BASIC DESIGN STUDY REPORT
ON
THE NORO FISHERIES INFRASTRUCTURE DEVELOPMENT PROJECT
IN
SOLOMON ISLANDS

MARCH 1989

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request of the Government of Solomon Islands, the Government of Japan has decided to conduct a Basic Design Study on the Project for Noro Fisheries Infrastructure Development in Solomon Islands and entrusted the study to the Japan International Cooperation Agency (JICA). JICA sent to Solomon Islands a survey team headed by Mr. Shiro Ebisawa, Director, Office for Overseas Fishery Cooperation, Oceanic Fisheries Department, Fisheries Agency, Ministry of Agriculture, Forestry and Fisheries, from November 6 to November 29, 1988.

The team exchanged views with the officials concerned of the Government of Solomon Islands and conducted a field survey in the Project area. After the team returned to Japan, further studies were made. Then, a mission headed by Dr. Shigeru Shimura, Fisheries Development Specialist, Institute for International Cooperation, JICA, was sent to Solomon Islands from February 12 to February 24, 1989, in order to discuss the draft report and the present report has been prepared.

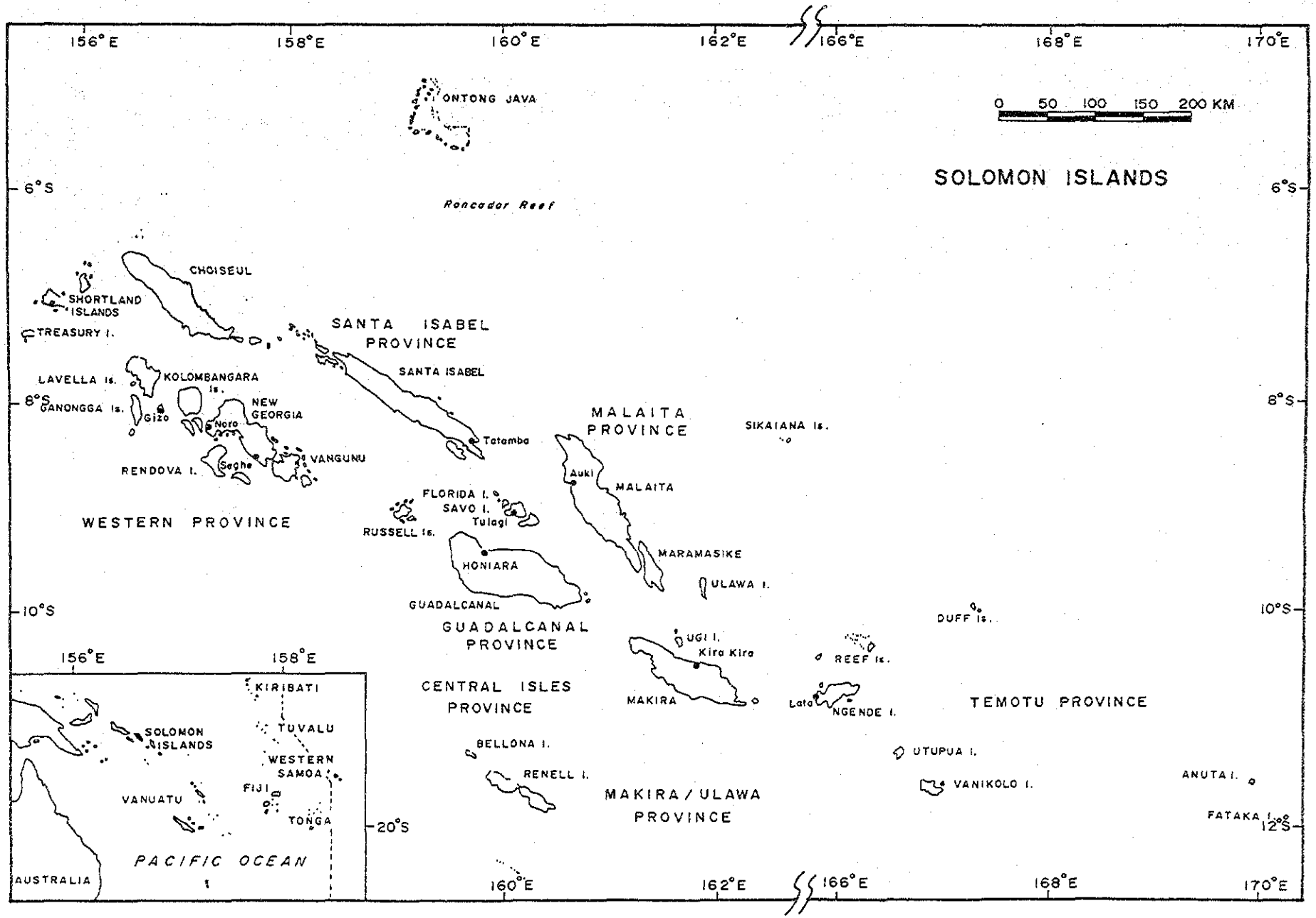
I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of Solomon Islands for their close cooperation extended to the team.

March, 1989

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency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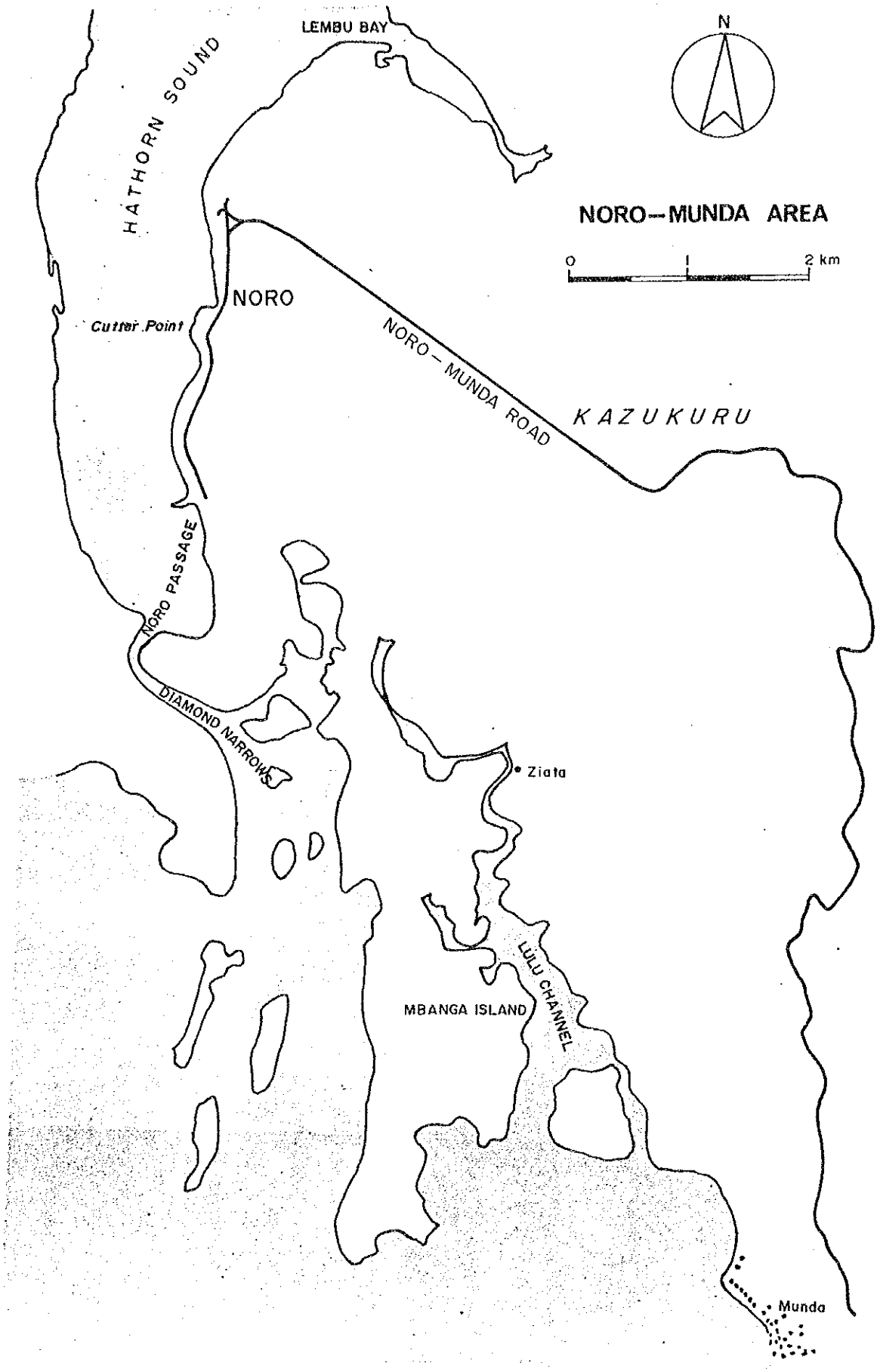
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MBANGA ISLAND
Munda

SUMMARY

The Solomon Islands are composed of a relatively large land area of 28,400 km^2 and a 200 mile economic zone of 1,630,000 km^2. There are rich skipjack and tuna resources in this vast economic zone, and the country's skipjack and tuna fishing industry has experienced spectacular growth over the past 10 years, thereby making a huge contribution to the national economy in terms of foreign exchange, employment, and the GDP.

The skipjack and tuna industry in the Solomon Islands has developed in Tulagi, in Central Province, and Noro, in Western Province. As part of its general policy of regional diversification, the Government of Solomon Islands has formulated a plan to develop Noro as the central city of Western Province. This plan, which is called the Noro Township Development Plan, envisages stimulating population growth in the Noro area through industrial development focusing on the fishing industry and has been implemented on the basis of the Government's 1985-89 National Development Plan. The basic urban infrastructure, comprising a deep-water wharf, water supply and sewage facilities, roads, and power generating facilities, has almost been completed.

As the second stage in Noro's development, the Solomon Islands Government has drawn up the Plan for the Development of Fisheries Infrastructure in Noro (hereafter called "The Plan"), whose objectives are to construct fuel storage facilities, cold storage facilities, and a Community Center to strengthen the area's industrial base, centering on the fishing industry. The Solomon Islands Government has requested grant-aid from the Government of Japan to bring this Plan to fruition.

Pursuant to this request, the Government of Japan, through the Japan International Cooperation Agency (JICA), sent a Basic Design Study Team to the Solomon Islands from November 6 to 29, 1988, headed by Mr. Shiro Ebisawa, Director, Office for Overseas Fishery Cooperation, Oceanic Fisheries Department, Fisheries Agency, Ministry of Agriculture, Forestry and Fisheries. The Study Team conducted a field survey, including boring

surveys, collected data, and discussed the contents of the request with the concerned authorities of the Solomon Islands Government.

Based on the survey, it was confirmed that: 1) the urban infrastructure in the Noro area is being steadily developed, based on an elaborate plan and solid long-term prospects; 2) the fishing industry in the area, based mainly on skipjack and tuna, has considerable room for further growth, from the standpoint of both Total Allowable Catch (TAC) and resource development potential for bottomfish; and 3) a policy of increased catches and added value would be highly effective in promoting the industry's development.

Based on discussions with the Solomon Islands Government, we reached the conclusion that, to achieve the Plan's objectives, it would be most appropriate to develop, on a priority basis, facilities to strengthen the production base along with facilities linked directly to improving the health and welfare of local residents, on a scale that would minimize the fiscal burden on the Solomon Islands Government. Following is an outline of the facilities required for the subject Plan, based on the findings of the Basic Design Study:

1. Oil Storage Facilities:

Tank	3,000 kl x 2 units
Administration building	1-story, concrete block construction; floor area-- 60 m^2
Oil pipes	Oil intake pipe, ø200, approx. 2.5km, buried Distribution pipe, ø150, ø100, partly buried
Fire fighting equipment	Foam-type

2. Shore Facilities:

(1) Wharf:

1) Landing wharf

Length	100m
Depth	-6.5m
Crown height	+1.7m

2) Repair wharf

Length	50m
Depth	-3.0m
Crown height	+1.7m

3) Wharf for small vessels

Length	20m
Depth	-1.5m
Crown height	+1.2m

(2) Shore Facilities:

1) Cold storage: Steelframe, 1-story, floor area $1,220m^2$
Storage capacity: 250 tons x 2 rooms = 500 tons, -25°c
Quick freezing equipment: 3 tons x 2 rooms = 6 tons, -35°c
Pallets: 2.25(l) x 1.25(w) x 1.2(h)m, 525 units
Forklifts: 2-ton electric type, 3 units
6-ton diesel type, 2 units
Weighing equipment: 2-ton bench scale, 1 unit

2) Administration building: Steel frame, 1-story, floor area $224m^2$

3) Small ice plant: Steel frame, 1-story, floor area $128m^2$
Ice making capacity: 500kg/12hrs, block ice

4) Workshop: Steel frame, 1-story, floor area $78m^2$

3. Community Center:

(1) Community Center: RC construction, 2-story, floor area $514m^2$

(2) Dormitory: RC construction, 1-story, floor area 593m^2

4. Related Facilities:

(1) Electrical facilities

Lighting fixtures, lighting and power circuit facilities

(2) Water supply and sewage

Water supply and sewage facilities, rain water tanks

5. Small Workboat:

11.2(l.o.a) x 3.5(b) x 1.3(d)m, 12gt (approx.), 130ps

6. Equipment:

(1) Training equipment

Workshop equipment for outboard motor repair

Fishing gear for training in fishing operations

(2) Basic clinical equipment

The implementing organization for the Plan up to the implementation stage is the Noro Fisheries Development Project Coordination Committee, which was specifically organized for this project. Upon completion, management will be delegated to various organizations, depending on the character of each facility. The oil storage facility will be under the supervision of a management company to be formed by the Investment Corporation of Solomon Islands; the shore facilities will be operated by the Solomon Islands Ports Authority, the Community Center by the Western Province Government, and the small workboat by the Solomon Islands Ports Authority.

It is anticipated that the oil storage facility, the shore facilities, and the small workboat can be operated on a self-sustaining basis. However, the Community Center, as a welfare facility for residents of Noro and the surrounding areas, will require an operating budget of about SI$29,000 per year, and so the Western Province Government will have to take steps to secure an appropriate budget for this facility.

Since the fisheries infrastructure to be established in Noro on the basis of the Plan would be used by the entire fishing industry, regardless of fish species or type, it will be a public facility available to all. Based on this new complex, it can be expected that the foundation of the fishing industry, oriented mainly to skipjack and tuna, will be significantly strengthened.

When we consider the enormous role the fishing industry already plays in the economy of the Solomon Islands, the development of this new fishery base in Noro can be expected to contribute in a major way to the restructuring of the nation's economy through an expansion of catches and an increase in added value. And there will be immense benefits as well from the establishment of this fisheries infrastructure in terms of developing Noro as the core city of Western Province.

Based on the above considerations, the Basic Design Study Team concludes that there is considerable justification for implementing the Plan on the basis of grant-aid from the Government of Japan.

CONTENTS

CHAPTER 1 INTRODUCTION

In the 1985-89 National Development Plan, the Solomon Islands Government has established the Noro area as a priority development area in Western Province and has set a goal of building this area into the core city of that province from both an industrial and cultural standpoint.

Pursuant to this Plan, the Government has, since 1986, been engaged in developing the necessary urban infrastructure, including an international port, a water supply and sewer system, roads, residential land development, and power generating plant, with completion targeted for March 1989.

In the wake of this infrastructure development, the Solomon Islands Government has also been developing the requisite facilities to expand industrial activity in the Noro area, centered around the fishing industry. To this end, the Government has prepared the Plan for the Development of Fisheries Infrastructure in Noro (hereafter called "the Plan") and has requested grant-aid from the Government of Japan to realize this Plan.

In response to this request from the Solomon Islands Government, the Government of Japan decided to conduct a Basic Design Study on this Plan. Under the auspices of the Japan International Cooperation Agency (JICA), it dispatched a Basic Design Study Team to the Solomon Islands, headed by Mr. Shiro Ebisawa, Director, Office for Overseas Fishery Cooperation, Oceanic Fisheries Department, Fisheries Agency, Ministry of Agriculture, Forestry and Fisheries. The team visited the Solomon Islands from November 6 to 29, 1988. The field survey involved reviewing the request by the Solomon Islands Government together with the contents and appropriateness of the Plan. The team also conducted a survey on the state of development in the Noro area, the implementing structure for the Plan, and the area in the vicinity of the Plan site, including bottom topography measurements and soil tests.

During its visit, the team held a series of discussions with officials of the Solomon Islands Government, and the results were compiled into a Minutes of Discussions, copies of which were signed and exchanged. After returning to Japan, the team analyzed the survey findings, evaluated the benefits that the Plan would bring to the development of the Solomon Islands fishing industry, and prepared a basic design of the most appropriate types and scale of facilities. The contents of this basic design have been compiled as a draft final report.

In order to explain the contents of the report, another team led by Dr. Shigeru Shimura, Fisheries Development Specialist, Institute for International Cooperation, JICA, was sent to Solomon Islands from February 12 to 24, 1989. The team reviewed and discussed with the concerned officials of the Solomon Islands Government the basic design study included in the draft final report.

This report incorporates the above results and contains the most appropriate basic design for the facilities of the Plan, the implementation plan, project evaluation, recommendations, etc.

CHAPTER 2 BACKGROUND OF THE PROJECT

2.1 National Development Plan

The Solomon Islands extend from 5-12°S and from 154-172°E.
The country is composed of 6 main islands and some 400 other islands of various sizes. Its land area is 28,400 sq. km, second only to that of Papua New Guinea among the Pacific Islands countries.

Since annual rainfall is 3,000-3,500 mm, and the country has a tropical climate and volcanic soil, it is endowed with well-developed forest resources. It is characterized by relatively hilly terrain, and potentially arable land is limited to only 3,400 sq. km, or only about 12% of the total land area. At the present time, an estimated 30% of total arable land is under cultivation.

The country's 200 mile Exclusive Economic Zone, on the other hand, extends over a broad area of 1,630,000 sq. km, and so the Solomon Islands are blessed with rich fishery resources. With regard to skipjack and tuna resources in particular, given their vital importance to the national economy, research efforts have been underway to estimate resource size and, at present, the annual total allowable catch is set at 75,000 tons.

