADING FACILITIES IN OR NEAR VISAKHAPATNAM

JUNE 1968

OVERSEAS TECHNICAL COOPERATION AGENCY
GOVERNMENT OF JAPAN

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Preface

India is one of the richest countries in iron ore resources of the world and its reserves are prospected more than 30,000 million tonnes. Thus, iron ore is said to have occupied an important place in India's export drive, especially among the various deposits, Bailadilla deposit is regarded as a most promising one for export.

And with a view to developing its production capacity and to establishing the most economical means of transport from Bailadilla range, several investigations have been conducted so far and some are under way.

In the circumstances, the Government of India lately called on Japan for sending a team of experts to undertake a study and examination into proposed plan in regard to iron ore exports via east coast of India.

The Government of Japan, in reply to the above, entrusted the Overseas Technical Cooperation Agency with the task of implementing a survey for the proposed subject.

On the 29th of March, 1968, the OTCA dispatched the survey team to India consisting of nine experts headed by Dr. Hajime Sato, Director General of Japan Port and Harbour Association. During about three weeks investigation works, this team successfully arrived at a conclusion to be recommended to the Government of India.

Hereby presented is a report which is based upon the outcome of the survey already carried out.

Nothing would be more gratifying for us than this report could be proved worthy of careful study on the part of India, and thus be contributed to mutual benefit and friendship of our two nations, India and Japan.

Finally, I take this opportunity to express my heartfelt gratitude to the Government of India and the proper authorities, and Japanese people concerned for their kind cooperation extended to the survey team, without which this team could not have produced such a fruitful result.

June, 1968

Shin-ichi Shibusawa
Director General
Overseas Technical Cooperation Agency
Government of Japan

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CHAPTER I INTRODUCTION

CHAPTER 1 INTRODUCTION

1-1 OBJECTIVES

This survey team was organized at the request of the Government of India with a view to studying and examining into the alternative sities of the proposed plan – outer harbour of Visakhapatnam or Gangavaram for the additional mechanical ore loading plant. At the same time, this team was intended to investigate into the present state of the railway facilities between Bailadilla Mine and Visakhapatnam Port, and also to review its upgrading arrangements already in progress.

1-2 SCOPE OF SURVEY AND ITS SUBJECT

Visakhapatnam Port:

(1) Investigation and confirmation of the present state.

(2) Study and examination into the layout of the proposed outer harbour plan.

(3) Collection and study of data regarding natural condition, construction works and its cost.

(4) Investigation and confirmation of the present state of railway.

(5) Study and investigation into the railway upgrading arrangements already under way.

Gangavaram:

(1) Study and investigation into the proposed harbour plan.

(2) Study and examination into the proposed land transport plan.

Poona:

(1) Examination into the results of model test undertaken in regard to the alternative locations of the proposed harbour plan – Visakhapatnam outer harbour or Gangavaram.

1-3 NAME AND PRESENT POSITION OF THE MEMBERS

Dr. Hajime Sato, Leader (Civil Engineer)
Director General
Japan Port and Harbour Association

Mr. Atsusato Miyake, Member (Mechanical Engineer)
Deputy Director, Fifth District Port Construction Bureau
Ministry of Transport

Mr. Koji Tajima, Member (Civil Engineer)
Director, Tokyo Outer Loop Line Department
Japan Railway Construction Public Corporation

Mr. Teruo Muto, Member (Navigator)
Captain
Kawasaki Kisen Kaisha, Ltd.

Mr. Takao Horiguchi, Member (Civil Engineer)
Superintendent, Yokohama Research & Design Office
Second District Port Construction Bureau
Ministry of Transport

Mr. Kiyoyasu Mikanagi, Member (Civil Engineer)
Deputy Chief, Construction Section
Bureau for Port & Harbour
Ministry of Transport

Mr. Teruo Kawanishi, Member (Civil Engineer)
Deputy Chief, Planning Section
Port & Harbour Research Institute
Ministry of Transport

Mr. Yasushi Hirotani, Member (Economist)
Officer, Development Survey Department
Overseas Technical Cooperation Agency

Mr. Hiroshi Shiozawa, Member (Mechanical Engineer)
Assistant Chief, Safety & Operation Section
Railway Supervision Bureau
Ministry of Transport

1-4 PROGRAMME AND ITINERARY FOR THE SURVEY TEAM

This team was composed of the two groups, viz. Port & Harbour Group and Railway Group, each of which followed a separate schedule respectively. The former was consisted of seven members, namely, Messrs. Sato, Miyake, Muto, Horiguchi, Mikanagi, Kawanishi and Hirotani, and the latter Messrs. Tajima and Shiozawa.

The programme and itinerary already carried out is as follows:

Port & Harbour Group

February	29	(Thu.)	Lv. Tokyo for Calcutta
March	1	(Fri.)	Observation of the site of Haldia Project

			Visit to the Commissioners for Port of Calcutta
March	2	(Sat.)	Lv. Calcutta for Visakhapatnam
			On-the-spot investigation at Gangavaram
	3	(Sun.)	Visit to Visakhapatnam Port Trust; - Cruising entrance channel, proposed outer harbour site, etc.
			- Inspection of ore handling plant and berth
			Lv. Visakhapatnam for Hyderabad
	4	(Mon.)	Lv. Hyderabad for Bombay
	5	(Tue.)	Lv. Bombay for Poona
			- Inspection of the site of model tests undertaken in regard to the alternative locations of proposed plan
			- Discussion the results of the model tests
			- Collection of data
	6	(Wed.)	Same as above
			Lv. Poona for Bombay
	7	(Thu.)	Lv. Bombay for Madras
			Visit to Japanese Consulate General
			Visit to Madras Branch, Minerals & Metals Trading Corporation
	8	(Fri.)	Visit to Madras Port Trust; - Observation of the existing port facilities and the site of outer harbour plan
			Lv. Madras for Hyderabad
	9	(Sat.)	Study with data collected
	10	(Sun.)	Lv. Hyderabad for Visakhapatnam
			Joined with Railway Group

March	11	(Mon.)	Visit to Visakhapatnam Port Trust; - Preliminary discussions regarding layout, present facilities and operational functions - Inspection of ore handling plant including ore berths and other berths
	12	(Tue.)	Visit to Visakhapatnam Port Trust; - Inspection of ore exchange yard and dumper yard - Listening to explanation of alternative proposal regarding siting of future yard at Visakhapatnam - Listening to explanation of proposed Visakhapatnam outer harbour plan and Gangavaram plan
	13	(Wed.)	Visit to Visakhapatnam Port Trust; - Discussions regarding the above plans
	14	(Thu.)	Interim report making
	15	(Fri.)	Visit to Visakhapatnam Port Trust; - Presentation of team's opinions and conclusion regarding the proposed plans
	16	(Sat.)	Lv. Visakhapatnam for Delhi
	17	(Sun.)	Free
	18	(Mon.)	Visit to Ministry of Port & Shipping; - Courtesy call on the Minister - Presentation of interim report, followed by discussions Visit to Japanese Embassy; - Reporting to the Ambassador regarding the progress and outcome of the survey
	19	(Tue.)	Visit to Railway Board; - Courtesy call on the Chairman Visit to Minerals & Metals Trading Corporation - Courtesy call on the Chairman
	20	(Wed.)	Lv. Delhi
	22	(Thu.)	Ar. Tokyo

Railway Group

February	29	(Thu.)	Lv. Tokyo for Calcutta
March	1	(Fri.)	Visit to South Eastern Railway; - Collection of data
	2	(Sat.)	Lv. Calcutta for Visakhapatnam Visit to Waltair Railway; - Listening to explanation on the existing K-B Line
	3	(Sun.)	On-the-spot investigation between Pendurti and Gangavaram regarding proposed line On-the-spot investigation between Kottavalasa and the terminal
	4	(Mon.)	Lv. Waltair for Kirandul via Koraput
	5	(Tue.)	Inspection of Kirandul Station and Bailadilla Mine No. 14 Deposit
	6	(Wed.)	Inspection of Bailadilla Mine No. 5 Deposit On-the-spot investigation between Bhansi and Jagdulpure
	7	(Thu.)	On-the-spot investigation between Araku and S. Kota
	8	(Fri.)	On-the-spot investigation of marshalling yard at Waltair and ore unloading plant
	9	(Sat.)	Study with data collected
	10 12	(Sun.) – (Tue.)	Joined with Port & Harbour Group following the same schedule
	13	(Wed.)	A.M. same as above P.M. Visit to Waltair Railway; - Discussions regarding the K-B Line and its upgrading plan
	14	(Thu.)	Interim report making

March	15	(Fri.)	A.M. Visit to Visakhapatnam Port Trust; P.M. Visit to Waltair Railway; - Reporting on the results of study and investigation
	16 – 22	(Sat.) – (Thu.)	Same schedule that of Port & Harbour Group

CHAPTER II CONCLUSIONS

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2-1 IMPORTANCE OF VISAKHAPATNAM PORT

Visakhapatnam Port is situated alongside the East Coast of India and just in the midway between the two ports – Calcutta and Madras.

The volume of cargoes handled by this port during 1965 – 66 amounted to 4,460,000 tonnes and that in 1966 – 67 5,940,000 tonnes.

Among them, iron ore handling has been largely increased with the facilitation of loading equipments, that is, from 1,710,000 tonnes in 1966 to 2,160,000 tonnes in 1967. This trend will be further remarkable with intensive performance of mining works. The Government of India reportedly prospected that the volume would reach 12,000,000 tonnes per year in the near future.

On the other hand, there are various industries in and around Visakhapatnam Port at present such as oil refinery, fertilizer, shipbuilding, etc. and in future this area will occupy a more important place as an industrial zone in accordance with industrialization in India.

Meanwhile, this port is promised as a port not only for iron ore shipment but also for commerce and industry affairs. Therefore, it is important to take up the proposed plan for mechanical ore loading plant as part of the comprehensive port and harbour development plan with a view to construction of the "Great Visakhapatnam Port".

2-2 TREND OF ORE CARRIERS TOWARD LARGER SIZE

Ore carriers tend to be larger rapidly in these several years. For those countries who demand for ore largely overseas, it is a matter of keen interest how to cheapen the transportation cost. From this point of view, the above trend will be easily understood.

The increase of steel production capacity in the world seems to accelerate the trend toward mammoth ore carriers construction.

The statistics of ore carriers construction orders as of January, 1966 shows that 87% of the total orders is for the size of over 50,000 DWT, 65% for over 60,000 DWT and 27% for over 80,000 DWT, and compared with that as of January, 1967 is corresponded to 81%, 78% and 57% respectively.

At the beginning of 1968, the trend of ore carriers toward larger size became more conspicuous, that is, 93% for over 60,000 DWT and 80% for over 80,000 DWT were ordered to construct. The number of over 100,000 DWT bulk carriers ordered in Japan amounted to nine, including four bulk carriers of 147,000 DWT, four ore/oil carriers of 127,700 DWT, 127,600 DWT, 104,773 DWT and 104,700 DWT, and one ore carrier of 101,700 DWT.

From the above, it is easily foreseen that vessels bigger than these carriers will be built in the near future. Considering this fact, Visakhapatnam Port will be required to be equipped with mechanical ore handling plant for accommodating more than 100,000 DWT ore carriers.

2-3 FACILITATION OF VISAKHAPATNAM PORT TO COPE WITH THE TREND OF VESSELS TOWARD LARGER SIZE

The present Visakhapatnam Port possesses a vast land of 10,000 acres belonging to the Port Trust and the inner harbour comprising three artificial channels – Northern Arm, Northwestern Arm and Western Arm, an approach channel thereinto, a ship-sunk type breakwater, and a sand trap to maintain a good depth of above approach channel. The maximum capacity of the port which can accommodate vessels is about 40,000 DWT.

The inner harbour, with the existing vast land and the expansion of the artificial channels, will be promised of its further development in the future. However, due to the existence of hard rock-bed in the port entrance and shipyards located nearby the turning basin, the expansion works for larger size vessels will become difficult to a certain extent.

Consequently, the proposal for outer harbour development is a requisite not only for iron ore carriers but also for oil tankers to import crude oil with a view to meeting the trend of vessels toward larger size.

However, it is by no means an easy work to construct the outer harbour capable of accommodating larger size vessels under the natural conditions of the East Coast of India.

Needless to say, the necessity of the outer harbour construction is caused by an economic pressure. On the other hand, this is also supportable from the following favourable points existed in this port:

(a) The existing sand trap is effective for maintaining the depth of water in the approach channel. This suggests that there is a possibility to find out means for maintaining further deeper water-depth of the channel in the future.

(b) The Dolphin's Nose hill plays a role of shelter against the wind during the south-west monsoon season and it will help easier loading works in the outer harbour.

(c) There is a possibility to make a flexible plan for the outer harbour development in the case that vessels become larger and any unexpected transport revolution occurs. And it is also another fact that the layout of equipments can be made so that the rock-bed may be excavated to the minimum possible extent.

(d) The outer harbour development is effective for the future upgrading of the inner harbour.

Among the above, the capability of maintaining the deeper water-depth is one of the most important points to be kept in mind.

Consequently, it is required to give a careful consideration on the layout of the breakwaters. Above all, whether or not the proposed southern breakwater construction will keep a good effect of the present sand trap, should be fully examined by ways of model tests or others.

2-4 OUTER HARBOUR PLAN

Basing upon the foregoing point of veiws, this survey team carefully examined various plans for the outer harbour development drawn up by the Government of India, and arrived at a conclusion, that is, we agreed in principle with the layout of breakwaters, approach channel, turning basin and berths which were shown in the Visakhapatnam Alternative-3 Plan.

In addition, the following are our recommendations related to the above plan:

(1) The proposed length of the breakwaters should be maintained in view of obtaining necessary tranquillity, minimizing siltation and also making the maneuvering of vessels easy, within the outer harbour.

(2) It will be appropriate to design the structure of the ore berth for the future accommodation of 150,000 DWT vessels, and to reserve space for additional ore berth with possible expansion in mind.

(3) Regarding the rock-bed boring in the proposed outer harbour site, it is further necessary to undertake an elaborate core boring work in order to obtain full information on the depth of rock-bed and its hardness. As a result, re-examination into the ore berth alignment, the location of the turning basin, etc. should be carried out. A success in minimizing the dredging of rock-bed will shorten the period for the outer harbour construction.

(4) It is desirable that the spending beach and the wave dissipating arrangement inside the breakwaters be made as much as possible, as these facilities are believed to be effective in maintaining tranquillity inside the harbour.

(5) In the interim report presented by this survey team, it was recommended that the depth of water within the harbour may initially be available for 70,000 DWT vessels, to be progressively improved in stages for larger size vessels. However, in view of the present trend of vessels toward larger size and from the economic point of view in undertaking the harbour construction, it is appropriate that the water-depth from the very beginning be available for 100,000 DWT by dredging over the minimum necessary space, to be expanded stage by stage for further larger vessels enough to make their maneuvering easy within the

harbour. The capacity of the loader should initially be kept 6,000 t/h ranging upto 12,000 t/h in response to the trend of vessels toward larger size.

(6) It was also recommended in the interim report that the capacity of dumper yard, car dumper, ore stock yard, stacker, reclaimer and belt conveyor be specified in the feasibility report for each stage of expansion. So far today, however, no result from the above is obtained. According to the team's study since returning home, it seems difficult to raise the productivity of the dumper to any extent so far as the yard is located at the present place, even though any means such as improvement of tracks for empty wagons is applied. Therefore, the existing yard is required to keep a capacity corresponding to 6,000,000 t/y shipment and another yard with the same capacity should be provided in the midway of the conveyor track stretching toward the outer harbour site, and thus total capacity of the yards will become met to 12,000,000 t/y shipment. At any rate, earliest possible decision on the scale of land facilities is strongly required and enough space for future expansion of these facilities should be reserved.