Since independence in 1978, the Government of the Solomon Islands has been implementing a development policy in accordance with a National Development Plan, with the current Plan covering the period 1985-1989. However, in 1986, as a result of a recession caused by a slump in the prices of primary products in the international market, the Gross Domestic Product registered minus growth; in addition, a major cyclone in May 1986 caused severe damage, particularly to agricultural products. As a consequence, the Government was compelled to establish a more limited set of goals from among the wide-ranging objectives of the original 1985-89 Plan. The result was a "Programme of Action 1987-89", which was activated in 1987 and places top priority on rebuilding the nation's economic foundations.

Under this Programme of Action 1987-89, more urgent priority has been accorded to programs related to a strengthening of the production infrastructure in an effort to extricate the country from the export recession and negative economic growth. For this purpose, it has mounted a program aimed at effective utilization of aid and increased public investment, and has improved conditions for utilizing domestic resources and private energies.

The main export products from the Solomon Islands are copra, timber, fish, palm oil, and cocoa. However, export values are subject to wide variations in two respects: fluctuation in the volume of production, owing to climatic factors and purchase prices, and price changes on the international market for these commodities. It is, therefore, very difficult to stabilize foreign exchange earnings from exports.

Table 2.1 shows the trend in exports, by principal product, over the 1983-87 period.

Table 2.1 Principal Export Products

(in millions of SI$)

	1983	1984	1985	1986	1987
Copra	8.4	32.2	23.5	5.9	10.3
Timber	20.4	30.1	24.8	35.7	37.2
Fish	29.2	28.2	31.9	52.9	52.6
Palm Oil	8.8	19.1	13.7	6.0	6.6
Cocoa	2.3	3.4	5.0	6.5	9.5
Other	2.6	5.0	5.0	7.9	11.0
TOTAL	71.3	118.6	103.9	114.9	128.3

Source: 1987 Annual Report, Central Bank of Solomon Islands

As the above figures show, exports increased in 1984, reflecting a rise in international markets for copra and palm oil, fell back 12.4% in 1985, but recovered sharply in 1986 as a result of a marked increase in the

fish catch and an expansion of timber production. The good showing in 1987 reflected mainly a general recovery in world markets.

Imports, on the other hand, showed an 18% annual increase over the 4-year period from 1984-87, with the annual rate of increase for foodstuffs reaching 26%. The share of foods in total import value in 1987 rose to 15.7%, from 11.6% in 1984. About a quarter of all food imports are accounted for by rice, purchases of which have been increasing, owing to a halt in the domestic production.

Trends in imports, by principal category, are shown in Table 2.2.

Table 2.2 Main Imports by Category

(in millions of SI$)

	1983	1984	1985	1986	1987
Foodstuffs	8.2	13.1	15.7	18.0	20.2
(Rice only)	(0.8)	(2.1)	(2.8)	(4.1)	(4.9)
Fuel Oil	17.9	19.1	20.8	21.7	19.9
Machinery	18.5	20.1	27.0	39.0	39.3
Manufactured goods	17.4	20.2	26.0	31.7	40.1
Other	8.6	11.3	13.2	6.1	15.4
TOTAL	70.6	83.8	102.7	116.5	134.9

Source: Same as preceding table

Imports have been steadily growing year by year, not only as a result of quantitative increases but also as a consequence of the devaluation of the Solomon Islands dollar. The nominal balance of trade showed a deficit in 1987 of some SI$ 17,000,000, not serious in its own right, but, when imports are valued on a border price or a CIF basis, the deficit is aggravated by a major increase in payments for ocean freight and insurance attendant on the decline in the value of the country's currency. Thus, the value of imports in 1987 reached SI$ 165,700,000 on a CIF basis, resulting in a revised trade deficit of SI$37,400,000, which exceeded more than 29% of export value in that year.

The financial condition of the Solomon Islands Government in recent years shows a structure wherein revenues cover about one-half of expenditures, with the deficit covered by foreign aid. Ninety percent of revenues are derived from taxation.

The Solomon Islands Government has been holding down general expenditures in an effort to generate funds for projects under the Development Plan, but revenues continue to fall short of ordinary expenditures. Fiscal trends over the 1983-87 period are shown in Table 2.3.

Table 2.3 Government Revenues and Expenditures

(in millions of SI$)

	1983	1984	1985	1986	1987
Revenues	34.4	47.7	53.2	57.5	69.4
Disbursements	53.8	58.9	76.0	97.6	133.7
(Ordinary)	(39.2)	(46.1)	(59.0)	(65.7)	(77.1)
(Capital account)	(14.5)	(12.8)	(17.0)	(31.9)	(56.6)
Deficit conditions covered by:	19.4	11.2	22.8	40.1	64.3
(Grants)	(6.0)	(4.7)	(2.1)	(25.4)	(30.2)
(Foreign loans)	(7.7)	(4.6)	(6.8)	(18.3)	(35.1)
(Domestic sources)	(1.4)	(2.9)	(14.5)	(-1.6)	(-1.1)

Source: Documents prepared for the Round Table Meeting, Geneva, October 1988, Government of Solomon Islands

The country's debt service ratio was still below 15% in 1987, which is not considered a critical level. The Government, nevertheless, intends to exercise due caution in implementing future programs on the basis of commercial loans, particularly in the public sector.

The following table shows recent trends in foreign borrowing by the Solomon Islands Government.

Table 2.4 External Debt

(in millions of SI$)

	1983	1984	1985	1986	1987
Outstanding Foreign Debt	79	79	125	172	222
Debt Service	7.1	10.3	10.8	11.0	18.7
(Principal)	(1.9)	(2.8)	(4.6)	(3.6)	(10.4)
(Interest)	(5.2)	(7.5)	(6.2)	(7.4)	(8.3)
Foreign Debt as a percent of Exports	6.6%	8.7	10.4	9.4	14.6

Source: Same as preceding table

Over the above period, there has been a steady decline in the exchange value of the Solomon Islands dollar vis-a-vis the principal foreign currencies; between 1985-87, in particular, there was a substantial drop of 56% against the U.S. dollar. While the decline in the value of the currency has been effective in expanding exports and restraining imports, it has had an inflationary impact by raising import prices. As a result, the consumer price index for the capital, Honiara, showed a rise of 13.6% in 1986 (from the previous year) and 11% in 1987, but the increase is believed to have settled back to the 9% level in 1988.

Under the above conditions, the Solomon Islands Government is currently managing the economy in accordance with the Programme of Action 1987-89, which sets three principal objectives: a 5-6% annual GDP growth; bringing the rate of inflation down in stages to the 5-7% range; and building foreign exchange reserves to the equivalent of 3-4 months of import requirements.

The authorities are attempting to achieve these goals through a policy of tightening credit and restraining demand so as to plug the fiscal deficit, on the basis of curtailing expenditures while maintaining tax

revenues, and by according top priority to resource development in order to strengthen the nation's economic structure.

The various programs for resource development have thus far been prioritized on the basis of:

1) the amount of increased food production and cash income they will actually bring; and

2) their projected contribution to economic self-sufficiency and stability on the basis of their ability to create new employment opportunities, boost foreign exchange earnings, and increase government revenues, taking into consideration the fact that previous programs have emphasized mainly infrastructure development based on borrowings from international financial organizations, which have resulted, at the implementing stage, in an increased burden for the Government and, after completion, in the responsibilities of operating the new facilities.

As a result of the above priorities, new hope has been kindled in the areas of timber and fisheries products, which have shown spectacular growth in recent years. With regard to fishery products in particular, an increase in catches and added value can be anticipated as a result of the investment in large purse seiners and the start-up of a new cannery, and it is therefore expected that this will contribute meaningfully to job creation and the buildup of foreign exchange receipts.

It is felt that the most effective means of establishing a firm economic structure over the medium term is to expand and strengthen industrial activity. With the sound fiscal and foreign exchange base resulting from these efforts, there will also be a need for infrastructure related to product diversification and commercial development on the basis of small-scale production activity of a type which will involve local communities --which is, of course, a major long-term goal of socioeconomic development in Solomon Islands.

While a number of programs are already being considered in these directions, it is hoped that during 1989 they can be specifically built into the next National Development Plan for 1990-94, which is intended to solidify the overall structure.

2.2 The Fisheries Development Plan

Fisheries development has been accorded a high priority both in the original 1985-89 National Development Plan and in the Programme of Action 1987-89. The following six fishery development programs have been budgeted in the National Development Plan and are already underway or at the stage of planned implementation.

(1) Construction of Large Purse-seine Vessels

The construction plan has been executed for two skipjack tuna vessels in the 500 ton class to develop skipjack and tuna resources around the main islands group.

(2) The Fisheries Development Plan Phase II

This is a plan to strengthen the operational base of the national fisheries corporation, National Fisheries Developments Ltd. (NFD), via the improvement of pole-and-line vessels and a cannery feasibility study.

(3) Noro Fisheries Infrastructure

This program involves the development of cold storage facilities for fishery use, slipways, oil storage tanks, and housing in the Noro New Town area.

(4) Development of Village Fishing Enterprises

This program is to provide vessels, gear, and operating funds to 20 fishing groups operating at the community level in rural districts, based on existing Fisheries Centers.

(5) Giant Clam Breeding Pilot Project

This program involves the development of facilities for a hatchery and a coastal aquaculture center for giant clams.

(6) Coastal Bottom Fisheries Development Project

This project is intended to develop bottomfish fisheries and to demonstrate fishing gear and techniques for this type of fishery.

Fisheries are already positioned to make a major contribution to national development in terms of both generating foreign currency and creating jobs. The role of this sector is expected to become even more important in the future, at least over the medium term, with implementation of the various development programs moving ahead smoothly. However, from a longer-term perspective, two specific problem areas have been identified:

(1) Commercialization of rural fisheries, whose development has lagged far behind that of the skipjack and tuna industry, and the generation of new sources of cash income in these rural districts; and

(2) Improvement of the operating structure and profitability of NFD.

The solution of both of these problems will, in our judgment, require a considerable amount of time and the steady development of a series of programs oriented toward these goals.

The waters in the vicinity of the Solomon Islands are influenced by the south equatorial current which flows in a westerly direction. While there are no large rivers, fishery resources are abundant, owing to the prevailing natural conditions-- a relatively large land area of about

28,400 sq. km, the existence of a tropical rain forest, and a complex ocean bottom configuration.

Fishery resources in the coral reefs are particularly important to the artisanal fisheries and certainly contribute a major portion of the animal proteins consumed by the Solomon Islands people. However, an exact stock size for reef fish has not yet been identified in quantitative terms.

There are a number of bottomfish species with economic value. There are commonly found, at 100 - 200 m depths, Emmelichthyidae fish including small-toothed jobfish and ruby snapper, and at depths shallower than 100 m, Lutjanidae including redfin snapper and Lethrinidae fishes. These bottomfish are seen as very suitable for small-scale commercial development. However, the only feasible means of developing information as to the exact size of the resource and the amount of fishing effort that can be tolerated is to take steps to examine the data developed through the Coastal Bottom Fisheries Development Project that was initiated in 1988.

With regard to skipjack and tuna, abundant resources have been identified in the Solomon Islands area. Development is moving steadily ahead, and these species have already become an indispensable part of the nation's economy. In addition to skipjack, yellowfin, bigeye, albacore, striped marlin, sailfish, and dolphinfish are also taken in commercial quantities.

Skipjack and tuna are generally termed "highly migratory species", which are understood to migrate over a wide area. But skipjack and yellowfin populations have been discovered whose migration patterns are confined to areas in and around the Solomon Islands.

Skipjack resources are quite abundant in the areas enclosed by the six main islands group, while other rich resources have been found in outer waters and in waters to the southeast in Temotu Province. While the size of these resources has not yet been established, it is generally felt

that there is ample room for the development of skipjack resources in the southwestern Pacific, and so, in the Solomon Islands as well, efforts are being made to expand catches within the constraints of a policy of avoiding concentration of fishing effort in particular areas.

At present, the Total Allowable Catch (TAC) per year for the skipjack and tuna pole-and-line and purse seine fisheries in Solomon Islands waters is set as follows:

Main Group Archipelago	40,000 tons
Temotu Area	15,000
Balance of 200-mile zone	20,000
Total	75,000 tons

Pole-and-line vessels operate in the Main Group Archipelago, with a catch history as follows: 25,300 tons in 1985, 38,600 tons in 1986, 23,900 tons in 1987, and an estimated 31,000 tons in 1988. It is felt that little leeway exists for further expansion of fishing effort in these waters.

In waters outside the Main Group Archipelago, the purse-seine fleet is presently catching about 6,000 tons per year. Two large single purse seiners were added to the fleet during 1988, with full-scale operations scheduled to begin in 1989. Assuming that these two new vessels are able to catch 5,000-10,000 tons per year combined, the total catch capability of the existing skipjack and tuna fleets can be estimated at some 45,000-55,000 tons per year, a level that falls short of the existing TAC. Accordingly, it can be expected that the future development of the skipjack/tuna fishery will focus on methods to achieve optimum catch efficiency in waters outside the Main Group Archipelago. Efforts will also be called for to improve the efficiency of the fishing industry as a whole by rationalizing landing and storage methods and generating added value through processing.

2.3 Present Status of the Fishing Industry

The fishing industry in the Solomon Islands is polarized into a commercial-type fishery directed at skipjack and tuna, which occupies a key niche in the country's industrial structure, and a community-level subsistence fishery. There has been no development to date of the kind of small-scale fishing industry such as is often found in certain other countries of the Pacific Islands, which targets mainly high-grade bottomfish for sale on the domestic or export markets. The development of this type of fishery is highly desirable from the standpoint of the Government's policy of fostering economic development based on direct local participation, and so the authorities will be required to develop a number of programs to this end. Future progress in this area will have to await the results of the Coastal Bottom Fisheries Development Project, for which the experimental operations started in February 1988, on the basis of technical cooperation from Japan's Overseas Fisheries Cooperation Foundation, and the Development of Village Fishing Enterprises Program, which is expected to be implemented under the Third Lome Convention.

(1) Role of Fisheries in the National Economy

A number of distinct characteristics have been observed with respect to the position of the fishing industry in the national economy. First is the high share of fisheries in the GDP. Of the total $219 million GDP at factor cost in 1986, fishery production accounted for $23,900,000, meaning that 10.9% of GDP is generated by fisheries alone. However, included in this $219 million figure is $46,900,000 of non-monetary production (almost entirely primary products) and so, if we limit ourselves only to the monetary GDP, the share of fisheries rises to 13.9%.

Secondly, we may note the extremely important position occupied by marine products as a foreign exchange earner. As we have seen, the Solomon Islands have five main export products: fish, timber, copra, cocoa, and palm oil. As primary products, all are subject to price fluctuations on

the international market. Within this group, fishery exports in 1986 accounted for a full 48% of the country's export value and for 44% in 1987. As the nation's largest producer of foreign exchange since 1985, this sector is growing in importance with each passing year.

The export value of fish shown in Table 2.1 includes frozen, smoked, and canned products but excludes such marine exports as Beche-de-mer, shark fins, trochus shell, and pearl shells, valued at $1,990,000 in 1986 and $3,750,000 in 1987. It may be noted that the growth in exports of these non-fish marine products has been exceptionally rapid.

Fishery production in the Solomon Islands is expected to increase from the present level of 40,000 tons a year to about 60,000, given the absence of resource constraints and the increment in catches through the introduction of purse seiners. And, with the start-up of the new cannery, there will presumably be a major increase in exports of canned products of high added value. Thus, a continued increase in the share of fishery products in total exports may be anticipated.

Finally, the fishing industry has an important role to play in providing employment opportunities. Based on 1986 data, the total employment in the Solomon Islands was about 24,000 persons, of whom 7,250 were employed by the central government, 1,470 by provincial governments, 1,120 by other government agencies (e.g., public corporations), 12,490 by private industry, and 1,670 by other non-profit organizations and associations.

The number of Solomon Islander employees of the two Solomon Islands fishery companies come to about 1,300 combined, accounting for 10.4% of the 12,500 persons employed by the private sector. Thus, the role of this industry in employment generation is extremely important. With the decline in job opportunities in the timber products and agricultural sectors, high hopes are held for sustaining employment levels, through an expansion of the fishing industry, which has a powerful spill-over impact on related industries.

(2) Industrial Fisheries

The skipjack and tuna fishery in the Solomon Islands is dominated by two companies: Solomon Taiyo Ltd. (STL), established in 1973, and National Fisheries Developments Ltd. (NFD), established in 1979. STL is a Solomon Islands corporation, with 51% of its shares owned by the Investment Corporation of Solomon Islands (ICSI) whose shares are completely owned by the Solomon Islands Government. NFD, on the other hand, is 100% owned by ICSI--in other words, it is a state corporation. Thus, the Government directly participates in the management of both companies and has final responsibility for their operation.

STL presently operates 22 skipjack pole-and-line vessels in the 60-100 ton class (of which 10 are company-owned and 12 are on charter, with Okinawan registry) along with one purse-seine fleet. NFD directs its operations for both skipjack and tuna, using 12 company-owned skipjack pole-and-line vessels in the 50-100 ton class, one pole-and-line vessel of Tuvalu registry in the 100 ton class, and two large purse-seine vessels in the 500 ton class.

In addition to the fishing vessels of Solomon Islands registry, Japanese tuna longline vessels operate in the country's 200 mile zone under a fisheries agreement. U.S. tuna purse seiners are also authorized to fish in the northeastern area, representing about 10% of the Solomon Islands 200 mile zone, based on a comprehensive fisheries agreement between the U.S. and various Pacific Islands countries, which came into effect in June 1988.

The following table shows recent trends in fish landings by vessels of the two fishing companies in Solomon Islands.

Table 2.5 Fish Landings by Industrial Fisheries

(in tons)

1983	1984	1985	1986	1987
32,219	35,927	31,106	44,207	31,812

Source: Same as preceeding table

The 1987 catch dropped sharply from 1986, owing to unstable fishing conditions which developed during the latter half of the year. However, the landings in 1988 recovered to an estimated 40,000 tons.

The two new large purse seiners, purchased in 1987, are expected to start full-scale operations in 1989 and, assuming that these two vessels are able to take 8,000 tons of fish per year, even allowing for unpredictable changes in water temperature and other oceanographic conditions, the overall catch is expected to reach about 45,000 tons in 1989. However, even so, this catch level would still fall far short of the 75,000 ton annual TAC for skipjack and tuna, and so consideration is likely to be given to adding additional purse seiners as a means of improving fishing efficiency, reflecting the Government's policy of avoiding a concentration of fishing effort in particular areas in the interest of resource management.

Based on data for 1987, skipjack accounted for some 75% of the total catch by the skipjack/tuna fleet, yellowfin for 20.5%, and other species for 4.5%, with yellowfin incidental catch ratios characteristically high. The incidental catch of yellowfin by the purse-seine fleet averaged 46.6% over the 4-year period 1984-87. In the case of the pole-and-line vessels, based on information from industry informants, the average incidental catch ratio is believed to be in the neighborhood of 8-10%, though according to 1987 figures this ratio reached 12.6%. With respect to the incidental catch ratios for yellowfin for the two new purse seiners acquired by the NFD in 1988, subject to the results of the first year of

full-scale operations in 1989, it may be anticipated that values will be close to those recorded to date by the existing purse-seine fleet.

2.4 Background and Nature of the Request

The Solomon Islands Government, with the intention of developing Noro into the core city of Western Province both on industrial and cultural levels, has designated the Noro area as one of the priority development areas in its 1985-1989 National Development Plan. The Noro development plan, which was referred to as the Noro Port and Infrastructure Development Programme (hereafter called 'Noro Township Development Plan'), is a comprehensive urbanization program to create a new city through industrial development centering on fisheries by constructing an international port, a water reticulation and sewer treatment system, housing plots, a power plant and roads.

Western Province is composed of New Georgia Island, Choiseul, Kolombangara and other main and small islands. The land area is 9,312 sq. km, which is the largest among the seven provinces in Solomon Islands. The population based on the 1986 census was 55,400 people, which accounted for 19% of the total population. The provincial capital, Gizo, has been developed as a transshipment place for copra and timber since the British colonial days. However, the limited land area of approximately 60 sq. km and scarcity of flat land have been hindering development of social infrastructure such as an international airport and harbor.

As was the case at one time for transferring the nation's capital from Tulagi to Honiara, the Government has formulated the Noro Township Development Plan in the hope of building Noro into the main city of Western Province. The purpose of the Plan is to develop rich fishery and forestry resources in Western Province and to decentralize the population from the capital, Honiara. Under the Plan, the construction of a deep-water wharf, roads, a water reticulation and sewer treatment system and housing plots have been progressing with targeted operation from March

1989 with a grant from the EC, while the power plant was completed in 1988 with a loan from the Asian Development Bank.

The Solomon Islands Government has requested grant-aid from the Government of Japan for establishing an industrial infrastructure focusing on fisheries as well as facilities to provide cultural and welfare services to the residents, which, according to the Plan, are to follow the completion of the above urban infrastructure. The contents of the request were as follows:

(1) Fuel Oil Tanks and Piping

3,000 kl tank x 2

Piping, pump, extinguishing equipment, etc.

Accommodation for Manager x 1

(2) Cold Storage and Freezing Facilities

500 ton Cold Storage x 1

10 ton Freezing Facility x 1

Wharf (with Dolphin) 15m x 30m

Pallet Carrier (2 ton) x 4

Forklift (6 ton) x 2

Accommodation for Storage Manager x 1

Accommodation for Engineer x 1

(3) Slipway and Workshop

Slipway 30m x 1 (for NFD, STL and local boats under 150gt)

Workshop x 1 (for repairs and maintenance work)

Wharf 40m x 1 (for repairs and maintenance work)

Dock House for Captain and Engineer x 1

Accommodation for Dock Manager x 1

Accommodation for Master Engineer x1

(4) Community Center

The center will provide educational and entertainment rooms, first-aid and rest rooms. The building will be approximately 600 sq m.

Accommodation for Trainers x 5

Dormitory for Trainees (20 rooms) x 1

Accommodation for Center Manager x 1

(5) Market Center for Small-Scale Fisheries

Ice-making Machine (1 ton/day) x 1

Ice Store (5 ton) x 1

Truck (2 or 3 ton) x 1

Accommodation for Center Manager x 1

(6) Small Port Workboat

This boat is required for the following:

(a) Standby pilot boat

(b) Running ship lines to mooring points

(c) Towage of small fishing boats & others

(d) General workboat usage

Further to the requested items above, additional information regarding the operational organization has been provided by the Solomon Islands Government as follows:

Cold Storage and Freezing Facilities
-- Solomon Islands Ports Authority

Fish Market Center
--Western Province Government

Fuel Oil Tanks
--Lessee to be decided through tender

Small Port Workboat
--Solomon Islands Ports Authority

Community Center
--Western Province Government

Slipway and Workshop
--Under review

CHAPTER 3 NATURE OF THE PLAN

3.1 Objectives

The Noro area has been developing an urban infrastructure under a comprehensive township development plan and has also, since 1976, been developing as one of the Solomon Islands' main fish landing ports. It is hoped that the Solomon Islands' skipjack and tuna fishery will, in the years to come, grow rapidly in terms of both catch volume and value-added through processing after landing. The purpose of the subject Plan is to develop a fishery infrastructure in the Noro area to support this fishing activity and also provide needed facilities, on both the cultural and welfare level, for Noro's increasing population, a growth that is linked mainly to that of the fishing industry.

A major requirement in this fishery development program is to overcome the inadequacies in fuel supply and refrigerated warehouse facilities, which presently are a severe bottleneck in fishery development.

In the area of cultural and welfare services as well there is an important need for basic clinic facilities to raise the health levels of Noro and the surrounding areas as well as training programs geared mainly to young people. These services are considered vital to accomplishing the Plan objectives.

Fishery development in the Noro area will also contribute to the nation's overall fishery development, which occupies a strategic position in the country's economy. And, with a parallel improvement in social services, Noro can be built into the core city of Western Province on both the industrial and cultural level.

3.2 Review of the Request

In the course of the Basic Design Study, it was recognized that, with the international port, water supply and sewer system, and other infrastructure projects now almost completed, the various facilities under this Plan for developing the fishery infrastructure are vital to the future of the Noro area.

The objectives, the nature of the facilities, the management system, and the implementing organizations for the Plan were also deemed to be appropriate. However, with regard to the following programs, it was felt that some difficulties would be encountered in making them part of the Plan from the standpoint of either practical considerations or Japan's existing guidelines for grants-aid. As a result, on the basis of discussions with the concerned officials of the Solomon Islands Government, the Plan contents were modified accordingly.

(1) Employee Housing

It would be difficult, under Japan's present grant aid system, to provide single-family housing primarily for long-term personal occupancy. This point was explained to the Solomon Islands officials during the field survey, and they agreed to eliminate this item from the Plan.

It became clear during the survey that housing conditions in the Noro area are extremely difficult and that there is an acute need for residential construction. But, in view of the fact that Western Province has already started construction on 65 prefabricated homes from Australia with an appropriation of $3.5 million, indicating that the Solomon Islands authorities are achieving results in this area through their own efforts, we concluded that the elimination of the single-family homes would have no significant impact on Plan implementation.

(2) Slipway

Subsequent to the request for a slipway in the original request document, the Solomon Islands Government reconsidered the desirability of building this facility at the present time, reaching the conclusion that a final determination would be made during the next 12 months. The Government, therefore, asked the Basic Design Study Team to include the slipway provisionally as a survey item and defer a final decision on its construction until the implementation stage. The team expressed the opinion, based on a careful explanation of Japan's grant-aid system, that it would be difficult to include the facility on this basis and obtained the Solomon Islands Government's consent to its exclusion.

A slipway and repair facility already exists in Tulagi, Central Province, geared to steel vessels of 100-300 gt, and this facility is operated by Sasape Marina Ltd., a public corporation that is 100% owned by the Investment Corporation of Solomon Islands. However, since this facility is antiquated and often idle and is beset, in addition, by problems in the area of operating technology, it is not running smoothly. Recognizing that these facilities play an important role in supporting the fishing and marine transport industries as core industries in the economy, the Solomon Islands Government concluded a management agreement with a private Australian firm in September 1988 in a bid to restructure the operations at this facility.

Under these conditions, the Government has become concerned that the building of a slipway at Noro at this time might well result in a dilution and weakening of scarce manpower and operating technology in the country. The authorities will, therefore, closely monitor, over a period not to exceed 12 months, the progress achieved at Sasape Marina Ltd. and then make a decision as to the appropriateness of building a slipway at Noro.

Based on the findings of the field survey, the Noro area is used by over 60% of the country's skipjack pole-and-line vessels as a landing base, and an improvement in operating efficiency is greatly desired. In addition, the only slipway facility for up to 60 gt vessels in Western Province is at Gizo. It was recognized, therefore, that there is indeed a

great need for this facility among inter-island and domestic cargo vessels servicing the Western Province area. However, since responsibility for operations and maintenance after completion would lie with the Solomon Islands Government, it is only fitting that their final opinion regarding the desirability of the Noro slipway be fully respected. Accordingly, we decided to give consideration in our layout plan to a possible future site for a slipway to be used by fishing vessels in the Noro area.

(3) Fish Market

The resident population of the Noro area is presented, for the time being, around at 2,000 people. Figuring annual per capita fish consumption in the Solomon Islands at 26 kg, the demand for fish in the Noro area comes to about 52 tons per year. Based on the survey findings, a large quantity of skipjack and tuna is presently being landed at Noro, and various by-catch species are being distributed through a variety of channels. It has been decided, therefore, that there is little need for a fish market facility predicated on the development of new distribution channels. However, there is a demand for ice for small boats and canoes from nearby villages that converge on Noro to land copra and other commodities (for the return trip), and so a decision was made, with the consent of the Solomon Islands authorities, to include only the small ice-making plant and ice storage bin among the fish market facilities that had been originally requested.

3.3 State of the Noro Township Development Plan

Noro is situated at almost the western edge of New Georgia Island in Western Province (157°12' E, 8°13'S) about 300 km west-northwest of the capital, Honiara. Being located in about the middle of Hathorn Sound, there is little influence from wind or waves, while tidal variation is also small, at about 90 cm. In addition, tidal currents are quite weak, and there is a wide hinterland with very sharp sea bottom gradients. Noro is, then, a naturally good port.

Close to excellent fishing and bait grounds for skipjack and tuna, Noro has been developed as a landing base for these species as well as a collection and shipping point for copra. It enjoys, therefore, ideal conditions for growing into an industrial city with fishing as its core activity. Given this background, Noro has long been the logical central city of Western Province, displacing the provincial capital at Gizo, whose future development is handicapped by numerous physical constraints.

Concrete planning at the governmental level for the "Noro Township Development Plan" started in 1981, and, after a series of implementation surveys, construction work got underway in 1986. The area incorporated in the Township Plan extends some 3 km in a north-south direction, with the central portion designated as the port and commercial district, the northern side as the industrial area, and the southern side as a residential area. This is a truly comprehensive urban plan anticipating a population of 2,000-2,500 by the year 2000. The specific facilities and equipment encompassed by this Plan are summarized below.

a) Expansion of the International Port

...Large deep-water wharf
...Customs facilities

b) Industrial and Residential Infrastructure

...Roads

...Water supply and sewage

...Power plant

...Oil storage tank

...Housing construction

c) Expansion and Strengthening of Key Industries

...Construction of a cannery

...Expansion of fishery-related facilities

d) Improvement of Social Services

...Convention facilities

...Schools

...Hospitals

...Sports and recreational facilities

...Parks

...Government agencies

...Markets

Priority has been given to the infrastructure portion of the overall plan. The power station has been built with a loan of U.S.$7,200,000 from the Asian Development Bank; the deep-water wharf, roads, water and sewage facilities, and power transmission lines through a grant-in-aid from the EDF (European Development Fund) of U.S.$10,000,000; and the cannery with an investment by STL of SI$25,000,000. Some of these facilities have already been completed, and it is expected that by March 1989, all of the basic infrastructure will be ready for use. Following is a brief description of the principal facilities under the Noro Township Development Plan.

(1) Deep-water Wharf

This wharf is positioned as a facility that is essential to the development of a truly international port geared to the export of such products as copra, timber, and canned fish. It has been designed to

permit the direct berthing of large cargo vessels. The main specifications of the wharf are as follows:

Wharf length	:	62m
Plan depth	:	- 16m
Plan crown height	:	+1.7m
Structural method	:	steel pilings

The wharf will make possible direct berthing by large cargo vessels, that are expected to call at Noro as the country's No. 2 international port, and by large tankers. In addition, the wharf will be used by domestic cargo and inter-island vessels. The facility has been built entirely with grants-in-aid from EDF.

(2) Roads, Water and Sewer System

All of these infrastructure projects are being carried out under a grant-aid from EDF. The road project includes a trunk road, traversing the Noro area from north to south, branch roads, and local roads within residential districts. The trunk and branch roads are to be asphalt.

The water facilities will draw water from the Ziata River, about 5 km southeast of Noro. The water will be filtered and chlorinated and then supplied through a network of distribution pipes to the Noro area. The water supply project is being planned to supply sufficient water to meet three days' requirements by the year 2005.

Sewer facilities are just about completed, except only the installations to treat effluents, and are expected to become operational in March 1989.

Followings are the specifications of the road, water supply and sewer projects.

Roads:

Main trunk road	9 - 11.65 m wide, about 6.5 km long (paved)
Residential and other roads	

	5 - 6.75 m wide, about 4.1 km long (paved)
Drainage ditch	

Water supply and sewer:

Water tank	900 kl (effective storage volume)
Delivery capacity	45 l/second
Incidental equipment	Filter tank, chlorination equipment, control unit
Distribution pipes	Total about 17,000 m
Sewage sedimentation tank	About 1.6 ha

(3) Power Station

The plant supplies the Noro area with its power needs. Three units of 1,500 KVA generator have been completed. For the time being, two of these units are used to deliver power, with the third held in reserve. A foundation has also been built to allow for future mounting of one more unit. Since the construction work on the distribution pipes from the oil storage tank has now been completed, once the fuel starts to flow, pilot operations will become possible.

The generators are operated by the Solomon Islands Electricity Authority and SIEA plans to launch commercial operations from March 1989. It is expected then that power supply in the Noro area will be switched to a commercial basis.

(4) The Cannery

If Noro is to develop as a city, an industrial base must be nurtured, and the fishing industry has been designated as a core industrial section under the Noro Township Development Plan.

Since Noro is already a skipjack and tuna fishing base, the foundation for a fisheries city already exists. However, with the start-up of the cannery, 400 new jobs will be created, and the area will begin to acquire

the attributes of an industrial city. The operation of the cannery will have a profound influence on Noro's development in terms of increasing the amount of landings and fresh fish processing and improving the living standards of its employees.

Production capacity of the new cannery is ultimately expected to reach 1.1 million cases per year on a two-shift basis.

3.4 Natural Conditions of the Site

In determining the contents of the Plan, an environmental conditions survey was conducted the at the site relating to tide, current, depth, waves, soil characteristics (including borehole tests) and meteorological conditions and the obtained data were analyzed. The survey location map is shown in Fig. 3.1.

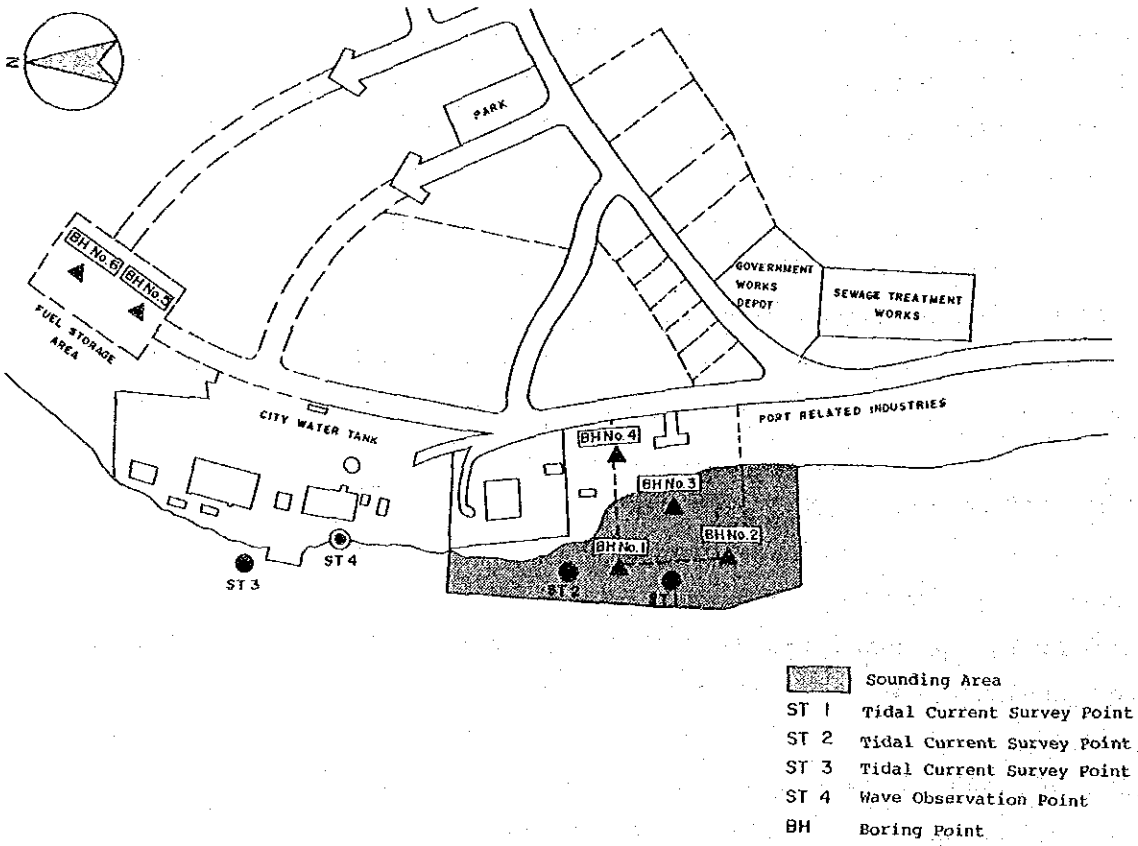


Fig. 3.1 Survey Location Map

3.4.1 Meteorological Conditions

(1) Winds:

There is no observatory in Noro and the weather records there are unobtainable. However, in Munda, some 13 km southeast of Noro, general meteorological observations have been continued since 1954. The subject area lies within the southeast trade winds belt and no conspicuous topographic difference has been found between Noro and Munda. It appears that Noro and Munda share similar weather characteristics. Therefore, we have utilized the weather observation records at Munda over 20-year period of 1968-1987, in order to obtain the meteorological characteristics necessary for the design and construction of the facilities.