2-5 DIMENSIONS OF 100,000 DWT AND 150,000 DWT ORE CARRIERS AND REQUIRED KEEL CLEARANCE

(1) Dimensions

	LOA	LPP	B	D	d (m)
100,000 DWT	260	250	40	22	15
150,000 DWT	303	290	44	24	16.5

(2) Required keel clearance

a. 100,000 DWT

The following is the required keel clearance for the channel:

wave effect (rolling degree 3^{o})	1.1 m
absolute keel clearance	0.6 m
bodily sinkage	0.9 m
Total keel clearance required	2.6 m

Supposing the tropical draft of 100,000 DWT be 15.3 m, the required depth of water in the channel becomes 17.9 m. In case of -17.5 m depth of water in the channel, the time not available more than 40 cm of tide will be 20 – 30 % of the total time. Therefore, the depth of -17.5 m is acceptable.

b. 150,000 DWT

Required keel clearance in the channel is as follows:

wave effect (rolling degree 3^{o})	1.2 m
absolute keel clearance	0.6 m
bodily sinkage	0.9 m
Total keel clearance required	2.7 m

The tropical draft of 150,000 DWT be 16.8 m, the required depth of water in the channel is -19.5 m.

2-6 SOME CONSIDERATIONS FOR OUTER HARBOUR CONSTRUCTION

2-6-1 Littoral drift and countermeasures against beach erosion

From the past records of dredging works, the annual average volume of dredging caused by littoral drift amounted to nearly one million tonnes and half of them was undertaken at the site of the sand trap, and the rest at the outer channel. Most of the dredging works were caused by the sediment drifting toward north which might be judged from the directional intensity of waves.

Basing upon the outer harbour plan, the southern breakwater once extended will surely block the sand drift, but it is feared that a great volume of sands will be piled on the southern side of the outer harbour and as a result the sand trap will lose its ever effective role.

Therefore, some measures not to reduce its function should be inevitably taken in the selection of the type of breakwaters.

Regarding the treatment of impounded sediment, besides dredger, sand pump fixed on trestle is considered to be placed on the southern breakwater or on the extended screen in order to bypass the sediment toward the foreshore of the north coast where an erosion is supposed to occur. In case of sand-bypass, submerged pipe line is proposed to lay below the approach channel and swell compensator is also recommended to be installed in order to raise the rate of dredging operation.

On the other hand, it should be fully studied beforehand whether or not additional construction of sand trap off the seashore is necessary, if the role of the present sand trap should be declined or ceased and whether or not sand pump and dredger are available enough to stop the accretion on the southern coast.

Beach erosion, which is supposed to occur on the northern part of the outer harbour, will be intensified from the point of 500 m north of the northern breakwater to the Waltair point.

For the remedial measures against the eroded beach, it will be adequate to make combined works of groyens and detached breakwater or wave energy dissipation breakwater by using stones which will be inexpensively available nearby Visakhapatnam.

At the same time, beach nourishment will be a requisite, as a large quantity of littoral drift is considered to be blocked by the southern breakwater. In this regards, the foreshore will be possibly feeded by the sand-bypassing and the offshore by the dumping of dredged sediment.

The urban area of Visakhapatnam, almost involved between both the northern and southern breakwater, will probably be free from the threat of erosion, an appropriate treatment once be applied by starting the construction of the above two breakwaters simultaneously.

Perspectives of accretion and erosion and their counter-measures should be carefully taken up by examining every topographical change of the coast which may take place upon the extension of the breakwaters.

On the other hand, movable bed model test is desirable to undertake so as to investigate the general trends of topography, to find out any effective measures against sedimentation which may occur on the southern side, and to search any effective feeding site and scope for protecting the northern side from the erosion.

In relation to the above, various field observations and studies — such as routine observation of wave and current by ditectors, examination into vertical consistency distribution of the suspended material on the inshore and offshore, periodic topographical surveying, study on the grain size distribution and heavy mineral compositions of the coastal sediment, etc. — will be indispensable in order to make clear the problem of littoral drift and to find out its soluble ways.

2-6-2 Necessary points to be considered in undertaking outer harbour construction

One of the most important points for outer harbour construction is, needless to say, the fact that the long breakwaters have to be constructed even at a deeper point of water.

Remembering the past experience in Japan, there awfully damaged by typhoons and storms at several times and structures under construction were destroyed once and again. Considering the methods of construction works, the type of breakwaters should be selected to minimize the damage during their construction. In order to advance the breakwaters construction smoothly, a collection of statistical data regarding meteorology and hydrography should be made and it is also desirable to make a construction schedule by basing upon meteorological field observations and wave forecasts for short term.

By the same ways, a completion of breakwaters construction has been succeeded in Japan at high-wave sites along the Pacific Ocean.

2-6-3 Necessity of the future establishment of inner harbour plan in accordance with outer harbour plan

The iron ore loading capacity in the outer harbour will thoroughly depend upon the general capacity of the ore handling facilities installed in the inner harbour site. A series of the facilities should be laid out reasonably so that they may be capacitated to the maximum extent and at the same time enough space for possible future expansion should be reserved. Regarding the necessity of land procurement, it has already been touched upon in the foregoing.

The fact that the outer harbour is available for mammoth tankers will lead the following meaning, that is, the inner harbour site will become in the future a base for promising oil refinery and petro-chemical industries in India. Therefore, it is desirable to establish a land utilization plan for the purpose of pushing foreward a regional industrialization in stages by eliminating public nuisance.

With the enhancement of the industrialization, the inner harbour in line with the development of the regional economy will surely increase its handling of industrial raw materials as well as general cargoes.

It is difficult to outlook the future phases of transportation because this is now stepping into a revolutionary age. However, it is considered to be a high time to re-examine the lay-out of berths, the space for warehousing facilities, and also the railway and road which will connect the hinterland.

In fact, a development must be carried out progressively in accordance with a flexible scheme. In this regard, it is feared that the promising Visakhapatnam Port, although with the vast land, will be prevented from its growth, should it be made progress without any appropriate master plan for the development.

The outer harbour needs a large quantity of dredgings of sand and rock-bed for the construction, besides the construction of long breakwaters and that necessary cost for them is considered to be enormous.

Therefore, the development plan combining both the outer and inner harbour en bloc will be emphasized to make, and being based upon the above, an integrated management of the port should be reinforced in view of making the investment more effective and the calling-in of loans earlier.

2-7 RAILWAY

The present railway which was laid for transporting the Bailadilla iron ore to Visakhapatnam Port is an independent route from the existed line. This means that the present operation of railway is quite fit for transporting iron ore. In addition, a transport alignment has been performed at Kottavalasa to join with the East Coast main line directly in transferring passenger and general goods trains in view of the future development of the area alongside the railway line. So far as the above transport system is concerned, therefore, it seems to be appropriate.

However, it is a fact that some works are still remained incompleted and the transportation efficiency is likely to be lowered, although this line is designed for iron ore conveying.

For the purpose of enhansing transportation services, it will be a requisite to complete works such as ballasting, slope protection, precautionary arrangements against land slides and rock falls, and also installation of signalling equipments (including interlocking), blocking instruments as well as telecommunication equipments.

Furthermore, it will be also necessary to pay a due caution against rainfall as only a few years have passed since this line was constructed, especially protection works for embankment nearby both sides of bridges and at the transition points from embanking to cutting should be undertaken, if necessary.

Regarding the future upgrading plan in this line, it contains such subjects as increasing transport capacity per train and enhancement of operative efficiency by elevating the function of blocking system.

In this point, the above plan is considered to be adequate in view of its feasibility and economy.

However, there involves some problems as follows in relation to the increase of total weight of train which sould be carefully examined through a field experiment or others:

(a) Tractive force of locomotive

(b) Capacity of dynamic brakes upon running down the gradient of the Eastern Ghats section

(c) Capacity of vacuum braking apparatus

(d) Strength of coupler

The future plan based upon the development of BOY type wagon should be carried out as planned. Furthermore, it is necessary to make a preparation responded to the increasing capacity of both Bailadilla mine and Visakhapatnam Port, especially a training of personnel concerned is required. Finally, in view of the safety operation upon passing through the difficult line of gradients up and down, it will be worthy of consideration to install an air brake system, besides the increase of track capacity by speed-up.

CHAPTER III SELECTION AMONG PROPOSED HARBOUR CONSTRUCTION PLANS

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3-1 PROPOSED SITES FOR HARBOUR CONSTRUCTION

Gangavaram and Visakhapatnam are proposed for the alternative sites of new harbour construction to accommodate larger size ore carriers.

Gangavaram, a fishing village located about 10 km south-west of Visakhapatnam Port, is protected from the wave and wind of the SW to a certain degree by the existing Meraka Metta on the southern side and the depth of water in the proposed site is fairly deep. Behind the site, there is a salt-field laying on a plain land.

On the other hand, the proposed site in Visakhapatnam is located along the entrance channel north of the present port and behind the site there is an urban area where houses stand close together.

3-2 PROPOSED PLAN AT THE SITE OF GANGAVARAM

There are six proposals in the Gangavaram plan prepared by Indian side, which are seen in the attached figures ranging from No. 1 to No. 6.

Among the proposals, the Alternative-3 and 4 are off-shore type comprising deep drafted berths with trestles stretched from the land and consequently no dredging work is required there. The berth in the Alternative-3 is protected from wild waves by the breakwaters, while the Alternative-4 is not proposed to construct any breakwater.

The Alternative-1, 2, 5 and 6 are respectively planned to protect the turning basin and berth from waves by the breakwaters. Furthermore, each proposal, except the Alternative-5, is designed to construct a sand trap, while the littoral drift from the south is to be bypassed to the northern part of the harbour.

The design criteria of the channel are as follows:

depth of water	- 17.5 m
width	185 m
direction	east-west

The turning basin has -16.8 m depth of water and 610 m diameter.

As a result of recent boring test, it is made clear that the dredging work will involve a great deal of rock-bed dredging.

Regarding the land transportation facilities for iron ore loading, 19 km of railway, 24 km of power line and 11 km of road are proposed to construct and besides the iron ore transporting railway between Bailadilla and Gangavaram, the mechanical ore handling plant with a capacity of 12,000 t/h is arranged to be installed at the harbour site.

3-3 PROPOSED PLAN AT THE SITE OF VISAKHAPATNAM

There are three proposals in the Visakhapatnam plan prepared by the Indian side, which are seen in the figures attached hereto from No. 7 to No. 9. Each proposal is designed to construct a breakwater stretching from the present ship-sunk type breakwater toward the east along the port entrance channel in order to protect the channel and turning basin from the SSE and ESE waves. At the same time, by constructing another breakwater on the northern side, the harbour is to be enclosed.

The design criteria of the channel are as follows:

depth of water	-17.5 m
width	200 m

And the diameter of the turning basin is 610 m and its depth -16.0 m (N.B. -16.8 m is shown in the attached figures).

Furthermore, according to the proposals, ore berths for handling 150,000 DWT carriers, future coal or phosphate berth, future oil berth, etc. are planned to be laid in the harbour.

As for the littoral drift, besides the construction of a sand trap, it is to be bypassed toward the northern side as used to be.

These proposals are chiefly specified by the following locations of ore stock piles: In the Alternative-1, stock yard and dumper yard are to be constructed on the reclaimed foreshore, while in the Alternative-2 new dumper yard and car dumpers are on the nearby present facilities as well as stock yard on the open space reserved at the north-east of the Northern Arm. On the other hand, those equipments such as car dumpers, ore stock piles, loaders, etc. are to be linked by a belt conveyor. Regarding the Alternative-3, it is designed to improve the existing dumper yard by utilizing the present car dumpers, and to construct additional stock yard, to be connected with the loader of ore berths in the outer harbour by a belt conveyor running about 5 m.

3-4 SUPPORT OF VISAKHAPATNAM ALTERNATIVE-3 PLAN

The Gangavaram proposals involve the following problems:

a. A heavy rock-bed dredging in the proposed site is indispensable except the Alternative-3 and 4 of off-shore type. If the ore berth is planned to be displaced toward the off-shore to reduce the amount of rock dredging needed, the location of breakwater is at a fairly deeper point of water and its length longer. If the site of the harbour is displaced northward where rock-bed lies in a rather deeper water, the result leads to the same.

b. The Alternative-4, an off-shore type with no breakwater, will be able to avoid the deposition by sand drift and also the dredging of rock-bed. However, there are about 40% of the days with over 4' wave-height throughout the year and the number of the days available for loading is limited. In addition, the trestle needs a type of elevated one in designing of the height enough to meet the wave-height of 25' since it is not protected by any breakwater. For this purpose, the capital expenditure will be incurred enormous.

   On the other hand, the Alternative-3, in which the breakwater construction in front of the off-shore berth is planned, will be able to overcome the above-mentioned difficulties to a certain degree, but a large cost will be inevitably spent for the breakwater construction, because the water-depth at the site is -23 m and the length over 1,000 m. What is worse, it is not cleared whether or not the Tonboro phenomenon will occur, for which a maintenance dredging will come to be necessary.

c. Should the new port be constructed in the Gangavaram area, extra investments in such as railway, road, power line, etc. will be needed and that, upon the completion of the port, the providing for harbour crafts, maintenance facilities, signal station, etc. will duplicate that of Visakhapatnam Port.

For these reasons, the construction of the new port in this area for ore berthing facilities is considered to be uneconomical. Consequently, the suitable site for the port construction is limited only to the outer harbour of Visakhapatnam. In case of ore berths construction in the outer harbour, the following should be taken into due consideration:

a. The plan should be drawn out for 150,000 DWT vessels in view of the future trend of ore carriers toward larger size.

b. The volume of rock-bed dredging should be minimized in order to shorten the construction period and to economize the cost.

c. The tranquillity in the channel and basin should always be maintained in order to provide the vessels to and from the port with loading service at all times, except a rare case like cyclone.

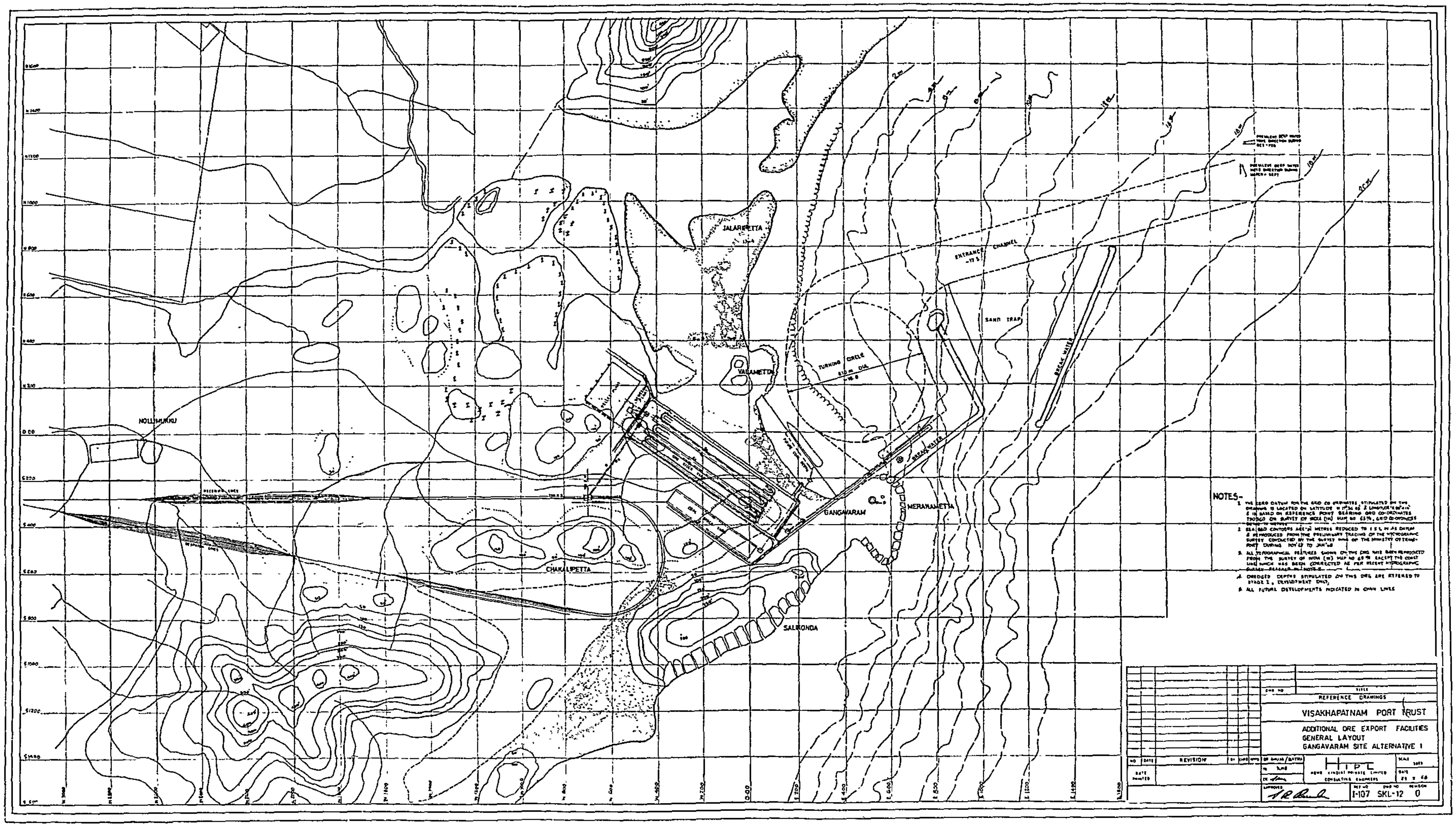
d. The occurrence of deposition by littoral drift in the port entrance should be minimized.

e. A flexible plan should be made out for providing berths to larger size bulkcargoes like oil tanker and coal carrier, besides for providing future ore berth.

f. The present ore loading facilities should be utilized as much as possible.

Among the proposed plans, the Visakhapatnam Alternative-3 is considered to be the most suitable one met to the above conditions.

No. 1


JALARIPETTA
GANGAVARAM
CHAKALIPETTA
ENTRANCE CHANNEL
SAND TRAP
TURNING CIRCLE
NOTES-
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5. ALL FUTURE DEVELOPMENTS INDICATED IN CHAIN LINES
REFERENCE DRAWINGS
VISAKHAPATNAM PORT TRUST
ADDITIONAL ORE EXPORT FACILITIES
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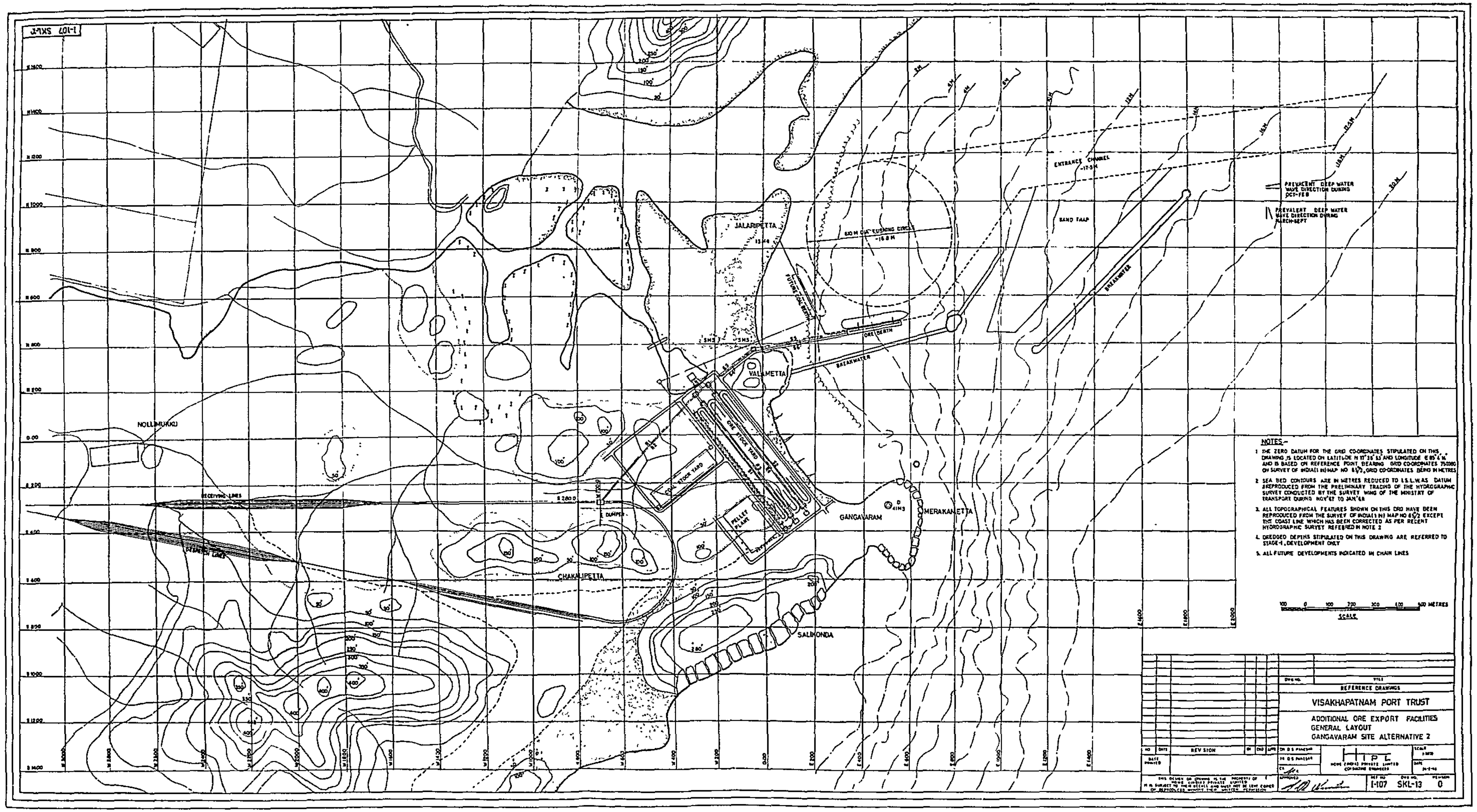

NOLLIMUKKU
JALARIPETTA
VALAMETTA
GANGAVARAM
MERAKANETTA
CHAKALIPETTA
SALIKONDA
BREAKWATER
ORE BERTH
COAL STOCK YARD
PELLET PLANT
ENTRANCE CHANNEL
RECEIVING LINES
PREVALENT DEEP WATER WAVE DIRECTION DURING OCT-FEB
PREVALENT DEEP WATER WAVE DIRECTION DURING MARCH-SEPT
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2 SEA BED CONTOURS ARE IN METRES REDUCED TO I.S.L.W.AS DATUM & REPRODUCED FROM THE PRELIMINARY TRACING OF THE HYDROGRAPHIC SURVEY CONDUCTED BY THE SURVEY WING OF THE MINISTRY OF TRANSPORT DURING NOV'67 TO JAN'68
3. ALL TOPOGRAPHICAL FEATURES SHOWN ON THIS DRG HAVE BEEN REPRODUCED FROM THE SURVEY OF INDIA(1 IN) MAP NO 65/2 EXCEPT THE COAST LINE WHICH HAS BEEN CORRECTED AS PER RECENT HYDROGRAPHIC SURVEY REFERRED IN NOTE 2
4. DREDGED DEPTHS STIPULATED ON THIS DRAWING ARE REFERRED TO STAGE-I, DEVELOPMENT ONLY
5. ALL FUTURE DEVELOPMENTS INDICATED IN CHAIN LINES
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SCALE
REFERENCE DRAWINGS
VISAKHAPATNAM PORT TRUST
ADDITIONAL ORE EXPORT FACILITIES
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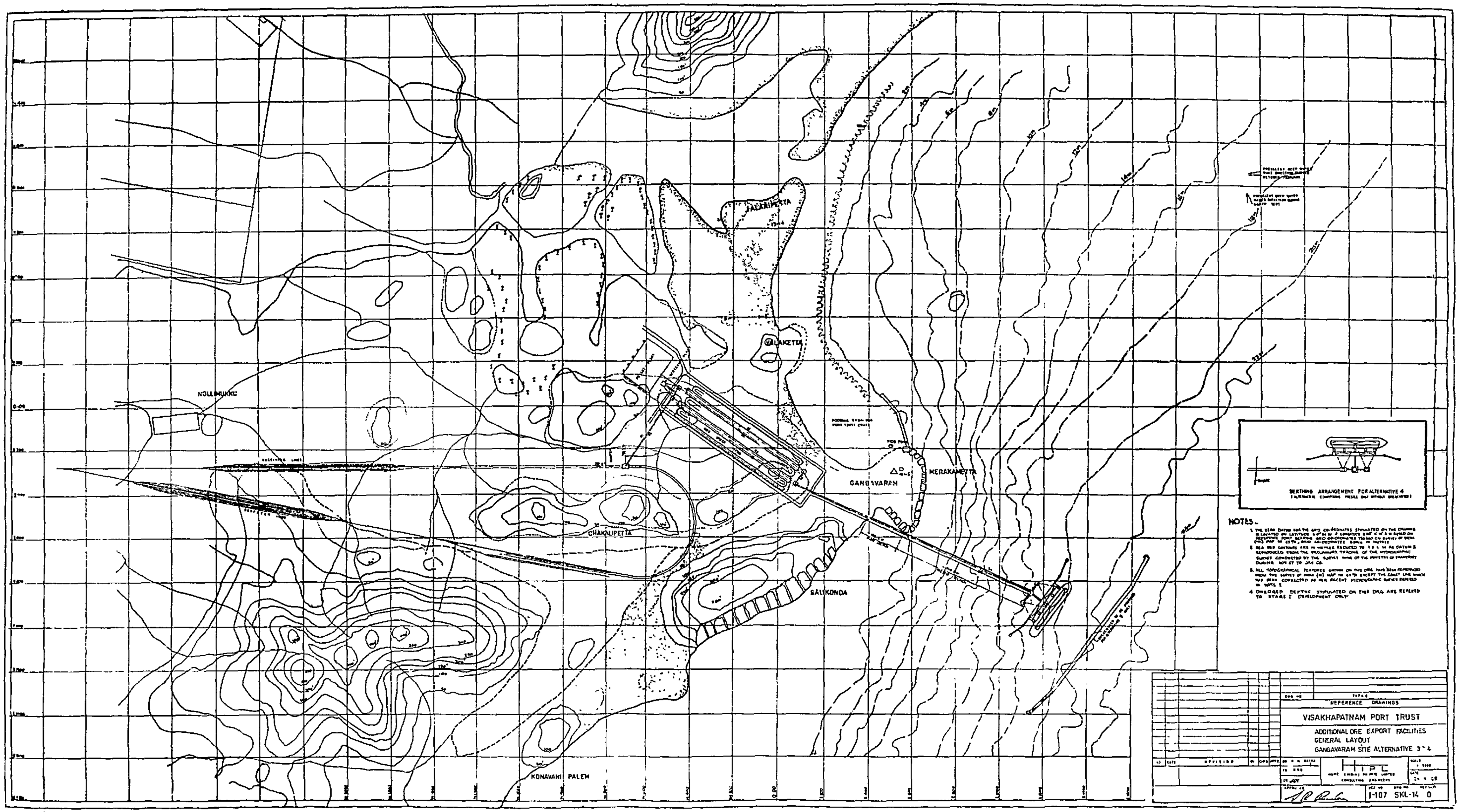

NOLLIPUKKU
GANGAVARAM
MERAKAMETTA
CHAKALIPETTA
SALIKONDA
KONAVANI PALEM
BERTHING ARRANGEMENT FOR ALTERNATIVE 4
NOTES.
REFERENCE DRAWINGS
VISAKHAPATNAM PORT TRUST
ADDITIONAL ORE EXPORT FACILITIES
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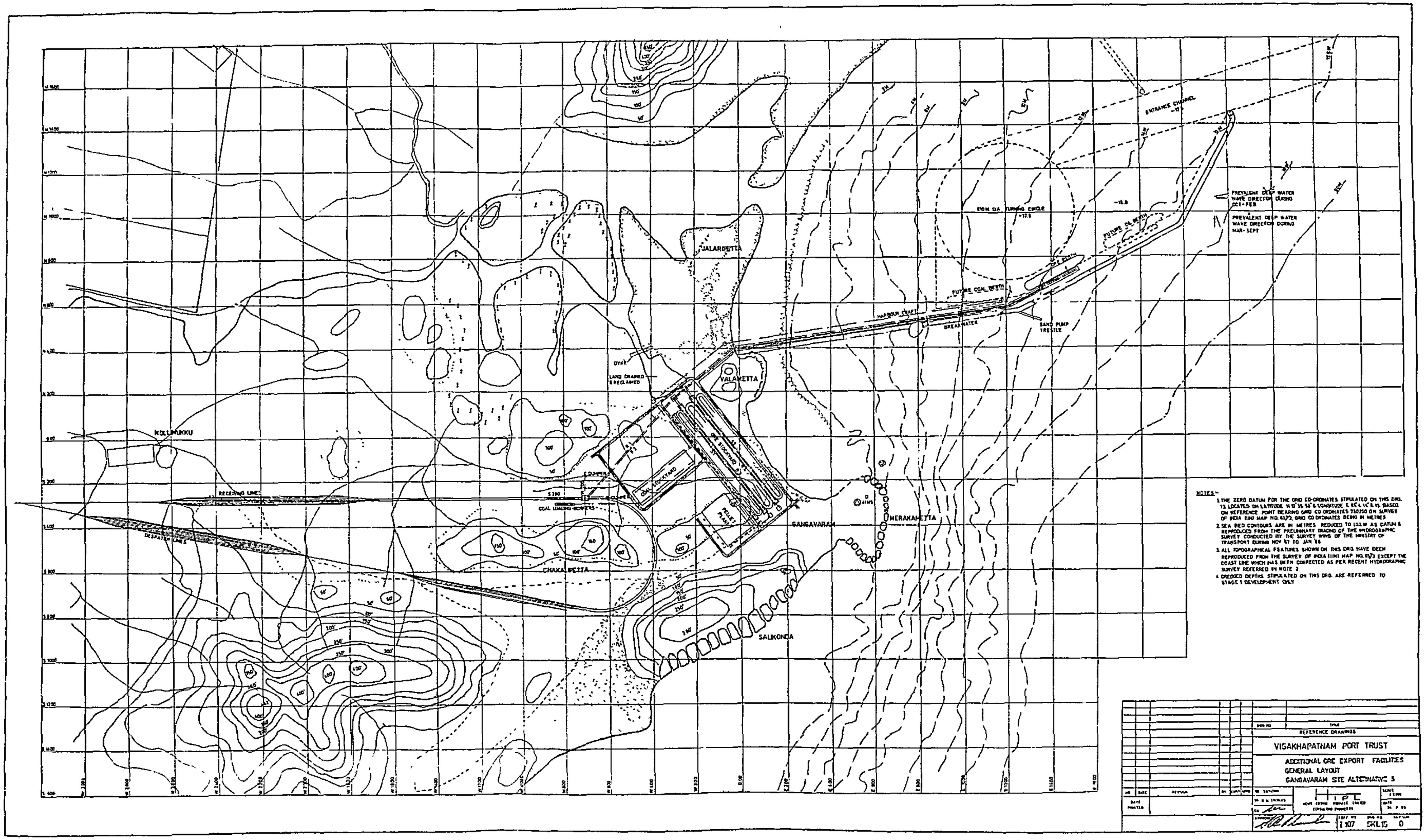
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PREVALENT DEEP WATER WAVE DIRECTION DURING OCT-FEB
PREVALENT DEEP WATER WAVE DIRECTION DURING MAR-SEPT
FUTURE COAL BERTH
HARBOUR CRAFT
BREAKWATER
SAND PUMP TRESTLE
JALARIPETTA
DYKE
LAND DRAINED & RECLAIMED
VALAKETTA
KOLLIPUKKU
RECEIVING LINES
DESPATCH LINES
COAL STOCKYARD
ORE STOCKYARD
CHAKALIPETTA
GANGAVARAM
MERAKAMETTA
SALIKONDA
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2. SEA BED CONTOURS ARE IN METRES REDUCED TO LSLW AS DATUM & REPRODUCED FROM THE PRELIMINARY TRACING OF THE HYDROGRAPHIC SURVEY CONDUCTED BY THE SURVEY WING OF THE MINISTRY OF TRANSPORT DURING NOV '87 TO JAN '88
3. ALL TOPOGRAPHICAL FEATURES SHOWN ON THIS DRG. HAVE BEEN REPRODUCED FROM THE SURVEY OF INDIA (1IN) MAP NO. 65/2 EXCEPT THE COAST LINE WHICH HAS BEEN CORRECTED AS PER RECENT HYDROGRAPHIC SURVEY REFERRED IN NOTE 2
4. DREDGED DEPTHS STIPULATED ON THIS DRG. ARE REFERRED TO STAGE 1 DEVELOPMENT ONLY
REFERENCE DRAWINGS
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ADDITIONAL ORE EXPORT FACILITIES
GENERAL LAYOUT
GANGAVARAM SITE ALTERNATIVE 5
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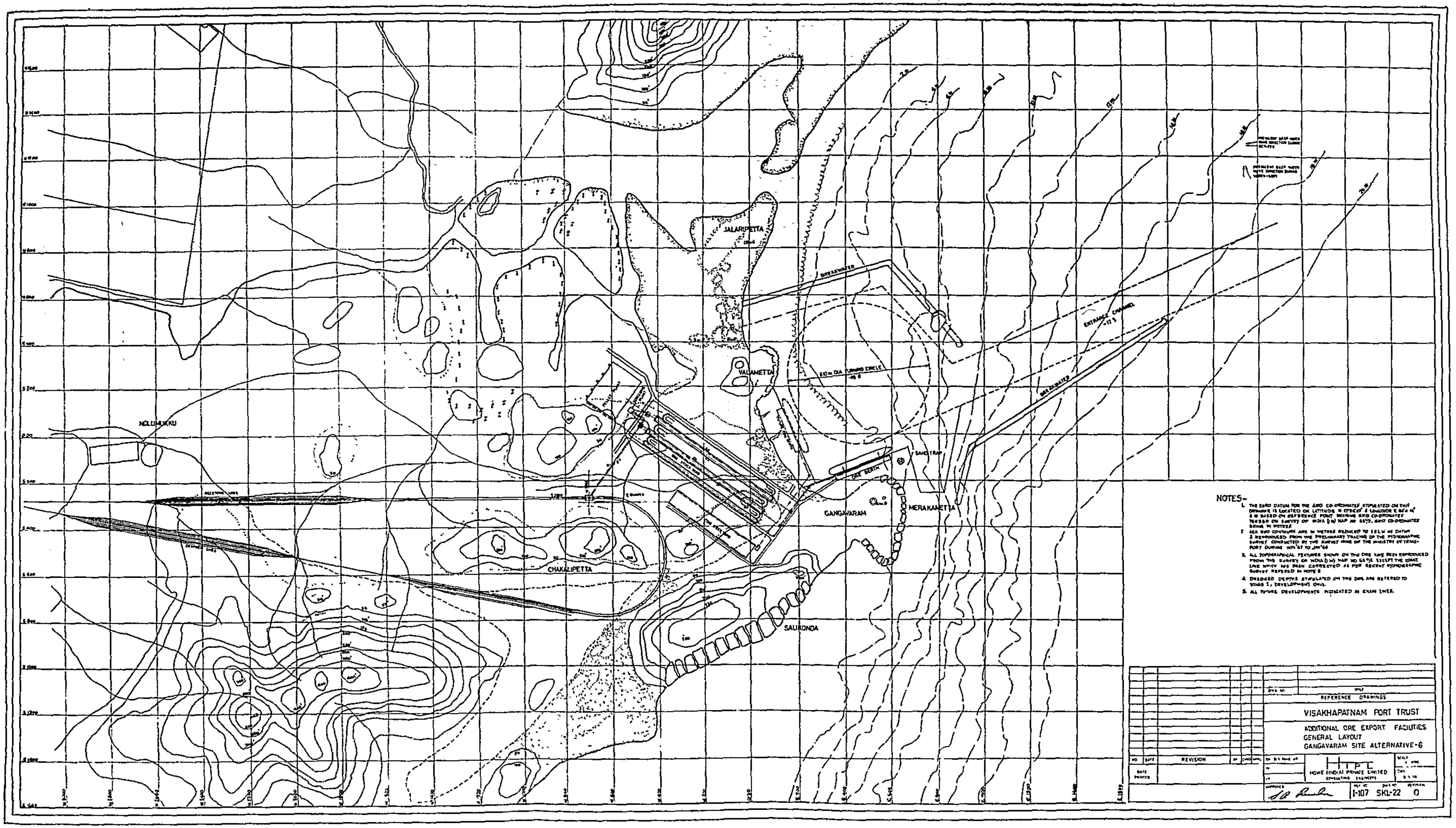
No. 6