According to meteorological observations at Munda, the subject area is a calm area, with generally weak winds. Based on monthly data on peak wind velocities over the 20-year period, the wind patterns are as follows.

1) Wind direction

Strong winds from May to November are mainly from the southeast; from December to April, they turn westerly. Table 3.1 and Figure 3.2 show the incidence of strong winds in the Noro area.

Table 3.1 Wind Incidence

D.	T.	PER.
N	8	3%
NNE	4	2
NE	10	4
ENE	1	0
E	25	11
ESE	13	6
SE	67	28
SSE	2	1
S	11	5
SSW	5	2
SW	31	13
WSW	12	5
W	35	15
WNW	1	0
NW	12	5
NNW	0	0
TOTAL	237	100

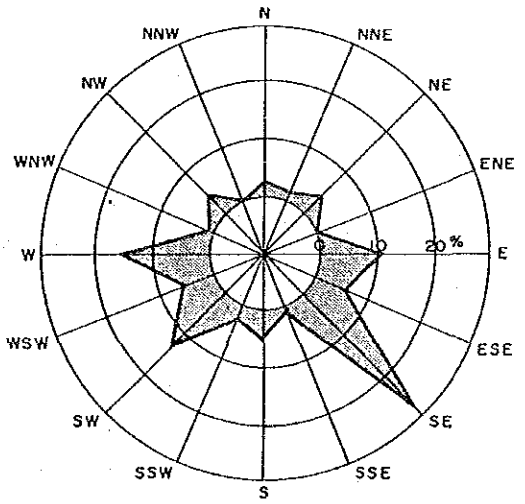


Fig 3.2 Wind Direction Frequencies

Based on the above, close to 70% of all winds in the area are accounted for by SE (28%), W (15%), SW (13%) and E (11%). These directions lie to the shore winds at the plan site and so do not cause high waves.

2) Wind velocity

Maximum wind velocity over the 20-year period has been about 20 m/s. Even when tropical cyclones pass through nearby areas, Noro often remains calm, with relatively low wind velocities. Velocity incidence patterns are shown below in Table 3.2 and Figure 3.3.

Table 3.2 Wind Velocity Percentage

VELOCITY	TOTAL	PERCENT
0-10(Kt)	75	31.6 %
11-20	137	57.8
21-30	22	9.3
31≦	3	1.3
TOTAL	237	100.0

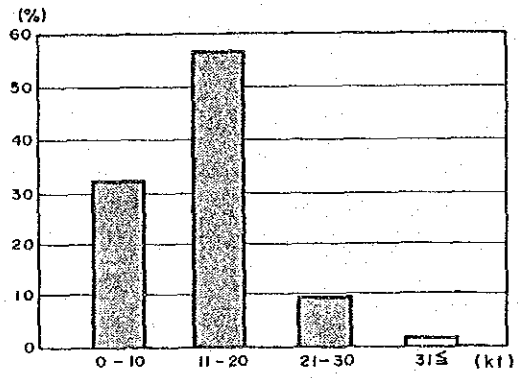


Fig. 3.3 Wind Velocity Frequencies

Based on the above data, 5-10 m/s winds account for about 58% of the total; 5 m/s for about 32%, or 90% for the two categories combined. Strong winds develop only once or twice a month, brought on by squalls, and their duration is not over one hour.

(2) Rainfall

Rainfall at Noro is typical of a tropical oceanic climate. Precipitation data are given in Figures 3.4 and 3.5 below.

1) Monthly Rainfall:

While a difference can be noted between the dry and rainy seasons, rainfall is generally high throughout the year, ranging from 200-400 mm/month. It totals 200-250 mm/month during the dry season and 350-400 mm during the rainy season.

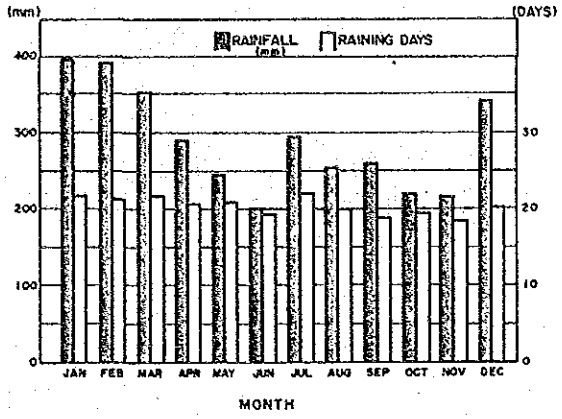


Fig. 3.4 Monthly Rainfall and Days

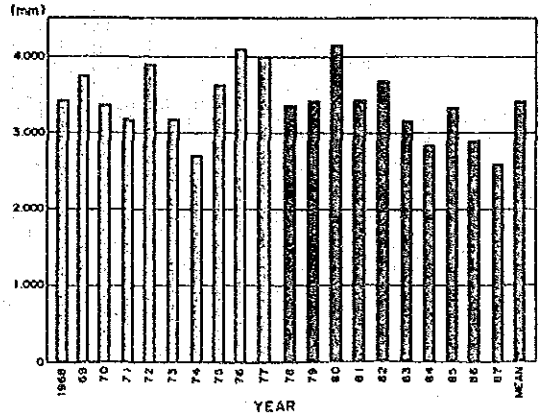


Fig. 3.5 Annual Rainfall

2) Number of Rainy Days

The number of rainy days shows a fairly wide dispersion over the year, but there is very little difference in the average number of days with precipitation between the rainy and dry seasons; the range is generally 19-22 days.

Rainfall is almost entirely associated with squalls and is regularly concentrated within a short period during the afternoon.

3) Annual Rainfall

Average annual rainfall is about 3,430 mm, a level quite characteristic of a high precipitation area. The annual range is from 2,600 - 4,100 mm.

(3) Temperatures

Figure 3.6 charts the average high and low monthly temperatures over the 20-year period. The monthly high is around 30°C and the low 24°C, with little monthly variation.

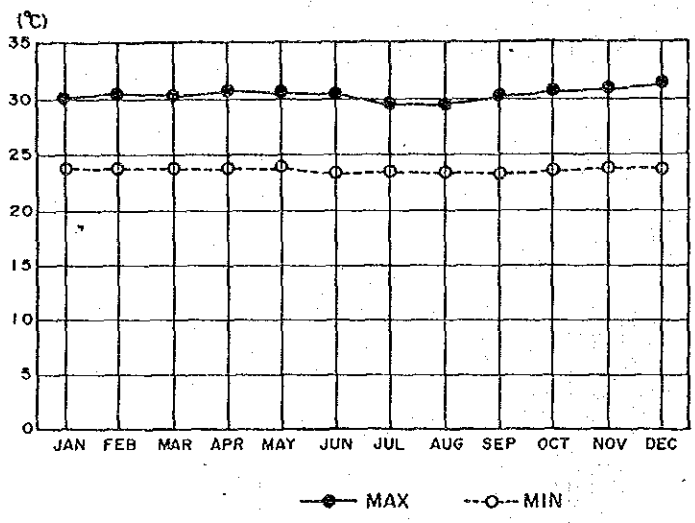
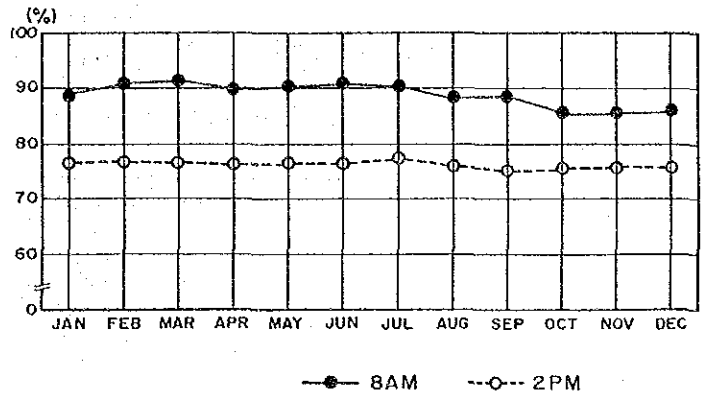


Fig. 3.6 Average Monthly Temperatures

(4) Humidity

Humidity patterns are characteristic of an oceanic type climate, with fog developing at night as a result of the cooling effect of moisture evaporation with the fall of temperatures. Fogs are most prevalent between 4-5:00 a.m., when the daily low temperatures are reached, bringing poor visibility and a sudden increase in humidity. Figure 3.7 shows monthly humidity patterns, comparing humidity at 8:00 a.m., just prior to the daily rise in temperatures, and at 2:00 p.m., the highest level of the day, just prior to the onset of the afternoon squalls.

Fig. 3.7 Average Monthly Humidity



The humidity at 8:00 a.m. shows an annual average of 88.8%, with a monthly range of 85-91%. It starts to fall in July, which corresponds to the season of lowest rainfall and rising temperatures.

The annual average at 2:00 p.m. is 76.1%, evidencing little monthly variation from the 8:00 a.m. readings, with an annual range of 75.2-77.3%.

3.4.2 Oceanographic Conditions

(1) Tides

In order to gain an understanding of tidal phenomena, tidal observations were conducted for 15 days, the minimum period required to compute harmonic constants. A harmonic analysis was made of the observation records, based on the Darwin Method. The various constants obtained are shown in Table 3.3.

Table 3.3 Harmonic Constants

SYMBOL	H(m)	K(°)	G(°)	NAME OF COMPONENT TIDE
M2	0.015	310.6	315.0	PRINCIPAL LUNAR
S2	0.023	185.5	201.1	PRINCIPAL SOLAR
K2	0.006	185.5	202.0	LUNISOLAR SEMIDIURNAL
N2	0.031	85.1	83.5	LARGER LUNAR ELLIPTIC
K1	0.281	205.8	214.0	LUNISOLAR DIURNAL
O1	0.049	197.7	193.9	PRINCIPAL LUNAR DIURNAL
P1	0.093	205.8	213.1	PRINCIPAL SOLAR DIURNAL
Q1	0.081	170.5	160.7	LARGER LUNAR ELLIPTIC
M4	0.011	247.8	256.6	LUNAR QUARTER DIURNAL
MS4	0.003	105.9	126.0	M2 + S2
A0	0.522			MEAN WATER LEVEL

NOTE) LATITUDE : 8-12-54 S LONGITUDE : 157-12-00 E
EPOCH : 1988-11-10-0 UNIT : METER
THEORY : T.I.METHOD FOR 15 DAYS

Based on these findings, the diurnal tides (k1, P1, and Q1) were predominant, with semi-diurnal elements (M2, S2, N2) very minor. Accordingly, as shown in the following equation, it can be seen that the tides have a distinctive once-a-day pattern.

$$1.50 \leqq \frac{K1 + O1}{M2 + S2} = \frac{0.33}{0.038} = 8.68$$

The observation period ran from November 10-24, 1988, so that there was no analysis of annual data. In view of the brevity of the observation period, it was not possible to examine phase differentials between the diurnal and semi-diurnal tides during the spring and fall lunar dates or to fully clarify the conditions at the various stages of the moon. Meanwhile, the crown heights for the shore-based and harbor facilities in the area were established as shown in Figure 3.8. The right-hand figures in Figure 3.8 represent actual data; the left-hand figures are those derived from the harmonic analysis conducted during the field survey. The datum level is +0.522, with Z0 derived from the Indian Spring Lowest Method as per the following equation.

$$Zo = So - (S2 + M2 + K1 + O1) = 52.2 - 36.8 = 15.4 \text{ cm}$$

While a difference of 15.4 cm can be seen in the datum level, the benchmark does not presently exist in the area and so the basis for this determination is not clear. However, the existing facilities have experienced no damage whatsoever to date from waves, tides, tidal waves of earthquake origin, or surging phenomena based on Seiche developing inside the harbor. There is, therefore, good reason to set the plan crown height of the new wharf under the Plan at the same level as the existing STL landing wharf.

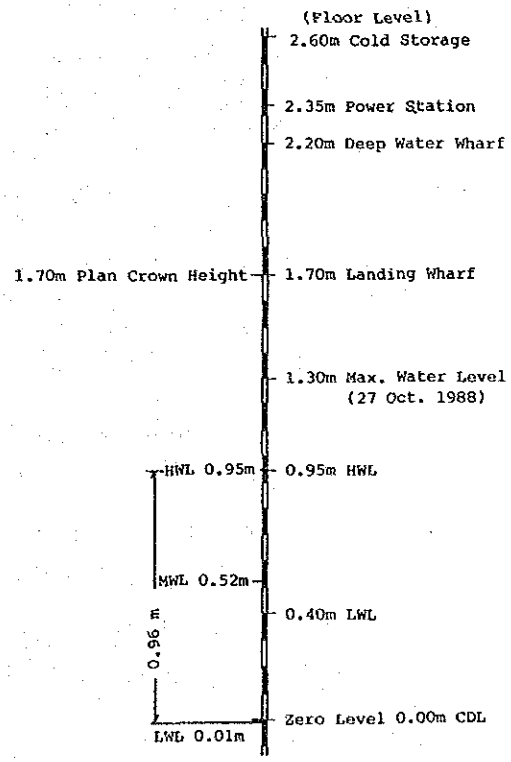


Fig. 3.8 Tidal Level

(2) Tidal Currents

Continuous around-the-clock observations of tidal currents were made at two points in front of the proposed site and another in the vicinity of the existing wharf (for a total of 3 points in all at 3 depths: 0.5, 2.0, and 5.0 m.) All 3 points and 3 depth layers revealed similar current directions and speeds. At the No. 1 observation point in the projected wharf area, a 24-hour harmonic analysis was made of tidal currents, and these were compared with the previous tidal constants, from which constants were derived for tidal currents.

The results of the computation are shown in Table 3.5 (harmonic analysis) and 3.6 (tidal elliptical elements for the sub-tides at the various depths).

The curves for sub-current speeds and the elliptical chart for tidal currents are given in Appendices-9 and 10.

Table 3.4

Maximum Values for Tidal Currents

Depth	Main Direction	Max. Current			
		Dir.	Speed	Dir.	Speed
0.5m	15 - 195°	29°	13.0cm/s	194°	12.4cm/s
2.0	25 - 205	35	13.0	204	10.1
5.0	25 - 205	34	7.2	207	10.3

The above maximum values represent the flow based on the flow phenomena of sea water based on the theory that the height of the sea surface periodically changes with the ebb and spring tides. In addition to tides, the horizontal flow of sea water is composed of such factors as the influence of topography, ocean currents, river currents, and wind-driven flow. However, the constant element in the vicinity of the site is extremely low.

Table 3.5 Diurnal Harmonic Analysis of Tidal Currents

P.T	N.D.		E.D.		Elliptic Factors						M.C. 343°	
					Long Axis			Short Axis				
	C.V.	Log	C.V.	Log	D.	C.V.	Log.	D.	C.V.	Log	C.V.	Log
0.5 m												
M2	0.4	285	1.3	145	285	1.3	322	15	0.3	232	0.7	305
S2	0.6	160	1.9	20	285	2.0	197	15	0.4	107	1.1	179
K2	0.2	160	0.5	20	285	0.5	197	15	0.1	107	0.3	179
K1	4.8	134	1.5	176	14	4.9	136	104	1.0	226	4.3	130
O1	0.8	126	0.3	168	14	0.9	128	104	0.2	218	0.7	122
P1	1.6	134	0.5	176	14	1.6	136	104	0.3	226	1.4	130
A0	-2.1		-0.4		2.1			191			-1.9	
2.0 m											51°	
M2	0.4	319	1.2	129	187	1.2	310	17	0.1	40	0.7	126
S2	0.5	194	1.8	4	287	1.9	185	17	0.1	275	1.1	1
K2	0.1	194	0.5	4	287	0.5	185	17	0.0	275	0.3	1
K1	4.1	140	1.8	171	22	4.4	144	112	0.9	234	3.9	151
O1	0.7	132	0.3	163	22	0.8	136	112	0.2	226	0.7	143
P1	1.4	140	0.6	171	22	1.5	144	112	0.3	234	1.3	151
A0	-2.5		-0.8		2.6			198			-2.2	
5.0 m											45°	
M2	0.1	354	0.8	121	275	0.8	302	5	0.1	32	0.5	115
S2	0.2	229	1.2	356	275	1.2	177	5	0.1	267	0.8	350
K2	0.0	229	0.3	356	275	0.3	177	5	0.0	267	0.2	350
K1	3.1	150	1.3	153	22	3.4	150	112	0.1	240	3.1	150
O1	0.5	141	0.2	144	22	0.6	142	112	0.0	232	0.5	142
P1	1.0	150	0.4	153	22	1.1	150	112	0.0	240	1.0	150
A0	-2.5		-1.5		2.9			212			-2.8	

P.T. Partial Tide
N.D. North Direction
E.D. East Direction
C.V. Current Velocity
D. Direction
M.C. Main Current

Table 3.6 Elliptical Element in Tidal Current

Depth	Lunar age date	Axis	M1			M2			M4			Constant	
			θ °	V cm/s	H h	θ °	V cm/s	H h	θ °	V cm/s	H h	θ °	V cm/s
0.5m	11/21	L	14	6.0	11.8	285	4.0	9.1	2	2.4	4.1	191	2.1
	-22	S	104	1.2	17.8	15	0.8	6.1	92	1.5	5.6	-	-
	11.8	S/L	0.20			0.20			0.06				
2.0	11/21	L	22	5.4	12.3	287	3.7	8.7	359	2.0	4.3	198	2.6
	-22	S	112	1.1	18.3	17	0.2	11.7	89	1.0	5.8	-	-
	11.8	S/L	0.20			0.05			0.52				
5.0	11/21	L	22	4.1	12.7	275	2.4	8.5	6	2.3	4.2	212	2.9
	-22	S	112	0.1	18.7	5	0.3	11.5	96	0.2	2.7	-	-
	11.8	S/L	0.02			0.11			0.08				

At all depths, we observed only a very weak residual current of 2-3 cm/s in a SSW direction. Similarly, the predominant tidal current was K1 (Luni-solar diurnal tide), with the main axis flowing in a NNE direction and a current speed of 5 cm/s.