NOLUMUKKU
JALARIPETTA
BREAKWATER
VALAMETTA
ENTRANCE CHANNEL
SAND TRAP
GANGAVARAM
MERAKAMETTA
CHAKALIPETTA
SAURONDA
NOTES-
REFERENCE DRAWINGS
VISAKHAPATNAM PORT TRUST
ADDITIONAL ORE EXPORT FACILITIES
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GANGAVARAM SITE ALTERNATIVE-6
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DATE PRINTED
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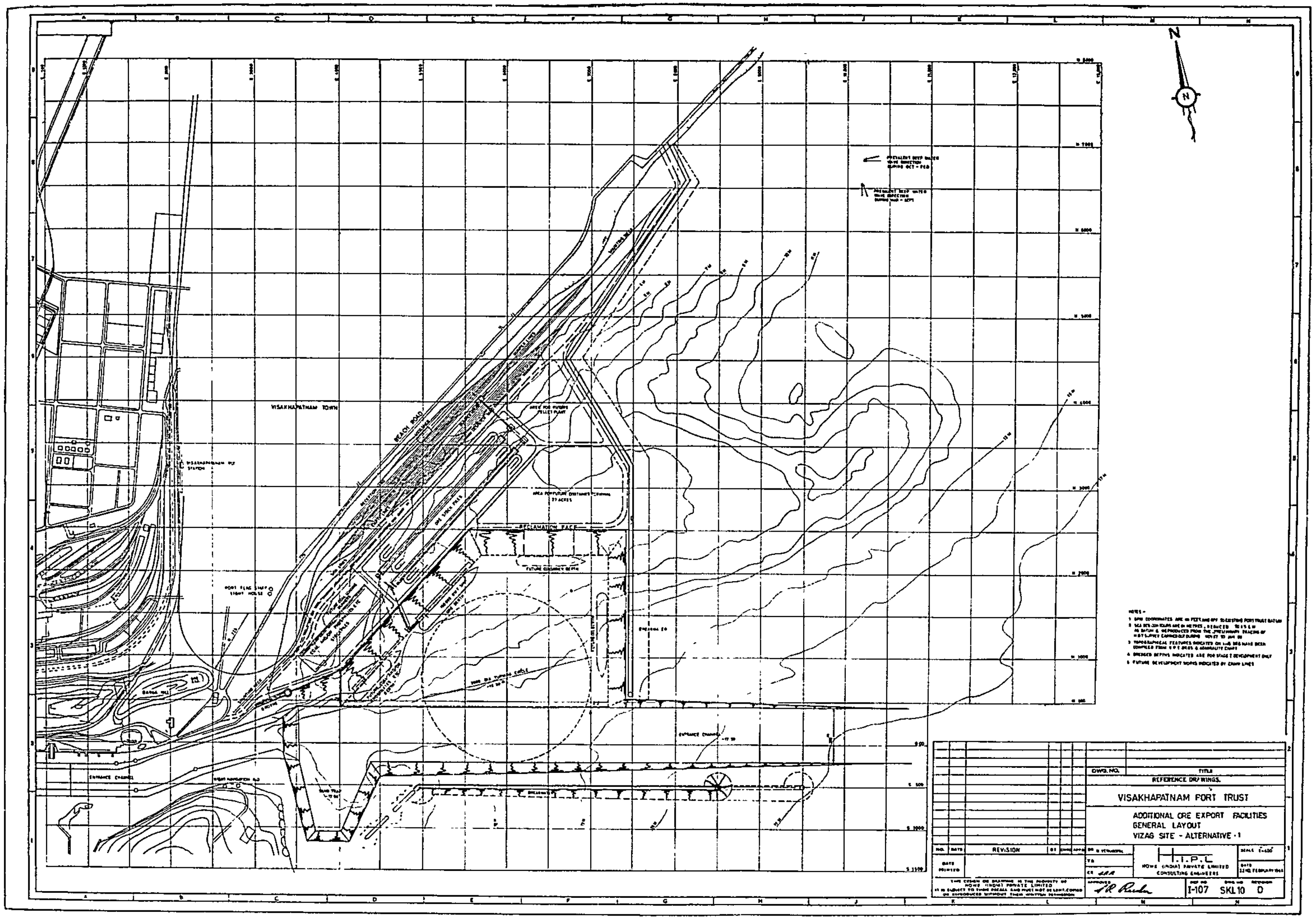
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VISAKHAPATNAM TOWN
BEACH ROAD
RECLAMATION FACE
DWG. NO.
TITLE
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VISAKHAPATNAM PORT TRUST
ADDITIONAL ORE EXPORT FACILITIES
GENERAL LAYOUT
VIZAG SITE - ALTERNATIVE - 1
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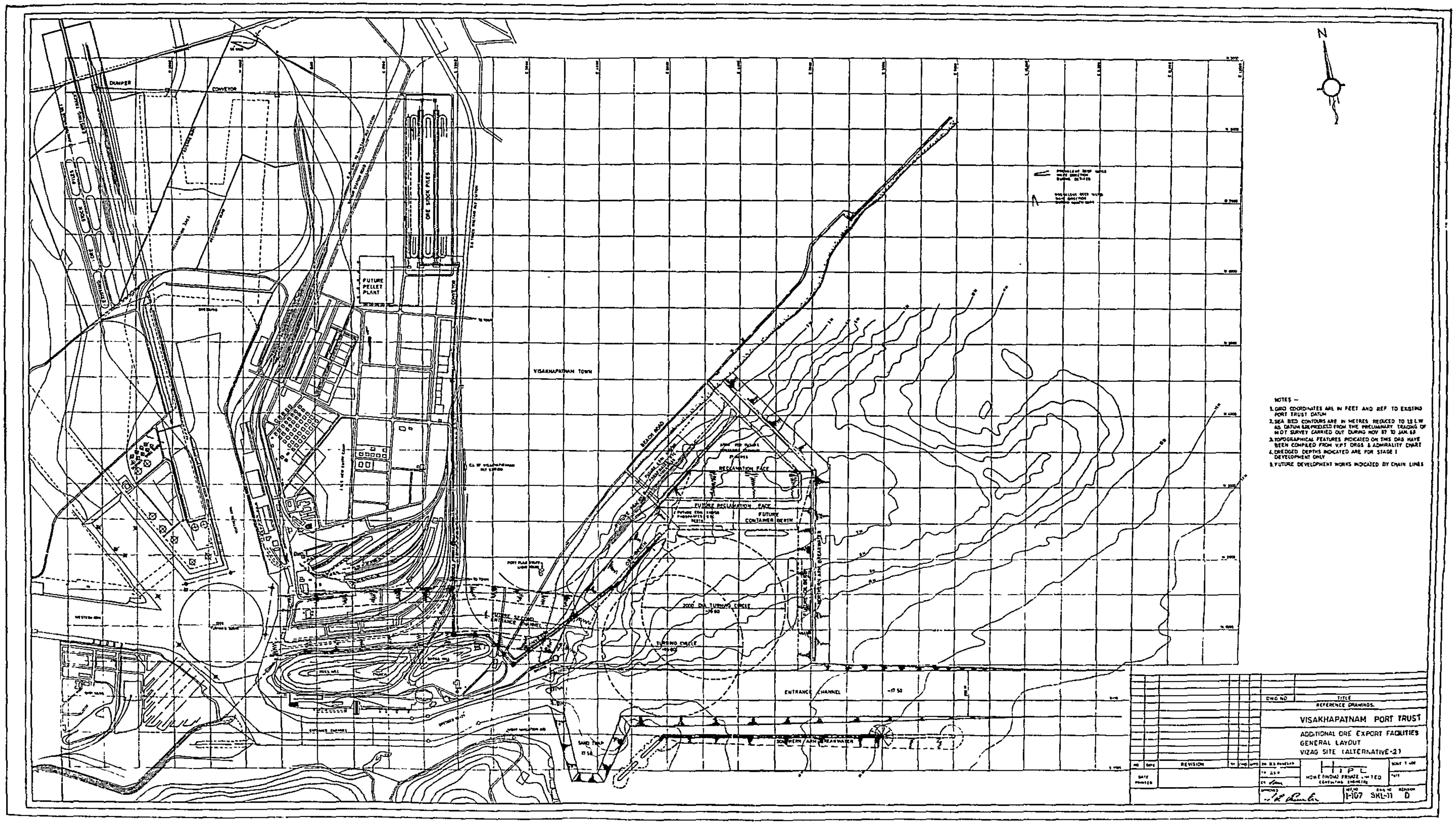
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DUMPER
CONVEYOR
ORE STOCK PILES
FUTURE PELLET PLANT
VISAKHAPATNAM TOWN
BEACH ROAD
RECLAMATION FACE
FUTURE RECLAMATION FACE
FUTURE CONTAINER BERTH
2000 Dia. TURNING CIRCLE
TURNING CIRCLE
FUTURE SECOND ENTRANCE CHANNEL
ENTRANCE CHANNEL
SAND TRAP
SOUTHERN ARM BREAKWATER
NORTHERN ARM BREAKWATER
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5. FUTURE DEVELOPMENT WORKS INDICATED BY CHAIN LINES
DWG NO
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ADDITIONAL ORE EXPORT FACILITIES
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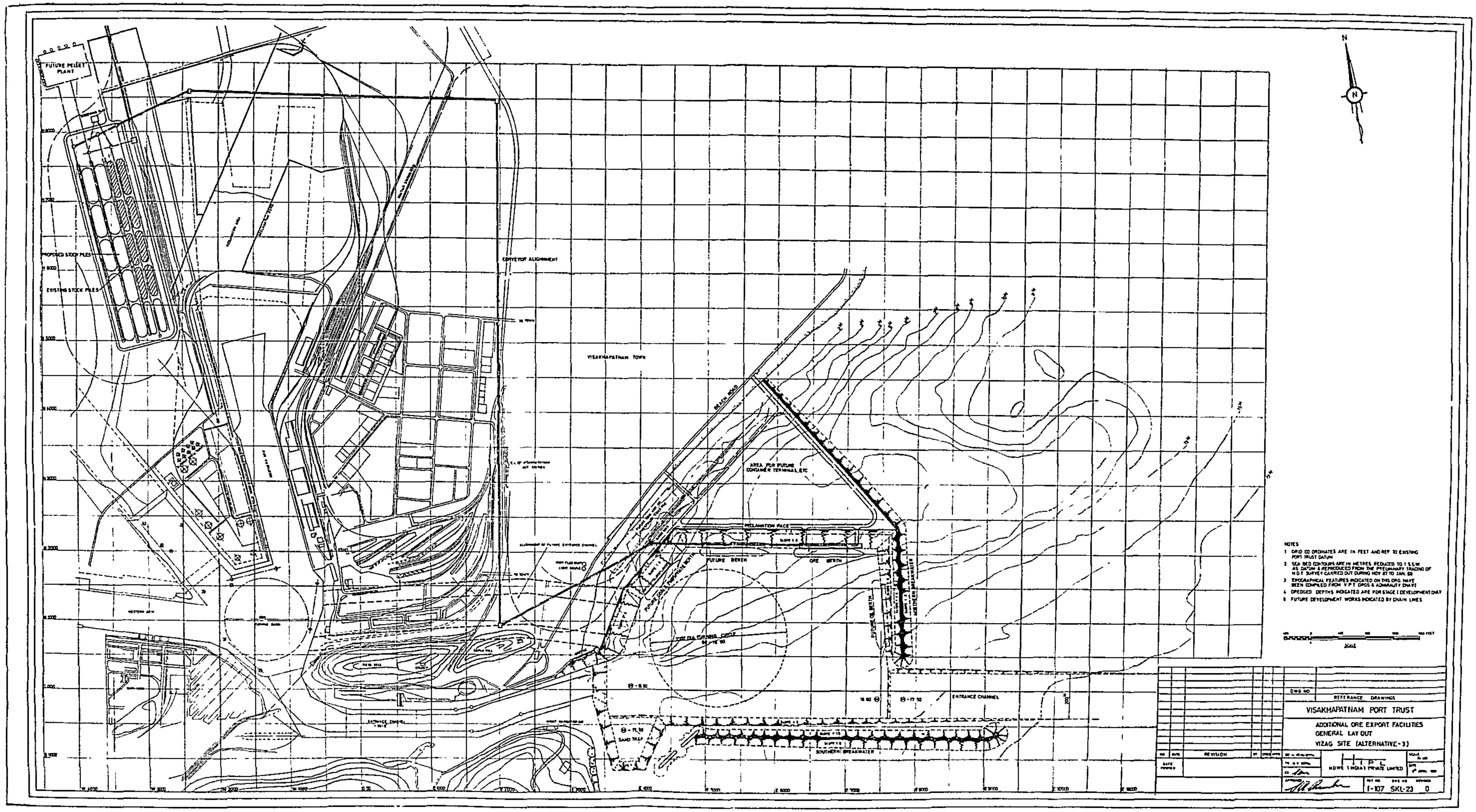
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RECLAMATION FACE
FUTURE BERTH
ORE BERTH
NORTHERN BREAKWATER
FUTURE OIL BERTH
SOUTHERN BREAKWATER
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1 GRID CO ORDINATES ARE IN FEET AND REF TO EXISTING PORT TRUST DATUM
2 SEA BED CONTOURS ARE IN METRES REDUCED TO I S L W AS DATUM & REPRODUCED FROM THE PRELIMINARY TRACING OF N.O.T SURVEY CARRIED OUT DURING NOV 67 TO JAN 68
3 TOPOGRAPHICAL FEATURES INDICATED ON THIS DRG. HAVE BEEN COMPILED FROM V P T DRGS & ADMIRALTY CHART
4 DREDGED DEPTHS INDICATED ARE FOR STAGE I DEVELOPMENT ONLY
5 FUTURE DEVELOPMENT WORKS INDICATED BY CHAIN LINES
SCALE
DWG NO
REFERANCE DRAWINGS
VISAKHAPATNAM PORT TRUST
ADDITIONAL ORE EXPORT FACILITIES
GENERAL LAY OUT
VIZAG SITE (ALTERNATIVE-3)
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CHAPTER IV EXAMINATION INTO THE VISAKHAPATNAM ALTERNATIVE-3 PLAN

CHAPTER IV EXAMINATION INTO THE VISAKHAPATNAM ALTERNATIVE-3 PLAN

4-1 PURPOSES OF OUTER HARBOUR CONSTRUCTION

4-1-1 Quantity of cargo handling in the outer harbour

The present Visakhapatnam Port is provided with 20 berths, excluding navy and ship-building facilities. During 1966–67, this port handled 222.7 million tones of import cargoes such as wheat, crude oil and other goods, and 371.2 million tonnes of export cargoes such as iron ore, manganese ore, pig iron, refined oil, sugar, etc., totalling 593.9 million tonnes, which is an increase by 80% in comparison with that of 1962–3. With exception of iron ore, the total volume during 1966–67 amounted to 396.4 million tonnes, that is, an increase by 20% compared with the 307.9 million tonnes during 1962–3.

This means that the rate of bulk-cargoes handling in the past several years exceeded over that of general cargoes handling. According to the forecast made by the Port Trust, the volume of bulk-cargoes handling will be increased more than ever in the future.

Furthermore, in view of the fact that the Q2 and Q3 berths for general cargoes have already been completed and the J1, J2, and J3 berths are also going to be improved, and that necessary space for future extension of the North Western Arm, Northern Arm, etc. has been reserved, the inner harbour will be fully accommodated for handling general cargoes in the future, except bulk-cargoes. Accordingly, it will be reasonable that the outer harbour is planned to deal with bulk-cargoes.

According to the data prepared by the Port Trust, it foresees that the volume of cargoes to be handled by the outer harbour will be:

(1)	iron ore	12–20 million t/y,
(2)	oil	4 million t/y,
(3)	coal	6 million t/y, and
(4)	raw material for fertilizer (rock phosphate, sulphus, etc.)	2 million t/y.

In this regard, oil is concerned with the expansion of the present oil refinery plant, coal with the establishment of iron & steel plant, and raw materials for fertilizer with the upgrading of the present plant including the establishment of new plant. So there is no urgent matter to construct berths for those cargoes as in the case of iron ore berthing facilities. Therefore, it is appropriate to construct ore berth initially in the outer harbour and to reserve space for the future construction of cargo-handling berth in stages as planned.

4-1-2 Ship size for berths

Since most iron ore is to be exported to Japan, the following informations as to the water-depth at the unloading wharf of iron & steel plants in Japan and the present trend of ship-building in the size of ore carriers should be obtained for the study of the ship size to be designed.

(a) Water-depth at the unloading wharf of iron & steel plants in Japan:

As be seen in Appendix I, the construction of -17.0 m ore berths is under way at Kimitsu Plant of Yawata Iron & Steel Co., which is located in Kisarazu Port of Tokyo Bay, for handling 125,000 DWT vessels and at Mizushima Plant of Kawasaki Iron & Steel Co. locating in Mizushima Port is the same construction plan, which will be completed within a few years and other constructions of deeper drafted ore berths, some of which will be improved by a margin of -18.0 m in the future, are also under consideration.

(b) Size of iron ore carriers:

The average tonnage of existing iron ore carriers in the world in 1967 was 32,600 DWT and that of carriers built in the same years was 64,500 DWT. As of January, 1967 about 80% of the carriers on order was over 80,000 DWT. This indicates that the trend of ore carriers toward larger size is still going on. On the other hand, the fleets of ore/oil carriers have remarkably been increased in these years, recording 39% of ore carriers in 1967.

The size of them is also likely to be larger and larger as ore carriers are, and for the reference, the average tonnage built in 1967 was 81,000 DWT, which is larger than that of ore carriers. Recently, the construction of over 200,000 DWT ore/oil carriers are considered in Japan.

From the foregoing, the proposed Visakhapatnam outer harbour plan capable of accommodating 100,000 DWT in the stage 1, which is scheduled to be completed within four years, and then 150,000 DWT in the stage II is considered to be adequate.

At the same time, it is advisable in the execution of the harbour construction to prepare flexible measures at all times against the trend that size of vessels will become larger than expected as used to be.

Regarding the future berth for oil tankers, the provisions such as channel and turning basin for 150,000 DWT ore carriers will be enough available for oil tanker, too, considering the fact that a consolidation of facilities for 70,000 DWT oil tankers is already in progress at Madras Port and that, in the rather short distance between India and the Middle East, any advantage given to mammoth tankers such as 200,000 DWT or 300,000 DWT tankers will be little. In this relation, any other vessels smaller than ore carriers or oil tankers will not be a subject for discussion.

Therefore, the design criteria for channel, basin and the like in the outer harbour, once taken up for ore carriers, will cover every berthing matter for other vessels.

4-2 CHANNEL AND TURNING BASIN

4-2-1 Outline of proposed plan

The channel proposed in the Alternative-3 is 200 m wide and -17.5 m deep, and its direction is east-west. On the other hand, the turning basin is designed to be 610 m of diameter and -16.0 m of depth (-16.8 m is put in the attached figure).

These dimensions are considered for 100,000 DWT vessels and for 150,000 DWT are not cleared yet. As a premise for examination into the harbour plan, the dimensions of 100,000 DWT and 150,000 DWT ore carriers are assumed as follows: (Ref. to Appendix II)

	LOA		LPP		B		D		d
100,000 DWT	260	x	250	x	40	x	22	x	15
150,000 DWT	303	x	290	x	44	x	24	x	16.5

4-2-2 Width of channel

Generally, it is said that the width of channel for larger size vessels be 1.0 times as long as their length. If so, the width for 100,000 DWT will be 260 m and that for 150,000 DWT 300 m. Consequently, the width of 200 m originally proposed becomes narrow, that is, 0.77 times the length of vessel for 100,000 DWT and 0.67 times for 150,000 DWT.

However, the width should be considered from such a point of view as tugboat, figure of channel, influence by external force, bottom nature, etc. and the width of channel at most ports in the world does not necessarily reach 1.0 times as long as the length of vessels (Ref. to Appendix III). In view of the fact that the figure of the channel is straight and the material of the bottom is fine sand, the width of 200 m originally proposed will be judged acceptable under the conditions of one way control, sufficient power of tugboats and below 10 m/sec wind velocity, and in this case the effect of wave protection by the breakwater should be taken into consideration.

4-2-3 Water-depth of channel

The draft of ore carriers upon entering the port is not particularly concerned with the decision of the water-depth of the channel, because they are considered to be under the ballasted draft in case of calling at the port. The keel clearance for full loaded vessels upon sailing must be 1.5 m comprising absolute keel clearance of 0.6 m and allowance of 0.9 m for bodily sinkage considering the influence of waves.

(a) Pitching and heaving

Because of waves and swells, sailing vessels may cause pitching and heaving. In this connection, keel clearance of the channel for larger size vessels is said to be half of wave-height.

Judging from the fact that there are 90% of the days when the wave-height is under 3 m in the proposed outer harbour and the operation of the tugboat becomes difficult with over 3 m wave-height, the wave-height is considered to be 3 m under the worst condition. The channel is protected from prevalent wave by the southern breakwater at the water-depth of -17.0 m and the wave-height of 3 m is assumed to be lower to the two third viz. 2 m at the above depth of water. Therefore, the required keel clearance against the pitching and heaving will be half of 2 m viz. 1 m.

(b) Rolling

As a result of rolling motion taken place by waves and swells, the draft of vessels is increased. The relation between rolling degree and increasing draft is shown below:

degree of rolling	1^{o}	2^{o}	3^{o}	4^{o}	5^{o}
100,000 DWT	0.35	0.70	1.05	1.40	1.75 (m)
150,000 DWT	0.38	0.77	1.15	1.54	1.92

It will be difficult to estimate the degree of rolling when vessels pass through the channel. However, it is assumed to be 3^{o} on the following ground that:

(a) The channel of about 450 m off the northern breakwater is protected by the southern breakwater,

(b) Deeper point of water is located at a rather short distance from the head of the southern breakwater, that is, about 500 m to the point where the depth is -17.5 m, and about 1,200 m upto where the depth is -19.0 m and

(c) Since the resonance period of 100,000 DWT vessels in still water is 13.5 second and upon sailing they proceed against waves, it is unlikely to resonate with waves.

Consequently, the keel clearance against rolling will be 1.05 m for 100,000 DWT vessels and 1.15 m for 150,000 DWT vessels. As there is little probability that pitching, heaving and rolling of vessels take place simultaneously, so only rolling is a subject of consideration for keel clearance against wave effect.

Providing the draft of vessels in Visakhapatnam Port, located in a tropical zone, be equal to the full draft plus 30 cm, the water-depth of the channel is as follows:

	100,000 DWT	150,000 DWT
absolute keel clearance	0.6 (m)	0.6 (m)
bodily sinkage	0.9	0.9
wave effect	1.1	1.2
total keel clearance required	2.6	2.7
draft made use of tropical zone	15.3	16.8
	17.9	19.5

As a result of the above, it will be seen that the water-depth of the channel of -17.5 m as proposed wants 40 cm more for 100,000 DWT, so that vessels have to leave the port by waiting for tiding in case of higher waves.

On the other hand, there is an opinion that adequate water-depth of the channel for larger size vessels is 1.2 times as deep as the draft which is measured from mean tide-level.

When the mean tide-level in Visakhapatnam Port is considered to be 0.8 m, the necessary water-depth for 100,000 DWT is:

0.8 – 1.2 x 15.3 .... -17.56 (m)

And the water-depth for 150,000 DWT is:

0.8 – 1.2 x 16.8 .... -19.36 (m), and this result is consistent with the above opinion.

Here is another suggestion that the area from the head of the southern breakwater to the -18.0 m water-depth line should be maintained a depth of -18.0 m, because this area is not protected by the breakwater.

4-2-4 Turning basin

(a) Depth of water

The keel clearance of turning basin should be absolute keel clearance of 0.6 m and allowance of 0.5 m for wave effect (half of 1 m wave-height in the harbour), totalling 1.10 m.

(b) Diameter

Diameter of the turning basin is generally considered to be twice as long as the length of vessels. Supposing 100,000 DWT be 260 m long, and 150,000 DWT be 303 m long, diameter of 610 m in the turning basin will be appropriate as planned.

(c) Location

The present annual number of vessels handled by the inner harbour amounts to 600 – 700 and the average per day to and from the port is four.

Assuming the general average size of ore carriers which will call at the outer harbour in the future be 70,000 DWT and the loading volume be 12 million tonnes per year, the number of the above vessels throughout the year will be 183, in other words, one per day on the average.

Considering the fact that vessels usually enter and leave the port at irregular intervals, harbour crafts and navy crafts passing through the channel are not included in the above number, and in future the number of vessels calling at the port is likely to increase with the expansion of both the outer and inner harbours, it is worried that the maneuvering of ore carriers may be interrupted by those vessels which go to and come from the inner harbour, because the turning basin of the outer harbour is partially overlapped with the channel approaching to the inner harbour.

In this regards, if the turning basin and the channel are designed to be separated each other, additional capital expenditure to the channel, breakwater and other facilities is necessary.

Therefore, it will be unavoidable to locate the turning basin as proposed. In return, navigation aids system enough to keep the passing vessels safe and to make the operation of the port effective should be established positively.

4-3 BERTH

4-3-1 Number of berths

This port, enclosed by the breakwaters, will be very difficult to be expanded in the future, once constructed. As for the target of iron ore shipping of 6 million tonnes in Stage I and 12 million tonnes in Stage II, it will not absolutely be impossible to load them with one berth, provided other conditions are satisfied by installing the loader capacities of 6,000 t/h and 12,000 t/h respectively. However, reservation of space for additional construction of one more ore berth is recommendable with a view to:

(a) Coping with the diversity in sizes of ore carriers,

(b) Providing vessels with better service by decreasing waiting time,

(c) Meeting a necessity of waiting berth when vessels to and from the inner harbour are increased in the number with the execution of the harbour expansion plan and the maneuvering of ore carriers are severely hindered by these vessels,

(d) Exporting iron ore more than 12 million t/y, and

(e) Dealing with the case that the berth on the land side is forced to be constructed for 100,000 DWT in Stage I, and the berth on the off-shore side is arranged for future 150,000 DWT in Stage II, because a little change of the alignment for the berths and breakwaters is proved to be incapable of decreasing the volume of rock-bed dredging for 150,000 DWT as a result of more precise boring test on the soil condition.

4-3-2 Lay-out

The berth should be laid in the same direction of prevalent wind. There is no alternative other than the lay-out originally proposed in extending the breakwater as shorter as possible and in dredging the rock-bed to the minimum possible volume.

Since the boring points undertaken recently were rather coase in view of the topographical condition of the rock-bed and that most of the borings were washing type, the volume of rock dredging required was not made clear. Accordingly, the lay-out of the breakwaters and berths should be altered to a certain extent, if necessary, from more detailed boring tests.

The proposed lay-out of the berth is supposed to be reasonable as the existing Dolphin's Nose is effective in protecting the port from the southwest wind. However, it will be necessary for the port services to provide tugboats with sufficient powers in anticipation of the fact that some vessels may find it not so easy to approach to the wharf at rough days with the northeast wind.

4-3-3 Depth of water

The depth of water at the berth should be at least as deep as full draft plus absolute keel clearance of 0.6 m. In addition, considering the swell effect of 1 m high inside the harbour, maximum necessary depth of water will be -16.4 m for 100,000 DWT and -17.9 m for 150,000 DWT, which are obtained by adding half of the wave-height at the above berth.

4-3-4 Length of ore berth

As for the extension of ore berth, necessary length for head and stern lines should be as long as the length of vessels plus over 100 m, that is, 360 m for 100,000 DWT and 400 m for 150,000 DWT.

4-3-5 Fender

In case of designing fender, it should be taken into account that approaching speed rate of vessels is 10 cm per second under the condition of full displacement.

4-3-6 Strength of bollard and bitt

Regarding the strength of bollard and bitt, about 200 tonnes for head line and stern line will be necessary.

4-4 BREAKWATER

According to the Alternative-3, the breakwaters consist of a southern breakwater and a northern breakwater. The southern breakwater is to be connected with the existing ship-sunk type breakwater which is located on the outer side of the sand trap, and be stretched about 2,500 feet toward S 79° E in parallel with the present entrance channel.

The northern breakwater, covering the beach of the urban area, is to be stretched out about 2,500 feet toward S 35° E from the point moved about 5,000 feet north-east of the present port entrance and furthermore about 2,500 feet toward S 8° W.