Table 3.7 Residual Current

Depth	Direction	Speed
0.5 m	191 deg.	2.1 cm/s
2.0	198	2.6
5.0	212	2.9

From the above findings, it may be seen that the major components of the tidal current are a direction of NNE-SSW and a maximum current speed of 13 cm/S. However, the maximum speeds that can develop over the course of a year are; 20cm/s at 0.5m depth, 20cm/s at 2.0m and 15cm/s at 5.0m.

Accordingly, even if a new wharf is built as projected, although the main direction of the tidal current would be almost parallel to the face line of the wharf, the current speed would not be such as to interfere with vessel moorage or berthing.

(3) Waves

1) Design Wave Height

There are no wave observation records for the Noro area, and so wave estimates were made in order to compute design wave height.

Since Noro is located on Hathorn Sound, it enjoys favorable wave conditions. Swells and high waves from offshore have been cut off owing to the shelter provided by the islands. We thus carried out a wave analysis using the Sverdrup-Munk-Bretschneider (S.M.B.) Method.

The gale winds used for these estimates were of a tropical cyclone class or NE-NW winds of maximum velocity, which are considered the most dangerous in terms of wave development in Noro. The data base was wind observation records at Munda over the 34-year period 1954-1987. (Cf. Table 3.8)

Table 3.8 Maximum Wind Velocity

WIND (KT)					
NO.	YEAR	MONTH	NAME	D.	V(Kt)
①	1967	DEC	ANNIE	W	10
②	1968	OCT	GISBLLE	SE	16
③	1970	DEC	ISA	W	12
④	1972	JUN	IDA	W	30
⑤	1986	MAY	NAMU	SW	25
1	1954	AUG	--	NNW	25
2	1956	APR	--	N	15
3	1974	APR	--	NW	40
4	1981	JAN	--	NE	15

(1) - (5) are tropical cyclones

Even with the approach of a cyclone, the maximum wind velocity is below 15 m/s, while the wind duration is short, and so there is little effect on wave development. Thus, all in all, conditions are quite favorable in the area.

The wind direction of cyclones (1) - (5) show a fetch of about 1.5 km W and shore winds from the SW and SE, with wind velocity of 15 m/s or less. These cyclones were, therefore, eliminated from the calculations, and waves were determined vis-a-vis winds No.1 -4 as offshore waves (Ho) at point Ao shown in Fig. 3.9.

Table 3.9 Wave Estimates

					A_0		Noro	
	D.	V(Kt)	Fe(Km)	te(hr)	H_0 (m)	T(s)	H(m)	T(s)
1	NNW	25	25	2	1.2	4.2	0.5	4.6
2	N	25	150	1	1.2	4.7	0.5	4.7
3	NW	40	30	0.75	1.4	4.4	0.4	4.4
4	NE	15	50	1.5	0.6	3.7	0.3	3.7

The indentation phenomena based on sea bottom topography of the offshore waves (Ho), while reaching the Plan site, was not considered for the following reasons:

The period of the Ho is 3.7-4.7 sec, with wave length quite short, at 21.4-34.5m, and in view of the deep waters in Hathorn Sound, changes in wave crest and wave direction based on indentation are small, tending to move in a forward direction, and so the rate of attenuation in wave heights, based on indentation, is also small. Since the Plan site is exposed only to the north, diffraction phenomena are greatly influenced by the directions of the estimated waves.

Based on the above estimates, design wave characteristics have been set as follows:

Wave height	(H 1/3)	0.5 m
Period	(T)	5.0 sec.

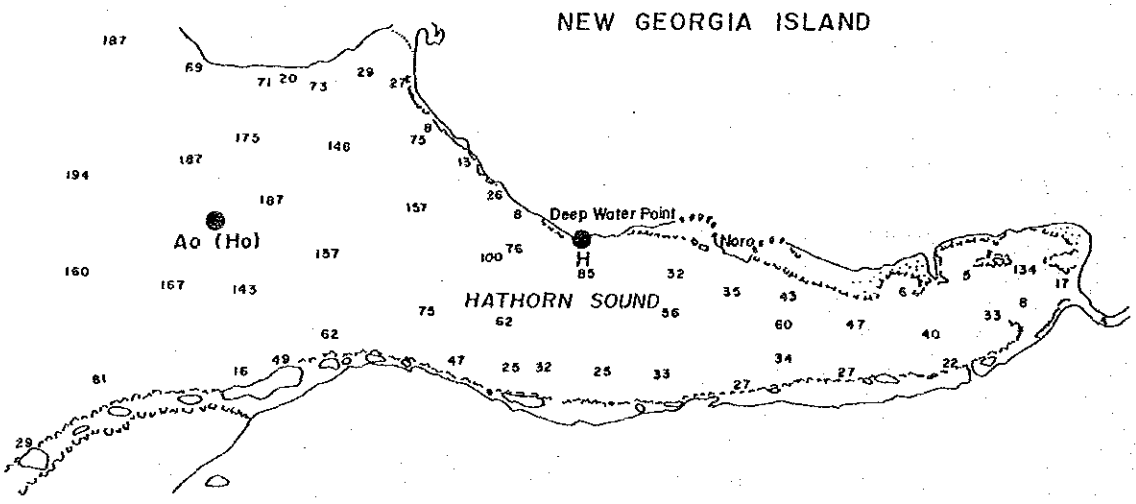


Fig. 3.9 Wave Estimation Points

2) Wave Observations

Wave observations were conducted twice daily at the site during the survey period, at 0900 and 1500 hours.

Table 3.10 Wave Records

DAY	TIME	WAVE	WIND	REMARK	DAY	TIME	WAVE	WIND	REMARK
11/ 8	-	-	-		11/17	09:00	0	0	
	14:00	0	0			15:00	0	0	
11/ 9	09:00	0	0		11/18	09:00	0	0	
	15:00	1	2-3	Squall		15:00	0	0	Squall
11/10	09:00	0	0		11/19	09:00	0	0	
	15:00	0	0	Squall		15:00	0	0	
11/11	09:00	0	0		11/20	09:00	0	0	
	15:00	1	2-3			15:00	0	0	
11/12	09:00	0	0		11/21	09:00	0	3	
	15:00	0	0			15:00	0	0	Squall
11/13	09:00	0	0		11/22	09:00	0	0	
	15:00	1	3-4			15:00	0	0	Squall
11/14	09:00	0	0		11/23	09:00	1	5-6	
	15:00	0	0	Squall		15:00	0	0	Squall
11/15	09:00	0	0		11/24	09:00	1	2-3	
	15:00	0	0	Squall		15:00	0	0	
11/16	09:00	1	3-4		11/25	09:00	0	0	
	15:00	1	3-4	Squall		15:00	0	0	Squall

The following conclusions can be drawn from the above table:

1) During the observation period, wave heights on most days were close to zero.

2) There were no waves of swell origin, while rough seas developing from squall winds were almost all about H 1/3= 0.3m, T=4.0 sec.-- lasting for about an hour or so.

3) White caps are seen at wind velocities of 4-6 m/s but show Ho/lo= 0.3-0.4 and are breaking waves. This type of wave (spilling breakers) moves gradually, with partial breaks.

4) Wave direction tends to be northerly--that is, almost parallel to the planned face line of the wharf. Thus, wave direction should pose no problems in terms of wave pressure acting on structures, safety of vessel mooring, or washing action of the waves.

(4) Depth Measurements

Depth measurements were made to obtain a detailed depth chart, as required for the port facility plan. This was done using an echo sounder installed on a survey boat. For shallow waters around coral reefs, lead was used. Vessel positions were obtained via sextants and scale tapes in

order to improve the accuracy of the data. The measurement line and station intervals were all set at 10 m. The depth chart is given in Appendix V-11.

3.4.3 Soil Conditions

(1) Subsoil Layers

The survey area is almost entirely coral limestone. Rock shaped coral reefs about 40 m wide and less than 1 m deep are found around 100 m from the shore, while deep elliptical lagoons (-2m) are found on the shore side of the reefs. Coral reefs in the Noro area are fringing, terrace-type reefs that are almost always connected to the island. In light of the above conditions, boring surveys were conducted at two locations on the projected wharf face line on the coral reef and at one location in the inner lagoon for the shore facilities site. The borehole logs are shown in Appendix V-12.

Fig. 3.10 presents the estimated soil layer sections of the planned face line of the wharf, based on the results of the borehole tests.

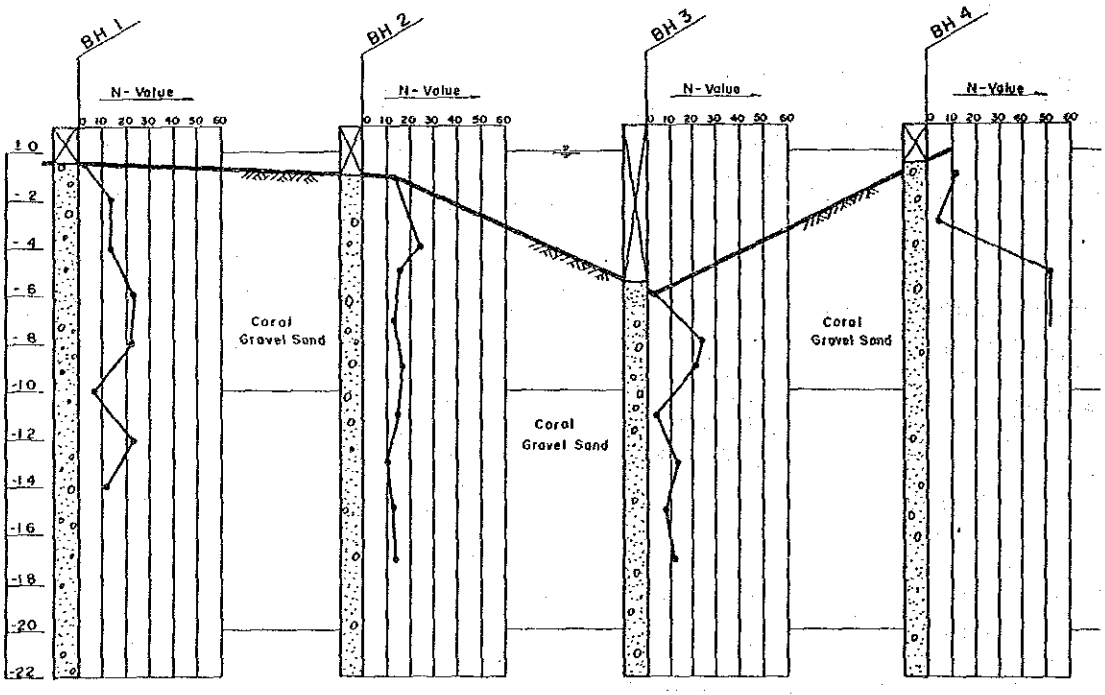


Fig. 3.10 Sectional Chart of Soil Layers

With regard to the soil layer composition of the subject sections, survey depths of up to 22 m revealed a mixed layer of coral reef and coral sand, with thin layers of coral limestone also occurring irregularly. N values, based on the standard penetration test results, were 4-25, which represents a medium-to-high value in terms of the relative density dispersion scale for soil layers.

N values for the coral limestone layers were not measured in this survey, but they are hard layers with a presumed N-value of 50 or more. Accordingly, since the soil layers are of sandy consistency, the design constants used in the wharf design were as estimated from the N values. The average N values for the soil layer are in the order of 10-15 and so, taking the dispersion scale into consideration, a design N value of about 10 would be appropriate.

(2) Soil Tests

Based on the results of the boring survey, BHI and BH2 exhibit similar tendencies. The particle size distribution curves for four samples from BH1 and BH3 are shown in Fig 3.11

At the demarcation line between sand and gravel, the passing particle at BH3 is about 30%, as opposed to 50% at BH1.

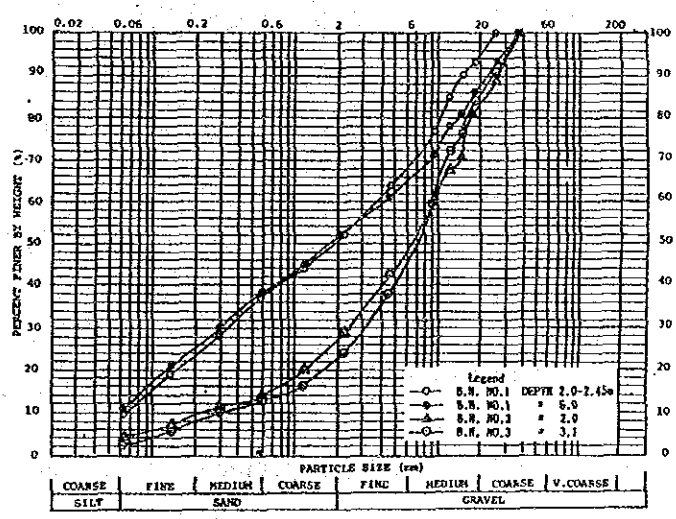


Fig. 3.11 Particle Size Distribution Curve

Soil has been sampled for the laboratory tests at random from the proposed site for the oil storage tank. We have obtained the following test results:

Particle size characteristics	
Gravel (>2,000 micron)	59.7%
Sand (74 - 2,000 micron)	25.5%
Silt (5 - 74 micron)	6.5%
Clay (<5 micron)	8.3%
Maximum diameter	38.1mm
Uniformity coefficient (Uc)	606.8
Curvature coefficient (U'c)	14.04
Specific gravity of particle	2.698

The above results show that the sampled soil contains 59.7% gravel as a major composition, with 8.3% clay, and thus the soil can be classified into GC under the Unified Soil Classification System. The plasticity chart has been derived from the liquid limit and plasticity index, as shown in Fig. 3.12.

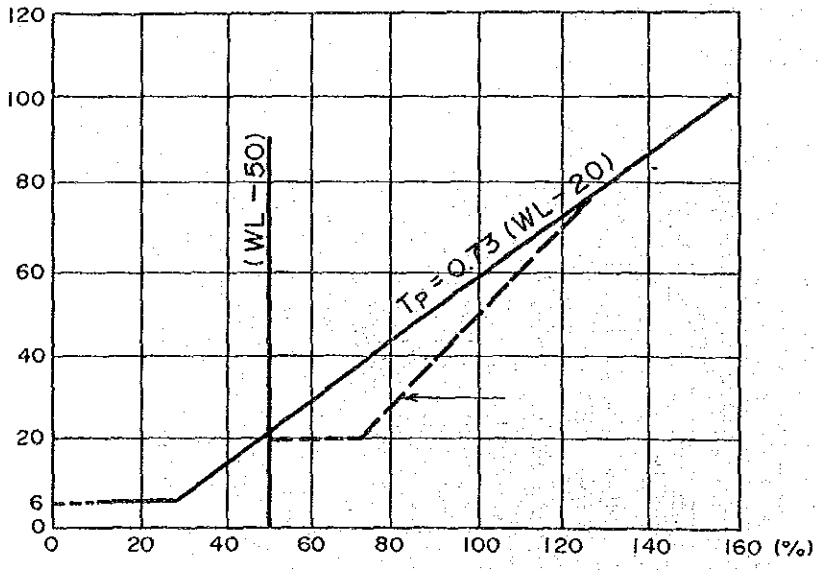


Fig. 3.12 Plasticity Chart

From Fig. 3.11, we can conclude the soil characteristics as follows:

(a) Permeability is large

(b) Dryness factor is small

(c) Volume change ratio is high

(d) Rigidity near plasticity limit is small

It has been judged from the above characteristics that the soil is suitable for use as filling material as well as roadbed and subgrade materials.

Fig. 3.13 charts particle size distribution curves. The particle distribution curves show a similar tendency to that for the BH1 conducted at the reef area of the projected landing wharf site and it can be estimated that soil at the reef area is also of coral limestone origin.

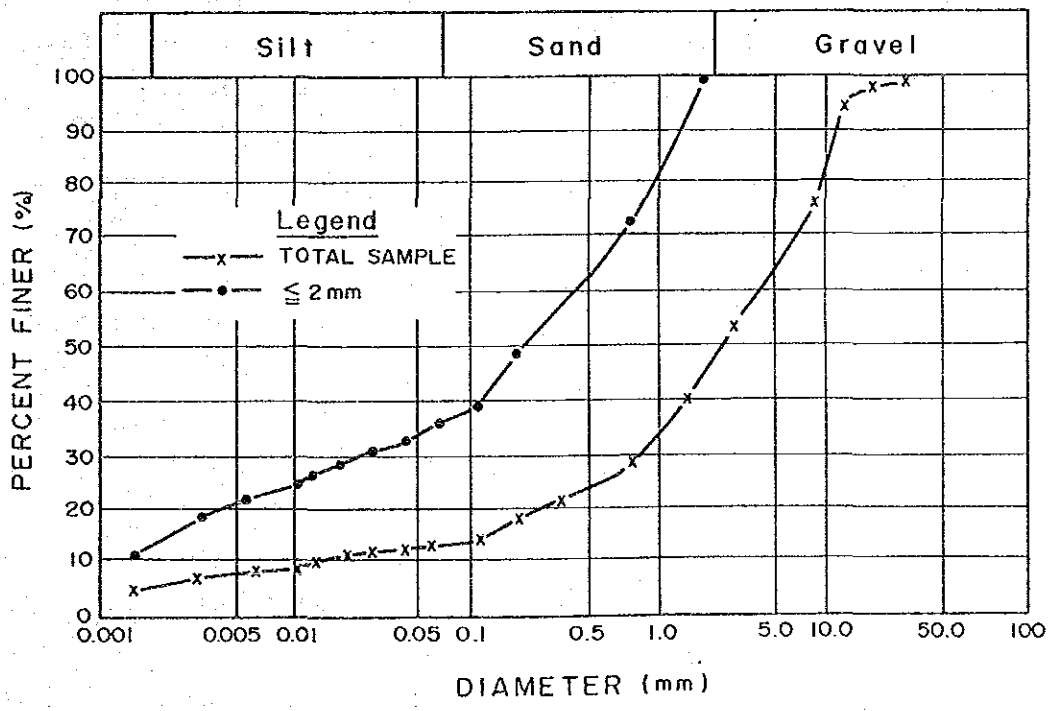


Fig. 3.13 Particle Size Distribution Curve

(3) Drift Sand

Drift sand may be classified by its moving characteristics into sand movement along the sea bottom by vortex and movement in the water by fluid pressure. The former is known as tractive sand drift, the latter as floating sand drift. These phenomena develop from wave action and, as

a result particularly of breaking waves, bring about changes in bottom depth and the shape of the beach.

Under the condition of the design wave (H 1/3 = 0.5m; Period T=5 sec.) which is determined on the basis of wave estimates, the maximum depth for moving the bottom sand becomes 1.7m, assuming the medium particle diameter ds=0.2mm.

The coral sand used in the landfill operations have gravel (2,000 micron or more) of almost 60% and sand (74 - 2,000 micron) of 25.5%; thus, gravel and sand are the major components. In addition, the fill area in front of the Noro cannery, in the vicinity of the deep-water wharf and in front of the power plant, shows no evidence of wave-induced erosion. The continuous duration of high waves (H 1/3 = 0.5m) is not more than 1 hour, and no erosion of the backfill sand will be caused by wave action.

3.5 Outline of the Plan Facilities

The target facilities for the Project are as follows:

Facility	Main Items
1. Oil Storage Facility	Oil storage tanks, intake and distribution pipe lines
2. Cold Storage Facilities	Quick freezer, refrigeration room, forklift, pallets, scale, administration building, wharf
3. Small Workboat	General-purpose small workboat for harbor use
4. Community Center	Clinic, meeting room, training room, and trainee dormitory
5. Small Ice Making Machine	Block ice making machine, ice storage bin
6. Outboard Engine Workshop	For use in training courses on the repair of outboard motors

Following is a brief outline of the subject facilities.

3.5.1 Oil Storage Facility

At present, the only oil storage tanks in the Noro area are the 750 kl facility owned by STL and the 400 kl tank for the SIEA power station which is expected to start commercial operations in 1989. But, since these tanks have been built for particular objectives, they are privately-owned facilities. Thus, it is necessary now to provide publicly owned tank facilities for unrestricted use as a means of stabilizing fuel supply and lowering fuel costs. The

following facilities and related equipment will be required for this purpose:

(1) Oil storage tank facility

Oil storage tank
Oil bund
Administration building
Fire-fighting equipment

(2) Distribution pipes

Fuel oil distribution pipes
Fuel oil intake pipe
Terminal facilities

The oil storage tank is to be situated to the north of central Noro. In accordance with API (American Petroleum Institute) standards, which have been applied to the installation of this facility, an oil bund and fire-fighting equipment will be required. The oil intake facilities from the tankers will have to be built on the deep-water wharf in the commercial port along with an intake pipeline to the oil storage tank of about 2,500 m. Fuel distribution pipes will have to be laid to the existing pipe connecting STL and SIEA tanks, and the new wharf in front of the cold storage to be provided under this Project. The fuel intake pipe will also be used for fuel distributions in the commercial port. In addition to the above oil storage tank and pipes, the access road which has been provided with EC aid up to the city water tank will have to be extended, while a small administration building will also be required.

3.5.2 Cold Storage Facilities

Fish landings at the Noro fishing base presently average about 2,100 tons per month, but they are expected to increase, starting in 1989, to the 2,500-2,600 ton level. The rated capacity of the existing

refrigerated warehouse is only 600 tons, but in actual practice there are times when supplies far exceed this capacity. Thus, fish carrier vessels with freezer facilities of the group purse-seiner time their return to port to coincide with the arrival of reefer cargo vessels and transfer their catches directly to the latter vessels. There is no denying that these arrangements are having an undesirable influence not only on selective storage but also on the efficiency of fishing operations in general.

In order to overcome the shortage in refrigeration capacity, it has become necessary to build refrigeration facilities to permit selection and storage geared to high-value yellowfin catches. Since the yellowfin is exported for canning, the storage temperature is to be -25°C. Other facilities that will be required in addition to the cold storage include a quick freezer for processing yellowfin before cold storage after it is landed in iced or chilled form; a wharf for landing and loading; and an administration building including offices, a storage area for equipment, and a maintenance workshop. For the storage of high-grade fish and the upgrading of stevedoring operations, the palletized storage method has been deemed most suitable, and so there will also be a need for pallets, forklifts, and other related equipment, such as weight measuring devices.

The wharf must be capable of berthing reefer carriers of about 4,000 tons. In addition, an area will be needed behind the wharf so that the shore-based facilities can be functionally placed, along with an area for catch selection and transshipments from purse-seine carriers berthing at the wharf. The discharge of catches by fishing vessels will be difficult while reefer vessels are being worked, but since existing facilities can be utilized at such times, there is no particular need to provide for these operations in the Project.

3.5.3 Small Workboat for Harbor Use

The port of Noro is under the management of the Solomon Islands Ports Authority (SIPA) and is the country's No. 2 international port after the capital, Honiara. Based on the consolidated development plan for the Noro area, a deep-water wharf (fronting on waters 18 m deep) is being built with a grant from the EC, which will make possible the direct berthing of large cargo vessels plying international routes.

When foreign vessels enter or leave Noro harbor, they are required to take on pilots, and all regulations in effect at Honiara port apply equally to Noro. Accordingly, starting in 1989, the Solomon Islands Ports Authority plans to adopt the same management at Noro as that now in effect at Honiara.

The SIPA serves Honiara with three vessels: a pilot boat of 32 ft. and 2 launches of 25 ft. and 16 ft. respectively. At Noro too, the intent is to provide the same services as at Honiara, which creates an immediate requirement for a small workboat to provide piloting services and handle other harbor duties.

The workboat is planned to meet the above objectives. Its functions are as outlined below:

1. Piloting and shuttling operations between the shore and boats moored in the harbor.

2. Assistance in guiding vessels to their berths.

3. Provision of floating hoses to oil tankers.

4. Tugboat services for barges.

5. Towing services for vessels whose freedom of movement is impaired.

Of the above functions, No. 2-5 require mainly tugboat capabilities. And, when considering the possibility of this boat being used also as a supply boat and for other general purposes, it must be given particularly good stability despite its small size.

3.5.4 Community Center

The Solomon Islands Government intends to develop the Noro area as the core city of Western Province, but even now the area already functions as a strategic transportation and economic hub for residents of the many islands scattered across this province. Given this background, there is a need to provide a Community Center as a training center for fishery courses geared to the entire Western Province area.

In addition, from the standpoint of providing health and welfare services to the fishing vessel crews, fishermen and residents of the Noro and surrounding areas, it is essential that the Center also include a clinic for medical consultations and primary care.

Given the high proportion of young people in the Noro area, it is also important that this Center be equipped with a meeting room and information facilities for cultural and other activities within the service area.

Accordingly, the subject Community Center will incorporate the following three functions together with management and dormitory facilities to support these functions.

(1) Training facilities.

(2) Meeting room and outdoor plaza for local cultural activities.

(3) A clinic with primary care facilities.

(4) Incidental facilities.

(5) A dormitory for trainees.

Following are the essential functions for each of the above categories:

(1) Training

The intent is to provide a training facility directed primarily at various ministries of the Central Government for training at the provincial level and at the Youth Congress organized by the Ministry of Home Affairs and Provincial Government.

The contents of these program, however, vary widely and consideration must be given to allowing flexibility in the use of the facility. The training courses that are presently being discussed may be classified as follows:

Training Courses

Group A: Courses with a strong outdoor element generating considerable noise and dust--

a) Carpentry, woodworking
b) Agricultural
c) Light electrical equipment
d) Outboard motors

Group B: Quiet, indoor courses--

a) Cooking and bread-baking skills
b) Sewing and cutting

Group C: Courses centering in classrooms--

a) Family planning
b) Home medical care
c) Business planning

d) Accounting

e) Project planning

(2) Cultural Facilities

The room requirements at the Center include a library, small conference room, and a multi-purpose meeting area. In order to achieve effective use of the facilities, reciprocal use of the various rooms should be considered.

1) Library and small conference room--

Information resources in the Noro area are limited, and so it is extremely important to provide information and knowledge through the medium of a library, videos, and the like. However, under present conditions, the number of books that the Center can store will be quite small, and it is difficult to image a sudden expansion in the library collection within the first few years. Accordingly, it is considered very likely that the reading room space in the library will double as a small conference room and as an area for social gatherings.

2) Lecture room--

This room will be reserved for courses under Group C above.

3) Multipurpose meeting area--

An assembly room or plaza to handle various types of meetings and events and to serve as a recreation area is an important priority for the Community Center, particularly in view of the high proportion of young people in the area. This type of facility can be realized through intensive use of the high raised floor areas-- i.e., the pilotis section-- which are well suited to the local climate and environment. It will be possible to activate the space as a sort of "facility outside

the facility". We have, therefore, reserved the pilotis area for this purpose in the overall plan.

(3) Clinic

The clinic facilities, which are intended to provide primary care, should be given careful consideration in developing facilities appropriate to the level of medical care in the area.

Medical facilities in the Solomon Islands may be divided into three categories: hospitals, clinics, and health centers. Hospitals and clinics are operated by the Ministry of Health and Medical Services of the Central Government, while the health centers are under the management of provincial governments. In addition to these public facilities, private facilities, operated mainly by churches, also play an important role in delivering medical care.

Although the clinic in this Plan is being handled physically as a part of the Community Center, its operation will be under the direct control of the Ministry of Health and Medical Services. In Western Province, there are presently hospitals at Gizo and Munda and 29 clinics. The personnel at these facilities is as shown below

Present State of Medical Facilities in Western Province (as of 1986)

	Hospitals	Clinics
No. of facilities	2	29
No. of beds	94	200
No. of physicians	4	-
No. of registered nurses	34	41
No. of nurse aids:		
trained	24	24
untrained	-	1

SOURCE: Solomon Islands Statistical Bulletin No. 15/87

The Ministry of Health and Medical Services anticipates that the clinic will be run by one permanent registered nurse, assisted by two permanent nurse's aids, under the general guidance of rotating outside physicians. The facility size and contents should be adjusted for operation and management by these personnel. The following functions will be required for the clinic.

1) Consultation room
2) Child welfare room
3) Anteroom for nurses
4) Other incidental facilities

(4) Incidental Facilities

The following rooms will be required under this category:

1) Administration office/Instructor's rest area
2) Manager's office
3) Lavatory and washroom
4) Entrance hall, stairs, corridor

(5) Dormitory for Trainees

This is a facility for boarding trainees from outlying areas at the Center and will incorporate the following functions:

1) Accommodations for trainees
2) Accommodations for instructors
3) Common areas

The required functions have been established in accordance with the above classification.

1) Trainee dormitory--

The Community Center is intended to serve not only the people of Noro but the entire Western Province area as well, and the curriculum will not be confined only to fisheries. The dormitory facilities too must be able to accommodate trainees from remote areas. At present, there are no public facilities for accommodation in the Noro area, and so the new dormitory will be an indispensable part of the Center.

During the field survey, it became clear that the dormitory need not be of the single-room type and that no problems would be encountered from multi-occupancy. We have, accordingly, allowed for two and four occupants per room.

2) Accommodations for instructors--

The likelihood is that instructors will reside at the Center for longer periods of time than the trainees. We have, therefore, decided to provide single rooms for the teaching staff, equipped with private showers and toilets.

3) The common areas will include the following:

a) Dormitory manager's office
b) Cafeteria, kitchen, lounge
c) Toilet and shower room
d) Storeroom
e) Entrance, lobby, corridors, stairs

3.5.5 Small Ice-making Plant

The ice from this plant is to be provided to fishermen and other residents in neighboring villages in the Noro area. Ice demand often develops for use during the return trips of canoes bringing copra and other products from nearby villages to the Noro collection area. As a result, this demand will not be constant. In addition, the major source of demand on a per-trip basis may be expected to come from the fish

collection vessel, Kuarao, which is operated by the Fishery Center in Gizo, the capital of Western Province. This vessel distributes ice in about 1.5 ton quantities when gathering fish from communities in western New Georgia Island.

Considering the high outside temperature, wide distribution area, and the long transport times, the type of ice produced at this ice plant should be block ice, which is convenient to store. The weight of one slab of block ice is 25 kg, which makes it capable of being handled manually. Since demand will not be constant, ice storage will be required to some extent, and we have, accordingly, provided for an ice storage bin with an inside temperature of 0°C.

3.5.6 Workshop for Outboard Motors

Noro's main characteristic is that of a fishing base, and so there is a great need for practical training courses in the methods of repairing disabled outboard engines belonging to residents of the city and surrounding communities.

The use of outboard engines is quite common in the Western Province area, so there is a clear need also for a facility that will train outboard engine technicians.

The workshop then, will be dedicated to this objective, and, based on the expected scope of its activities, should comprise a room for training in outboard engine repairs along with a storage area for parts and supplies.

3.6 Technical Cooperation

As will be discussed later in Chapter 6, the Solomon Islands Government is amply equipped to put together a suitable operating structure for the subject Plan facilities. In our judgement, the Oil Storage Tank, the Shore Facilities (including the cold storage), and the Small Workboat can all be self-sustainably operated.

Among the various facilities, the cold storage is the one that requires the most sophisticated technical skill in continuing operations, from the standpoint of both the equipment and warehouse management. Since the Solomon Islands Ports Authority is be in charge of this facility, there should be no problem whatever regarding the management structure. However, in as much as the main duties of this organization are in the area of port management, it is unreasonable to expect that it will have accumulated all of the technical expertise required for the operation of a refrigerated warehouse. From this standpoint, it is highly desirable that technical assistance be extended through the dispatch of two qualified specialists to provide guidance in equipment maintenance and warehouse operations. We believe that the dispatch of these specialists will raise the efficiency of operations not only in the cold storage facilities but in the other facilities as well.

CHAPTER 4 BASIC DESIGN

4.1 Basic Guidelines

The basic design has been developed as shown below, after taking into consideration the background and nature of the request, natural conditions in the area, and the condition of fishing and other industries therein.

1) The Plan contents have been developed to respond to functions that have been recognized as clearly necessary, and the scope of the facilities has been determined on the basis of appropriate demand forecasts, with a view toward minimizing maintenance and operating costs after completion.

2) Careful consideration has been given to the topography and oceanographic and meteorological conditions in the Plan area. The facilities have been designed to fit the climatic characteristics of the area in harmony with the surrounding environment.

3) Careful attention has also been paid to making the Plan compatible with the objectives and contents of the overall development plan in the area, particularly the shore-front development plan, including the shallow water portions.

4) In implementing the Plan, it is planned to use structures, materials, and building methods that reflect construction conditions in the area. A maximum effort will be made to contribute to the local economy by utilizing, wherever possible, local labor and construction materials during the construction phases.

4.2 Facility Plan

4.2.1 Oil Storage Facility

(1) Size Determination

1) The Tank Capacity

Consumption volume has been established by first determining the present annual consumption in the Plan area, and, with this as a base, then projecting future consumption for fishery use, the power generating plant, and the port facilities.

(a) Fuel consumption forecasts for fishery use

Total fuel consumption by the shore facilities and vessels of STL has been estimated at 9,002 kl in 1986, 8,947 kl in 1987, and 9,400 kl in 1988. Included in this volume is a maximum of about 150 kl per month for use by the shore generators; however, based on the actual consumption over the past three years, the average annual consumption is presently 9,100 kl.

Starting in 1989, the composition of the Noro-based fishing fleet is expected to change, and the resulting increase in monthly fuel requirements will be as follows:

Increases		Decreases	
(approximate figures)			
45 kl x 2 vess. =	90 kl	30 kl x 5 vess. =	150 kl
60 kl x 6 vess. =	360 kl		
Total	450 kl		150 kl

Accordingly, the net increase is projected at 450 - 150 kl = 300 kl/month or, based on the current 10 month operating year, an annual total of 3,000 kl.

The new power station, on the other hand, will start commercial operations during 1989 furnishing power to shore-based facilities at Noro. This will mean a decrease in fuel consumption of a maximum of 150 kl per month (1,500 kl per year), which have up to now been consumed by the shore generators.

From the above, the future annual fuel consumption, based on the present pattern of fishing operations, is expected to be:

9,100 kl + 3,000 kl - 1,500 kl = 10,600 kl

Starting in 1989, the pole-and-line vessels will be switching to year-round operations, which are expected to increase consumption by a factor of about 10%. Thus, the total annual consumption from 1989 onward by fishing vessels based at Noro may be forecast at:

10,600 kl x 110% = 11,600 kl

(b) Fuel demand projection for the power plant

The new power generating plant that is expected to come on stream in 1989 is expected to consume 4,590 kl of fuel per year, based on the following calculations:

Generator engine output	:	1,500 kva, 1,200 kw, about 1,800 ps.
Final average output	:	2 units x 75%
Fuel consumption ratio	:	165 gr/ps. hr. (estimated)
Specific gravity of fuel	:	0.85

Fuel consumption volume : 165 gr x 1,800 ps x 75% x 24 hrs. x 365 days x 2 units / 0.85 = 4,590 kl

(c) Forecast of fuel consumption by port facilities and other users

The fueling requirements for the commercial port, where a new deep-water wharf has been built, and the fishing wharf to be provided under this Plan will include foreign cargo vessels, reefer vessels, emergency arrivals in port, and the domestic cargo boats serving the Western Province area.

With respect to the foreign cargo vessels, the frequency of their port calls is low and so it may be assumed that the fuel demand at Noro for regularly scheduled general cargo vessels will be small. In the case of reefer vessels, since they do not follow regular routes, any fuel requirements will be strictly on demand. Thus, first priority should be given to domestic cargo vessels.