The tranquillity inside the harbour depends upon the entering direction of incident waves, the sheltering effect of the breakwater and wave dissipation facilities.

The direction of incident waves is prominent from the E to the S through the year (Ref. to Figure I), and when the wave-height over 6 feet is taken, it is seen in Figure 2.

As be seen from this figure, most waves are coming from the SSE but about 10% of them are from the E. The latter wave is caused by the NE monsoon and cyclone. Therefore, the sheltering effect of the breakwaters has to be studied by basing upon the waves from the E, ESE and SSE.

Regarding the examination into the tranquillity inside the harbour, the wave-height of the value at 95 – 99% of the cumulative frequency distribution is taken and in this case it corresponds to 10 – 14 feet. Consequently, the wave-height will be appropriately 3 m.

The wave dissipation inside the harbour will be obtained by leaving the existing beach as it is, by designing the inside surface of the breakwaters so as to minimize the reflection of waves and by constructing an artificial spending beach at the proposed site of the berth. As for the beach where an erosion is now taken place, further feeding on the foreshore will be necessary.

Regarding the structure of the breakwaters, rubble mound type, caisson type and composite type breakwaters are under consideration. The design wave-height for the structure of the breakwaters should be the value at 99.9% of the cumulative frequency distribution viz. 20 feet.

On the other hand, the design wave-height for the shallower part of the water-depth will be nough as large as 80 – 90% of the water-depth.

The design wave period is considered to be between 14 and 16 second.

One of the most important points for the construction of the breakwaters is to find the degree of influences given to the sand trap by the southern breakwater. As be seen in the 4 – 5, a great volume of sands drifting northward once be blocked by the southern-breakwater and be deposited there, a bar will be made on the outer side of the sand trap and the role of the sand trap which has been effective for over thirty years is likely to be spoiled.

This is a problem which may decide the fate of the outer harbour plan. Therefore, the southern breakwater should initially be designed so as not to decrease the existing role of the sand trap and if decreased, another steps to construct additional sand trap off the present sand trap or to by-pass the sediment blocked by the southern breakwater should be investigated in advance.

In the latter case, a careful study on the scale of the sand pump and its operative site, the structure of the trestle, etc. should be undertaken. All these things are matters of difficulty to forecast accurately, so that a detailed review by means of model test will be requisite. At the Central Water & Power Research Station in Poona, a fixed bed model test on the outer harbour plan has already been undertaken, but not yet on the Alternative-3. Now it is desired to start this test as early as possible.

Although the fixed bed model test is good for the examination into the sheltering effect of the breakwaters and also the tranquillity inside the port, it is not available for the study of the sand drift.

Therefore, a continuous movable bed model test is required to be undertaken. Through this test, the general trend of the accretion caused by the southern breakwater and some means to keep the existing sand trap effective or its alternative will be cleared.

The following is touched upon the relation between the length of the breakwater and the short stopping distance of vessels.

Considering the influences by delay of starting engine of vessels, wind, wave, etc., the short stopping distance of 100,000 DWT (under the condition of ballast) should be, at the shortest, 3 – 5 L (L stands for length of vessels).

From this point of view, it is seen that proposed extension of the southern breakwater is fit to this condition and the decision on this extension rather depends upon the littoral drift and tranquillity inside the harbour.

4-5 LITTORAL DRIFT

4-5-1 Characteristics of sand drift

The bottom sediment in Visakhapatnam is consisted of small grains and the slope is about 1/100. So it can be imagined that the sediment is easily influenced by wave and current, and transferable to a vast area. Since the report of Ash & Rattenbury was issued, Indian side interprets that the transport belt of sand drift is about 600 feet from the shore-line. This is equivalent to the water-depth of about 3 – 4 m, that is, a surf zone.

Therefore, the above opinions are released on the ground that most sands, due to small grain, are likely to be suspended in the surf zone and it is at a glance regarded as mud sea.

However, according to the results of observations and experiments which make use of radio isotope and others as a tracer, the critical depth the bottom of which is remarkably moved, reaches to even deeper part of the off-shore. And, it is said that the wave-height should be taken the value at 95 – 99% of the cumulative frequency distribution in case of drawing up a port and harbour plan. The bottom sediment in Visakhapatnam is considered to be moved even to near -20 m depth of water.

In the direction of sand movement, the northerly drift is prominent judging from the directional intensity of waves, especially considering the waves of higher than 6 feet, 87% of them transport the sediment toward the north. On the other hand, the southeryly drift seems to occur in the NE monsoon or cyclone season, but most of them are supposed to be caused by meteorological disturbances, because the wind in the NE monsoon season is not so wild.

The median diameter of bottom sediment near the shore-line is d50 ... 0.160 – 0.175 mm, inside the sand trap d50 ... 0.175 mm, and in the dumping area (including dredged rock) d50 is over 0.200 mm. The median diameter in the sand trap and dumping area is artificially disturbed, and not seen as natural as it is. In other places influenced little by the dredged material, the median diameter is d50 ... 0.100 mm or below and the mean diameter d ... 0.100 – 0.120 mm. Furthermore, the grain size is nearly uniformed and it is fairly sorted out, showing the sorting coefficient of 1.20 – 1.30.

4-5-2 Transport rate of drift

From the dredging records covering a period of 20 years since 1937, the annual amount of dredging which is considered to be caused by the sand drift is about 1 million tonnes on the average and sometimes about 1.4 million tonnes at the maximum, and most of them are considered to be caused by the northerly drift.

On the other hand, the sediment drifting south-ward, although varied by the meteorological distrubances in a certain year, is supposed to be under 20% of that drifting north-ward.

Today's estimation methods in regard to the transport rate of littoral drift are available, provided the mean diameter be over 0.200 mm, in the Pacific and Atlantic Ocean, and also in other inlandseas where the meteorological disturbances do not take place so many times. However, the results come to be quite different among those methods. Meanwhile, these methods will not be applicable to the east coast of India where the grain size is so small and a keen reaction against wave and current is seen.

In this regard, taking an example of Kashima Port in Japan which has, to some degree, a similar sea-bottom condition to Visakhapatnam, the estimated transport rate with the progress of breakwater extension amounts to 600 – 650 thousand m^3 which move toward the north and south respectively and the mean diameter is d ... 0.130 – 0.150 mm, bottom slope 1/100, the value at 95 – 99% of the cumulative frequency distribution of the wave-height 2.5 – 3.5 m, and the period 11 second. From this point, it will be foreseen that the volume of sands drifting north-ward in Visakhapatnam be about 1 million m^3 per annum, considering the existing small grain and the constantly continued hydrographical condition such as the SW monsoon.

4-5-3 Accretion and erosion

According to the Alternative-3, the head of the breakwater is proposed to be laid at the depth of -16 – -17 m and the water-depth of the channel as deep as -17.5 m. As the critical depth of the sand movement is considered to be as deep as near -20 m, it is supposed that there exists a bottom movement in the vicinity of the harbour entrance, and occurs deposition near the head part of the southern breakeater.

However, it is unlikely that the volume of deposition be increased so much, because there is no great gap of water-depth between the channel and its vicinity. The amount of dredging in the sand trap has been about 500 thousand tonnes per annum, that is, about 50% of the annual average volume of dredging and the rest dredging is in the outer channel.

Consequently, in view of the vast volume of sands drifting north-ward, their deposition on the outer side of the sand trap and on the southern part of the southern breakwater will be more than 0.5 million tonnes annually, considering the progressive extension of the breakwater.

Next comes a most important problem, that is, how to treat this accretion by means of sand pump or dredger. If failed in this treatment, the maintenance of water-depth in the port entrance will come to be quite difficult with the possible advancement of the shore-line on the shouthern side.

The beach erosion which is supposed to occur on the northern coast of Visakhapatnam with the execution of the outer harbour plan will be intensified as far as Waltair point. On the coast north of the above point, there are many rocky hills protruded into the sea and the sandy beach located between the hills is also likely to be eroded.

However, it is considered to be not so severe as on the beach south of Waltair point. As regards the urban area of Visakhapatnam, almost of it is contained between the northern and southern breakwaters.

So this area will be possibly avoided from the threat of erosion, so far as each breakeater is constructed simultaneously.

Regarding the remedial measures against the eroded beach, it will be adequate to apply a combination type of groynes and detached breakwater or wave energy dissipation breakwater by making use of stones which will be inexpensively obtainable in the vicinity of Visakhapatnam.

At the same time, it is a requisite to feed the beach by sand by-passing to the foreshore of the northern coast and by dumping the sediment from dredger to the inshore or offshore, because the natural supply of drift is considerably reduced.

At present, the sediment in the sand trap is almost dredged by dredger, to be dumped to the offshore of the northern coast and the volume of sand by-passing is decreasing. This is possibly due to the fact that the by-passing may prove a hindrance to the vessels to and from the inner harbour. However, the feeding to the foreshore where an erosion is considered to be taken place will be successfully performed without any trouble by installing a submerged pipe line running under the entrance channel from the sand trap. This kind of pipe line is widely introduced in Japan. In addition, there is about 2,000 – 2,500 m from the sand trap to the foreshore of the northern beach of the outer harbour, a special attension to the pumping power should be paid and the attachment of swell compensator for dredger will be a subject for due consideration in view of raising of dredging efficiency.

As a conclusion, the problem of sand drift which may take place in the execution of the outer harbour plan will be solved by treating appropriately the sediment on the southern part of the outer harbour and maintaining the water-depth at the entrance channel of the breakwater as deep as possible, and thus by tackling the erosion on the northern beach of the outer harbour with the utilization of the sediment.

4-6 CONSTRUCTION WORKS OF OUTER HARBOUR

There needs a large quantity of works for the construction of Visakhapatnam outer harbour, and that it is difficult to complete the works in a period of four years after the starting without any introduction of high technique and any execution schedule for large scale works.

Particularly, it seems that the rock dredging and the construction of caisson in case of composite type breakwater, are likely to become bottle necks through the entire works. And to minimize the incidental damage during the execution and to make progress it smoothly, it is required to apply a skillful working process and technique, in which meteorological and sea conditions should be due considered.

4-6-1 Dredging

(1) Dredging of sediment

Basing upon the prepared sounding map, if the channel is dredged upto -17.5 m and the basin -16.0 m, the dredging volume will amount to nearly 4 million m^3, and in case of the channel of -19.0 m and the basin of -18.0 m, the volume is roughly estimated 14 million m^3.

(2) Dredging of rock-bed

Assuming the soft rock capable of dredging by the cutter suction dredger be 2 m thick from the refusal point of the washing boring, and the forefront of the coal berth be not dredged in the Alternative-3, the rock dredging volume will amount to 150,000 – 200,000 m^3.

In order to undertake dredging of the above volume at the site of -19.0 – -20.0 m water-depth within a short period, the use of large size and effective drilling barge will be necessary. Any how, in order to know the exact volume of rock dredging which requires blasting, it is desirable to undertake an investigation by core boring in detail and a study on a little revision of the alignment of the wharf and the turning basin, and thus to minimize the dredging volume of the rock.

4-6-2 Breakwater construction work

(1) Amount of work

Although varied by designs to a large extent, the approximate amount of work will be as follows:

In case of composite type breakwater;

rubble-mound	about 600,000 m^3
concrete block	about 200,000 m^3
concrete cassion	(15 m long) about 90 box
	(10 m long) about 80 box

In case of mound type breakwater;

rubble-mound	about 1,600,000 m^3
concrete block	about 200,000 m^3

Actual volume of rubble-mound will be largely different from the designed volume on the occasion that the scoring of the slope-toe and the sinking of stones into the sea bottom are intensified.

(2) Execution of composite type breakwater

As it takes time considerably for the construction of the cassion, the construction equipments should be fully provided. It is considered possible to set the cassion through every season except the cyclone and SW monsoon season. However, it is desirable to elaborate the execution process and schedule with caution because the setting-up of the cassion under wave and current needs a higher technique and good experience. For the reference, the following are examples of the breakwater construction performed in Japan. In both Kashima and Onahama Ports, the setting of cassion has been carried out at a high rapidity by forecasting wave in the short, medium and long period respectively. The 67 cassions were placed to a distance of 1,000 m at Kashima Port in 1967, and at Onahama Port 40 cassions were laid as far as 400 m in 1966. In these ports, the observation by a wave detector has been successfully undertaken and the comparision of the results of the forecast with that of the actual observation has also been made. And further elevation of the forecast activities and more rapid ways of the works are still under exploration in the above parts.

In Onahama Port, it is said that the hitting rate of the short term forecast was 70% in March, 1961, provided the permitted error was 0.5 m.

On the other hand, a caution should be paid to the cassion which is not yet filled and covered as it is sometimes broken by waves during works.

At the same time, it is an important point for raising the efficiency of the works execution to minimize the leveling works of rubble-mound which largely depends upon human power.

(3) Execution of mound type breakwater

It is an atractive factor to be able to obtain a lot of inexpensive good stones in the vicinity of the construction site.

However, a great volume of stones is needed for the works and a large scale execution process and schedule is required to draw so that the works may be completed in a short period.

For the reference, there is an example of large scale rubble mound works in Japan.

The construction of anti-tsuname breakwater at Ohfunado Port is the case. There conducted the rubble mound works at a rate of 1,500 m^3 per day on the average in 1963 and 3,000 m^3 in 1964.

At the outer harbour of Amsterdam in Holland, the construction of mound type breakwater with a total length of 3,300 m was succeeded under a large scale execution process and schedule.

It is also necessary for the construction of the same type breakwater to consider steps for minimizing the scoring of slope-toe, the burying and scattering of rubble mound which may take place during or after the construction works.

However, such phenomena will be unavoidable to some degree, so it is desirable that these possible factors be preliminarily contained in the works execution schedule.

4-7 LOADING FACILITIES

4-7-1 Ship loader

(1) Clear hight, outreach, working range

Ship loader should be designed enough to maintain clear height and outreach fit for 150,000 DWT ore carriers and also for smaller vessels of 50,000 DWT.

Necessary values for 150,000 DWT are as shown below.

clear height:	20.2 m above datum level
outreach:	half of ship-width viz. 22.0 m
working range:	210 m

(2) Capacity and number

It will be appropriate to install initially one ship loader with the capacity of 6,000 t/h and, in response to the increasing size of vessels and the increasing amount of ore handling, additional same type loader should be equipped in stages. These are today's common trends in various countries of the world.

It is also necessary to take measures against possible lowering of loading efficiency which may occur upon hatch to hatch transfering, and against accident and repair in the stage of one loader installation.

4-7-2 Belt conveyor

(1) Starting and stopping

The motor torque of belt conveyor should be equipped enough to be capable of starting even with a full load of ore.

On the other hand, if the surge bin is installed, the stopping control of the belt upon the completion of loading should be enough arranged, as it is desirable to minimize the volume of residual ore on the belt.

(2) Capacity and number of line

It will be adequate to lay one line initially comprising the belt of 1,500 mm wide and the capacity of 6,000 t/h, and in the stage that additional ship loader is installed, it will also be good to set up one more line of the same type belt conveyor.

However, it will be necessary to reserve space from the beginning for two lines installation at the underground and overhead site. And in the course of the line passing through urban area, a covering to protect from the dust nuisance and danger should be arranged.

4-7-3 Surge bin

Installation of the surge bin will be fairly effective from a view to distributing ore euqally to the two ship loaders and to stocking it upon hatch to hatch transfering.

At the same time, belt conveyor should be designed so that ore may be left on the conveyor as little as possible by its effective control system for stopping when the loading is completed.

As it seems difficult to transfer a large volume of ore at once from the site of surge bin to the ore stock yard, the installation of such a surge bin as responded to each grade of ore will be required.

4-8 ORE HANDLING FACILITIES IN LAND

4-8-1 Car dumper, dumper yard

(1) In the stage of 6 – 8 million tonnes per year

At present, a train composing of 40 goods wagons with each 55 tonnes capacity is handled four times every day on the average and the annual volume of handling amounts to 2.3 million tonnes.

The ideal cycle time for a locomotive to pull out and push in a train from and to the ore exchange yard in the dumper yard is said to be 195 minutes, but the actual cycle time is estimated to be rather longer than the above.

And it is said that the designed cycle time of each car dumper is 135 second and actual one 150 second, that is, each of them has an average capacity of 23 car/h.

In other words, with two car dumpers the total capacity is said to be 2,500 t/h in the case that 55 T wagon is used and 3,200 t/h in case of 70 T wagon. However, actual result is 1,700 t/h with 55 T wagon, and will be about 2,200 t/h with 70 T wagon.

Now that any detailed operation schedule or any line improvement plan is not cleared yet so far, a correct judgement will not be born. However, it will be possible to handle ore of 6 – 8 million tonnes per year by improving the wagon operation schedule (including overlapping of locomotive cycle time), the line alignment (especially, empty line and push-up line to car dumper), and also the car dumper operation, besides by adopting the 70 T wagon.

(2) In the stage of over 6 – 8 million tonnes per year

It seems to be difficult to handle ore more than 6 – 8 million tonnes per year with the present car dumper and dumper yard facilities, even though the improvement of facilities and its operation is carried out to a considerable extent. Therefore, the introduction of additional car dumper and dumper yard becomes a requisite in order to handle ore over 6 – 8 million tonnes per year, and for this sake enough space should be obtained in advance.

At any rate, a comprehensive plan for facilities reinforcement should be set up at the earliest possible opportunity.

4-8-2 Ore stock yard and belt conveyor, stacker, reclaimer, etc.

(1) Stock yard

The proposed stock yard containing the present yard (planned capacity: 400,000 T), is to be expanded toward the river stream side of the North Western Arm. Furthermore, in response to the trend of vessels toward larger size and increasing volume of cargo-handling, this stock yard is planned to be expanded toward the site of present ore berth and the height of stocking be increased upto 12 m, to be corresponded to ore shipment of 12 million tonnes as expected.

(2) Stacking system

At present, ore dropped into the hopper by two car dumpers is transfered by two feeders to the No. 1 and No. 2 conveyors and thus stocked by the stacker. From the stacker, ore is put on the conveyor once again by the hopper stationed above No. 2 conveyor, and is loaded into vessels directly. Each of No. 1 and No. 2 conveyor has a capacity of 2,670 t/h and the improvement plan of No. 2 conveyor is under way, to be increased upto 3,200 t/h capacity by June, 1968.

In the outer harbour plan, additional stock piles are to be facilitated and a conveyor of 3,000 t/h and a stacker of 3,000 t/h are also considered to be installed.

(3) Reclaiming system

At present, ore is reclaimed by two power shovels of 1,300 t/h nominal capacity each (actual total capacity of the two is about 1,000 t/h), and being through the hopper set up above No. 2 conveyor, as well as through No. 2 and No. 3 conveyors, ore is transfered to the surge bin and finally led to the conveyor running toward the loader.

In addition to that, a new bucket wheel reclaimer of 2,000 t/h is ordered to be installed, and the capacity of both No. 2 and No. 3 conveyors are also planned to be increased upto 3,200 t/h each.

In relation to the outer harbour plan, No. 2 conveyor is said to be used exclusively for stacking in the first stage, and, on the other hand, two belt conveyors (3,000 t/h each), running toward the reversed direction of the above conveyor and the reclaimer corresponded to them are to be equipped. In the second stage, where a new loader is to be provided, additional conveyor and reclaimer will also be equipped.

(4) Opinion in regard to the above plan

As for the outer harbour plan, it will be adequate to utilize the present stock yard and other facilities concerned to the maximum possible extent, and thus to improve and expand them in stages.

On the other hand, it will be necessary for this sake to make a comprehensive upgrading plan, as there are many limits in using the present facilities. In any case, these consideration should be specified thoroughly in the feasibility study for each stage of expansion.

Regarding the stock yard, it is favourable that the existing yard is improved for loading of 6 million tonnes per year and in the stage of additional car dumper installation, a new yard is facilitated on the midway of the proposed conveyor line for loading another 6 million tonnes per year, and totally accommodated for loading of annual 12 million tonnes. The following are the points come up to the mind:

a. The existing loading facilities should be specified without delay as to when and how these be utilized.

b. Regarding the stock yard, the volume of stock and enough space responded to the trend of vessels toward larger size and the annual volume of ore handling should be specified in stages and necessary arrangement for them should be made without delay.
Above all, the stocking height has to be decided with caution as the land is not so good for the stock pile. If necessary, foundation improvement plan should be comprised.

c. In relation to the capacity of No. 1 conveyor, it is said that there is no improvement plan at present. However, in view of the possible use of 72 T wagons in the future, a capacity of over 3,000 t/h should be given including that of feeder. And the capacity of the existing stacker should also be a subject for increase.

d. It is favourable that the reclaimer of 2,000 t/h which is to be installed in due days be improved upto 3,000 t/h in accordance with the outer harbour plan. On the other hand, it is desirable that the present power shovels be used for other purposes such as for loading at the existing berth.

e. According to the proposed plan, the capacity of the reclaimer seems to be 3,000 t/h x 2 = 6,000 t/h for a loader of 6,000 t/h in the first stage, and for two loaders of 6,000 t/h each in the second stage, it seems to be corresponded to 3,000 t/h x 3 = 9,000 t/h plus the capacity of surge bin. However, the provision of another reclaimer is recommendable on the ground that the actual capacity of that is generally too much lower than the nominal.

4-9 TUG-BOAT, NAVIGATION AIDS, NAVIGATION CONTROL SYSTEM, ETC.

4-9-1 Tug-boat

According to the proposed plan, two boats of 1,500 HP are to be newly constructed and totally four boats are considered to be used by adding the existing two boats of 1,200 HP.

However, it requires further examinations. So far as Japan is concerned, Japan Association for Preventing Sea Casualities reportedly indicates the necessity of four boats of 2,000 HP for 100,000 DWT vessels and the Seto Inland Pilot asserts three boats of 2,000 – 2,500 HP, and the Japan Tugboats Association three boats of 2,500 HP for 80,000 – 100,000 DWT vessels.

Supposing various resistances of 100,000 DWT vessels under the full draft be wind velocity of 10 m/sec, drifting speed of 0.15 m/sec, and tidal current of 0.10 m/sec, the total tonnage will be 54 tonnes including wind pressure of 16 T and water resistance of 38 T. Therefore, in case of 30^{o} degree of operative oscillation, the necessary thrust of the tugboat will be $54/\cos 30^{o}$ –– 62.5 T and providing its thrust be one ton per 100 HP, 100,000 DWT vessels need the boats of 6,250 HP. Taking above values, required horse power and its number should be decided from the view-point of the reduction of the time necessary for the maneuvering of vessels to and from wharf and also of the sea accident prevention.

4-9-2 Navigation aids

(a) Harbour rader is a requisite from the viewpoint of the navigation control.

(b) Fairway buoy and leading light should be necessarily installed.

(c) The provision of V.H.F. is required at any cost.

(d) Transceiver is supposed to be used by pilot at present and it will also be necessary in the outer harbour.

(e) At the head of the breakwater, light house should be set up.

4-9-3 Navigation control system

(a) The proposed width of the channel absolutely needs the introduction of the navigation control system.

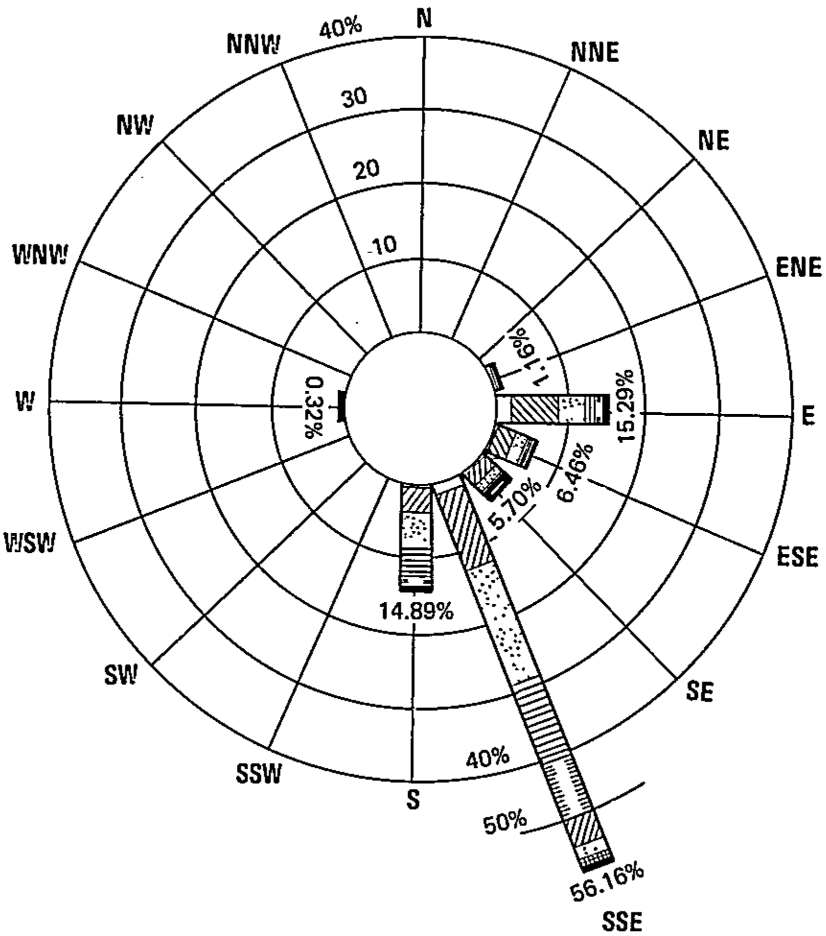
(b) The priority order to and from the harbour must be made clear in the harbour regulations, and that, it can be done by means of something visible besides V.H.F.

4-9-4 Handling of ore/oil carriers

As regards to gas free certificate, some standards of gas density should be cleared in the port regulations.

At the same time, the training of tank cleaner should be undertaken. Now that the releasing of oil into the sea will not be permitted anywhere in future, the ways of used oil treatment should be fully taken up in the outer harbour plan.

Fig. 1
Directional intensity distribution of waves during the years.

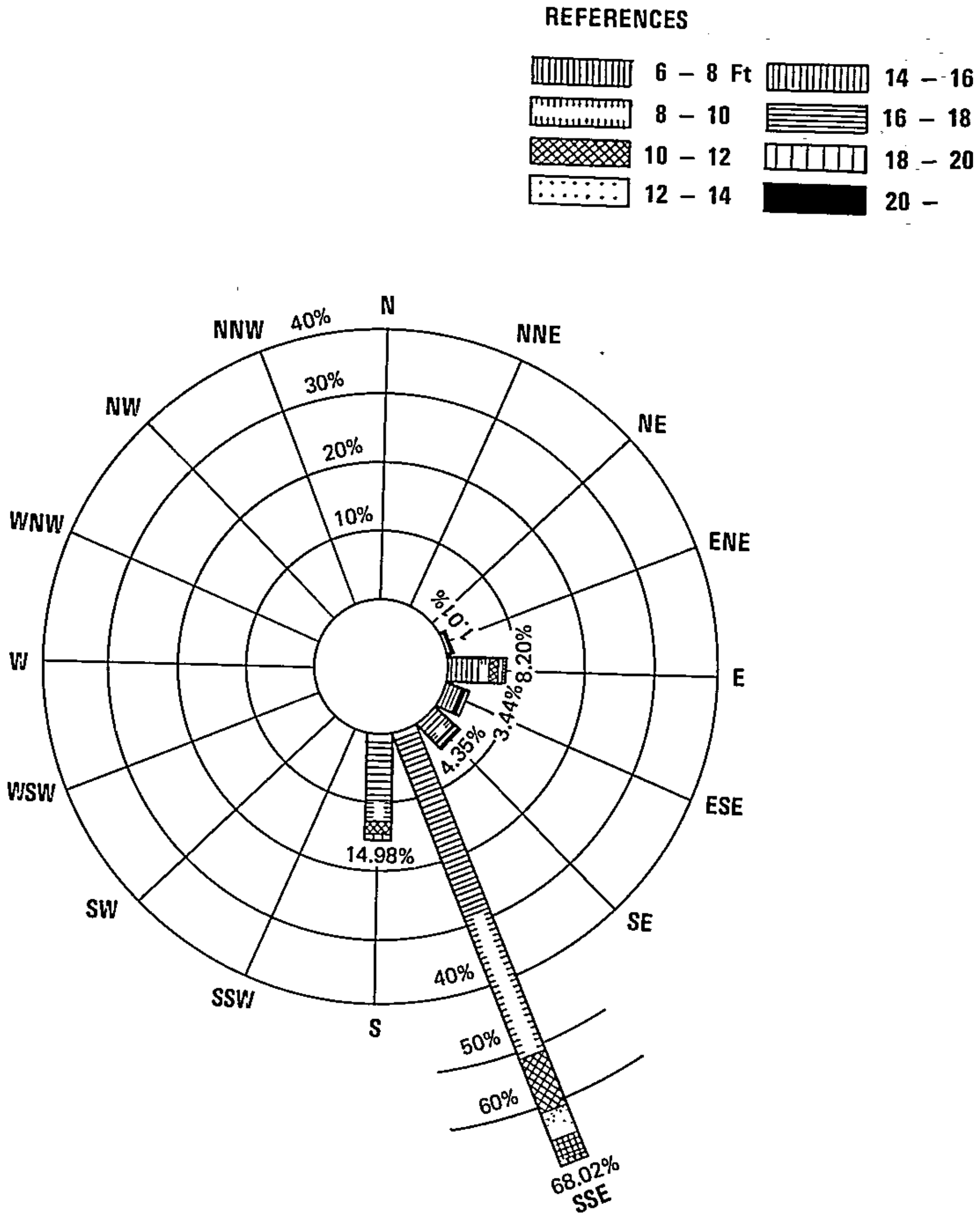


REFERENCES

0 – 2 Ft
2 – 4
4 – 6
6 – 8
8 – 10
10 – 12
12 – 14
14 – 16
16 – 18
18 – 20
20 –

Fig. 2

Directional intensity distribution of waves higher than 6 feet during the years.



CHAPTER V PRESENT STATE OF RAILWAY AND ITS FUTURE PLAN

CHAPTER V. PRESENT STATE OF RAILWAY AND ITS FUTURE PLAN

5-1 BACKGROUND OF RAILWAYS CONSTRUCTION

The plan of the "K-B Line" construction over a distance of 445 km between Kottavalasa in the East Coast main line of Indian Railways and Kirandul in Bailadilla mine and that of the railways which runs about 26 km from Kottavalasa to the Waltair's ore exchange yard located in the East Coast main line contiguous to Visakhapatnam Port, were carried out by the Indian Government Railways from late 1960 and their works were started from early 1962 with a view to transporting iron ore of 6 million tonnes from Bailadilla mine every year.

Since then, the above lines were used for the transportation of construction materials for the first time in May, 1966 and from May, 1967 the iron ore transportation was started.

Until March 12, 1968 iron ore of about 400,000 tonnes was conveyed by the rail of 190 trains. The iron ore railway line between Kottavalasa and Waltair is laid in parallel with the East Coast main line and takes a separate route in its operation from the main line.

On the other hand, this line basing upon the standard of the BG/ML is designed as a single line comprising the steepest gradient of 1 in 60, and the maximum degree of 8^{o} in curvature.

5-2 PRESENT STATE OF K-B LINE

(1) Track bed and construction

Embanking was undertaken by making use of stones and rocks of laterite loam which were produced from tunnel and cutting works, and also from both sides of the line.

However, at some slopes the protection works are still remained incompleted.

Regarding the tunnel, there are 61 tunnels throughout the line and at some points open cuts artificial tunnels are under construction in order to protect the track from land slides or rock falls.

The bridges, designed in accordance with the Indian Railway Code, were checked for the increasing load caused by the multiple operation of diesel locomotives.

(2) Track

The rail weighs 90 lb/yard and the ballast is 8 inch deep from the bottom of sleeper, and the formation is 20 feet wide.

The tracks of the line are mostly completed at present with the exception of some ballasting by crushed stones and, at some parts of the station tracks, the extension works of track skeleton are in progress.

On the other hand, the ballasting works of crushed stones are actively being carried out and these stones are piled in many places. In the section where the ballasting of crushed stones is not completed yet or light steel sleeper is still used, the speed of the running train is limited at a rate of 32 km/h.