Other sources of fuel demand can be expected to develop from small fishing vessels, vehicles, machinery, and towns and villages in the Noro area. While, admittedly, this market is quite small, the Plan facility must, nevertheless, as a public-service facility, be geared to accommodate such requirements on a regular basis. The above fuel demand is expected to be irregular in nature and, since there are no figures on past requirements, is very difficult to forecast accurately. Nevertheless, in view of the fact that there are about 70 privately-owned cargo vessels of 10-100 gt at present in the Solomon Islands as well as about 20 inter-island vessels of 30-230 gt operated by the Solomon Islands Government, all of which cruise regularly to all parts of Western Province,

and based on an expected increase in future demand owing to the lower prices and more stable supply that the Plan facilities will bring, consumption from this sector may be forecast at about 150 kl/month, or 1,800 kl per year.

Combining the fuel requirements estimated in i) - iii) above, total demand may be forecast at 11,600 kl + 4,590 kl + 1,800 kl = 17,990 kl/year.

At present, there are two companies in the Solomon Islands that distribute intermediate petroleum products, and which operate two large tankers of 8,000 dwt and 34,000 dwt respectively. Judging by information provided by these companies, it may be expected that these large tankers will call at Solomon Islands ports 3-4 times a year. Assuming fuel deliveries, then at a rate of 4 times per year, the storage capacity of the oil tank may be calculated at:

17,990 kl / 4 calls/year = 4,497.5 ==> 4,500 kl

Fuel is taken on by these tankers at relatively distant ports. At the same time, the Plan facility is intended to supply fuel on a regular basis as a public utility and so must be at all times in a position to provide fuel at low prices. This means that the facility will have to store permanent oil reserves of at least 25% of consumption.

Accordingly, the required capacity of the oil storage tanks becomes:

4,500 kl x 1.25 = 5,625 kl

In order to lower prices of fuel delivered by the large tankers, the minimum level of supplies per call has been set at approximately 5,000 kl. Considering that there are virtually no

operating costs associated with the fuel storage tank facility and that there is considerable leeway at the Plan site, the planned tank capacity has been set at 5,625 kl ==> 5,700 kl.

To allow for repairs and maintenance shutdowns, the storage requirements will be divided between two tanks. Accordingly, the capacity per tank may be set at:

5,700 kl / 2 = 2,850 kl ==> 3,000 kl

The tanks will be circular, with a diameter of about 17.5 m and a height of about 13.7m.

2) Oil Bund

The installation of an oil bund is required by the specifications of the API, which are the governing standards for this facility. The API stipulates that, when storing fuel or other dangerous substances, an oil bund must be installed, as shown below, to prevent leakage.

(a) The capacity of the bund should be 110% of that of the subject tank, and a bund serving two or more tanks should be 110% the capacity of the largest tank.

(b) The height of the bund should be not less than 0.5m.

(c) When the diameter of the tank is less than 15m, it should be at a distance of at least 1/3 of tank height and, when 15 m or more, at a distance of at least 1/2 tank height.

Of the two tanks included in this Plan, the larger has a capacity of 3,000 kl. Accordingly, if the bund height is set at 1m, the required area for this facility will be about 43.5 m x 74 m.

3) Administration Building

This facility, which is intended to administrate tank operations, will comprise, by the very nature of its functions, an administration office, sleeping quarters, a materials storage room, and space for fire-extinguishing apparatuses.

Three persons will be working in the administration building; a superintendent, a general maintenance man, and a night watchman. Based on consideration of the space requirements for fittings and work areas, the required floor space for this building will be 60 m^2.

4) Fire Extinguishing Equipment

Fire fighting apparatus are essential in a facility storing dangerous substances, and the API regulations call for foam-type equipment. We have, therefore, set equipment specifications in accordance with these regulations.

5) Oil Intake Pipe

The oil intake pipe will run from the terminal at the deep-water wharf, the only place at which large tankers can berth safely, to the oil storage tanks. From a safety standpoint, the pipe will be buried. To prevent rust, epoxy-coated pipes will be used which will be given anti-corrosion treatment, in addition to cathodic protection.

Since the existing road is almost the shortest possible distance from the terminal to the oil storage tank and use of this road would eliminate the problem of land acquisition, the pipe will be laid along the side of this road.

Pipe diameter, based on the data shown in Appendix V-1, will be 8". The guideline used to determine diameter has been fuel intake from the tanker within a 24 hour period.

6) Fuel Distribution Pipes

Fuel distribution pipes will run from the oil storage tank to the oil pipe connecting the sub-tanks at STL and the SIEA power generator compound as well as to the commercial port and fuel dispensing station at the fishing wharf which is to be built under this Plan. The pipe will branch from the intake pipe at the closest point to the various receiving facilities. The pipe-laying method, materials, and rust-inhibiting methods will be the same as for the intake pipe described in 5).

The diameter of the distribution pipes has been set with a view to completing the refueling operation for the largest receiving facility (i.e., the power plant sub-tank) within normal working hours (8 hours). Based on the calculations in Appendix V-1, a 6" diameter will be used. However, for refueling purpose for vessels, 4" diameter pipe will be used.

7) Terminal Facilities

The terminal facility for the oil intake pipe at the commercial port will comprise a reverse-stop valve, a stop valve, and a hose-connection flange. A small hut will also provide storage space for the connecting hoses for the tanker (5 hoses of 8" each), fire-extinguishers, and other necessary equipment.

The terminal facility for fuel distribution to the fishing wharf, which is to be built under this Plan, will include a reverse-stop valve, stop valve, flowmeter, hose joints, and distribution hoses. These items will be stored indoors from security and safety considerations.

(2) Structural Considerations

1) Oil Storage Tank

Unless there are special reasons to the contrary, the accepted type of tank used for this purpose is invariably cylindrical steel. This is due to the fact that steel materials are the most efficient in terms of ease of tank design. This type of structure is deemed to be most suitable from the standpoint of cost and construction time, and so a cylindrical type steel tank will be used in the Project.

The Plan site is a gradually sloping area, running along the longitudinal center line, with a downward gradient of about 3-5m on both the southeastern and northwestern sides. Based on boring surveys at two locations, the standard penetration test value (N) showed values in excess of 50 immediately below the surface, confirming the existence of a solid foundation. Accordingly, there is no need for piles or soil improvement, and, if we employ an excavated foundation, it can be concluded that the conditions will permit use of the natural ground. Thus, the tank bottom will be placed on a sand layer spread over the excavated natural ground, with the surface area to be reinforced by reinforced concrete. The soil generated by the excavating operations (about 22,500 m^3) will be used as part of the backfill for the area to the rear of the landing wharf.

2) Administration Building

This has been designated as a small building with a floor area of about $60m^2$, using base modules of 4m x 5m. The function of this facility will be to supervise storage of a large volume of combustible materials, and so, from a fire-safety standpoint, a concrete block structure would be most appropriate.

(3) Finishing Materials

1) Roofing

In the small-scale facilities in the vicinity of the Plan area, the most prevalent type of roofing is galvanized steel sheet. But since the Plan facility is to be a management building for the storage of dangerous substances, there is a particular need to employ materials with adequate fire-retardant properties. As a result, it has been decided that the roof will also be concrete, as in the case of the structural materials.

The roof structure will be of the flat roof type which is frequently used in block construction owing to ease of construction.

2) Exterior Walls

Concrete blocks will be used for the exterior walls. Finishing materials will be mortar with spray paint.

3) Interior Finish

The floor finish for the office, machine room, and storage areas will be cement mortar, which has a long service life. The floor in the sleeping quarters and toilets, from the standpoint of residential use and sanitation, can be vinyl type flooring material and tile, respectively. Interior wall finishing will be cement mortar with a paint finish in the concrete block sections.

The ceiling finish will be painted plywood in the office and sleeping quarters and exposed ceilings in the storage areas and machine room.

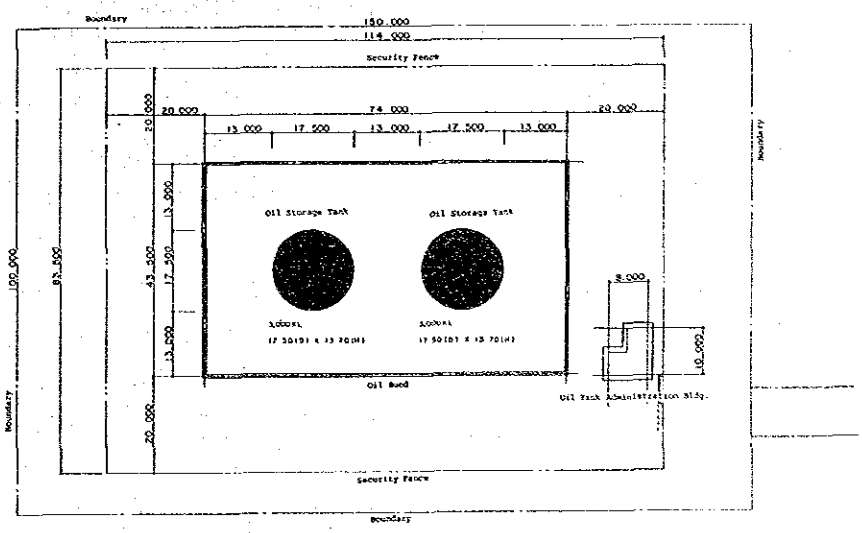
(4) Layout Plan

A 150 x 100 m area has been set aside for the oil storage facility. The site has a gentle downward gradient of about 3m to the eastern side.

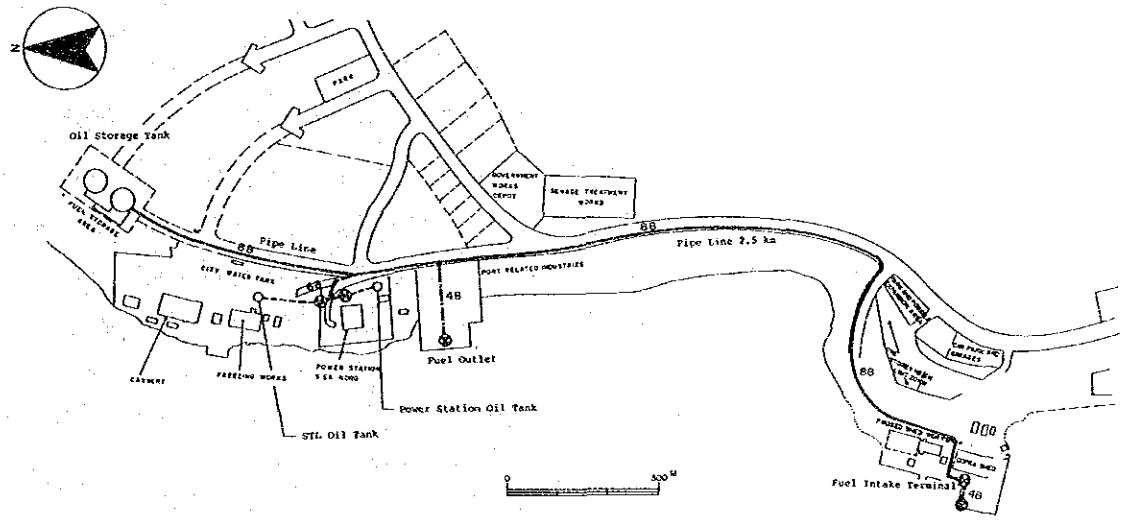
It is highly desirable that the tank, as a storage area for dangerous substances, be set back as far as possible from the property line. Accordingly, in this layout plan, the tank facility has been positioned in the central portion of the site.

The administration building for the tank has been located at the south-west corner, near the access road.

The layout plan and pipe-routing plan, based on the above considerations, are shown below.



Layout Plan for the Oil Storage Tank



Piping Route

4.2.2 Shore Facilities

This section will discuss the shore facilities to be constructed within the Noro port area. These include the cold storage, the administration building, the fish landing wharf, the workshop, and the small ice-making plant.

(1) Determination of Facility Size

1) Cold Storage

(a) Fish Landing Projections

From 1989 on, the main source of fish landings at the Noro base will be the 22 pole-and-line vessels (60-100 ton class) belonging to STL (of which 10 are owned and 12 chartered) and one purse-seine fleet. The breakdown of the Noro fishing fleet is as follows:

Table 4.1 The Noro Fishing Fleet

	No. of Vessels	Brine Hold	Ice Hold *1
STL: Owned vessels	10	(6)	(4)
Chartered vessels	12	(0)	(12)
Purse-seine fleet	1 *2	(2)	(0)

*1 Including chilled boats
*2 The purse-seine fleet comprises 4 boats; 2 of which serve as reefers

Average annual catches over the 5-year period 1984-88 by the skipjack pole-and-line vessels, as shown in Table 4.2, totalled 1,047 tons from the company-owned vessels and 1,240 tons from the chartered vessels. The probable mixture rate of yellowfin, the directed species, in the total catch, according to vessel operators, is in the order of 10% each year. In 1987, however, the rate was much higher, at 12.6%. However, for planning purposes, we shall assume a continuing rate of 10%.

Table 4.2 Catches by Pole-and-Line Vessel (tons)

	Company-owned	Chartered
1984	1,165	1,487
1985	857	999
1986	1,299	1,501
1987	792	1,002
1988(March-Oct.)	1,123	1,218
5-Year Average	1,047	1,240

Source: Fisheries Department Annual Report, Min. of Natural Resources, 1987 (1988 data based on interviews)

The average annual catch by the purse-seine fleet over the 4-year period 1984-87 was 6,160 tons/year, with the yellowfin incidence at 46.6%. The catch history for group purse-seiner is shown below.

Table 4.3 Catches by the Purse-seine Fleet (tons)

	1984	1985	1986	1987
Skipjack	3,097.0(57%)	2,314.4(38.7%)	3,062.0(52.0%)	3,398(46.3%)
Yellowfin	2.286.0(42%)	3,456.0(57.8%)	2,391.0(40.5%)	3,385(46.2%)
Other species	55.0(1%)	207.0(3.5%)	442.0(7.5%)	550(7.5%)
Total	5,438.0(100%)	5,977.5(100.0%)	5,895.0(100.0%)	7,333(100.0%)

Source: Same as preceeding table

The following table shows projected 1989 landings in the Noro area, based on past performance.

Table 4.4 Projected Landings (tons)

	Frozen	Iced	
Skipjack			
Pole-and-line			
Owned	6 vess. x 1,047 x 0.9 = 5,654	4 vess. x 1,047 x 0.9 = 3,769	
Chartered	-	12 vess. x 1,240 x 0.9 = 13,392	
Purse seiner	6,160 x 0.53 = 3,265	-	
	8,919	17,161	26,080
Yellowfin			
Pole-and-Line			
Owned	6 vess. x 1,047 x 0.1 = 628	4 vess. x 1,047 x 0.1 = 419	
Chartered	-	12 vess. x 1,240 x 0.1 = 1,448	
Purse seiner	6,160 x 0.47 = 2,895		
	3,523	1,867	5,390
TOTAL			31,470

Based on the above analysis, the annual projected landings of yellowfin in the Noro area work out to 5,390 tons-- 3,523 frozen and 1,867 iced. The pole-and-line vessels fish a 10-month year, the purse-seine vessels 10.3 months. Thus, the average effective catch per month comes to 530 tons. And, starting in 1989, all vessels will be operated throughout the year.

The ratios of peak monthly catches vis-a-vis average monthly catches for all pole-and-line vessels in the Solomon Islands are shown in the following table.

Table 4.5 Monthly Catches by Pole-and-Line Vessels

	1984	1985	1986	1987	1988*
Monthly average catch (A)	3,059	2,523	3,864	2,392	3,426
Peak month	5	7	11	4	8
Catch during peak month (B)	4,913	4,141	5,296	4,110	4,466
(B)/(A)	1.61	1.64	1.37	1.72	1.30

Source: Ibid. *(March-October)

The same analysis for the group purse-seine operations is shown below.

Table 4.6 Monthly Catches by the Purse-Seine Fleet

	1984	1985	1986	1987
Monthly average catch (A)	543	597	589	666
Peak month	7	12	1	1
Catch during peak month (B)	942	977	848	850
(B)/(A)	1.73	1.64	1.44	1.28

Source: Ibid.

From the above data, it can be clearly seen that, in every one of the years reviewed, the peak monthly landings came to at least 1.3 times average monthly landings.

(b) Capacity Requirement

The average monthly landing of yellowfin as a targeted species is 530 tons and, in peak months, at least 30% higher (689 tons). Assuming about one port call per month by reefer vessels, the indicated capacity requirement for the cold storage will range from 530 tons, on an average basis, to 689 tons in peak months.

Since the operating costs for this warehouse will vary directly with its size, setting capacity to accommodate peak supplies is not necessarily desirable. In any case, it is possible to deal with capacity shortages during peak periods by such methods as adjusting the arrival times of carrier vessels, better use of warehouse space, and direct loading of reefer vessels. In addition, starting in 1989, the Noro vessels plan to conduct year-round operations, including during lean periods, and so it may be anticipated that average monthly catches will slightly decline.

Accordingly, if the planned storage capacity is set at a level of 500 tons, just short of the present average monthly landings, the warehouse would be able to accommodate about 94% of monthly catches and 73% of peak month catches.

During the 3-year period 1986-88, exports of frozen fish from the Solomon Islands via reefer transport vessels were as shown below.

Table 4.7 Exports of Frozen Fish (tons)

	1986	1987	1988
No. of reefer vessels calling on Solomon Islands	25	20	22
Annual exports (tons)	39,600	26,400	27,000*
Average amount carried per vessel (tons)	1,584	1,320	1,227

Source: Data based on interviews (*: estimated)

In other words, the average load per reefer vessel over the past three years was 1,377 tons. The structure of fish transport is generally changing from one based on long-term contracts with particular shippers to spot contracts with unspecified shippers, which enables the vessels to maintain a more flexible schedule. Along with this change, there has been a continuing trend toward larger reefer vessels, which means an increase in break-even loads. As a consequence, there is, in our view, considerable economic logic, from the standpoint of reducing ocean freight for frozen fish, in shipping at least 1,000 tons per vessel.

Based on the above analysis, if the amount of fish stored in the cold storage is set at the equivalent of about 1 month's catch, the required capacity becomes 500 tons. On the other hand, if it is set on the basis of the most economical shipment size for reefer transport vessels, the ideal capacity becomes 1,000 tons. However, given the present lack of well-developed techniques for accurately predicting fluctuations in catches, the refrigerated warehouse plan must be predicated on a considerable variation in landings.

Accordingly, the most suitable strategy will be to select a storage capacity of 500 tons, a level which entails very small economic risk.