(3) Station

There are 38 crossing stations between Kottavalasa and Kirandul and 13 stations (including Kottavalasa and Kirandul) are already opened, and furthermore additional three stations are to be opened by late March, 1968.

In the crossing stations, one to five loop tracks of 2,250 feet long are installed and the length of the platform is 600 feet.

The ore exchange yard in Waltair new marshalling yard is located nearby the car dumper yard of Visakhapatnam Port and iron ore trains go directly to the site of the ore exchange yard without joining with the main yard.

On the other hand, the tracks at Kottavalasa are arranged so that a direct train service can be available between K-B line and the East Coast main line.

(4) Signalling

Signalling is under installation at present with the future handling of through trains in mind. Especially, in the section between S. Kota and Similiguda, colour light signals are to be equipped. This is based upon the plan to introduce a tokenless block system in the future.

(5) Block instruments

Regarding the block system, a neales and token block system will be introduced and until its completion (equipments are to be supplied by October, 1968), electric speaking instruments with paper line clear will be continuously used as ever.

(6) Telecommunication facilities

In relation to the telecommunication facilities, three circuits including train wire circuit, section controllers and maintenance order wire are installed in the two sections at present, that is, between Waltair and S. Kota, and between Araku and Kirandul.
(Remarks: in the section between S. Kota and Kottavalasa, underground cable is under construction and a circuit of P & T is temporarily used.)

However, due to the use of iron wire, no communication throughout the entire sections is available.

Regarding the telegraphic communication, wireless services are installed at five stations.

(7) Locomotive and goods wagon

Diesel electric locomotive of WDM2 type is used at present. Regarding the goods wagon, BOX type of 55.2 T capacity is running on the line and, with the increase of the transportation, BOI type of 57.4 T capacity is to be introduced.

(8) Operation of locomotive and goods wagon

There is a locomotive shed at the new marshalling yard of Waltair where, besides refuel, periodic check and inspection in regard to operation are undertaken there. At Kirandul, refuel and inspection services are also handled when locomotives shuttle.

Regarding the assisting engine in the Eastern Ghats section, it is used between Araku and S. Kota for shuttle service.

Primary maintenance for goods wagons is undertaken on the sick lines of the Waltair's ore exchange yard, and inspection of each train at both Waltair and Kirandul.

Besides the above, vacuum test for decending gradients is done at both Kirandul and Koraput.

(9) Operation

In order to pull a 3,200 T iron ore train (composing of 40 BOX type goods wagons) ascending the steepest gradient of 1 in 80, multiple-unit control running by connecting three DM2 type locomotives is introduced. On the other hand, as for descending the gradient of 1 in 60 in the Eastern Ghats section, dynamic braking by multiple-unit control composing of four locomotives and one assisting engine is applied there. In relation to the brake for stopping, vacuum brake equipped with wagons is used intially and then switched on air brake of locomotives after trains stop. This is based on the view to protection trains from the lowering of operative efficiency because vacuumbraking takes a long time until it becomes calm.

(10) Control system

Sub-control offices set up at Jagdalpur and Araku are in charge of the section between Koraput and Kirandul, and also between Kottavalasa and Koraput.

However, it is considered to be a temporary arrangement until copper wires are used for the communication circuit in exchange for the present iron wires.

5-3 FUTURE PLAN

(1) Station

It is planned to pen 38 crossing stations between Kottavalasa and Kirandul by the time when 4 million-ton iron ore is transported annualy, and furthermore 5 crossing stations for 12 million-ton iron ore conveying every year.

(2) Block instruments

Until the 8 million-ton iron ore per annum is transported, some parts of neales token instruments are to be changed for tokenless block instruments, which with the increase of the transportation will be more installed in stages and thus a higher blocking efficiency will be maintained.

(3) Telecommunication facilities

It is planned to provide the entire line with a good service of telephone by changing the present iron wires for copper ones and by setting up a control office at Waltair to control the entire line. Meanwhile, an along-line telephone service which is available from any point to contract the control office will be obtained. Installation of spare circuit for multipurpose is also under consideration at present.

On the other hand, alternative use of carrier telephone or wireless telegraph is under examination in anticipation of the case that the above communication service should become no available due to the long distance.

(4) Goods wagon

New goods wagon — BOY type is currently under development and its trial production is to be completed in June, 1968.

BOY wagon for iron ore transporting has the same length that of BOI wagon, but its carrying capacity is largely increased to be 72 T, which may meet the possible increasing volume of transportation in the future.

(5) Operation

On the occasion that tractive load is increased with the introduction of BOY wagon, four linked WDM2-type locomotives are planned to be used. On the other hand, for descending the gradient of 1 in 60 in the Eastern Ghats section, five linked locomotives are to be operated in view of supplementing the brake power.

5-4 CONCLUSION

As means for transportation upgrading, there are two ways – the increase of train operative frequency and that of train unit weight tonnage. The following are referred to these subjects:

(1) Increase of train operative frequency

a. Doubling of track

b. Increase of crossing stations

c. Speed-up of train

d. Improvement of block instruments

e. Installation of holding capacity at both the ends of the section where exists a bottle neck in train operation

f. Improvement of operation schedule

(2) Increase of unit weight tonnage

a. Increase of wagon number

b. Introduction of wagons capable of carrying heavier weight

Among these means, the transportation upgrading plan in K-B line is rather put stress, as foregone, on the increase of transportation per train, that is, the introduction of BOY goods wagon and the raise of operative efficiency — introduction of tokenless block instruments, and its operation schedule is worked out so as to meet the increasing volume of transportation.

At the same time, this plan is aimed at increasing both the passenger and general goods transportation, besides the iron ore conveyance, in view of the comprehensive development of towns and villages along the railway line.

From the above-mentioned, K-B line upgrading plan is considered to be generally adequate.

The following is concerned with the goods wagon number and the operative frequency in regard to the train for iron ore transportation. The relation between the maximum number of linked wagons and the loop length of crossing station is shown as:

$$N = \frac{L - (Le + Lb + \alpha)}{Lf}$$

N	:	maximum number of linked wagons	
L	:	loop length	2,250 feet
Le	:	length of locomotives	56.2 feet x 4 or 5 locomotives
Lb	:	length of brake van	30 feet
a	:	reserving distance	100 feet
Lf	:	length of goods wagon	

The following is a table related with the maximum number of linked wagons:

Type of wagon	BOX	BOI	BOY
Wagon number per train	42	49	48

From the above number, iron ore train number necessary for diagram making is shown by type of wagon as follows, providing two cases viz. annual operation of 360 days and 300 days be taken up:

Type of wagon / Annual transporting tonnage (million)	BOX	BOI	BOY
4	5 6	4 5	
6	8 9	6 8	5 6
8		8 10	7 8
10		10 12	9 10
12			10 12

Remarks: Upper number is shown for annual operation of 360 days and lower number for 300 days.

APPENDIX

Appendix I

PORT CONDITION OF IRON & STEEL COMPANIES IN JAPAN

(as of August, 1967)

Companies	Ports	Channel width (m)	Channel depth (m)	Berth name	Berth length (m)	Berth depth (m)	Maximum permissible draft (m)	Unloader (capacity x number) for ore	Unloader (capacity x number) for coal
Yawata	Yawata	220	9.0	No.16/17/18	150 each	9.0	8.5		
				No.1	200	11.0	10.5	1,500 t/h x 1	
	Tobata	400	13.0	No. 2	200	11.0	11.0	1,000 t/h x 2	
				No. 3	250	13.0	13.0		
					290	12.0	12.0		400 t/h x 2
					290	12.0	12.0		
	Sakai	300	12.5		210	12.5		1,000 t/h x 2	
					255	12.5			
	* Kimitsu	350	17.0		285	17.0		1,500 t/h x 2	
					335	17.0		500 t/h x 3	
Fuji	Muroran	300	13.0		220	13.0	13.0	1,000 t/h x 2	
	Kamaishi	90	9.3		230	9.3	9.3		
	Hirohata	250	13.0	Tsuruta	423	9.5		700 t/h x 1	
		250	13.0	Chuo	313	13.0			
		250	13.0	Kamota	762	7.5			
	Nagoya	200	12.0		500	13.0		1,500 t/h x 2	
								300 t/h x 1	

Companies	Ports	Channel width (m)	Channel depth (m)	Berth name	Berth length (m)	Berth depth (m)	Maximum permissible draft (m)	Unloader (capacity x number) for ore	Unloader (capacity x number) for coal
Nippon Kokan	Kawasaki	100	9.0	Oshima	293	9.7	9.0		
		100	9.0	Ogimachi	447	9.2	9.0		
		340	12.0	Ogishima	320	13.5	11.8	1,000 t/h x 2	750 t/h x 2
	Yokohama	85	9.0	No. 2	130	9.0	8.8		
	Fukuyama	300	14.0	No. B	280	16.0		1,500 t/h x 2	
				No. F	180	11.0			
Kawasaki	Chiba	250	12.0	No. 1	500	9.5	9.5		
		250	12.0	No. 2	530	12.0	12.0		
	Mizushima	350	16.0	No. 1	304	16.0	13.5	1,500 t/h x 1	
		350	16.0	No. 2	200	11.5			500 t/h x 2
Sumitomo	Wakayama	200	13.5	No. A	172	9.5	9.5	250 t/h x 1,	500 t/h x 1
				Bo. B	365	14.0	13.0	500 t/h x 1,	700 t/h x 1
	Kokura	130	10.0		246	10.0	10.0	300 t/h x 2	
	* Kashima		16.0			16.0			
Kobe	Amagasaki	140	11.0		366	11.0	9.5		
	Nadahama	220	13.0	KS No. 2	236	10.0	9.0		
				KS No. 3	334	13.0	12.0		
	* Kakogawa	400	16.0	(for oil/	300	14.0			
				ore)	350	16.0			
				"	350	17.0			
				"	350	17.0			
Nakayama	Funamachi	150	9.0	Nakayama	160	9.0		150 t/h x 3	
					160	9.0			120 t/h x 2
Osaka	Nishijima	150	10.0	Sakurajima	180	9.4	9.2		
Nisshin	Kure	no limit	no limit	No. 2	130	11.0		300 t/h x 2	

Remarks: * = under planning

Appendix II (1)

DIMENSIONS OF JAPAN'S ORE CARRIERS (OVER 70,000 DWT)

(as of July, 1967)

Name of ships	Cargo	DWT	Lpp	W	D	d
Wakahata	ore	93,113	240.00	36.80	17.60	12.90
Tsukushi	ore/oil	91,256	226.06	36.00	19.10	13.268
Chitosegawa	"	88,458	226.06	36.00	19.10	12.890
Chihayakawa	"	86,097	225.00	35.30	19.00	12.835
Yashimasan	bulk	85,721	231.00	36.00	18.50	12.439
Fujisan	ore	84,221	232.00	34.80	18.25	12.338
Ynsui	ore/oil	81,350	222.00	36.20	16.80	12.20
Australia	ore	81,305	225.00	35.30	18.50	12.22
Yawata	"	81,144	216.00	35.70	18.70	12.64
Oiso	"	81,144	216.00	35.70	18.70	12.58
Shoku	bulk	75,931	236.22	31.85	18.74	11.93
Ogishima	pellet	73,037	-	-	-	11.952

Appendix II (2)

DIMENSIONS OF VESSELS (OVER 70,000 DWT) ORDERED FOR CONSTRUCTION TO JAPAN'S SHIPBUILDING COMPANIES DURING APRIL, 1967 – MARCH, 1968

Ship Owner	Cargo	DWT	Lpp	W	D	d
Satankers, Inc. Ltd.	bulk (4)	147,000	272.00	43.30	24.69	17.40
San Juan Carriers	ore/oil	127,700	277.00	42.00	22.60	15.77
"	"	127,600	277.00	42.00	22.60	15.80
Vale De Rio Dose Ltd. Navegâcao S/A	"	104,773	248.00	38.00	21.30	15.69
"	"	104,700	245.00	38.94	22.30	15.70
N. Y. K.	ore	101,700	249.00	39.60	19.70	14.40
Japan Line	ore/oil	98,300	244.00	38.94	20.90	14.60
O.S.K. & Nihonkai Kisen	"	95,915	244.00	38.94	20.90	14.30
Showa Kaiun	"	97,600	240.00	38.00	21.30	15.00
Mitsui O.S.K.	"	97,580	240 00	38.00	21.30	15.00
Japan Line	"	96,200	244.03	38.94	20.60	14.49
Daiichi Chyuo Ship	ore	92,700	237 00	38.50	19.30	14.10
N. Y. K.	ore/oil	93,700	237.00	38.50	20.60	14.34
"	"	93,700	237.05	38.50	20.60	14.34
H. Clarkson Co., Ltd.	ore	96,700	251.00	40.80	22.50	14.00
Sanko Ship Corp.	ore/oil (2)	89,700	237.00	38.50	20.60	13.85
N. Y. K. & Shinwa Kaiun	"	87,500	226.00	38.00	20.50	14.35
Leif Negh & Co., A/S	"	86,400	237.00	38.94	22.00	13.72
Nippo & Showa	"	82,530	235.00	38.00	21.00	13.25
Japan Line	"	76,700	226.00	36.00	19.10	13.30
General Overseas Financing Co., Ltd.	"	76,000	243.00	36.50	20.00	12.90
Kristiansands Tankrederi A/S Jointly & Severally with A/S	bulk	73,610	242 62	32.16	18.59	13.61

Appendix III

DIMENSIONS OF CHANNEL WIDTH, TURNING BASIN AND LOADER HEIGHT IN SOME PORTS FOR ORE CARRIERS

Ports	CHANNEL WIDTH				TURNING BASIN			LOADER HEIGHT		
	Channel width (m)	Max. LOA (m)	Ratio	Remark	Basin diameter (m)	Ratio	Tugs (HP)	Loader height (above HWL)(m)	Outreach (m)	Size of ship (DWT)
Port Hedland	183	259	0.71	weak current	550	2.2	2,000 x 2	13.1	22.8	55,000
Port Bampier	152	235	0.65					18.3	21.4	65,000
Geraedton	92	185	0.50		336	1.8	1,000 x 1	9.8	15.2	20,000
Glad Stone	183	228	0.80							
New Castle	152	198	0.77	calm	305	1.5	1,000 x 2 others 2			
Port Kemkla	113	222	0.51	calm	366	1.7	1,000 x 1 900 x 1			
Tubarrao	205	259	0.79		600	2.3	1,250 x 1 1,600 x 1	13.5	29.0	100,000
Long Beach	122	113	0.57	calm				12.8	15.3	65,000
Los Angeles	152	259	0.42		760 x 445	2.9 x 1.7		15.2	21.3	80,000
Nonfolk	244	305	0.80	calm				14.0	30.4	80,000
Pittsburgh	165	228	0.72	calm						
Lorenco Margues	101	220	0.46					18.3	20.7	50,000
Port Elizabeth	366	265	1.38	weather, sea cond. bad				12.2	17.7	50,000
Visakhapatnam	76	193	0.40		366	1.9	1,500 x 2 1,000 x 1 900 x 1	12.6	17.7	35,000

Ports	CHANNEL WIDTH				TURNING BASIN			LOADER HEIGHT		
	Channel width (m)	Max. LOA (m)	Ratio	Remark	Basin diameter (m)	Ratio	Tugs (HP)	Loader height (above HWL) (m)	Outreach (m)	Size of ship (DWT)
Paradeep	190	193	0.99		360	1.9	1,000 x 1	12.5	17.1	35,000
Red Wood	92	166	0.55		520 x 274	3.1 x 1.7				
Huasco								13.0	18.3	68,000
Chiba	250	250	1.00		500	2.0	1,400 x 2	18.0	22.2	50,000
Dokai	120	166	0.72					17.9	19.8	20,000
Himeji	220	220	1.00					18.1	16.0	50,000
Muroran	300	250	1.20					21.2	14.8	75,000
Sakai	250	230	1.09		390	1 7	1,800 x 1 1,500 x 3 1,600 x 1	17.6	22.5	55,000
Kokura	200	190	1.05	current				19.9	18.5	35,000
Amagasaki	120	176	0.68	calm				20.5	22	37,00
San Nicolas								13.1	18.3	80,000
Mocamedes								18.0	30.5	120,000
Porl hatta				(off-shore type)				15.2	22.8	60,000

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