(c) Storage Layout

There are two possible methods of storing 500 tons of fish: 1) all in one room or 2) divided among a number of rooms.

Generally speaking, if in and out movement of a warehouse is balanced and the storage requirements are in line with its capacity, the single-room method is more efficient.

The storage cycle will start from a situation of zero inventory following shipment, with a gradual accumulation of new stock until the next shipment. If, then, the single-room storage method were chosen, during the first half of each storage cycle, the warehouse would be operating at only 50% of capacity, which would entail relatively higher operating costs than the divided storage method, giving rise to a major economic loss. In addition, considering the possibility of machinery breakdowns and the need for periodic maintenance checks as well as the need for ample lead time in procuring replacement parts, the risks associated with the single-room method, which leaves no fall-back alternative, are quite considerable. It has been decided, therefore, that the divided method (2) would be most suitable for the Plan's purposes.

With regard to the number of rooms to be provided, if the total storage volume is constant, there will be an inverse correlation between the number of rooms and storage efficiency (storage capacity - room capacity). Considering this factor along with the higher initial cost associated with a large number of rooms, we have elected to divide the total planned 500 ton storage capacity into two rooms handling 250 tons each.

(d) Storage Method

Fish storage methods include individual stacking, racks, and pallets.

Individual stacking bruises the fish, while cold air does not get through to the lower layers and the fish must be handled manually. This method, therefore, is not suitable for large-volume storage facilities. However, since it does have the advantage of good storage efficiency, this method is suitable for small-scale refrigerators handling small quantities of relatively inexpensive fish.

The rack method involves the storage of fish on racks inside the warehouse. Since this method also requires manual handling, even though it entails time limitations on movements into and out of the warehouse, this method is suitable for refrigerated warehouses handling a small volume of relatively high-value fish.

The pallet method involves the storage of fish on uniform-sized pallets, and so product can be moved on pallet units. On the one hand, bruising is minimal and handling quite fast; on the other hand, considerable space is required for movement by material handling equipment, such as forklifts. Accordingly, particularly in the case of small warehouses, storage efficiency is quite low. Thus, this method can be said to be suitable only for large cold storage handling a large volume of relatively high-value fish.

The capacity of the Plan facility (500 tons) is relatively large, while the value of the stored commodity (yellowfin) is quite high. And, since the entire 500 tons of fish must be discharged in a short period of time to coordinate with the arrival of carrier vessels, we have concluded that the pallet storage method would be the most appropriate for the subject facility.

(e) Pallets for Storage Use

Two types of storage pallets-- flat and box-shaped-- will be used. The flat pallets will be used for the storage of fish in bags or boxes, while the box type will be used for fish that are separately frozen, as in the case of yellowfin, the target species to be stored at the planned facility.

The pallet dimensions will be those that have been found to be easy to use, based on past experience. In the case of large fish that are not uniform in size or specifications, the most commonly used pallet size is 1 - 1.5 m (W) x 1.8 - 2.5 m (L) x 1.0 - 1.5 m (H).

In the case of the box-type pallet, we will use a size that is quite popular in Japan: 1.25 m (W) x 2.25 m (L) x 1.20 m (H). When storing frozen yellowfin, this size of pallet has a capacity of about 1 ton (0.4 ton/m^3).

(f) Cold Storage Rooms

i) Cold Storage

The capacity of each refrigerated room will be 250 tons. Since the capacity per pallet is one ton, 250 pallets will be required in each room.

In the case of pallet storage, the pallets are usually stacked in layers. A substantial stacking height is required in cramped urban-type facilities, but a low stacking height is much more efficient in terms of product handling. Generally speaking, 3-5 layer stacks are most commonly used.

In this Plan, the goods are to be discharged from the warehouse in large-volume lots and so good handling efficiency is a must. In addition, since there is relatively ample leeway at the Plan site, the 3-layer system will be employed.

Accordingly, the number of pallets per layer will be: 250/3 = 83.7 ==> 84 pallets. Allowing a space of 10 cm for the front-rear direction and 20 cm for the right-left direction between pallets, the required floor space becomes:

$$84 \times [(1.25 + 0.1)W \times (2.25 + 0.2)L] = 286.23m^2.$$

Sufficient space for forklift operations should be added to this figure.

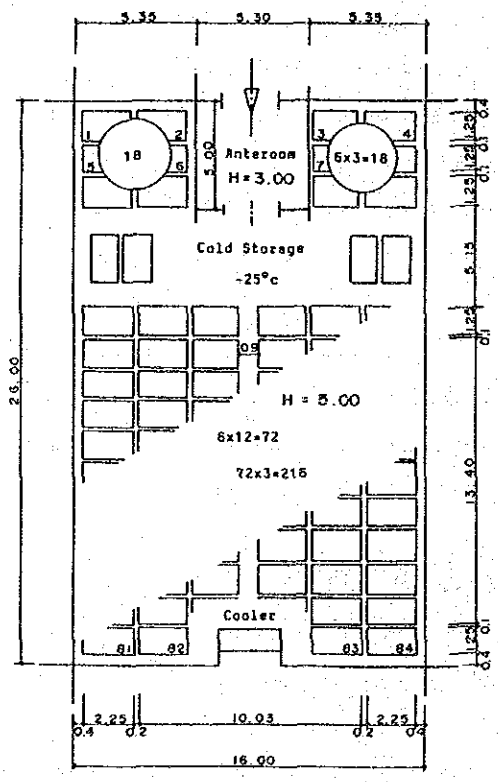
Ceiling height for 3-layer pallets, including a safety allowance, will be 5 m.

3 x 1.2 + 1.4 = 5.0 m
(pallet no.) (pallet height) (safety margin)

ii) Anteroom

The anteroom will serve as a buffer area to prevent heat loss by exchanging cold inside air with hot outside air during receiving and discharging operations. The floor area will have to be large enough to permit the passage of forklifts.

Considering the dimensions of the forklifts and the safety distance to the walls, the required floor space in the layout plan comes to about 26.5m^2. Adding space for lead corridors to the 286 m^2 area of the refrigerated room, the total requirement for the latter becomes 389.5 m^2. Further adding the 26.5 m^2 for the anteroom, the total area becomes 416 m^2. The plan is as shown below.



iii) Insulation

a) Walls and ceilings

As insulation in the cold storage, insulation material will be installed in the concrete and other structural members, while insulating panels will also be used.

The installation of insulating material to the structural members is frequently used in the case of multi-story structures, as seen in urban areas, where the site is subject to various restrictions. However, in the case of a single-story structure, the insulating panel method is most commonly used because it is economical, insulation efficiency is good, uniform insulation layers can be obtained with relative ease, and the construction period is short. In this Plan, the conditions clearly favor use of this technique, and so insulating panels will be installed in the walls and ceilings.

Since the warehouse operations will be by forklift, the panel specifications will be ribbed; the finish will be PVC coated steel sheets to avoid interior and exterior corrosion; and the insulation layers will use urethane foam material. Panel thickness in both walls and ceilings will be 150 mm in view of the high outside temperatures in the area.

b) Floors

Since the floor will have to support a heavy load from the three layers of pallets and the forklift operations inside the warehouse, the floor structure will be reinforced concrete. The insulating materials will be styrofoam, which has good pressure-resistance, with the upper surface finish to be poured concrete. Dehumidifying will be accomplished by sheets, with a dehumidifying layer to be installed above and below the insulating material.

To prevent freezing, a PVC ventilating pipe will be laid under the concrete flooring.

c) Heat-insulated doors

The insulation doors between the outside area and anteroom and between the anteroom and warehouse will be electrically operated. The faces will be stainless steel insulated by hard foam urethane. A defrost heater will be installed in the area outside the doors to prevent freezing.

In order to minimize the effect of outside temperatures, a plastic curtain will be installed in the anteroom along with an air curtain in the refrigerated area.

(g) Quick-freezing Equipment

i) Quick-freezing Room

In order to maintain freshness and quality in the fish, it is mandatory to avoid bringing fish that have been landed in iced or chilled form directly into the refrigerator for slow freezing. In terms of temperature control in the refrigerator as well, bringing the temperature of the incoming fish close to that of the cold storage is desirable from the standpoint of maintaining the quality of frozen fish already in the cold warehouse.

In the subject Plan, such fish will be quick-frozen prior to entry into the warehouse. The fish to be quick-frozen will be yellowfin landed by pole-and-line vessels in iced or chilled form, which totals 1,867 tons per year. Assuming that landings are made on 300-330 days in the year, the daily volume to be quick-frozen will come to 5.7-6.2 tons.

Since the fish is landed at different times of the day by a number of fishing vessels, it will be desirable, from the standpoint of cost and quality control, to divide the freezing operations into two batches. Accordingly, the quick-freeze facility will be divided into two rooms. If freezing operations are then geared to the volume of landings, the processing capacity per room becomes:

(5.7 - 6.2 tons) / 2 sections = 2.9 - 3.1 tons

The freezing room required to process these 3 tons/day will have two compartments. The temperature upon completion of the freezing operation will be the same as that in the cold storage (-25°C).

Possible freezing methods include brine, plate, and air-blast freezing. Considering the fact that the quality control and processing of 6 tons per day is a relatively large task and considering the entry and discharge operations by forklift, we have selected the air-blast method using freezing racks.

The size of the freezing racks has been determined on the basis of the following assumptions:

Target species: yellowfin

Average size:	body length	1.0 m
	width	0.4 m
	weight	25 kg

The rack weight (including fish), on the presumption that the fish will be handled by forklifts, will be 2 tons. Assuming that the unloaded rack weighs 0.5 tons and the frozen fish 1.5 tons, two freezing racks will be required in each freezing compartment. With rack size at:

2.4 m (W) x 2.0 (L),

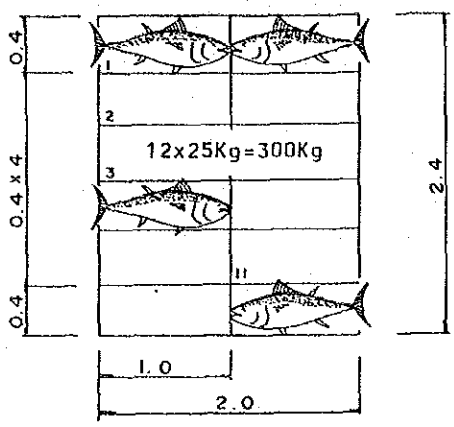
12 yellowfin can be loaded at one time. With five rows, the total rack load becomes:

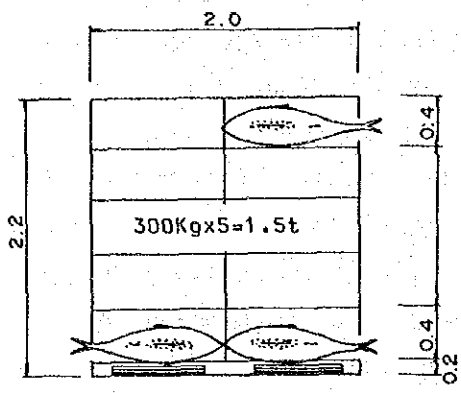
12 fish x 25 kg = 300 kg x 5 rows = 1,500 kg

Anticipating a space of 40 cm between rows and a base dimension of 20 cm, the rack height becomes 2.2 m.

Based on the above calculations, the rack dimensions will be:

2.4m(W) x 2.0m (L) x 2.2 m (H)





On the basis of the above arrangement, and taking into consideration the placement of the cooler and circulating chamber, the required floor area has been set at $60m^2$.

ii) Anteroom for Handling Operations

The operations to be performed in the anteroom include hand loading and unloading of the catch onto or from the racks and moving of the racks by forklift to the freezer room. Since the width of the anteroom will be the same as the freezer, here we will consider only depth measurements.

The total required depth will be approximately 12 m-- about 5 m for in-and-out movement by forklift and 7 m for loading and removal from the racks. On this basis, the required area will be about $180m^2$.

iii) Insulation Structure

Since the usage conditions for the freezer will be essentially the same as for the cold storage, the same wall, ceiling, and floor structure will be used.

The heat-resistant door will open manually in both directions to allow ease of movement, and a defrost heater will be installed to prevent freezing.

(h) Machinery Room

The machinery room will contain equipment for use in the refrigerated chamber and quick-freeze room.

i) Cold Storage

Given conditions--

a) Building size: 26m x 16 m x 5.0 mH (=2,080 m^3) x 2 rooms
b) Storage capacity: 250 tons x 2 rooms
c) Warehouse temperature: -25°C
d) Outside temperature: 33°C (relative humidity 80%)
e) Temperature on entry: -15°C
f) Heat resistant ceiling/ exterior walls: ribbed panels 150 mm thick
floor: styrofoam 150 mm thick

Based on the above conditions, the total cooling load per room, as per the load calculations shown in Appendix V-2, will be 30,300 kcal/hr.

ii) Quick-freezing Room

Given conditions--

a) Freezing volume to be handled: 3 tons x 2 freezing units
b) Freezing time: 18 hours
c) Temperature on conclusion of freezing: -25°C
d) Temperature on intake: 10°C
e) Room temperature: -35°C
f) Freezing point: - 2°C
g) Residual freezing heat: 57 kcal/kg
h) Specific heat: prior to freezing-- 0.82 kcal/kg °C
after freezing-- 0.46 " "

Based on the above conditions, the total cooling load, as per the load calculations shown in Appendix V-2, will be 22,400 kcal/hr.

Following are the equipment requirements established from the above load estimates.

Cooler:	30 kw x 4 units
Condenser:	2 units
Receivers (high/low pressure):	1 each
Control panel:	1
Back-up generator:	300 kva x 1

After allowing for placement of the above equipment and providing space for receipt, discharge, and maintenance, the required floor area has been set at approximately 150 m^2.

(i) Handling Area

A handling area will be required in front of the warehouse to provide space for sorting the catch on receipt and discharge. In this Plan, ample space has been provided to permit full utilization of the forklifts for sorting in front of the warehouse entrance, with a view to improving efficiency.

(j) Cold Storage Equipment

i) Pallets

Pallets are intended to improve the efficiency of fish loading operations at the cold storage, and so we plan to use steel pallets with a high compression and pulling power. The inside dimensions of the Plan pallets will be approximately:
1,100 mm(L) x 2,100 mm (W) x 1,100 mm (H),
with a capacity of 2.5m^3.

If the fish being handled are yellowfin, the weight would be 400 kg/m^3, and so a load weight of about 1 ton/pallet can be expected. Accordingly, to handle 500 tons of yellowfin, 500 pallets would be required.

Considering the number of pallets in need for repair due to the impact of forklift operations along with regular maintenance, it would be appropriate to provide a 5% reserve supply of pallets. Thus, a total of 525 pallets would be satisfactory. And to extend the useful service life of the pallets, they will be treated with hot-dipped galvanized coating.

ii) Forklifts

a) Forklifts for use inside the warehouse

These forklifts are intended to move fish into and out of the cold storage. Since they will operate mainly inside the warehouse, we have specified electric forklifts with -25°C specifications. With the load weight per movement at about 1,000-1,500 kg, allowing an extra margin, the load weight has been set at 2 tons.

When a reefer vessel arrives at port, the fish must be withdrawn from the warehouse in a very short period of time. However, since the operating time is figured at about 3 minutes per unit, the total elapsed time required to move all 500 pallets would be about 25 hours (1,500 minutes).

The total time of continuous forklift operations, under conditions of 100% load, would be 300 minutes. If the unit is recharged at some point for one hour, this time can be extended another 10%. However, since normal output is 50-80%, a 65% figure is used here. On this basis:

$$300 \text{ min.} \times 1.1 / 0.65 = 508 \text{ min.}$$

And, with a one-hour recharge,

$$508 + 60 \text{ minutes} = 9.5 \text{ hours,}$$

which is a proper cycle for one shift.

Accordingly, figuring 9.5 hours of operation, the required number of units becomes:

$$1{,}500 / 9.5 = 2.63 \text{ units.}$$

In other words, 3 forklift units should be appropriate.

b) Outdoor forklift operations

Consideration is being given to the use of larger forklifts for outdoor use as a means of improving loading efficiency in the movement of pallets from the cold storage to the wharf. Since there is no problem with gas exhaust when used out-of-doors, diesel forklifts have been specified for this purpose.

In order to permit these forklifts to move cans and containers and other cargos in addition to fish pallets, a 6-ton forklift has been specified. The average transit time for moving cargo from warehouse to wharf -- its main function-- is 3 min/movement. As two pallets can be moved at a time, the rate of movement becomes: 2 pallets/ 3 min/ forklift. The carrying capacity of in-warehouse forklifts would be 1 pallet/minute, and so the required number of units becomes:

$$1 / 2/3 = 1.5 \text{ or } 2 \text{ units.}$$

iii) Weighing Equipment

This equipment is to be used to weigh fish at the time of landing and loading. Since it will be advantageous, from the standpoint of operating efficiency, to weight the catch by individual pallet lot, we have specified a method whereby the fish is directly loaded onto the platform by forklift. Since the pallet weight is about 200 kg, the contents will weigh about 800-1200 kg. Thus, the scale must register at least 1400 kg. Allowing some reserve, a 2-ton scale has been specified. In order to facilitate forklift handling, we have specified the underground pit method to equalize the platform and the ground level.

iv) Maintenance Equipment

To permit maintenance of the compressor units, ice-making equipment, pallets, and forklifts, tools and equipment regularly required will be provided for the workshop adjoining the cold storage. However, the specialized tools for the repair of forklift engines will not be provided; when such repairs are required, these can be done at the outboard engine repair workshop located within the site. The required equipment will include the following:

Electric welding equipment and parts	(1 set or unit each)
Gas cutting tools	
High-pressure washing equipment	
Grinder	
High-speed cutter	
Bench drill	
Compressor	
Hand tools	
Jack	

v) Other

A water tank must be provided to wash the fish prior to freezing and for other refrigerator operations. There will also be a requirement for thermal clothing to be worn while working in the refrigerator.

Water tank for fish washing	2 units
Thermal clothing	10 garments

k) Section Plan of the Refrigeration Facilities

The planned facilities are composed of cold storage rooms (2 rooms x 250 tons), a quick-freeze room, including an anteroom for handling, a machinery room, and a handling area. The catch will flow in two channels: