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ROYAL IRRIGATION DEPARTMENT
MINISTRY OF AGRICULTURE AND COOPERATIVE
GOVERNMENT OF THE KINGDOM OF THAILAND

FINAL DESIGN REPORT
FOR
DOK KRAI – MAB TA PUD WATER PIPELINE PROJECT
IN
THE EAST COAST AREA

(MAIN REPORT)

AUGUST 1982

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request of the Government of the Kingdom of Thailand, the Japanese Government decided to extend technical cooperation in the Detailed Design for the Pipeline System from Dok Krai to Mab Ta Pud in the East Coast and entrusted the work to the Japan International Cooperation Agency (JICA). Under the JICA Development Survey Program, a study team, headed by Mr. Yuichi Katayama, CTI Engineering Co., Ltd., associated with Sanyu Consultants Inc., conducted the detailed design study in Thailand and Japan from November 1981 to August 1982.

The team carried out a field survey and data analyses and has prepared the present report in collaboration with the Royal Irrigation Department.

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 deep appreciation to the officials concerned of the Government of Thailand for the close cooperation extended to the team.

August, 1982

Keisuke Arita

KEISUKE ARITA
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

August 31, 1982

Mr. Keisuke Arita
President
Japan International Cooperation Agency
Tokyo, Japan

Dear Sir,

We have the pleasure of submitting the Final Report on the Detailed Design for the Pipeline System from Dok Krai to Mab Ta Pud in the East Coast of Thailand, in compliance with the Terms of Reference given to us by your Agency.

Prior to the start-up of works we rightly understood the urgency and importance of the Project and throughout the period of design work we have dedicated ourselves to accomplish our mission to satisfaction of the parties concerned.

On the meeting held at Japanese Embassy on Nov. 25, 1981, the Thai Government emphasized that reliability of the system, the short construction period, economical construction cost and utilizing the local resources were of great interest.

Considering it, the Detailed Design Team made the following decisions on the issues at the early stage:

* Fulfilment of good quality and scheduled construction period can be realilzed by placing the tender as a package and attracting the best class contractors who will be able to manage the whole work competently.

* Cost saving and local resources' utilization can be realized by identifying and specifying the local participation as much as possible, in providing the man-power, materials and products.

The Feasibility Study of "The East Coast Water Resources Development Project", the preceeding study of the design work, had been in execution since February 1981. The study consisted of two sub-projects, namely Nong Pla Lai and Ban Bung sub-projects. The present pipeline design work has been based on the feasibility study then conducted as a part of the sub-project.

When the design work started, the Feasibility Study was still in progress. The Detailed Design Team, reviewing the Interim Report of the Study and exchanging informations with the Feasibility Study Team, had to make solid and concrete decisions on the matters of design criteria and engineering principles on which further works of design should be founded and constructed systematically.

From the commencement in November 1981 to the completion in August 1982, the Detailed Design Team has submitted the reports of Inception, Progress I and II, Engineering, Design in that order and the Tender Documents, well in accordance with the original schedule.

Throughout the nine months' period, each staff has carried out his responsibility dutifully and the team leader has coordinated the staffs' efforts, steering the team towards the goal.

As we submit this report, we are proud that our works have successfully solved all of the conceivable conditions of design and construction in technical, legal and administrative aspects.

We wish to express our sincere gratitude to the staff of JICA, Embassy of Japan, and Royal Irrigation Department and other agencies of Thai Government for their assistance and collaboration.

Very truly yours,

Y Katayama

Yuichi Katayama
Leader
Detailed Design Study Team
CTI Engineering Co., Ltd.
Associated with Sanyu
Consultants Inc.

ROYAL IRRIGATION DEPARTMENT

BANGKOK, THAILAND

CABLE ADDRESS: RID Bangkok

No. 731 /2525

August 25, B.E. 2525

Mr. Yuichi Katayama
Team Leader
Detailed Design Team for Water Pipeline
in the East Coast
Japan International Cooperation Agency

Re: Final Reports and Tender Documents

Dear Sir:

In connection with the Dok Krai – Mab Ta Pud Water Pipeline Project in the East Coast of Thailand, for which the Royal Irrigation Department (RID) is designated as the project executing Agency by the Government of Thailand, we have received to date the following mentioned reports and documents from your team.

Drafts of

* Prequalification Tender Documents
* Tender Documents for Construction
* General Conditions of Contract
* Special Stipulation of Contract

--------------- on April 15, 1982

Drafts of

* Design Report
  - Main Report
  - Supporting Report
* General Specifications
* Particular Specifications
* Bill of Quantities
* Contract Drawings

--------------- on July 2, 1982

Printing by Public Relation and Printing Services Branch, Royal Irrigation Department (P.421-May.1979-1,000.)

Draft reports and draft documents have been reviewed in due course by technical and legal personnels of RID and other Government Agencies concerned, and also fruitful discussions on the said documents have been continued between representatives from Thai side and your team.

Our comments on your draft reports and draft documents derived from our reviewal as well as conclusions reached in the discussion meetings are as summarized in the Minutes of Meeting dated July 8, July 14 and July 28, 1982, respectively.

This is, therefore, to inform you with our greatest pleasure that you may kindly proceed to finalization of those draft reports and documents through incorporating descriptions as presented in said Minutes of Meeting. It is expected that we will be furnished with the following reports and documents as final ones by the end of August 31st.

* Main Design Report
* Supporting Design Report
* Instructions to Tenderers
* Conditions of Contract
* Particular Specifications
* General Specifications
* Bill of Quantities
* Contract Drawings

Your kind attention on the above will be highly appreciated.

With our thanks to what your team has done for the subject project as well as to the close cooperation extended by JICA Tokyo.

Yours sincerely,

Sunthorn Ruanglek

Sunthorn Ruanglek
Director General

cc: 1. JICA Bangkok Office
2. JICA Head Quarter, Tokyo

SUMMARY

1. Eastern Seaboard Development Plan

The discovery of huge offshore natural gas deposit in the gulf of Thailand and the success of striking and leading it onshore by a long underwater pipeline is going to change the situation of eastern seaboard area drastically.

The natural gas has been led to the north to be utilized in power generation and cement production, while in Mab Ta Pud a part of it is being used in producing coarse gasoline through the dew point process.

According to the study report of Eastern Seaboard Development Planning, heavy and chemical industries such as integrated steel, pig iron, chemical fertilizer, ammonia, soda ash and petrochemicals are going to be planed in the area surrounding Mab Ta Pud. Those industries will naturally induce downstream ones and supporting industries in the close-by area.

The deep sea port of Sattahip is now being expanded and a new port in Laem Chabang in projection stage will facilitate the export of liquefied petroleum gas. Laem Chabang area will also be developed to house light and higher level industrties.

New industries and old, existing industries will promote commerce and service business into expansion and development eventually.

The preparation of infrastructure is also under way. Adding to the existing highway system which is rather well organized and maintained, new railway system is already under construction. Power supply will be remarkably reinforced and improved telecommunication system will be expanded over the area.

The objective of economical and social development of the area is not limited to the pictures drawn above. When the area grows into a main community/industrial center of the region, it will much help in solving or preventing the problems which Bangkok is now facing and finding difficulties.

2. Problem of Water

The industrial/urban area covering Sattahip - Mab Ta Pud - Rayong is situated in Changwats Rayong and Chon Buri where natural blessing has been good except water. The rainfall is less than the mean of 1,300 to 1,500 mm/year in Thailand which is rather small in South East Asia. Within the two Changwats only two rivers, Bang Bung and Rayong river, are sizable.

Despite the advantageous topography of flat plain and location as the hinterland of the metropolis, agricultural development has been restricted owing to the shortage of stable water supply, it seems. The cities must depend their water mostly on artificial reservoirs, the capacities of which are limited possibly due to the topographical conditions. Facing the rosy future of development, however, is the problem of water because insufficiency of it will certainly affect the development adversely.

As it can be easily understood, the basic solution is to build dams in advantageous locations as many as possible and to produce the surplus water from them. The dams shall be located and managed so that they are most productive.

The feasibility study which proceeded the detailed design of Dok Krai - Mab Ta Pud water pipeline was originated from the aforementioned situation and approach. The study, titled "The East Coast Water Resources Development Project", comprises two sub-projects of Nong Pla Lai and Bang Bung and the former sub-project contains the water pipeline as a major part.

3. Dok Krai - Mab Ta Pud Water Pipeline Project

3.1 Requirements by Feasibility Study

The feasibility study concluded that the demand for municipal and industrial/community use will amount 57.8 MCM/year and it shall be covered by supplying at the maximum rate (design rate) of 2.62 m^3/sec flow. The water source is to be Dok Krai reservoir owned and managed by RID and the flow is to be transmitted to Mab Ta Pud by 1.35 m diameter pipeline of about 26.5 km in length.

3.2 Major Facilities of Project

The major facilities are:

Intake Tower, Intake Bridge, Pumps, Appurtenances at Dok Krai

Pipeline and Appurtenances connecting Dok Krai and Mab Ta Pud

Head Tank on Pipeline Route

Receiving Well and Receiving Reservoir at Mab Ta Pud

Telecommunication System for Operation and Maintenance

Power Supply

Buildings

3.3 Intake Tower, Intake Bridge, Pumps, Appurtenances at Dok Krai

The intake tower is located in the reservoir, 300 m upstream of the dam axis and 200 m offshore from the right bank. It is reinforced concrete structure, having the dimensions of 22 m long, 17 m wide and 19.8 m high. The structure has four stories and room for pumps at the bottom floor and the control equipment on the top floor.

The intake bridge which is to be used to bring the equipment into the tower in the construction stage and to be used for maintenance purpose in the later stage, is 160 m long consisting of 10 spans of 16 m each. It is made of prestressed concrete box girders and of 5.5 m width, of which 3.5 m and 2 m shall be used as road and pipe-support part respectively.

While the foundation of intake tower is spread foundation on granite rock. That of the bridge is rows of steel pipe piles.

Six pumps including one stand by are of 31.5 m^3/min., 79 m total head and vertical shaft centrifugal double suction type. Three air chambers, made of steel and about 100 cu.m in capacity, are installed onshore along the pipeline route and have function as the gadget in preventing water hammer effect between pumps and the head tank.

3.4 Pipeline and Appurtenance connecting Dok Krai and Mab Ta Pud

The head tank divides the total length of the pipeline of 26.5 km into two parts, 7.5 km upstream part and 19 km downstream part. The head tank has three different functional roles; control of pumps, filling water in the downstream part of the pipeline and protection of downstream part from water hammer. The pipeline runs along the RID-owned road, Route-3191 and Route-3 until it ends at Mab Ta Pud.

The pipe material is 11.9 mm thick steel plate which is to be fabricated to pipe by welding and completed pipe is painted with coal-tar enamel with glass cloth wrapping on the outside and lined with tar-epoxy inside. 1,350 mm diameter pipes are welded to be joined in the trench after being laid in place.

The appurtenances attached to the pipeline comprise air valves, drain (blow-off) valves and main valves. Those valves are placed in concrete boxes and covered.

3.5 Head Tank on Pipeline Route

As was mentioned before, the head tank has three roles, one is to prevent water hammer effect on pipes, second is to control the flow rate and the last is to fill water in the pipeline.

Located by the roadside of Route-3191 from about 7.5 km downstream of the pumping station, it sits on a hill of EL 82.00 m. Dimensions of the cylindrical tank are 16.0 m in diameter and 24.4 m in height and it is made of prestressed concrete, placed on spread foundation.

A pipework lying from the tank to a stream 400 m apart, is the spillway of the tank and can discharge 2.62 m^3/sec flow, the design flow of the pipeline itself.

3.6 Receiving Well and Receiving Reservoir at Mab Ta Pud

The receiving well is to keep the reception water level at the pre-determined elevation. Made of reinforced concrete it is divided into three portions for the said function and it has the overall dimensions of 29.7 m length, 11.0 m width and 6.6 m depth.

The receiving reservoir's role is for storage and preferably it shall have a larger capacity. Considering the effectiveness of stored quantity of water in it, the size is made 156 m long, 78 m wide and 3 m deep (of effective depth) so that the capacity amounts approximately 28,000 cu.m, equivalent to 3 hours flow volume at the design rate.

It is made of earthern embankment and is lined with EPT rubber sheet to prevent leakage.

The reservoir is placed downstream of the receiving well and connected to it and equipped with several outlets for future connection of supply and with a spillway.

3.7 Telecommunication System for Operation and Maintenance

The operation and maintenance of 26.5 km long pipeline which has three stations, pumping, head tank and receiving, cannot be worked without means of communication. As the introduction of public telephone network is to be waited till the end of 1984, a FM/VHF communication system must be prepared before the completion of construction. The system consists of two permanent stations, one at Dok Krai and Mab Ta Pud for each, and 14 mobile walkie-talkies.

Upon the introduction of public telephone network in the area, it will be connected to the internal telephone systems of both Dok Krai and Mab Ta Pud which are to be prepared in the project.

3.8 Power Supply

The power demand in Dok Krai, Head Tank and Mab Ta Pud is about 3,350, 30 and 152 kw.

3,350 kw demand in Dok Krai which is mostly for the large pumps can not be covered by the existing transmission line and PEA is going to prepare for it by installing a new line of 22 kv from existing transmission line along Route-36.

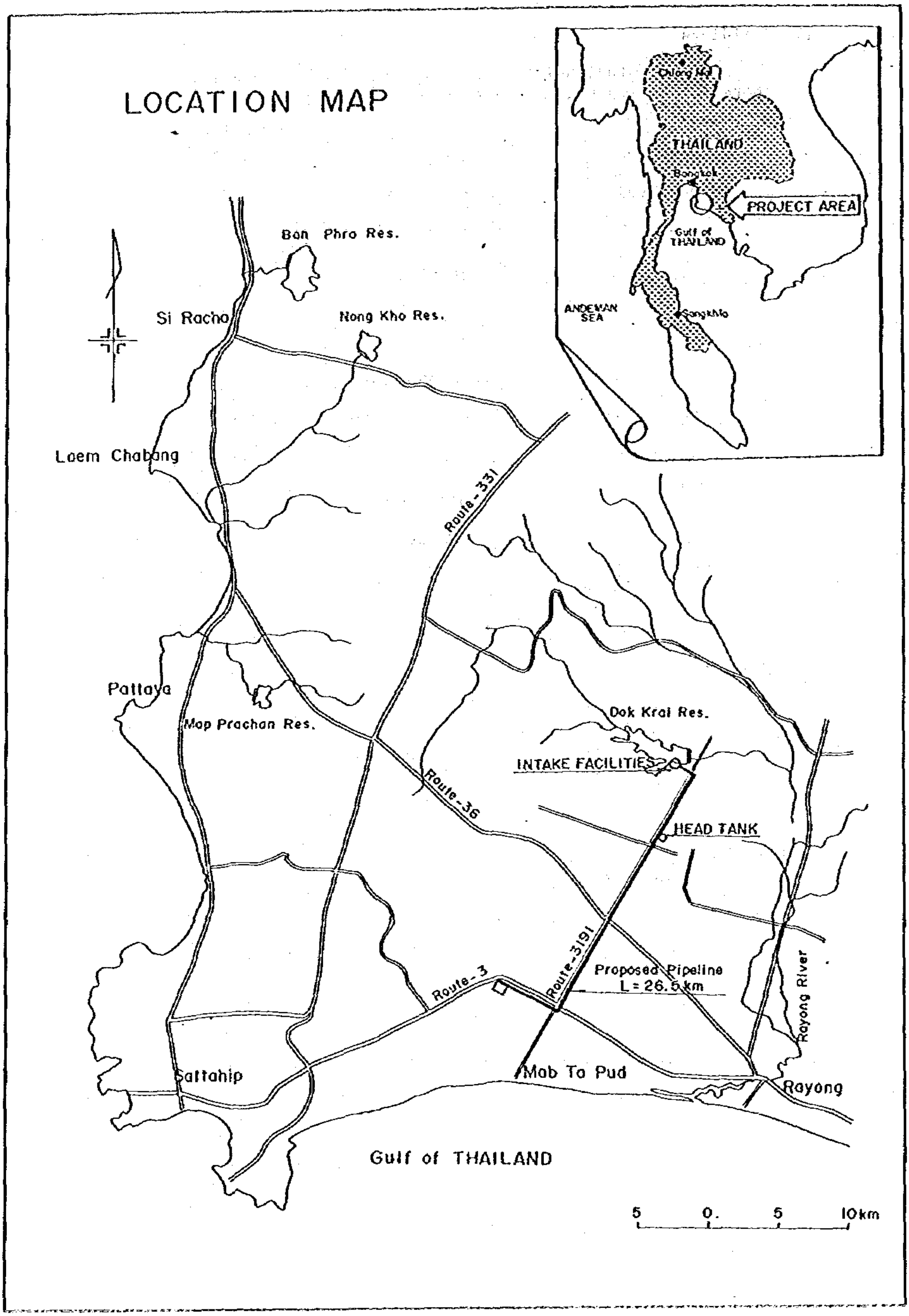
The Head Tanks demand is small and can be supplied by the existing line. Mab Ta Pud's demand 152 kw is for both the official and residential use. Approximately two thirds is for the living quarters of staffs in the compound, and it is also to be supplied by the existing line's reinforcement.

3.9 Buildings

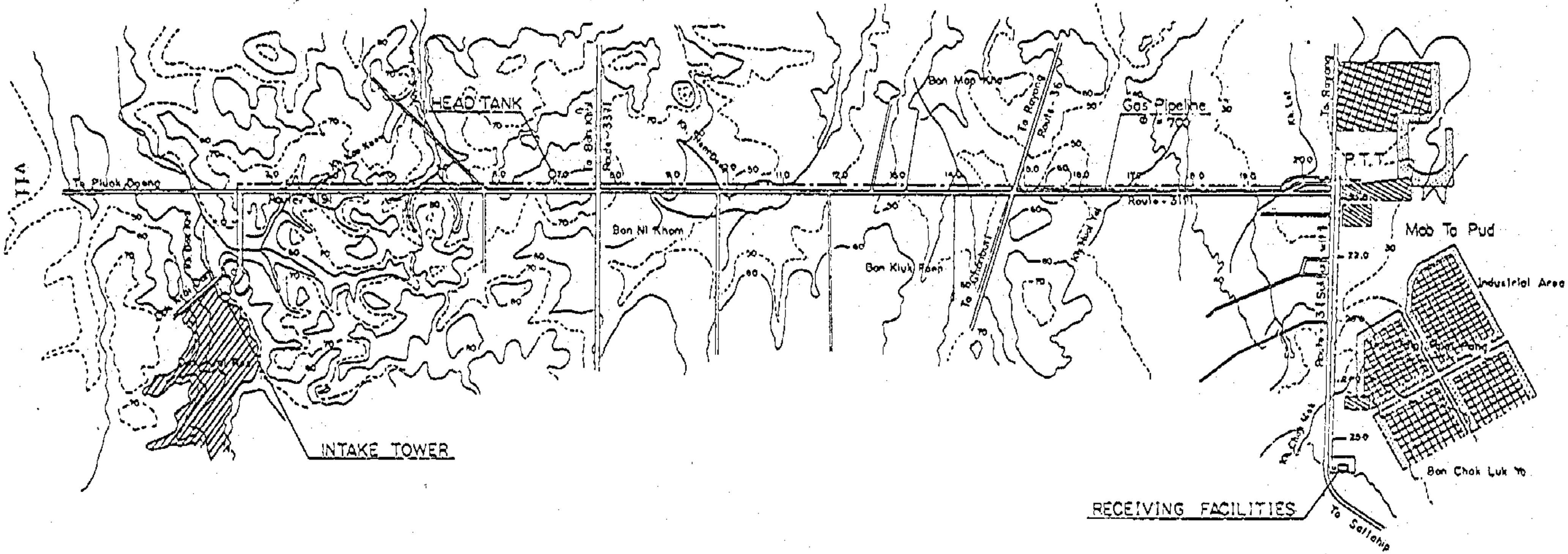
The buildings which are needed for the future use of operation and maintenance are to be listed as below:

Station	For	Floor Area (sq.m)
Dok Krai	Control House	563
	Office	97
	Substation	102
	Warehouse & Garage	79
	Compressor Room	22
Head Tank	Maintenance Hut	29
Mab Ta Pud	Office	214
	Repair Shop	125
	Generator Room	22

LOCATION MAP



SITE MAP



S = 1 / 100,000

0.0 5.0 km

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GLOSSARY OF TERMS AND ABBREVIATIONS

1) Local Terms of Administrative Areas

Thai	English
Changwat:	Province
Muang (Amphoe Muang, A.M):	City
Amphoe (A.):	Township
King Amphoe (K.A):	Sub-Township
Tambon:	Town
Muban (Bang):	Village
Tesaban:	Municipality
Su Khapiban:	Sub -Municipality

2) Natural Features

Khlong: Canal

3) Administrative Organization

ACFT: Agricultural Cooperatives Federation of Thailand

DTEC: Department of Technical & Economic Coopration

EGAT: Electricity Generating Authority of Thailand

IEAT: Industrial Estate Authority of Thailand

MAC: Ministry of Agriculture and Cooperatives

MOI: Ministry of Industry

NEA: National Energy Authority

NESDB: National Economic and Social Development Board

PAT: Port Authority of Thailand

PEA: Provincial Electricity Authority

PTT: Petroleum Authority of Thailand

PWWA: Provincial Water Works Authority

RID: Royal Irrigation Department

TOT: Telephone Organization of Thailand

4) Length

mm = millimeter
cm = centimeter
m = meter
km = kilometer

5) Area

m^2 = square meter
ha = hectare = 10^4 m^2
km^2 = square kilometer = 10^6 m^2
rai = 0.16 ha

6) Volume

l = liter = 1,000 cm^3
m^3 = cubic meters
MCM = million cubic meters = 1,000,000 m^3

7) Weight

mg = milligram
g = gram
kg = kilogram
t = ton = 1,000 kg
qwt = quintal = 100 kg

8) Time

s (sec) = second
m = minute
h (hr) = hour
d = day
yr = year

9) Currency

฿ = Baht
US$ = United States Dollar
US¢ = United States Cent

10) Electric Measures

kV = kilovolt
kW = kilowatt
MW = megawatt = 1,000 kW
kWh = kilowatt-hour
MWh = megawatt-hour = 1,000 kWh
kVA = kilovolt-ampere
Hz = hertz

11) Other Measures

% = percent
ppm = parts per million
rpm = revolutions per minute
HP = Horsepower
°C = Degrees centigrade
10^3 = Thousand
10^6 = Million
10^9 = Billion

12) Derived Measures based on the Same Symbols

m^3/s, m^3/sec = cubic meter per second

t/ha, ton/ha = ton per hectare

m^3/km^2 = cubic meter per square kilometer

mm/day = millimeter per day

l/day = liter per day

MCM/year = million cubic meter per year

m^3/yr = cubic meter per year

m^3/hr = cubic meter per hour

m^3/min = cubic meter per minute

l/sec = liter per second

l/sec/m = liter per second per meter

m/yr = meter per year

US$/ha = US Dollar per hectare

฿/ton = Baht per ton

kg/m^3 = kilogramme per cubic meters

$m^3/km^2/year$ = cubic meters per square kilometer per year

$m^3/s/km^2$ or $m^3/s/ha$ = cubic meters per second per square kilometer or hectare

฿/m^3 = Baht per cubic meters

13) Other Abbreviations

EL. = Elevation
W.L. = Water level
L.W.L. = Low water level
N.W.L. = Normal water level
H.W.L. = High water level
M.S.L. = Mean sea level
P.S. = Power station
S.S. = Substation
T/L = Transmission line
D/L = Distribution line
NNW = North-northwest
SSE = South-southeast
GDP = Gross domestic product
WHO = World Health Organization (UN)

CHAPTER I - GENERAL INFORMATIONS AND REVIEW OF FEASIBILITY STUDY

1.1 GENERAL INFORMATIONS

1.1.1 Objective of the Study

The objective of the study is to condense a detailed design work for the proposed pipeline system between the existing Dok Krai Dam and Mab Ta Pud. The proposed pipeline system will comprise intake tower, pipeline (Extension: 26.5 km), head tank, receiving facilities and control facilities.

1.1.2 Scope of the Study

Scope of the study are as follows:

1) Supervise of topographical survey along the pipeline

2) Supervise of geological survey along the pipeline

3) Review of feasibility study

4) Detailed design

Detailed design of this project include the following facilities and equipment

- Intake facilities

  Intake tower and control house
  Intake bridge
  Air chamber

- Pipeline L = 26.5 km

- Head tank

- Receiving facilities

  Receiving Well
  Receiving Reservoir

- Mechanical Equipment

- Electrical Equipment

- Buildings and Housings

  Buildings for operation and maintenance
  Housings for staffs

- Telecommunication System

5) Tender Documents

6) Prequalification

7) Implementation Program

8) Reports and Specifications

- Detailed Design Report (Main Report)
- Detailed Design Report (Supporting Report)
- General Specifications
- Particular Specifications
- Instructions to Tenderers
- Conditions of Contract
- Bill of Quantities
- Contract Drawings

1.1.3 Project Area

The project area subject to this study is in Changwat Rayong, on the eastern seaboard of Thailand. The proposed pipeline system which connects Dok Krai reservoir with Mab Ta Pud industrial estate extends approximately 26.5 km.

1.2 REVIEW OF FEASIBILITY STUDY

The review of the pipeline system, considering the scope of the detailed designing, are made respectively on the water supply plan, the water demand projection, the water supply capacity of the source and the basic criteria of facilities involved in the pipeline project. The detailed design covers only the pipeline of 26.5 km between Dok Krai and Mab Ta Pud, however, the facilities and their basic criteria of the pipeline has been planned taking the extension of pipeline between Mab Ta Pud and Sattahip of 21.9 km in the next stage into account. Accordingly, the Feasibility Study Report in its entirely was reviewed instead of referring only to the discussion of the Dok Krai - Mab Ta Pud pipeline route.

As to the facilities involved, intake tower, air chamber, head tank, receiving facilities are basically accepted in the detailed design by the Study Team, however, modification on their design features may be needed. They are due to the then incomplete topographic survey maps of the related sites and area. The modification is on the following four points based on the findings of the topographic survey conducted in the detailed design stage.

Provision of Receiving Reservoir

The receiving reservoir has been added for the following reasons.

The purification plant with water regulation capacity which is out of the scope of the Project, is expected to be provided by the completion time of the Project. When in course of time some difficulty arise and the purification plant is not ready by then, the receiving reservoir may serve to stabilize the supply to end users in place of purification plant assuring the performance of the pipeline system.

Another aspect of the provision is that the receiving reservoir takes over storage function tasked on future purification plant and could reduce the size of storage capacity of purification plant. The purification plant as well as distribution network, which inevitably be needed to supply water to the end users, are out of scope of the pipeline project and so far it is not only designed but also even planned in Thailand.

Changes of Elevation of Water Levels of the Receiving Facilities

The ground level at the proposed receiving facilities is surveyed by points in the feasibility study, however, surveyed arealy in the detailed design. The difference in the two surveys results the rise of the high water level of the receiving well by 3.00 m, from EL.60.00 m in the feasibility study to EL.63.00 m in the detailed design.

Relocation of Head Tank

The head tank recommended in the feasibility report to be located on a hill top which is located off from approx. 1.0 km from the pipeline, is recommended to be relocated to the nearby site of the pipeline allignment of Route-3191. Because a site suitable for installation of the head tank is found at the nearby the Route-3191 by arealy survey around the site conducted in the detailed design.

Modification on Pump Head

The pump head required to transmit water from Dok Krai reservoir to Mab Ta Pud is reduced by 11 m, from 90 m in the feasibility study to 79 m in the detailed design.

The reduction is realized by two: reduction of the high water level at the head tank, reduction of friction loss due to pipeline short-cut of approx, 2.0 km between the new and previous head tank's locations plus short-cut in the pipeline length of 1.1 km.

CHAPTER II - GENERAL FEATURES AND SITE CONDITIONS

2.1 GENERAL FEATURES

This project consists of following three main facilities;

- Intake Facilities
- Transmission Facilities
- Receiving Facilities

These facilities have to be designed to function as a system at any time in order to fulfill the demand of downstream, and to be safe in case of emergency.

2.1.1 Intake Facilities

Location

Intake facilities are located on the right bank of existing Dok Krai dam. The intake tower is inside the reservoir 200 m off its bank. The main controll office is on the bank and is connected to the intake tower with the intake bridge.

Main Facilities

Intake Tower	- takes reservoir water and boost it up with pumps.
Intake Bridge	- works as an administration bridge as well as an aqueduct bridge.
Air Chamber	- prevents water hammer between the head tank and pumps.
Administration Office	- operates and maintains pumps and other facilities near by.

2.1.2 Transmission Facilities

Location

Length of the pipeline between Dok Krai dam and the head tank is 7.5 km and that between the head tank and the receiving facilities is 19.0 km. 94 % of its total lengths is along Route-3191 and Route-3.

Main Facilities

Pipeline	- transmits the water pumped up from the reservoir to the receiving end in a closed conduit through the head tank.

Head Tank	- prevents the adverse effects on the pipeline and other facilities caused by water hammer and depending on water level in the tank, controls the number of running pumps.
Others	- as appurtenant facilities, there are air valves, blow-offs, main valves and branch valves for PTT and so on.

2.1.3 Receiving Facilities

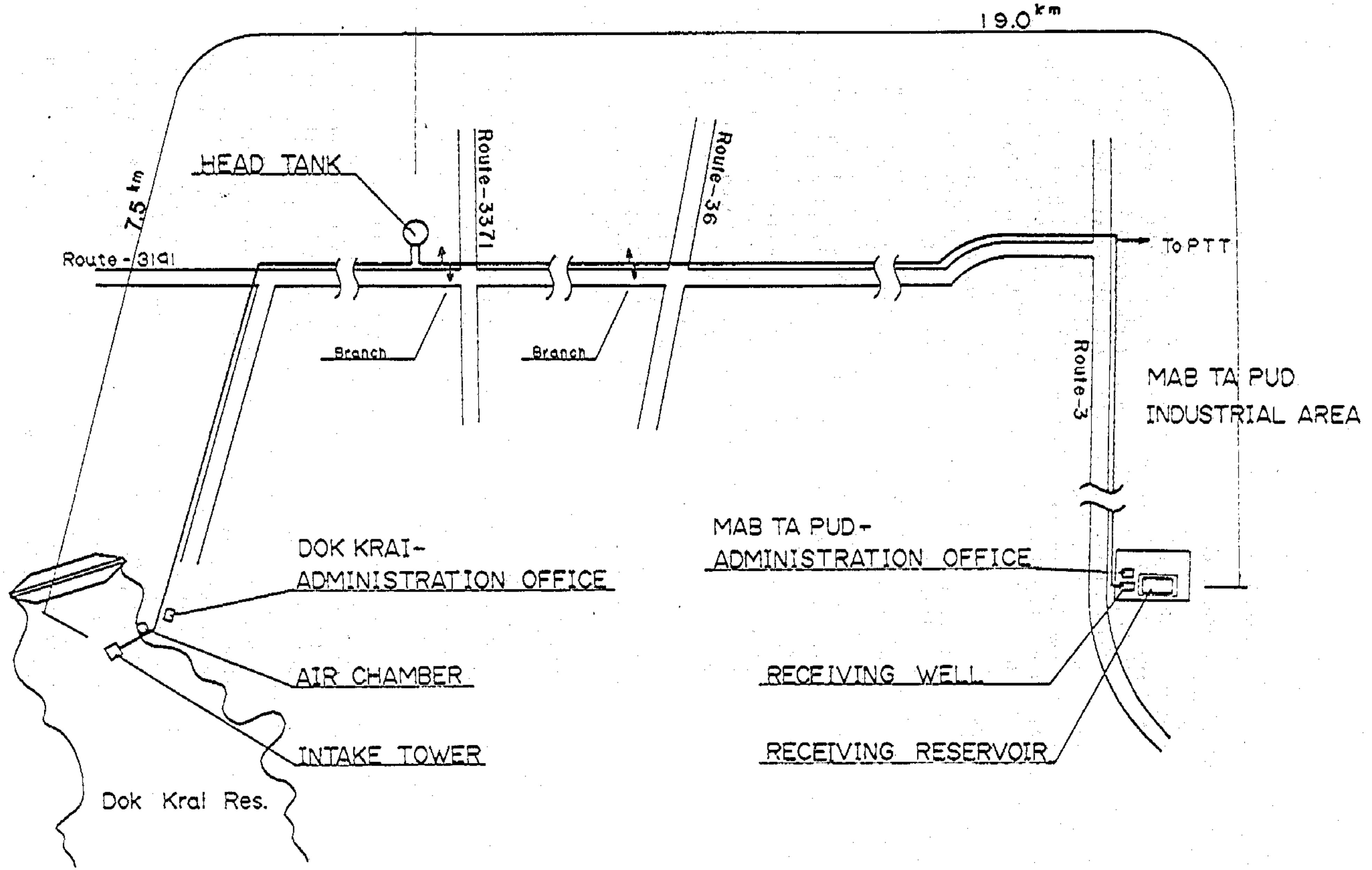
Location

They are located in the north to the industrial complex to be developed in Mab Ta Pud area and are on Route-3 in Ban Chak Luk Ya village, 5 km towards Sattahip from the intersection of Route-3 and Route-3191.

Main Facilities

Receiving Well	- keeps steady water level at the pipeline end.
Receiving Reservoir	- works as an facility against the fluctuation of water demand of downstream or in the case of emergency.
Administration Office	- operates and maintains not only the receiving facilities but also the whole pipeline system.

Fig. 2-1-1 Layout Plan of Main Facilities



2.2 SITE CONDITIONS

2.2.1 Pipeline Route

The water pipeline route runs about 26.5 km from Dok Krai Dam to the receiving facilities at Mab Ta Pud. The topography of pipeline route is characterized by gently rolling hills. It is divided into two parts; the one is characterized by a hilly area like around Dok Krai. The other is a low plain like around the crossing of Route-3. The altitude of the hilly area is 40-80 m above M.S.L., while that of the low plain is less than 40 m above M.S.L.

The geology of the route consists of granite. Most of the stream beds and low plains are covered with alluvial deposits. The surface of granite is highly weathered and has turned into decomposed granite. According to the subsurface explorations, no rock can be observed. The alluvial deposits consit of sand, silty sand and clayey sand layers. The thickness of the alluvial deposit is 3 m to 9 m approximately. The blow count of the decomposed granite layer is 2 to above 50. As for the alluvial deposit layer, the blow count is 1 to 20. At most places, from the surface to 3 m depth the blow count is mostly less than 30. It proves that excavation is not difficult for pipelaying. The soil is suitable for digging, backfilling and compaction. The ground water condition is favorable for pipelaying as the water table is 3 m below surface in the hilly area. In the low plain area, however, the water table is heigher than 3 m below surface. The condition of construction will be worse in the rainy season due to rise in water table.

2.2.2 Intake Tower Site

The intake tower site is proposed to be located 200 m offshore at Dok Krai Reservoir and 300 m upstream of the right abutment of Dok Krai dam axis. The reservoir is around 10 m deep at the site. Its bottom is gently inclining towards the center.

The geology at the intake tower is classified into decomposed granite at the top, and granite rock at the bottom. Covering these layers, there is a thin clay or clayey sand layer, submerged under reservoir water. The thickness varies from 0.2 to 0.5 m. The thickness of decomposed granite is 10 m or more on the shore, and it becomes thinner gradually as it goes towards the intake tower site. At the site of the intake tower, it is 3.5 m. The granite rock can be divided into four sublayers, depending on degrees of weathering; from the top to the downward highly weathered, moderately weathered, slightly weathered and fresh granite. The depths of both highly and moderately weathered granite are in the range of 1m to 5 m. Around the site, the blow count from surface to 3 m below shows more than 50. At the onshore area the blow count becomes larger as the depth increases. The count below 8.0 m depth is mostly above 50. The bearing layer is several meters below the reservoir bottom.

2.2.3 Head Tank Site

The head tank is located 800 m northeast of Ban Nikhom village. The site is the highest place along the proposed pipeline route (82 m from M.S.L.). The site area is gently rolling and covered by cassava, palm and mango trees.

The geology at the site consists of decomposed granite. No rock is observed from the surface to the 10 m depth. The blow count is above 30 throughout the depth and from 8 m to 10 m, blow count shows more than 50. The bearing layer is found at rather shallow depth. Ground water table was not observed down to 10 m depth.

2.2.4 Receiving Facilities Site

The receiving facilities are located 5 km northwest of the intersection of Route-3191 and Route-3 and also located at the big curve of Route-3. The area is covered by cassava field and it has enough flat land for the facilities. It is a rather high place compared with the circumference.

The geology at the receiving facilities consists of decomposed granite. The surface is covered with diluvial or alluvial deposit. The thickness of the surface deposit is about 7 m. The blow count below 4 m depth is more than 30. The bearing layer is found in rather shallow depth. The underground water table is 1.70 m to 3.60 m below the surface. On the average, its level is around 56 m above MSL during the dry season, and will rise by 0.7 m to 1.0 m during rainy season.

CHAPTER III - DESIGN CRITERIA AND DEFINITIVE PLAN

3.1 BASIC CONDITION AND STANDARDS

3.1.1 Design Flow Rate

The pipeline is to supply water to Mab Ta Pud and Sattahip for both industrial and municipal water. The annual water demand of both Mab Ta Pud and Sattahip is 57.8 MCM upon the result of the Feasibility Study.

Design flow rate of the pipeline system is calculated as below;

$$Qd = Wd \times fw \times C/365/86,400$$

Qd:	design flow rate (m^3/s)
Wd:	water demand = 57.8 (MCM/yr)
fw:	leakage ratio = 1.1
C :	load factor = 1.3

$$Qd = 2.62\ m^3/s$$

3.1.2 Standards

Standards and their abbreviations used mainly in the detailed design are listed here.

JIS	:	Japanese Industrial Standards
JWWA	:	Japanese Water Works Association
JSCE	:	Japan Society of Civil Engineering
AASHO	:	American Association of State Highway Officials
ACI	:	American Concrete Institute
AWWA	:	American Water Works Association
MWWA	:	Metropolitan Water Works Association
TIS	:	Thai Industrial Standards

3.2 PIPELINE SYSTEM

3.2.1 General

Generally speaking, when the extention of a pipeline system is long, an adverse effect of water hammer may be expected causing difficulty in pump operation and pipeline system maintenance. As for this pipeline, due to the long distance between pumping site and receiving end as well as topographic complexity of pipeline route, effects of water hammer is most likely to present serious problems, requiring careful study.

Accordingly, the study has revealed that the head tank, air chamber and other facilities, working in unison in the present design, are found to prevent the occurences of water hammer.

3.2.2 Pumping System

Water Hammer and Countermeasure

Water hammer effects in a closed conduit sometimes cause serious troubles on facilities. Water hammer is a hydraulic phenomenon directly attributable to every change in steady-state velocity, gradual or sudden, such as valve closure and pump tripping by electric power suspension. The adverse effects of water hammer must be avoided by countermeasures. It is evident from water hammer theory that water hammer will be of no problems in the case of short pipelines. Provision of free water surface in the middleway over the long pipeline is an example of economical sulution. If free water surfaces are to be provided, the pipeline may be cut into some shorter pipelines. Usually, surgetank, headtank, junction well or standpipe are employed for this purpose either independently or in combination.

The free water surfaces are provided to achieve the functions below:

- to provide compensation water quickly required by water hammer reflections to materially reduce pipeline pressures.

- to supply the additional water required by the propeller during load demand.

- to store water during load rejection.

Pump Operation

In operation and maintenance of pipeline system, control of the pumping system is very important because of delicate pump operation required for the system. In addition to abovementioned functions, free water surface on the midway of the pipeline has functions below:

- to make certain that the pendulation of water levels following load changes will be quenched positively and rapidly.

- to facilitate control of load difference between supply head and receiving end with simpler pump control method.

Open Type Pumping System

"Open Type Pumping System" is a system with free water surface in between the pipeline from pumping site to receiving end. "Closed Type Pumping System" is a system, on the contraly, without any free water surface in between.

To assure operation and maintenance of the pipeline system, "Open Type Pumping System" is to be used. The system is mentioned breifly here, detailed description of which will be discussed in it's own section.

1) Intake tower

6 pumps (1 for stand-by) are controlled by number according to water level in the head tank.

2) Air chamber

Air chamber is selected as a countermeasure against water hammer between pumps and head tank. It is concluded that surge tanks are not feasible because of the topographic complexities of the pipeline route.

3) Head tank

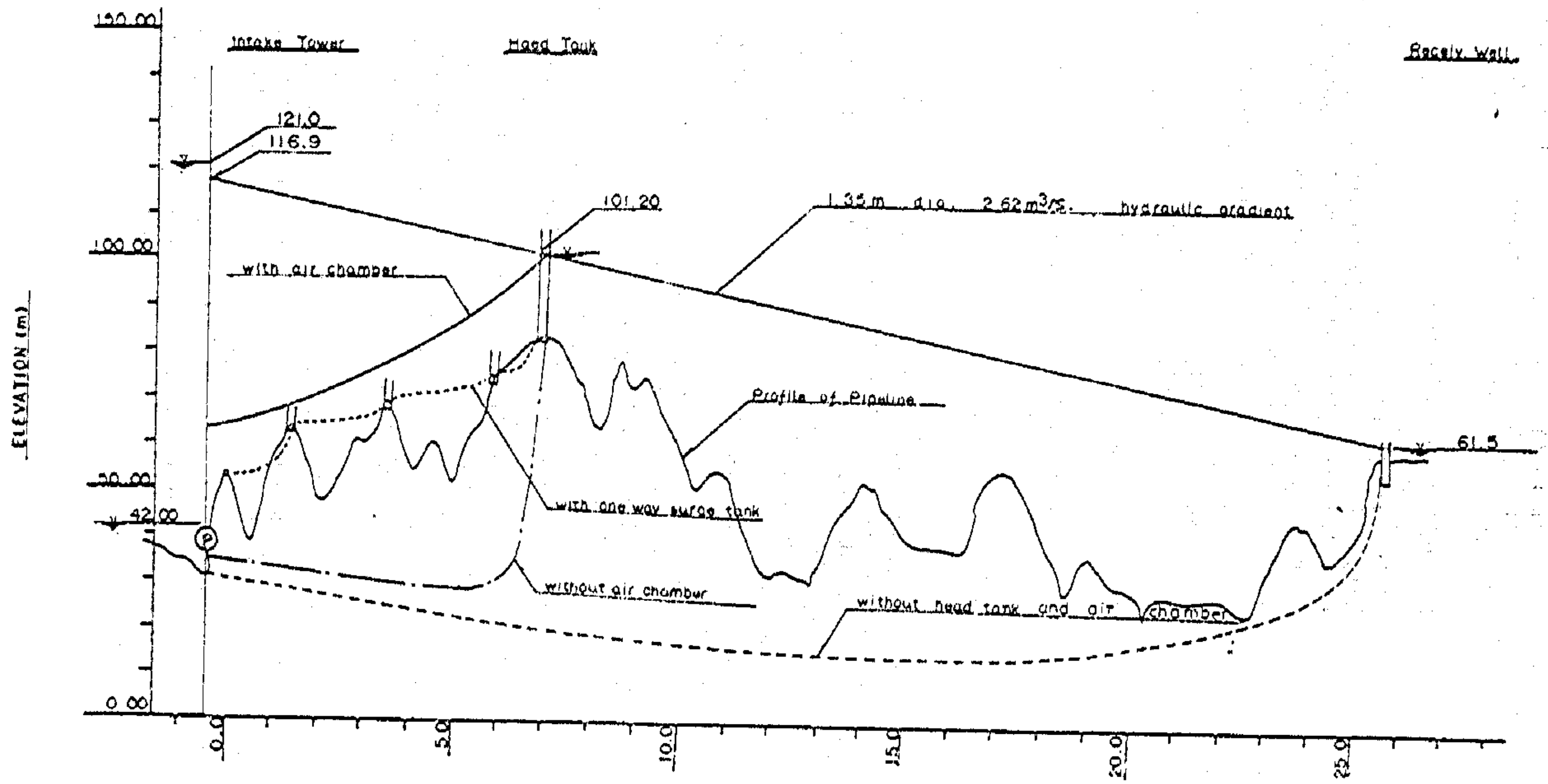
Cylindrical tank of fairly big capacity is to be located on the highest point on the midway to receiving end. Main functions of the tank are to reduce water hammer effects, to make sure of pump operation, and to fill pipeline with water in case the pumps fail to function.

4) Receiving well and receiving reservoir

To kill extra head when controlling the flow rate without adverse effects caused by cavitation, a special kind of control valve is installed in front of the receiving well. The receiving reservoir is planned as such that it will facilitate operation and maintenance.

Fig. 3-2-1 shows the result of water hammer analysis. It shows that adverse water hammer effects on the pipeline are reduced by the head tank and the air chamber between pumps and the head tank. As for the pipeline route between the head tank and the receiving well, there is no special facilities employed. It is needed to operate valves gradually so as not to cause adverse effects on the pipeline by water hammer.

Fig. 3-2-1 Water Hammer Analysis (Minimum Pressure)



3.2.3 Pipeline

Pipeline Route

The pipeline runs from the intake tower at Dok Krai reservoir to the receiving well at Mab Ta Pud along Route-3191 and Route-3. Whole length of the pipeline is 26.5 km and it is shown in Fig. 3-2-2 and the pipeline profile is shown in Fig. 3-2-3.

Fig.3-2-2 Sketch of the Pipeline Route

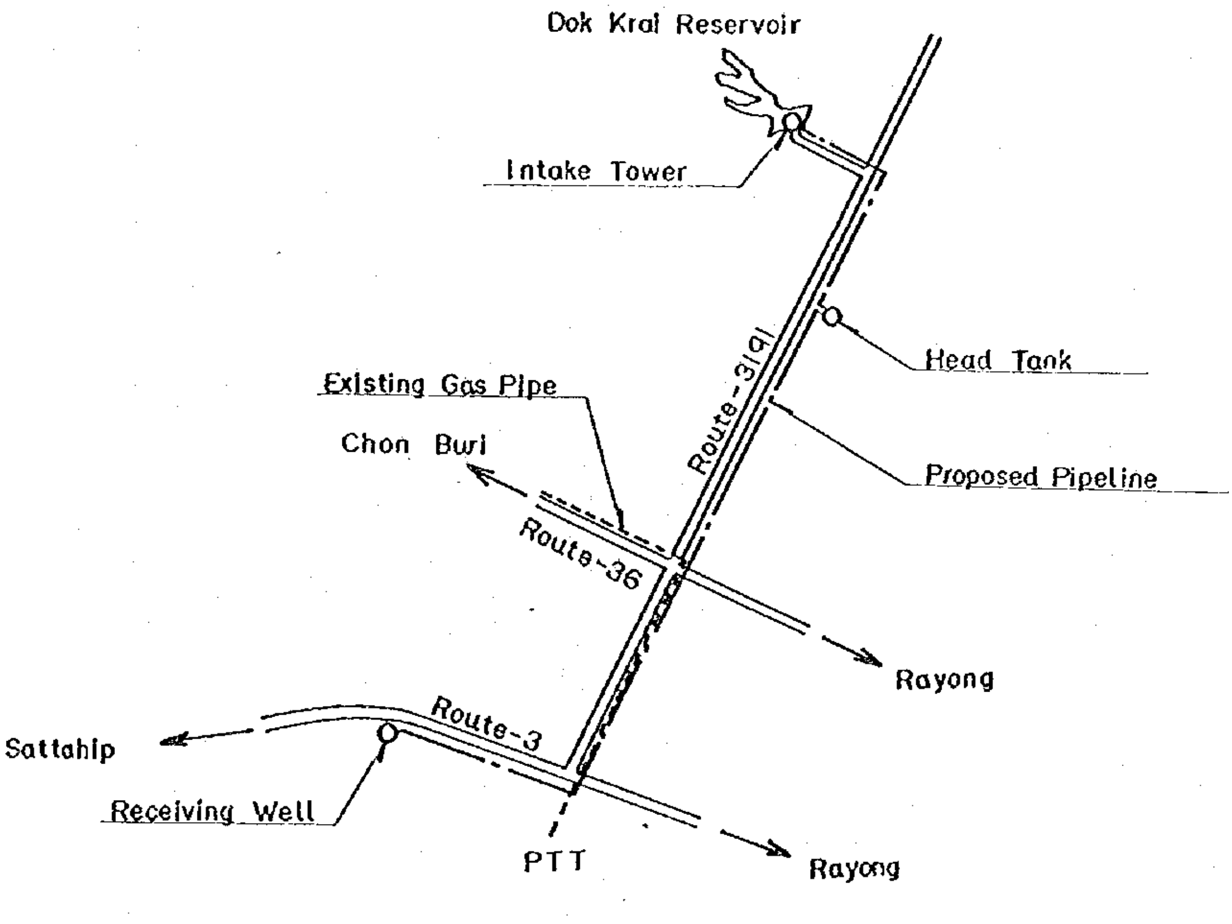
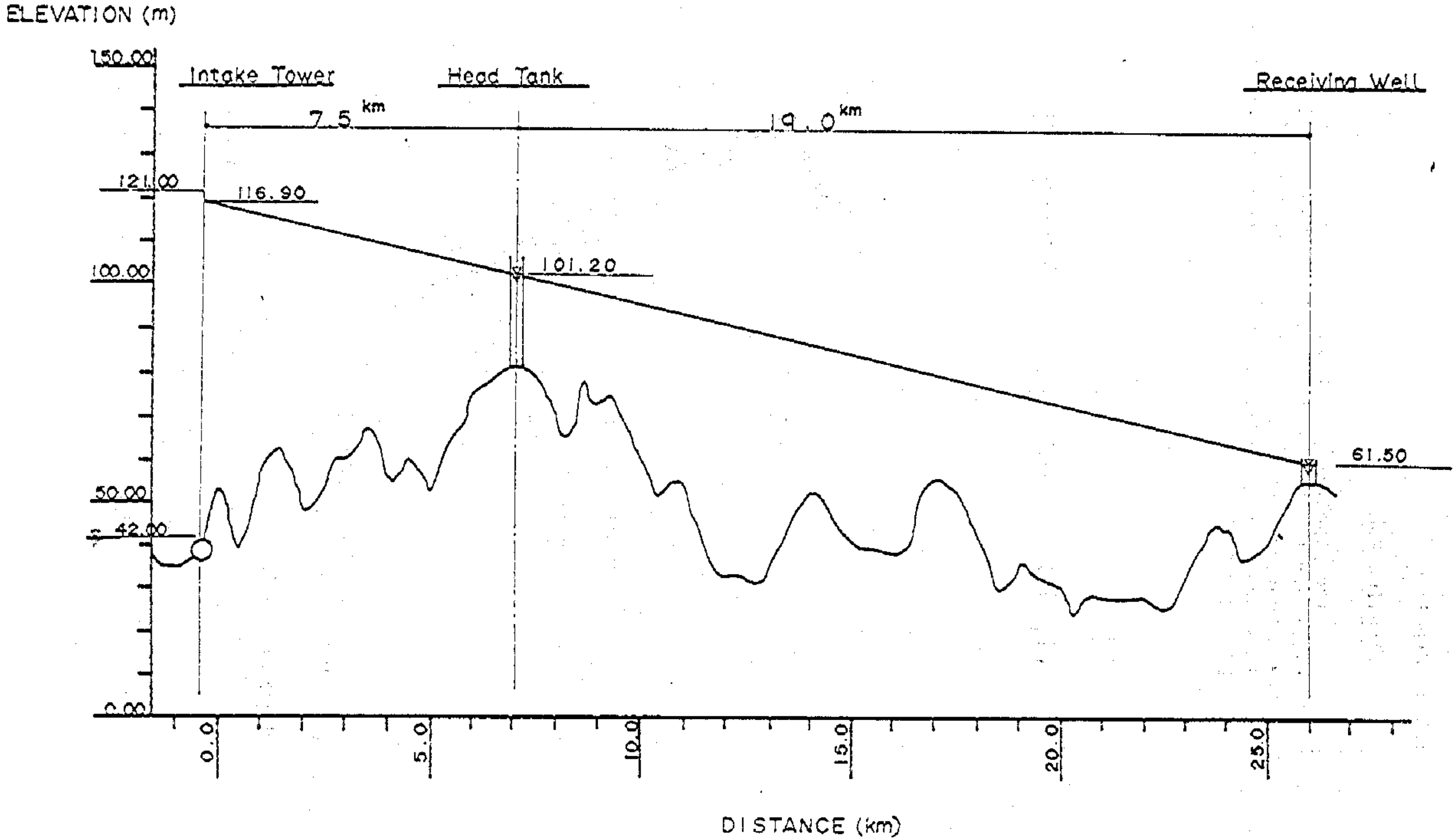


Fig. 3-2-3 Pipeline Profile



Pipeline route and standard alignment are decided based on the following factors.

1) Route between intake tower and Route-3191

Route : North side of RID road

Location : Distance from electric pole to the pipeline center shall be minimum 3 m

Length : 2,066 m (including pipe bridge of 185 m)

2) Route along Route-3191 up to Route-36 crossing

Route : East side of Route-3191

Location : Distance from R/W (Right of Way) to the pipeline center shall be around 5 m

Length : 13,367 m (Route-3191--Head Tank 5,384 m, Head Tank--Route-36 (STA 27) 7,983 m)

3) Route along Route-3191 between Route-36 crossing and Route-3 crossing (STA 44) (20k 777.2)

Route : East side of Route-3191 and the existing gas pipeline

Location : Distance from the existing gas pipe to the pipeline center shall be around 5 m

Length : 5,976 m

4) Route along Route-3 up to the receiving well

Route : South side of Route-3

Location : Distance from R/W (Right of Way) to the pipeline center shall be around 5 m.

Length : 4,941 m (Including receiving well pipeline, 45 m)

Total length: 26,350 m

Pipe Material and Coating

1) Material*

To select a suitable material for the pipeline, the following items shall be taken into account.

- To achieve maximum strength although comparatively higher in cost
- Good workability at site
- To facilitate fabrication of pipe in Thailand.
- To avoid leakage from joints as much as possible

After the comparative study, steel pipe with welded joints were employed.

2) Coating

External coating: Coal-tar enamel coating

Internal coating: Tar-epoxy coating

Pipe Diameter

Pipe diameter is decided by economical comparison in the Engineering Report No. 9, "Comparative Study of Pipeline Dok Krai - Mab Ta Pud - Sattahip". (Refer to Supporting Report)

Though the scope of work of this project is limited to the route between Dok Krai and Mab Ta Pud, the pipe diameter must be studied for the portion between Mab Ta Pud and Sattahip as both portions are closely related to each other.

The comparative study made in the Engineering Report for the portion between Dok Krai and Sattahip is based on the conditions below;

Conditions

. Water Level	Dok Krai Res.	EL. 42.0 m (Refer to 3.2.4)
	Mab Ta Pud (Receiving Well)	EL. 45.0 m
	or	EL. 60.0 m
	Sattahip	EL. 30.0 m

Design Flow Rate

Dok Krai - Mab Ta Pud	2.62 m^3/s (57.8 MCM/yr)
Mab Ta Pud - Sattahip	1.09 m^3/s (24.0 MCM/yr)

Pipe Diameter

Dok Krai - Mab Ta Pud	ϕ 1,200 mm	
	ϕ 1,350 mm	
	ϕ 1,500 mm	
Mab Ta Pud - Sattahip	ϕ 800 mm	
	ϕ 900 mm	
	ϕ 1,000 mm	

Formula for Calculation of Pipe Diameter - Hezene Williams Formula with C = 120

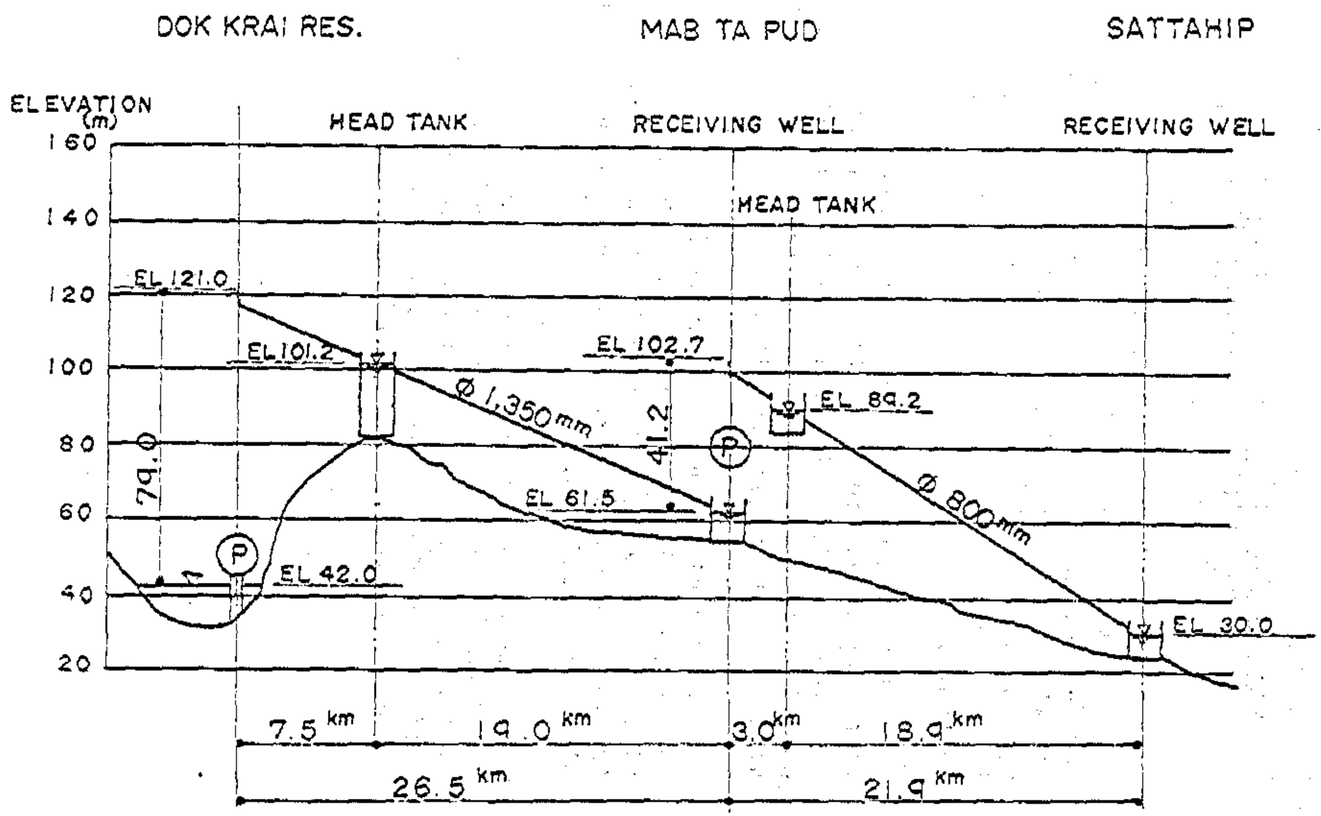
After the study of 18 cases with the combination of these factors such as the pipe diameter and water level at Mab Ta Pud, it was proved that the case in which the pipe diameter between Dok Krai and Mab Ta Pud is 1,350 mm, the same between Mab Ta Pud and Sattahip is 800 mm and the water level at Mab Ta Pud is EL 60.0 m is the most economical and suitable.

As the water level at Mab Ta Pud was decided temporarily, it has been finally decided at EL 61.5 m after topographic survey of the site with due consideration of comparative study which took into account the environmental conditions of the receiving site.

Considering economical judgement and other environmental factors, the abovementioned case is basically applied to the pipeline. Namely, pipe diameter between Dok Krai and Mab Ta Pud is 1,350 mm, and the hydraulic gradient of the case is shown in Fig. 3-2-4.

However at the final stage of the detailed design, modification of the receiving well's level and selection of the control valve necessitated rechecking of the hydraulic conditions stated heretofore. It is shown in the Supporting Report. The rechecking proved satisfactory.

Fig. 3-2-4 Hydraulic Gradient of the Pipeline



3.2.4 Intake Tower

General Features

1) Geological Features

The geology of the areas surrounding the intake tower is classified into 2 layers. Surface layer is decomposed granite and sub-layer is granite rock. From the boring test DH-1 and DH-2, stiff bearing stratum of granite rock is found.

2) Reservoir Stage

In designing intake tower, the rise in planning reservoir stage is taken into consideration.

Water level of Dok Krai reservoir

P.H.W.L.	= +54.100 m	(Planning high water level = P.N.W.L. + 2.0 m)
P.N.W.L.	= +52.100 m	(Planning normal water level = N.W.L. + 1.5 m)
N.W.L.	= +50.600 m	(Existing normal water level)
L.W.L.	= +42.000 m	(Pump suction low water level in suction sump)

Function of Intake Tower

Intake tower has two main functions as below:

- to take surface water from the reservoir
- to pump up the water to required head

and as concomitant functions,

- to avoid floating objects entering into the pipeline

Superstructure (Control House)

1) Control Room

As the intake tower is constructed in the reservoir, room in control house for operation and maintenance is limited, and therefore control office (Administration office) is to be placed not in the intake tower but on the shore.

2) Motor Floor

The motors are to be installed on the floor above P.H.W.L. to avoid intrusion of water during an emergency.

Substructure

1) Type of Structure

Box type stationery caisson made of reinforced concrete is settled at the destination.

2) Type of Pump

Vertical shaft double suction centrifugal type pumps are installed in waterproof base floor.

3) Design Conditions

Stability calculation

In stability calculation, the caisson body is assumed to be of spread foundation because of shallow embedded depth.

External force

In designing the substructure, dead load, seismic force, wind load, wave pressure and subsidiary loads are taken into consideration.

Member stresses

Members are designed so that the stresses at any portion of the members due to the loads may not exceed the allowable stresses given in 1.1 "DESIGN CONDITIONS" of Supporting Report.

Mechanical and Electrical Equipment

1) Pump

- Type	Vertical shaft double suction centrifugal pump
- Number	6 units (including 1 stand-by)
- Design discharge	$Q = 31.5\ m^3/min$
- Total head	$H = 79\ m$

2) Air Chamber

- Type	Cylinder type
- Number	3 units
- Normal water level	EL.60.0 m

3.2.5 Head Tank

Function of Head Tank

For the pipeline system, "Open Type System" with a head tank is employed as mentioned in 3.2.2, Pumping System.

It is proven that a head tank is absolutely necessary to serve the main and the first function of reducing the negative pressure in the pipeline between the head tank and the receiving well due to the water hammer in sudden power suspension.

Next, the control system of the pipeline is selected as pump unit number control in 3.3 CONTROL SYSTEM. In this control method, the flow difference between inflow and outflow is inevitable and the deference must be regulated at the head tank. This regulation of the difference is the second function.

The third function is to store water for an emergency. Once the power supply is suspended by an accident, the water in the pipeline between the pump and the head tank will remain by the check valve at the pumps, but the water between the head tank and the receiving well will flow out if the control valve at the receiving well is not closed soon enough.

Once the water have flowed out, it is troublesome to start up the pipeline system again. Before restart, the air drawn into the pipe must be released which usually takes a few days. The head tank must have a capacity to store water enough to fill the pipeline untill the control valve is closed perfectly.

Location of Head Tank

For the main purpose of reducing water hammer effect, it is most appropriate to place a head tank as near the intake tower as possible.

Also to minimize the height of the head tank, the location should be the highest place along the pipeline route.

In the Feasibility Study Report the top of a hill was proposed which is around 1 km away from the highest point of Route-3191.

The studies made after the F.S., however, revealed that it is more economical to construct the head tank along Route-3191 while achieving the same objective.

Capacity of Head Tank

1) For controlling pumps

The control method have been decided as the one that control by pump numbers (refer to 3.3 CONTROL SYSTEM). This means that control of running pump numbers is made by switching on and off of the motor.

2) For filling pipeline

In case of power failure or other accidents, the part of the pipeline between the head tank and the receiving well must be closed as soon as possible by a control valve at the receiving well. Otherwise, the water in the pipeline will flow out and make it empty.

The head tank must have a capacity for filling the pipe untill the valve is closed. The time for closing the valve is ,stimated at 20 minutes including 10 minutes spare time.

The required capacity with the design flow rate 2.62 m^3/s becomes:

$$V = 2.62\ m^3/s \times 20\ min. \times 60\ sec. = 3{,}144\ m^3$$

3) For water hammer

The capacity for water hammer prevention should be examined after the head tank dimensions are determined. The study described here is made after the dimensions were decided with both capacities for pumps control and pipeline filling, which is discussed in the following section.

After determination of both capacities for pumps control and pipeline filling, capacity for water hammer prevention is checked with those for two other functions. The result is shown in Fig. 3-2-6, with conditions set as below:

<u>Pump</u>

Discharge	31.5 m^3/min x 5 units
Total head	79.0 m

<u>Pipeline</u>

Thickness	11.9 mm	
Diameter	1,350 mm	
Material	steel	
Length	pump station - air chamber	220 m
	air chamber - head tank	7,280 m
	head tank - receiving well	19,000 m

<u>Water level</u>

Dok Krai Reservoir	LWL	42.0 m
	PNWL	52.1 m
Head Tank	LWL	99.55 m
	MWL	101.20 m
	HWL	102.85 m
Receiving well	NWL	61.5 m

<u>Diameter of head tank</u> 16 m

<u>Capacity of air chamber</u>

32 m^3 x 3 sets

Initial Conditions

pump suction level	LWL	42.0 m
head tank level	LWL	99.55 m
receiving well level	NWL	61.5 m
flow rate of pipeline		2.7 m^3/s (LWL to LWL)

value of c = 120

Control valve at the receiving well

type: multiport valve
close time: 10 minutes after 10 minutes extra waiting time

From Fig. 3-2-6 it is clear that with the conditions mentioned above the pipeline is safe and it can be said that the capacity to be allowed for water hammer is enough using the capacity for pump control and filling pipeline.

When a pump is started, a strong electric current flows after a moment. An instantaneous on and off of pump is detrimental to switches and motors. To prevent this detriment, around 60 minutes period is set for one cycle.

The control of the motor switch on and off is made by sensoring a water level in the head tank. The water level will rise in case that inflow exceeds outflow and when the water level rises to a certain level the switch turns off. Then as outflow exceeds inflow the water level goes down and at certain level the switch turns on again.

To spare 60 minutes for one cycle, it has been analyzed in the Engineering Report No. 7.2. that the tank capacity needs to be around 500 m^3 for one pump in the most strict case. (Refer to Supporting Report)

The control capacity for 6 pumps is as shown in Fig. 3-2-5.

Fig. 3-2-5 Control Capacity of Head Tank

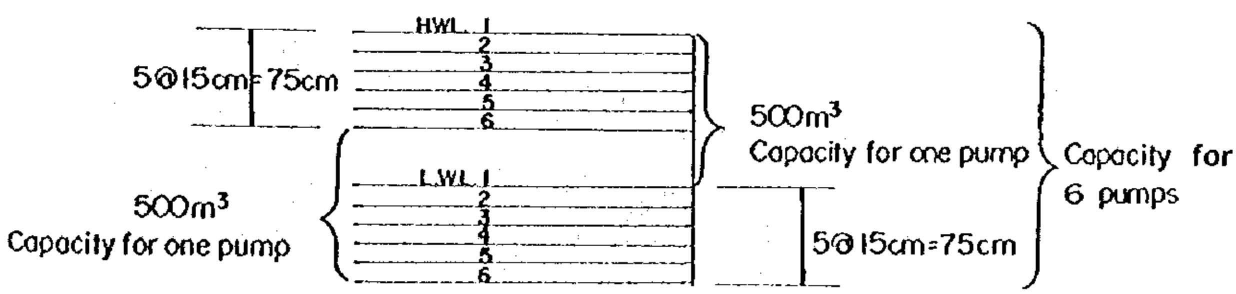
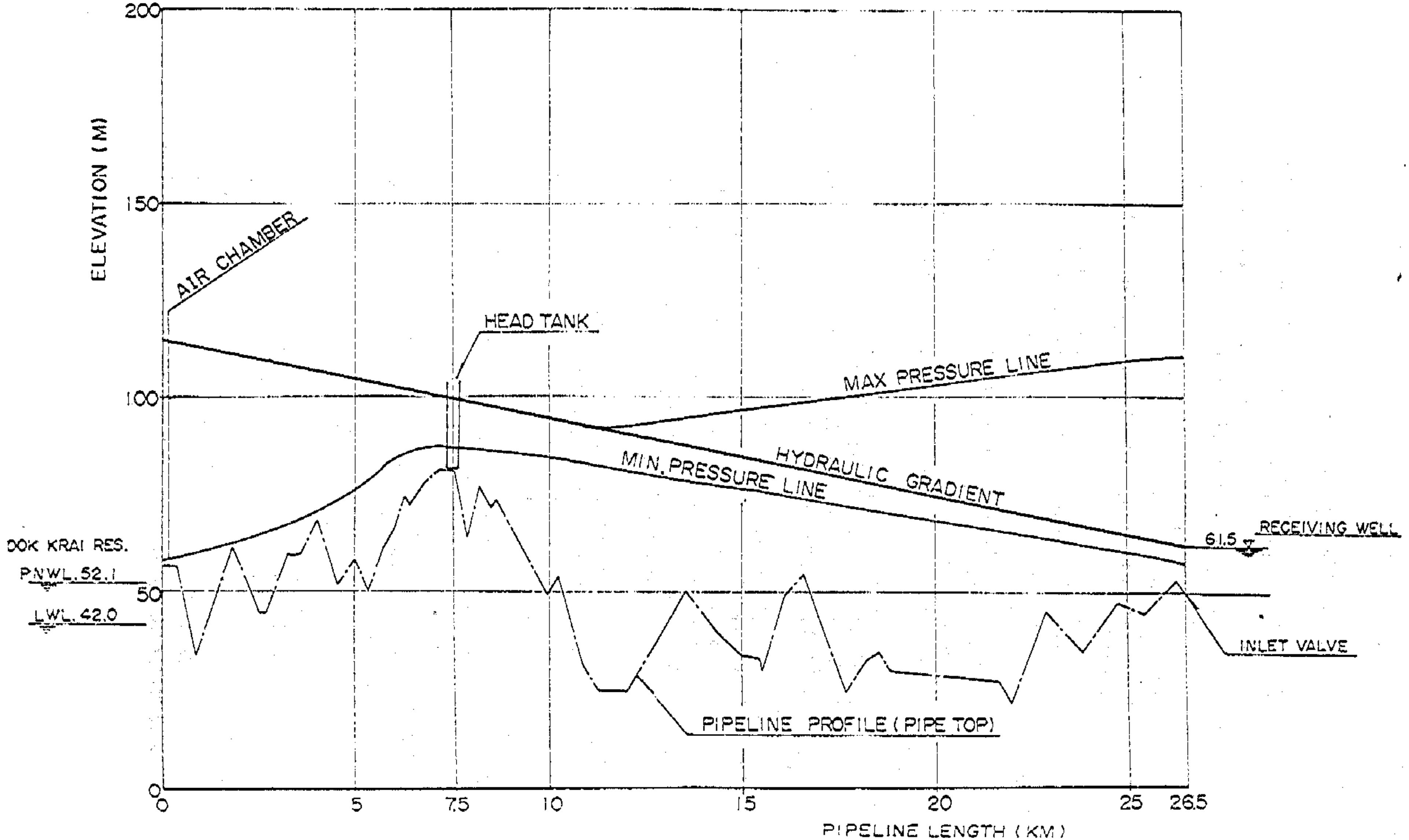


Fig. 3-2-6 WATER HAMMER ANALYSIS



3.2.6 Receiving Facilities

The location and water levels of receiving facilities are described in the preceding chapter. Therefore, the function, dimensions and other details are described in this chapter.

Receiving Well

1) Function

The receiving well has the following three functions:

a) To kill excessive hydraulic energy.

b) To keep water level constant at the end of transmission line.

c) To make metering and controlling of the flow easy.

To attain these functions, the receiving well will be divided into three parts: an inlet chamber, a calming chamber and an outlet chamber.

By the control valve installed in front of the inlet chamber, excessive hydraulic energy is killed. At the inlet chamber, water surface is turbulent and it will be made calm and steady through a perforated wall. Water level in the calming chamber is kept constant by a weir. The outlet chamber is connected to the receiving reservoir with a pipeline, so water level in the outlet chamber varies corresponding to water level of the receiving reservoir.

In addition to these chambers, overflow and valve chambers are attached to the outlet chamber and the inlet chamber respectively.

2) Capacity

To achieve the functions described above, the inlet chamber and calming chamber require to be capacitated as follows:

a) Inlet chamber : 550 m^3

b) Calming chamber : 700 m^3

These total capacities correspond to about eight-minute retention of design discharge.

3) Material

The materials which can be used usually for the receiving well are reinforced concrete or prestressed concrete. Considering the following characteristics, a reinforced concrete well is used for the project.

a) Economy of construction

b) Ease of construction

Receiving Reservoir

1) Function

The receiving reservoir shall have the following two functions:

a) Storage

The receiving reservoir shall have a storage function to maintain uninterupted water supply even in case of power failure or erroneous operation. The storage for this purpose will be taken as equivalent to 1-hour retention of design discharge (2.62 m^3/sec)

b) Regulation

The discharge of inflow into the receiving reservoir may vary seasonally and the outflow from the receiving reservoir varies from hour to hour. Therefore, a regulation function must be given to the reservoir.

Regarding the outflow from the reservoir, there are three discharge: one for industrial use at Mab Ta Pud (0.97 m^3/sec), one for municipal use at the same area (0.56 m^3/sec), and for combined use at Sattahip area (1.09 m^3/sec).

Although the discharge for Mab Ta Pud industrial and Sattahip combined use is constant, as stated above, there may possibly be small fluctuations. Therefore, storage for regulation purpose will be required and a volume equivalent to one-hour retention of design discharge for industrial use in Mab Ta Pud and combined use in Sattahip (2.06 cu.m/sec) is allowed.

Further for the municipal use at Mab Ta Pud, a storage volume of equivalent to five-hour retention of design discharge (0.56 cu.m/sec) will be given from precedents of similar water supplies.

2) Capacity

From the above discussions, the total capacity both for storage and regulation required for the receiving reservoir is 28,000 cu.m, and this capacity corresponds to three-hour retention of design discharge. The detail calculation is as shown below.

	Regulation hour		Storage		minute		sec	
V1 = 0.97 x (	1.0	+	1.0)	x	60	x	60	= 7,000 cu.m
V2 = 0.56 x (	5.0	+	1.0)	x	60	x	60	= 13,000
V3 = 1.09 x (	1.0	+	1.0)	x	60	x	60	= 8,000
							Total	= 28,000 cu.m (approx.)

3.3 CONTROL SYSTEM

3.3.1 Control Method

Usually there are three methods to control flow rate of a pipeline, namely by pump unit number, by valve opening, and by pump revolution speed.

3.3.2 Characteristics of Control Method

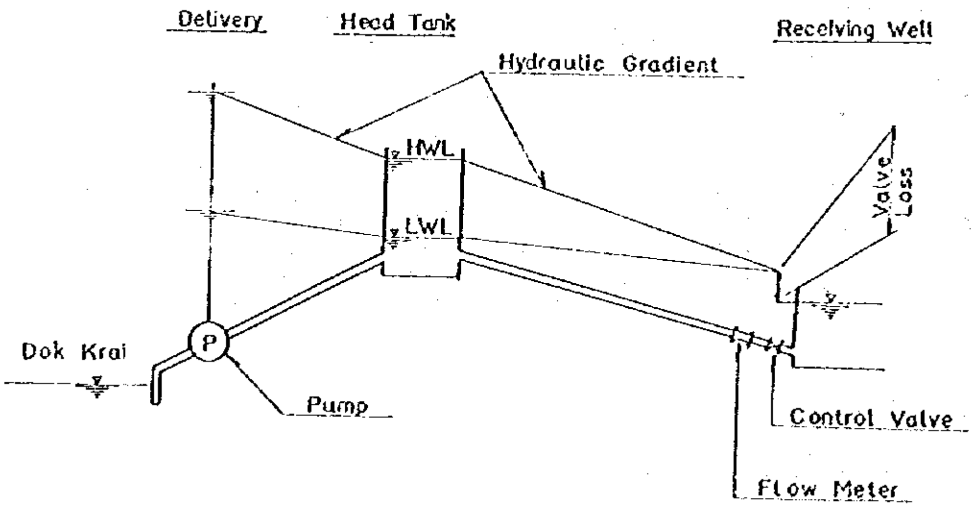
Control by Pump Unit Number

The flow rate is set by the control valve at the receiving well. On the other hand pumps of certain number discharge water to the head tank. The difference between inflow and outflow at the head tank is regulated by the head tank.

That is, if inflow raises the head tank water level to a certain point then one of the running pumps will stop automatically or manually. Then water level will go down to a certain point, then a pump will start again to repeat the cycle until waterlevel rise to a certain point which is set in advance.

Advantage of this method is that this system can operate fully automatically or manually. The equipment required is not very sophisticated and therefore less expensive. The shortcoming is that the head tank capacity for regulation is needed though it is small.

Fig.3-3-1 System and Components of Pump Number Control



Control by Valve Opening

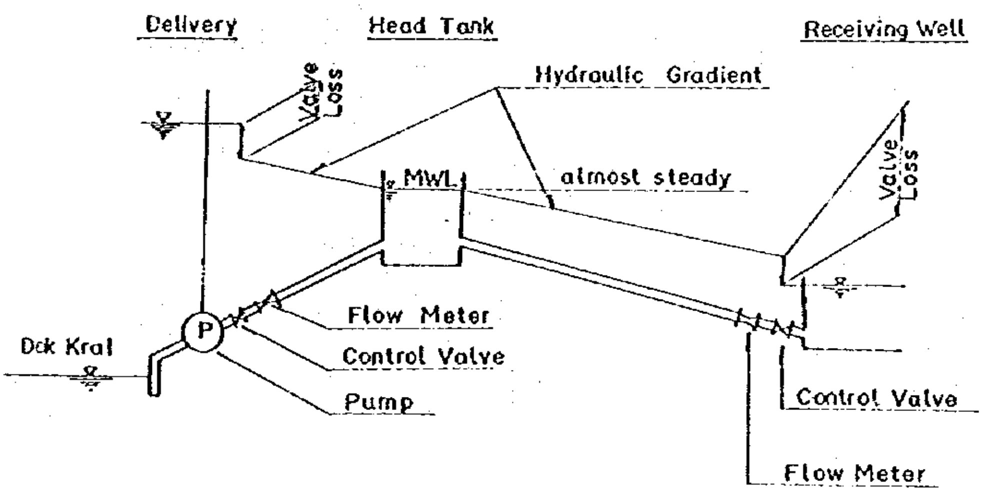
The required flow rate is set by the control valve at the receiving well and also by the valve at pump delivery side simultaneously. Excess flow rate of pump discharge will be cut at the pump valve.

It means that at the pump valve, head loss is expected to occur. The demerit of this system is that the control valve at the receiving well and at the pump must be operated simultaneously against flow change, or against the change of water level at Dok Krai Reservoir and it needs higher sophisticated system and so it should be much costly than the pump number control method.

Furthermore valve loss at the pump delivery valve is inevitable and it is uneconomical.

The advantage in this system is that it needs less operator than the one that control by pump unit number.

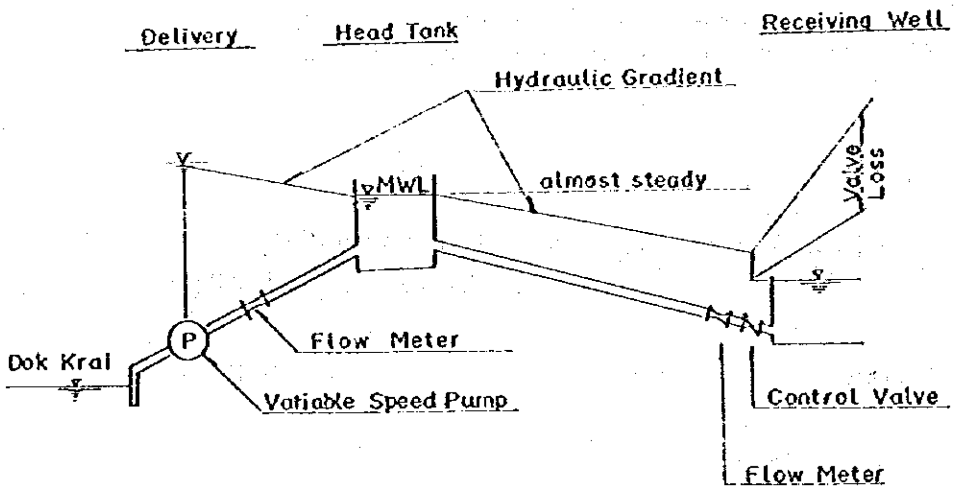
Fig. 3-3-2 System and Components of Valve Opening Control



Control by Pump Revolution Speed

The required flow rate is set by the control valve at the receiving well and pump discharge. Pump discharge is controlled by motor revolution. Variable revolution motors are employed and they are much expensive and to adjust inflow and outflow perfectly against change of water demand or water level at Dok Krai Reservoir, the most sophisticated system including a computer system shall be employed. So this system is most expensive, although less manpower is required.

Fig.3-3-3 System and Components of Pump Revolution Speed Control



3.3.3 Comparison and Conclusion

Request from Thailand Side for Control System

1) a simple system

2) low initial and running cost

3) not sophisticated system

4) easy operation and maintenance

5) to employ more manpower

Required Functions of Pipeline System

1) Exact flow rate is not needed as the receiving reservoir of large capacity is prepared.

2) As the operator are not expected to be well experienced at the initial stage, a simpler method is better to operate and maintain.

   Easy operation and maintenance will increase the reliability of the pipeline.

3) The system must be economical both in initial and running cost.

Consideration of Pump Unit Number Control Method

1) Fluctuation of flow rate at the receiving well is $\pm 2.5\%$ of design flow rate of 2.62 m^3/s which is caused by fluctuation of water level at the head tank when the motor switches on and off. This fluctuation figure is tolerable.

2) Initial cost and maintenance cost are most economical. But running cost is second to the best.

3) The system is simplest and most reliable.

4) At the head tank there must be an extra capacity for control, but it does not much affect the cost.

From these comparison, it is evident that control method by pump unit number should be employed.

3.4 OPERATION AND MAINTENANCE

3.4.1 Foreword

In the middle of June 1982 when this report is being written, the agency responsible for operation and maintenance has not been decided. Consequently this report will describe only the principal matters concerned, seen from the viewpoints of detailed design team.

3.4.2 Stations

- Mab Ta Pud Office

Mab Ta Pud station, with the receiving well and reservoir shall be the heart of the whole pipeline system owing to the following reasons:

1) The advantage of location can been easily recognized as it is by Route-3 and the railway under planning, and moreover it sits in the middle of Dok Krai and Sattahip where the pipeline will be extended in the years to come.

2) Having a rather large reservoir (3 hours full flow capacity), Mab Ta Pud can be considered as a water source connected directly to Dok Krai reservoir. The existance of water source, close to the large industrial and municipal consumption area, is very convenient for both the supplier and consumer.

3) Consequently Mab Ta Pud station must have the authority over the whole pipeline system in operation and maintenance matters, being provided with the equipments of controlling the flow, communicating with other stations and with the largest number of staff.

Dok Krai Pump Station

The second important station which is to lift and feed water to the pipeline. In the future when the pipeline system is transferred to other agency other than RID, however, a representative must be stationed here to cooperate with RID over the problem of controlling the flow of pipeline and the storage of the reservoir. Especially when the reservoir's storage becomes low in draught years, the problem will be keen even if a basic agreement is made well beforehand for such cases.

Head Tank Station

Far less important role in the system than the other two stations. The tank is for prevention of water hammer and of the pipeline being emptied, in case of the power failure and delayed control of valves.

3.4.3 Branching

Three points of branching the pipeline to supply water to the local needs and PTT are included. Consideration must be paid in the stage of operation so that the flow from branches are kept steady and does not cause bad effect on the main line. The design team formally requested PTT to take precautionary measure for the matter and the similar arrangement will be needed in the future when the supply at two other branches is started. This kind of branching is essentially undesirable for operation and maintenance and no more direct branching shall be permitted in the future, except from Mab Ta Pud reservoir.

3.4.4 Operation and Maintenance Principle

Operation

Considering the easiness in employing operators and the difficulties in maintaining high quality instruments, the design team conceived a relatively simple flow control and instrumentation system. In every day operation not much skill will be needed and yet the accumulation of experience and good record-keeping are very desirable. The know-how of operation and maintenance can be learnt much from studying well-kept file of records.

Maintenance

The equipments and facilities of pipeline will be classified as for how often and what kind of attention must be paid in maintenance works. For instance, the pumps and instruments are under continuous operation and naturally the records of even minor defects will be made to help maintenance. But the air chambers and generator which are used only in case of the power failure tend to be forgotten of good care and the negligence may cause serious trouble. They must be checked and recorded periodically. The pipeline buried deep underground can not be inspected but the road surface above it can be watched and recorded on periodical patrol tour. During the final stage of construction work, a program of maintenance works shall be worked out by all parties concerned.

Water Quality

Remarkable change of water quality will not take place in the foreseeable future unless the watershed of Dok Krai is developed in agriculture and industries. However, periodical water quality analysis shall be made for the sake of recording and in consideration of possible utilization of water for drinking purpose.

3.4.5 Organization

The design team wrote a report titled "Proposal on Organization for Pipeline Operation an Maintenance" and edited it as a part of the Engineering Report.

After the decision on the responsible agency is made, the report must be reviewed and the most suitable formation of operation and maintenance shall be found.

CHAPTER IV - DEFINITIVE DESIGN

4.1 INTAKE FACILITIES

4.1.1 Intake Tower

General

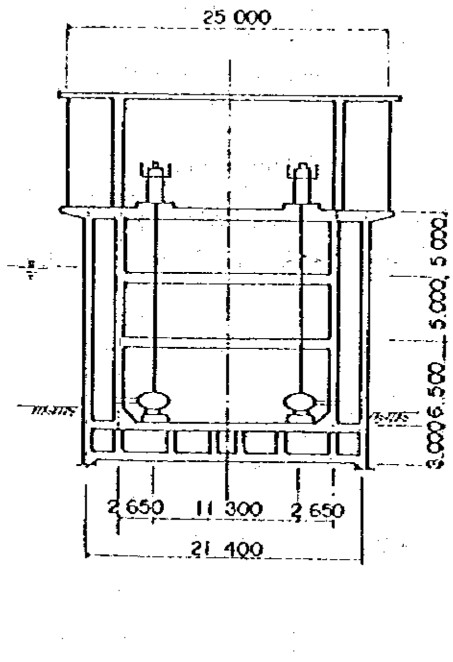
Intake tower consists of two main facilities, i.e., intake and pumping station, compositely built in single structure underwater in the existing reservoir.

Comparative study between "Jacket Type" and "Box Caisson Type" structure

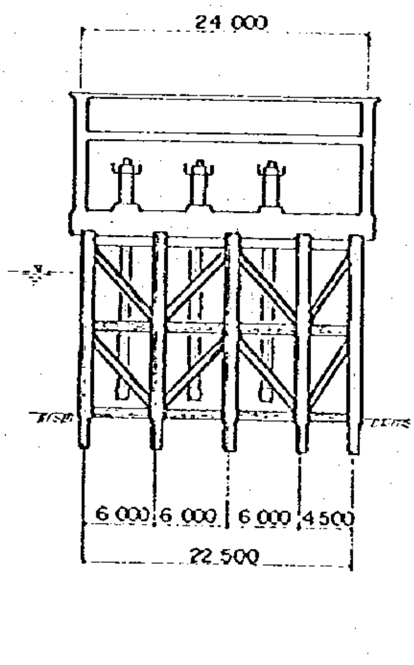
Two types of intake tower, "Jacket Type" and "Box Caisson Type" are studied. And it is concluded that "Box Caisson Type" intake tower is to be constructed because of the reasons below.

Fig. 4-1-1 Comparative Plan of Intake Tower

Box Caisson Type



Jacket Type



- Type of the pump installed in this station is "Vertical shaft mixed flow pump" for "Jaket type", and "Vertical shaft double suction centrifugal type" for "Box caisson type". Comparative study has proved advantage of centrifugal type.

- As for the durable years, jacket type structure is about 30 years, on the other hand, concrete structure is more than 50 years.

- In designing the structure, jacket type is inferior to caisson type because pile foundation consist of short piles, moreover impact uplift pressure caused by wave is very difficult to estimate.

- As for required construction time, these two plans are around the same.

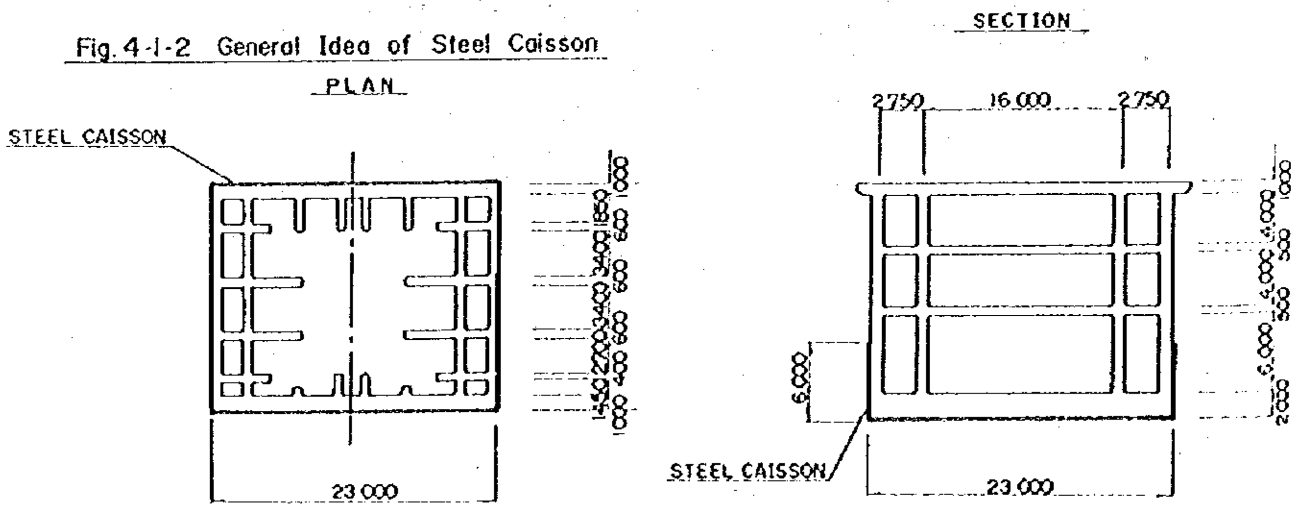
- As for construction cost, these two plans are approximately the same. So it is concluded that box caisson type is superior to jacket type when the durable years are considered.

Comparative study between "Steel Caisson" and "Concrete Caisson"

Steel fabricated caisson is studied as an alternative to concrete caisson to shorten the construction periods. In usual cases, a steel caisson is a caisson made of steel for every part of it. However, in this case, the concept is that steel-made forms for concrete structure can serve as a floating barge and "steel caisson" is used for it.

The study concluded that the construction cost and construction periods are around the same for the two types of caisson. And it is anticipated that there are some difficulties in use of steel as permanent members. This lead to rejection of steel caisson plan.

Fig. 4-1-2 General Idea of Steel Caisson



Stability analysis of caisson after completion

In the design of this type stationery box caisson, two kinds of analysis are required. One is the stability calculation during construction, and the other is the one after completion.

It is concluded that the caisson is stable in all study cases including the one after completion.

1) Design condition

Study case

Study Case

CASE	CASE NO.	WATER LEVEL	LOAD COMBINATION
In normal case	1-1	P.N.W.L.	P
	1-2	L.W.L.	P
At the time of earthquake	2	P.N.W.L	$P + E + W_D$
At the time of storm	3	P.N.W.L.	$P + W + W_P$
	4	L.W.L.	$P + W_P$

Here;
P; Principal Load
E; Earthquake force
W_D; Dynamic wave pressure
W; Wave pressure caused by wind
W_P; Wind pressure
P.H.W.L. = + 54.100 m
P.N.W.L. = + 52.100 m
L.W.L. = + 42.000 m

Allowable bearing capacity of foundation bed

In normal case $Qa = 60\ t/m^2$
At time of earthquake $Q'a = 90\ t/m^2$
At time of storm $Q''a = 75\ t/m^2$

Safety factor

Safety Factor

	Normal	Earthquake	Storm
Sliding	1.2	1.0	1.1
Overturnning	$e<B/6$	$e<B/6$	$e<B/6$

Here;
e; Eccentricity of caisson bed
B; Width of caisson bed

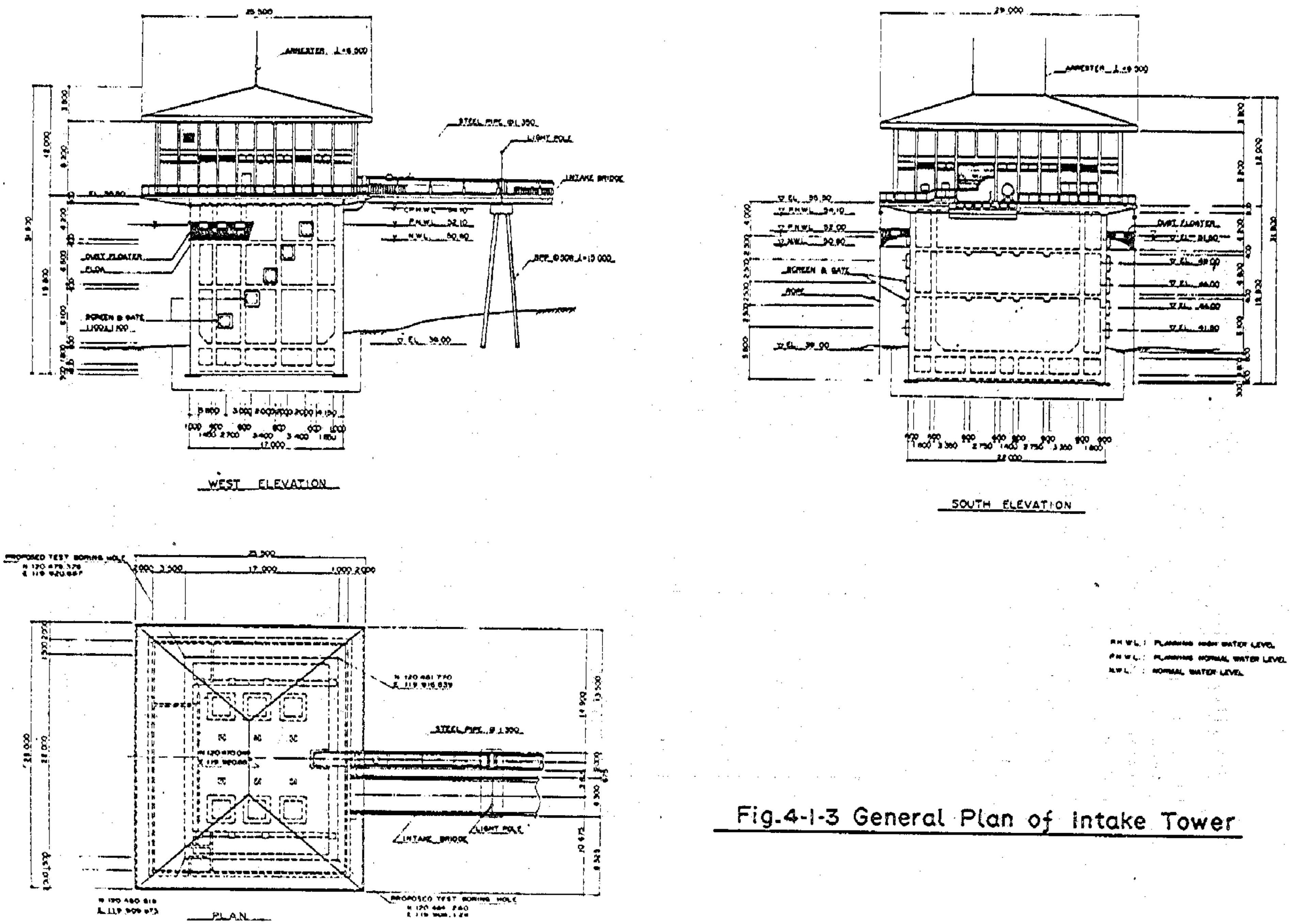


Fig.4-1-3 General Plan of Intake Tower

2) Result of study

Uplift

Safety Factor

CASE	VERTICAL LOAD (t)	UPLIFT (t)	V-U (t)	S.F.
1-1	11,185	6,022	5,163	1.9
1-2	10,757	2,244	8,513	4.8
2	11,185	6,022	5,163	1.9
3	11,277	6,770	4,507	1.7
4	10,757	2,244	8,513	4.8

Overturning and Sliding

Stability against Overturning and Sliding

CASE		OVERTURNING	SAFETY FACTOR FOR SLIDING
2	L.W.	1.36m <3.70m	3.8
	S.W.	1.99m <2.83m	3.8
3	L.W.	0.90m <3.70m	8.5
	S.W.	1.56m <2.83m	8.3
4	L.W.	0.12m <3.70m	8.3
	S.W.	0.48m <2.83m	6.8

Here; L.W.; Longer Width of Foundation
S.W.; Shorter Width of Foundation

Ground Reaction

Ground Reaction

(t/m^2)

		Ground Reaction q max	Ground Reaction q min	Allowable Ground Reaction
1-1	L.W.	13.8		60
	S.W	16.6	11.1	
1-2	L.W.	22.8		60
	S.W.	25.5	20.0	
2	L.W.	18.9	8.7	90
	S.W.	23.5	4.1	
3	L.W.	15.0	9.1	75
	S.W.	18.9	5.2	
4	L.W.	23.4	22.0	75
	S.W.	26.6	18.9	

Stability Analysis of Caisson During Construction

During the construction of caisson in the reservoir, the dead weight and the buoyancy must be well balanced at every stage of execution. This study shows a possible method of construction out of a number of alternative methods.

1) Construction stages

Proposed construction method of box caisson type has 5 different stages as shown below.

Construction Stages

Construction Stage	Brief descripton of stage
1	Construction of the base slab in the dock and tugging to the destination
2	Placing 1-st floor and outerwall of 1-st story
3	Placing partition wall in 1-st story and 2-nd floor
4	Placing filling concrete in base floor chamber
5	Placing outerwall and partition wall in 2-nd story

2) Draft of caisson body

Draft in each Construction Stage

Const. stage		$V(m^3)$	W(t)	ΣW(t)	D(m)
1	1 - 1	669.4	1673.5		
	1 - 2		97.5		
	1 - 3		117.0	1888.0	5.35
2	2 - 1	240.5	601.3	2489.3	6.96
	2 - 2	436.4	1091.0	3580.3	9.87
	2 - 3		40.3	3620.6	9.98
	2 - 4		-117.0	3503.6	9.73
	2 - 5		117.0	3620.6	9.98
3	3 - 1	27.1	67.8	3688.4	10.16
	3 - 2	78.5	196.3	3884.7	10.68
	3 - 3	86.4	216.0	4100.7	11.27
	3 - 4	150.7	376.8	4477.5	12.27
4	4 - 1	396.3	931.3	5408.8	14.76
5	5 - 1	343.4	858.5	6267.3	17.06

V; Bulk volume of the caisson body
W; Weight of the caisson body in each construction stage
D; Draft of the caisson in each construction stage $= \frac{\Sigma W}{22.0 \times 17.0} + 0.30$
ΣW; Accumulated weight of the caisson

4.1.2 Intake Bridge

In determination of a type of the proposed intake bridge, consideration is given to the three points mentioned below.

1. Length of Intake Bridge

2. Type of Superstructure

3. Type of Foundation Pile

Length of Intake Bridge

The length of the proposed intake bridge is determined as 160.0 meters based on the economical considerations. Generally speaking, construction cost of bridges is higher than that of embankments. It is economical to design length of a bridge to the required minimum. On the other hand, an embankment, if designed too high, will present problem of settlement due to consolidation and of structural instability. Based on the foregoing, bridge of 160.0 meters in length was derived as the most advantageous.

Type of Superstructure

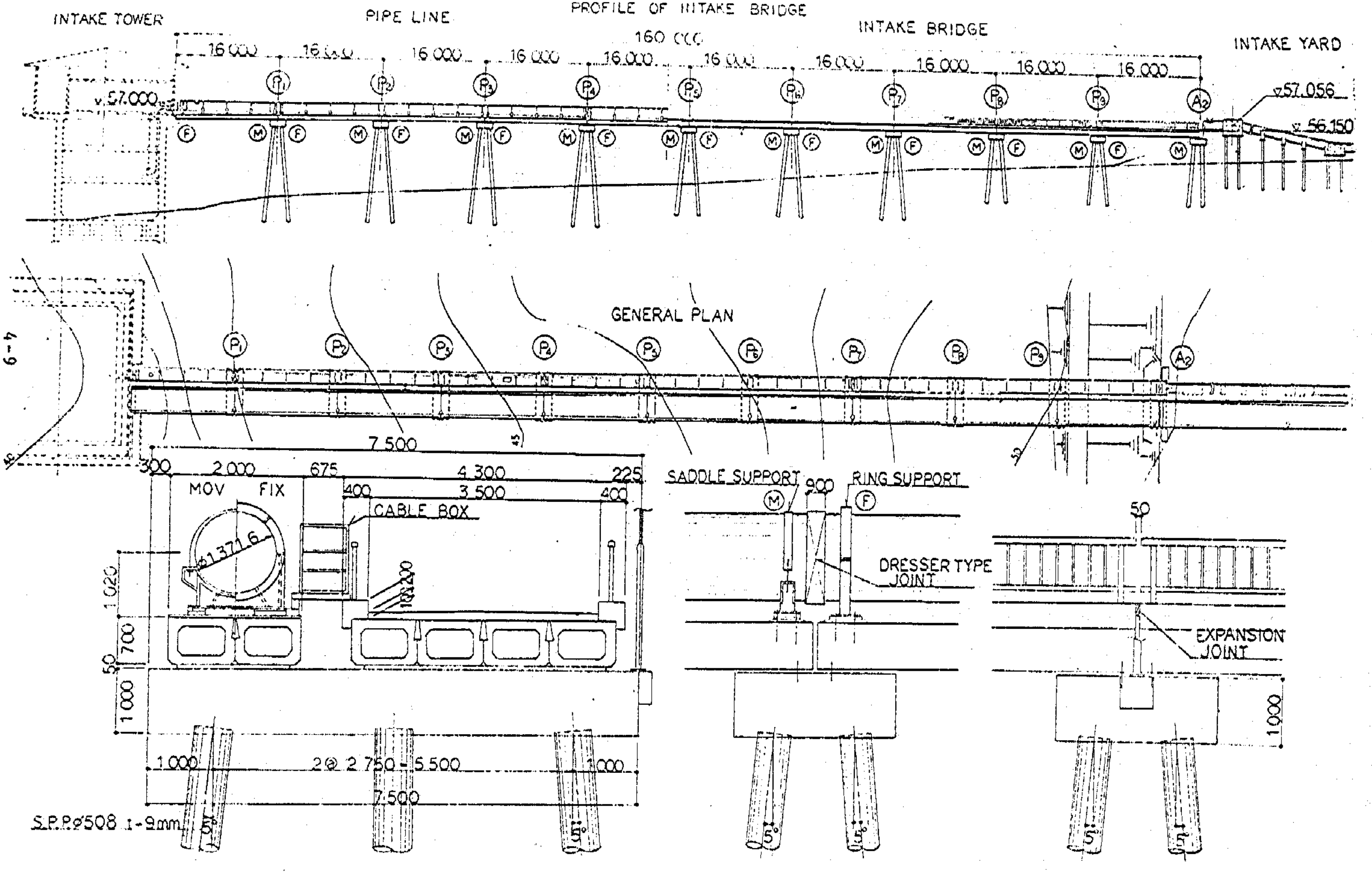
For the type of the superstructure, a PC girder, span of 16.0 meters each, is selected as suitable. For the proposed superstructure, either a steel plate girder or a PC girder may be considered. It is determined that PC girder is selected taking advantages in economy and ease of maintenance and administration in this particular case. In the case of a steel plate girder bridge, even under the most economical span of 30.0 meters, structural steel of 150 tons is required. The construction cost of the superstructure only is estimated at US$630 thousand. Whereas the PC girder, with a span between 10 and 16 meters, is estimated at something between US$220 and 260 thousand which is substantially lower in cost. In maintenance and administration phases, steel girder is required to be painted for corrosion prevention once in 7 - 8 years costing about US$20 thousand each. Taking the above-mentioned factors into consideration, PC girder is adopted for the required superstructure.

The span in this case is fixed at 16.0 meters taking ease in construction and low in cost into consideration. The PC girder, by Pretensioning Method, is factory manufactured and is readily available in spans from 10 to 20 meters ex stock. A bridge with PC girders of 12.0 meters in span needs 196 pcs. of girders with about 240 cubic meters of cast-in-place concrete. While with girders of 16.0 meters, the required quantity will be only 40 pcs. with much less quantity of about 76 cubic meters of cast-in-place concrete. This demonstrates the advantage of the 16.0 meter span girder in easier field construction work, less cast-in-concrete volume required and a shorter construction period. With regard to the construction cost including the substructure, a bridge, 160 meters in length, is about US$40 thousand less than the one with shorter span girders due to increased number of substructures required.

Type of Foundation Pile

For the foundation pile, steel-pipe pile is adopted based on the constructional and structural points of view. For the required foundation pile, steel-pipe and concrete pile may be considered as suitable. The geological features of the construction site of the proposed intake bridge are, as described in the Chapter II entitled, "Site Conditions," the depth from the surface to the bedrock is shallow. To firmly secure the required penetration depth into the bedrock, the steel-pipe pile with open-tip is more advantageous than concrete pile with solid-tip because of the open-tip which assures easier and safer in execution of the pile driving work. Also, where a footing is constructed on the top of the piles, concrete pile is less advantageous than steel-pipe pile because the top of the pile should receive on the spot chipping for a closer joints. For the corrosion resistance, concrete piles are better than the steel-pipe piles, however, with proper application of anti-corrosion paint, it is safe to say that both are about the same in their service lives. Based on the foregoing comparisons, steel-pipe pile is adopted as more suitable for the purpose. The construction cost of the intake bridge with steel-pipe pile is higher than the one with concrete pile but the difference is estimated at about US$20 thousand only.

FIG 4-1-4 GENERAL VIEW OF INTAKE BRIDGE



4.1.3 Air Chamber

General

As quoted in 3.2 "PIPELINE SYSTEM", air chambers are installed near the intake tower to mitigate water-hammer problem.

As for the tank and it's appurtenant facilities, they are described in detail in 1.7 "MECHANICAL EQUIPMENT" in Supporting Report.

Substructure

The proposed site of the air chanber is on the embakment of access road to intake bridge. The geological condition of the site is known as loose sand of top soil layer and decomposed granite of residual soil layer.

1) Pile foundation

R.C pile foundation having characteristics below is designed.

- Pile arrangement	N = 4 x 6	= 24 pcs.
- Pile length	L	= 7.0 m (7.5 m - 0.5 m chipping)
- Cross section of pile	a x b	= 30 cm x 30 cm
- Total allowable bearing capacity of the pile		
Vertical		528 ton
Horizontal		494 ton

2) Footing slab

R.C slab having characteristics below is designed.

- Width and depth	W x B	= 15.5 m x 8.8 m
- Thickness	D	= 0.6 m
- Main reinforcement	D-12	pitch = 25 cm

4.2 PIPELINE

4.2.1 Pipeline Installation

Cover Depth

The cover depth of earth, from the ground surface to the top of pipe, shall be between 1.5 m minimum to 3.0 m maximum except at the river and road crossings.

River Crossing Point

At the river crossing point, pipe shall have the minimum cover depth of 1.0 m, between river bed and pipe top, and covered with reinforced concrete of 15 cm thickness.

Road Crossing Point

1) Highway crossing

Open cut : Route-3191, Route-3371

Jacking : Route-3, Route-36

Cover depth : 3.5 m

2) Other road crossing

Open cut : cover depth, 1.5 - 3.0 m

4.2.2 Location of Appurtenant Facilities

Air Valve

Air valve of rapid type, ϕ 150 mm in dia., shall be installed at crest points along the pipeline. Those valves are attached on Tee with a manhole.

Blow-off

Blow-off, ϕ 400 mm in dia., shall be installed at trough points along the pipeline and river crossing points.

Main Valve

Main valve of butterfly type, ϕ 1,350 mm in dia., shall be installed at every 1 - 3 km distance of the pipeline and/or downstream of Blow-off points.

4.2.3 Joint

Welding Joint

Joint shall be made, in principle, by welding.

Dresser Type Joint

This joint shall be installed at points as described below.

- Closely to and on the upstream side of main valves
- Some connecting points of the pipe bridge for setting free from temperature stress

Flexible Joint

This joint shall be employed for the joint of inlet and/or outlet pipe which are embedded in heavy structures.

Distance between Flexible Joint and Bending Point of Pipe

The following table shows the minimum distance between bending point of pipe and flexible joint.

ANGLE OF BEND	DISTANCE
11° 1/4	l = 15 m
22° 1/2	l = 20 m
45°	l = 30 m
90°	l = 40 m

4.2.4 Anti-Corrosion Facilities

As the result of geological study, specific resistance of soil was denoted as follows.

Soil condition	Specific resistence
Surface soil	45,000 - 900,000 Ω cm
Saturated soil	35,000 - 65,000 Ω cm

These values are high enough and anti-corrosion means of the pipeline are not used except pipe coating. Concerning the gas pipeline, it is not decided whether or not PTT (Petroleum Authority of Thailand) execute the cathodic protection for a part of gas pipeline which runs parallel to the proposed water pipeline. For the present, the decision is that the water pipeline does not use the cathodic protection.

4.2.5 Branch for Consumer

Branch to PTT

Location	:	18 m apart from the downstream side of the crossing of gas pipe with Route-3 crossing
Pipe dia.	:	ϕ 500 mm
Pipe End	:	Valve stop, butterfly valve ϕ 500 mm

Branch to Village

- Location : Distance of 30 m before meeting the R/W of Route-36

  Pipe dia. : ϕ 250 mm x 2 branches (both sides of the pipeline)

  Pipe end : Valve stop, sluice valve ϕ 250 mm

- Location : Distance of 30 m before meeting the R/W of Route-3371

  Pipe dia. : ϕ 150 mm x 2 branches (both sides of the pipeline)

  Pipe end : Valve stop, sluice valve ϕ 150 mm

4.2.6 Identification Facilities of Pipeline Route

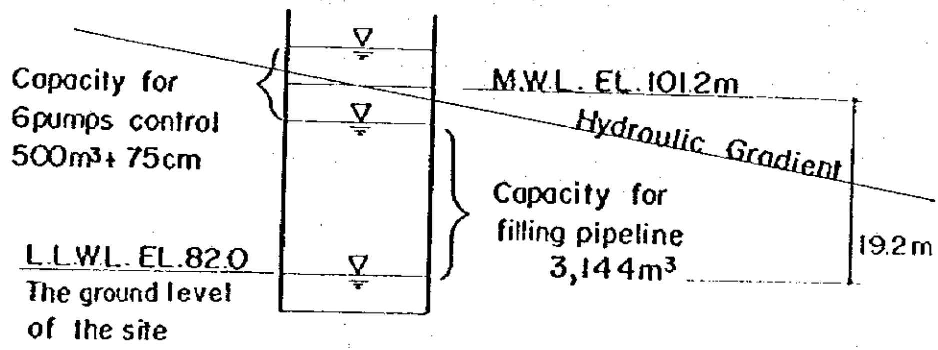
Marking posts shall be constructed on the ground above the pipe center at 300 m interval and on the both sides of large river crossing and horizontal bending points.

4.3 HEAD TANK

4.3.1 Structural Dimensions

The conditions decided so far are shown below.

Fig. 4-3-1 Water Level and Capacity of Head Tank

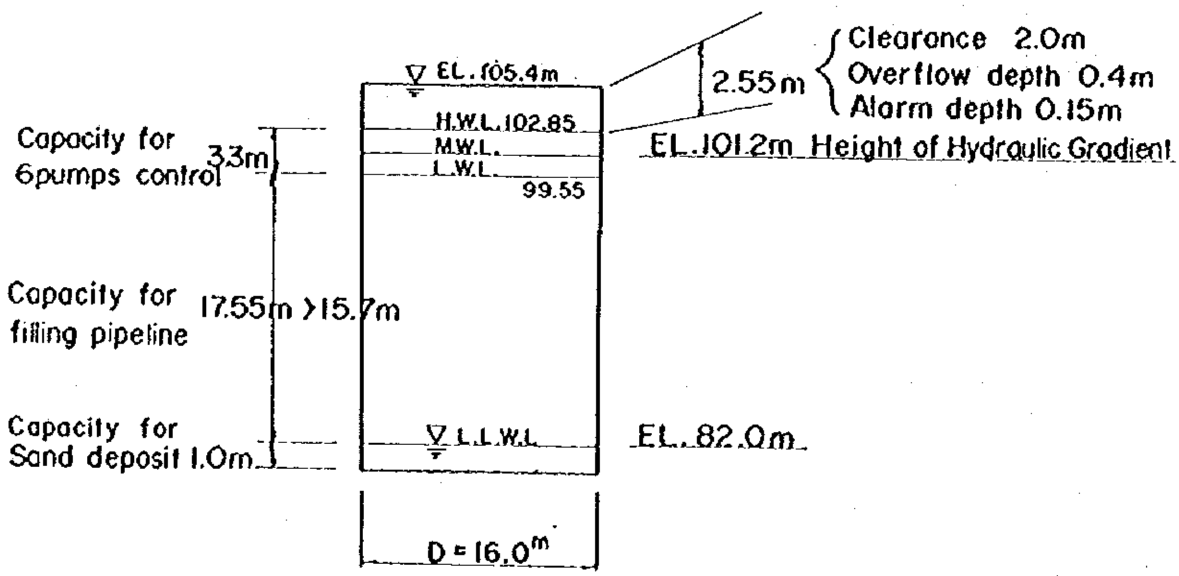


The head tank shall be cylindrical because of economical reason.

To satisfy above conditions, the inner diameter becomes 16 m, and the area will be around 200 m^2.

The depth of the capacity for 6 pumps control becomes 500 m^3/200 m^2 + 75 cm = 3.3 m, and the depth of the capacity for filling pipe becomes 3,144 m^3/200 m^2 = 15.7 m. These figures are shown in Fig. 4-3-2.

Fig. 4-3-2 Structural Dimension of Head Tank



At the top level of the capacity for control, toward up an alarm depth of 15 cm, overflow depth 40 cm and upper clearance of 2.0 m are provided. And below the LLWL, lower clearance for sand deposit of 1.0 m is provided. Total inner height becomes 24.40 m and total volume of the tank shall be 4,906 m^3.

4.3.2 Structure

For the head tank structure, R.C. type and P.C. type are compared. Steel type tank has been rejected owing to its higher cost.

The costs of R.C. type and P.C. type are shown below.

R.C. Type	1,570 x 10^3 US$
P.C. Type	735 x 10^3 US$

It is evident from above that P.C. type head tank is preferable.

4.3.3 Spill way

The head tank must have a spill way to divert excess water due to misoperation or malfunctioning of the system.

The spill way is a overflow type of morning glory and the water will divert through RCP ø900 mm to a stream which is around 460 m away from the head tank. The stream runs across Route-3191 and the proposed pipeline and has enough capacity to flow the design flow rate of the spill way which is 2.62 m^3/s.

4.4 RECEIVING FACILITIES

4.4.1 Receiving Well

Major Dimension

All figures show the internal dimensions.

1)	H.W.L.	:	63.00 m above sea level (in inlet and outlet chambers)
2)	Effective depth	:	5.40 m
3)	Freeboard	:	0.60 m
4)	Inlet chamber	:	10.00 m (width) x 10.00 m (length)
5)	Calming chamber	:	10.00 m (width) x 12.50 m (length)
6)	Outlet chamber	:	10.00 m (width) x 4.00 m (length)
7)	Overflow chamber	:	10.00 m (width) x 1.20 m (length)
8)	Valve chamber	:	5.00 m (width) x 10.00 m (length) x 3.60 m (height)
9)	Embankment	:	2.00 m (top width) x 2.50 m (height) x 1:2.5 (slope)

Appurtenant Facility

Stairs	:	To be built on the slope of embankment
Size	:	2.20 m (width) x 5.00 m (length in plan)
Material	:	Plain concrete

4.4.2 Receiving Reservoir

Structure

The structure of the receiving reservoir will be either concrete structure or earth embankment, selected on the basis of economical and engineering standpoints. Trial calculations comparing the two methods revealed that the latter is more economical, while the two are technically not very different. Therefore, for the present project, an earthwork reservoir will be adopted.

To prevent leakage of stored water through the earth banking, the bottom of the reservoir and slope of inside embankment will be lined with rubber sheet. On the other hand, the outside surface of the embankment will be covered with turf.

Major Dimension

1) H.H.W.L. : EL. 62.73 m

2) H.W.L. : EL. 62.20 m

3) L.W.L. : EL. 59.20 m

4) Effective depth : 3.00 m

5) Freeboard : 1.00 m

6) Depth under the L.W.L.: 0.3 - 1.0 m

7) Plan of reservoir : 78.00 m (width) x 156.0 m (length) (center line of embankment)

8) Embankment

Slope of embankment: inside 1:2 outside 1:2.5
Top width of embankment: 2.0 m

Appurtenant Facilities

1) To avoid unforeseeable overflows over the embankment due to misoperation, etc., a spillway will be constructed.

Size : 5.00 m (width) x 16.10 m (length) x 0.90 - 2.00 m (depth)

Material: Reinforced concrete

2) Pits

There are three kinds of pits which are inlet pit, outlet pit and drain pit. They have the following functions and are constructed of reinforced concrete.

a) Inlet pit : To kill the excessive hydraulic energy.

Size = 2.50 m (width, length) x 2.10 m (depth)

b) Outlet pit : To make outflow easy from the reservoir even in case water level goes down near the L.W.L.

Size = 2.00 m (width, length) x 1.60 m (depth)

c) Drain pit : To make removal of sediments easy

Size = 1.00 m (width, length) x 1.00 m (depth)

3) Stairs

To be built on the slope of the embankment

a) Size : 1.20 m (width) x 11.0 m (length in plan)

b) Material: Reinforced concrete

4.4.3 Pipeline in Plant

The receiving facilities include the following pipelines.

Receiving Well Inlet Pipe

1) Pipe

Inlet pipe, 1,350 mm, will be reduced to 1,200 mm at the flow meter and downstream.

a) Diameter: 1,350 mm, 1,200 mm

b) Wall thickness: 11.9 mm and 11.1 mm, respectively

c) Material: Steel

2) Valves

a) Betterfly valve: ϕ1,200 mm - 2 sets (manual control)

b) Multiport valve: ϕ1,200 mm (To be used for flow control (motor drive)

The multiport valve shall be capable of:

a) Not causing cavitation even with 42.30 m water head at upstream side of valve and 4.10 m water head at downstream side.

b) Controlling flow down to 10% of maximum 2.62 m^3/sec

Receiving Well By-pass

1) Pipe

a) Diameter: ϕ1,350 mm, ϕ1,200 mm

b) Wall thickness: 11.9 mm and 11.1 mm, respectively

c) Material: Steel

2) Valves and Boxes

a) Butterfly valve (manual control): ϕ1,200 mm - 2 sets

b) Valve boxes: These valve boxes accommodate all the four valves for receiving well by-pass and connection pipe of receiving well and receiving reservoir.

Size : 6.20 m (width, length) x 2.70 m (height)

Material : reinforced concrete

Connection Pipe of Receiving Well and Receiving Reservoir

1) Pipe

a) Diameter: ϕ1,350 mm

b) Wall thickness : 11.9 mm

c) Material: Steel

2) Valves and boxes

a) Buterfly valve (manual control): ϕ1,200 mm - 2 sets

b) Valve boxes: To be described in 2), above

Connection Pipe of Present Reservoir and Future Reservoir

The pipeline to connect the present reservoir and another reservoir to be constructed in future will be twin lines.

1) Pipe

a) Diameter : ϕ1,350 mm

b) Wall thickness : 11.9 mm

c) Material : Steel

2) Valves and boxes

a) Butterfly valves (manual control):/o1,350 mm - 2 sets

b) Valve boxes: 2 sets

Size: : 2.40 m (width) x 4.00 m (length) x 2.70 m (height)

Material : reinforced concrete

Outlet Pipe

There are five outlet pipes, one is for sattahip area and others are for Mab Ta Pud area.

1) Pipe

a) Diameter x Wall thickness

For Mab Ta Pud: ϕ700 mm x 6.0 mm

For Sattahip : ϕ900 mm x 7.9 mm

b) Material: Steel, wall thickness -

2) Valves and boxes

a) For Mab Ta Pud

Butterfly valves (manual control): /ϕ700 mm - 4 sets

Valve boxes:

Size : 2.20 m (width) x 2.10 m (length) x 2.00 m (height) - 4 sets

Material : reinforced concrete

b) For Sattahip

Butterfly valve (manual control): ϕ900 mm - 1 set

Valve box :

Size : 2.30 m (width) x 3.60 m (length) x 2.00 m (height) - 1 set

For Water Level Sensor Pipe

1) Pipe

a) Diameter : ϕ150 mm, ϕ400 mm

b) Material : Steel

Drain Pipe

1) For receiving well

a) Pipe : Diameter ϕ200mm, Material: Steel

b) Gate Valve (manual control) : Gate valve ϕ200 mm - 2 sets

2) For receiving reservoir

a) Pipe : Diameter ϕ300 mm, Material: Steel

b) Valve (manual control) : Gate valve ϕ300 mm - 1 set

Branch for Operators' Quarters

a) Pipe : Diameter ϕ75 mm, Material: Steel

b) Valve (manual control) : Gate valve ϕ75 mm - 1 set

Overflow Pipe

1) Pipe

a) Diameter : ϕ1,000 mm, ϕ1,200 mm

b) Material : R.C. Pipe

2) Man hole

a) Size : 1.80 m (width, length) x height (varies)

b) Material : Reinforced concrete

3) Energy dissipater

The energy dissipater has two functions: The first is to kill the excessive hydraulic energy and the second is prevention of river bed scouring.

a) Size : 3.00 mm (width) x 11.80 m (length) x 0.5 - 2.70 m (depth)

b) Material : Reinforced concrete

4.4.4 Landscaping

Grounding Formation

The ground formation around the receiving well and the receiving reservoir is determined so as to be balance digging and filling in earth work. The result obtained is 59.00 m.

Road in Plant

Specifications of road to be employed in the plan are as follows:

1) Width : 6.00 m

2) Surface : Pavement

4.5 ARCHITECTURE

Construction of buildings required for operation and maintenance of the proposed pipeline are planned at three sites --- Dok Krai reservoir, a source of water supply, receiving reservoir at Nab Ta Pud located 26.5 km down south of Dok Krai, and the Head-Tank located in between the two of the foregoing.

The type of all the buildings are simple, rigid frame structure. Outer wall of all the buildings are masonry relying on the skill of local labors.

In the design of the roof, corrugated asbestos-cement board in the gradient of 3 in 10 is adopted. Flat roof is avoided due to an anticipated leak of water through cracks caused by the exposure to the heat of the sun shine in waterproofing membrance.

Since the buildings are of public nature they are planned to be simple and functional in design. At the same time, special considerations are given to minimize environmental disturbances likely to be caused by the project construction.

The intake tower, with a large control house above the reservoir surface, which is located 200 m from the shore has mullions at about 2 meters intervals on the wide walls to add variations on otherwise plain flat wall surfaces so that the big structure will become less conspicuous. This is an example of the integration of an architecture into the landscape.

4.5.1 Dok Krai

Control House (4-stories Intake Tower)

Out of the total floor area, 75% of the floor is occupied by pumping equipment, and the rest of the area is for control room, electric power room, etc. Ventilation equipment are installed on the 4th floor mezzanine for the ventilation of high moisture content air from the machine rooms on the 1st, 2nd and 3rd floors. Fresh air intakes are installed at every floor.

Administration Office

The administration office, air-conditioned, is designed to accomodate enough space for a director, 5 - 6 maintenance staffs and several clerks at 7.0 sq. m per person.

Substation

The substation is designed to safely accomodate the proposed substation machinery and equipment.

Warehouse and Garage

The warehouse is for storage of spare parts and supplies required for maintenance of the pipeline system.

The garage is for 2 cars with a closet for miscellaneous items for routine car maintenance.

Air Compressor Room

The air compressor room is designed to safely accomodate the proposed air compressors for the air chamber.

4.5.2 Head Tank

Maintenance Hut

The hut is designed to accomodate 2 -- 3 maintenance staffs.

4.5.3 Mab Ta Pud

Administration Office

The design requirements are exactly the same as those of the ones of the Dok Krai office. The air-conditioned office is to accomodate a director, a deputy director, 8 - 10 maintenance staffs and several clerks. Also this office has a radio room for telecommunication equipment.

Repairing Shop, Warehouse and Garage

The repairing shop is for light repair of equipment furnished to the pipeline. The warehouse is for storage of spare parts and supplies required for maintenance of the pipeline. The garage is for 2 cars with a closet for miscellaneous items for routine car maintenance.

Diesel Engine Generator Room

An independent building is planned to house a diesel engine generator for emergency power source in the neighborhood of the main office. The dimensional particulars are to be fixed to accomodate the diesel engine generator installed.

4.5.4 Floor Area

Floor area of each buildings are shown below.

Location	Area, sq. m.
Dok Krai:	
Control House	562.99
Administration Office	97.20
Substation	102.06
Warehouse & Garage	79.38
Compressor Room	21.87
Head-Tank:	
Maintenance Hut	29.16
Nab Ta Pud:	
Administration Office	213.84
Repair Shop, etc.	124.74
Diesel Engine Generator Room	21.87

4.6 MECHANICAL EQUIPMENT

4.6.1 Pump

Type of Pump

In selecting the type of main pump, the vertical shaft mixed flow pump and the double suction centrifugal pump, two most widely used types, are compared and it is found that the latter has the following advantages over the former:

1) Simpler mechanism
2) Easier maintenance
3) Lower cost
4) Better efficiency

Number of Pump

In selecting the number of main pump, two cases of 6 and 4 pumps, each including 1 stand by, are compared and the former is found to be preferable from operation viewpoints in consideration of malfunctioning and repairing, although the latter has some advantage over the former due to the less number. A comparative study of both cases is made in detail in 4.6 "MECHANICAL EQUIPMENT" of the Supporting Report.

Pump and Appurtenance Specifications

1) Main pump

Type:	Vertical shaft, double suction centrifugal
Number:	6 units including 1 stand by
Design capacity:	31.5 m^3/min.
Head:	79.0 m
Voltage:	3,000 V
Diameter of suction:	500 mm

2) Discharge pipe

Diameter:	500, 900, 1,200 mm
Material:	Carbon steel

4.6.2 Air Chamber and Appurtenance

Air Chamber

Number:	3 sets
Design capacity:	Above 30 cu.m per set
Max. service pressure:	10 kg/cm^2
Normal water level:	Above EL. 60.00 m

Air Compressor

Number: 2 units including 1 stand by

Orifice Plates

Orifice plates are inserted in the inlet pipe of the chamber.

4.7 ELECTRICAL EQUIPMENT

4.7.1 Power Demand

The power demand required for this water supply system are as follows.

1)	Dok Krai	3,350 kW
2)	Head Tank	30 kW
3)	Receiving well and reservoir in Mab Ta Pud	152 kW

4.7.2 Receiving Power Voltage

Dok Krai Sub-station

- 3 phase 3 wire 22 kV 50 Hz

Head Tank

- Single phase 220 V 50 Hz

Receiving Well and Reservoir in Mab Ta Pud

- 3 phase 4 wire 380/220 V 50 Hz

4.7.3 Reception and Transformation at Dok Krai

Reception

One supply of 3 phase 3 wire 22 kV 50 Hz is to be supplied to two (2) banks of power transformer which run in parallel.

Transformation of Voltage

3 kV for main pump operation and 380/220 V for ancillary equipments shall be got through the two main tans-former of 22/3.15 kV and one station supply transformer of 3kV/380-220 V.

Type of Transformer Station

There are three (3) types of transformer station, outdoor and open, outdoor and closed, and indoor and closed. After comparison of above three types, indoor and closed type was selected.

Capacity of Main Transformer

Two (2) sets of main transformer are to be installed in the sub-station, one of two (2) transformers whose capacity is of 3,000 kVA, can transform power required for three (3) main pumps and for ancillary equipments.

Capacity of Station Supply Low Voltage Transformer

For ancillary equipments of main pumps, auxiliary facilities and lighting , 3-phase 380 V and 1-phase 220 station supply transformer of 200 kVA are to be installed in Dok Krai.

4.7.4 Emergency-Use Engine Driven Generator

Requirements and Conditions at Dok Krai and Mab Ta Pud

1) Dok Krai

A generator of 125 kVA with an engine of 150 HP shall be used, and a 490 lit. of fuel tank for 12 (twelve) hours operation shall be supplied.

2) Receiving well and reservoir in Mab Ta Pud

A generator of 65 kVA with an engine of 85 HP shall be used and a 490 lit. of fuel tank, same as that of Dok Krai, shall be supplied for 24 hours.

Generated Voltage and Engine Cooling

According to the equipments which shall be driven by the above generator at the main power failure, generated voltage is to be of 3-phase 4-wire 380/220 V 50 hz cooling system of engine shall be of air cooling.

Starting-Up of Engine

DC battery driven cell motor starting system shall be used. Engine starting shall be done automatically at the public power failure and that stopping will be done by operator's switch operation after the public power restored is on service.

4.7.5 Uninterruptable Power Source (U.P.S.)

Location of Installation

Each one set of DC110 V/AC110 V U.P.S. shall be installed in Dok Krai, receiving well and reservoir. DC110 V, U.P.S. shall be used for emergency lighting, alarm system operation control operation and charging to AC110 V, U.P.S. system.

Capacity of U.P.S.

Dok Krai .... DC 110 VA & AC 110 VA

Mab Ta Pud .... DC 110 VA & AC 110 VA

4.7.6 Metering Instruments

After the various study, type of instrument was decided as follows.

Flow Meter : Supersonic type

Level Meter

1) Intake tower : Diaphram type

2) Head tank : Pressure type and float type

3) Receiving well : Float type

4.8 TELECOMMUNICATION

4.8.1 Wireless and Public Telephone System

The public telephone system will not be available before December 1984, 4 months after the commencement of pipeline operation, in the area between Dok Krai and Mab Ta Pud. A wireless communication system shall be prepared for the operation consequently. Moreover, an internal telephone system which can be connected to the public system is needed at each of Dok Krai and Mab Ta Pud compounds where facilities and residencial quarters are arranged in an wide area.

4.8.2 Wireless Communication System

Frequency and Power

frequency: VHF/FM, 132 - 174 MHz
power : 25 watt

Stations and Antenna

permanent station: Dok Krai and Mab Ta Pud Office, each with 30 m high antenna

mobile station: 14 (fourteen) walkie talkies with rod antenna

In case of the future extention of pipeline to Sattahip, a permanent station will be set up there and the installation of "repeater" on Mab Ta Pud antenna will be necessitated, while no more mobile station is needed.

4.8.3 Internal Telephone System

The public lines, extensions and automatic telephone exchanges will be arranged as shown below:

Dok Krai

- public line —— pump station telephone exchange —— pump station
 — 18 extensions
- public line —— office

Mab Ta Pud

- public line —— office telephone exchange —— office
 — 18 extensions
- public line —— Engineer's residence

The number of extension is 20 for each station.

CHAPTER V - CONSTRUCTION SCHEDULE

5.1 GENERAL

The construction works in the Project consist of such works complicated with varieties as intake facilities constructed by caisson method, pumping facilities with high head, long distance steel pipelines, head tank by prestressing method, receiving facilities at terminal point of the pipeline, and building works. On the other hand, the time table of the construction is very tight in the total work period of 18 months lasting from March 1983 till August 1984.

According to the national development programme, furthermore, the net working period for each facility will be only 12 to 14 months, taking into consideration the periods for temporary and mobilization works at the beginning stage and for the final stage of test run of all facilities. Therefore, the construction schedule was studied very carefully as illustrated below, using the critical path method and graphical method.

Mobilization/Temporary works	2 months
Major construction works	14 months
Test run/Demobilization	2 months
Total	18 months

5.2 INTAKE FACILITIES

The site construction period is computed into 14 months except two months of preparatory works like mobilization and two months of the final works like test run and demobilization. During the construction period, many kinds of works should be executed in the limited area of the work site, and the works are the dry-dock construction, piling works of intake bridge construction, control house construction, installation works of pumping equipment, pipeline and air chambers, and other works including many temporary facilities.

These works should have close relations to one another with many overlapping in the work progress, some of the works should be executed simultaneously and the others proceeded immediately after execution of the others.

The Critical Path Method, therefore, was applied for establishing the construction schedule. Fig. 2-7-2 in Supporting Report shows characteristics of each work, supply of materials and equipment, and output of works. Under the conditions, the implementation of the major works based on the C.P.M. is shown as follows:

Mobilization	60 days
Dry Dock	60
1st Stage Caisson Concreting	43
Dry Dock Opening	12
Launching & Towing of Caisson	2
2nd-4th Stage Caisson Concreting	101
Final Settlement & 5th Stage Foundation Grouting	10
6th Stage Caisson Concreting	46
Control House Concreting	75
Installation of Pumping Equipment	75
Sub-total	484
Demobilization & Final Inspection, Test Run	65
Total	549 days

(Note: Number of the days from March 1983 till Aug. 1984 counts 549 days.)

5.3 PIPELINE

The pipeline works are divided into two, fabrication of steel pipes at factories and pipe laying at the site, and the pipe laying works will allow to have 10 months only from August 1983 till May 1984 for their execution.

In addition, one rainy season lies in this period of 10 months.

In order to complete the pipeline works under the above conditions, laying should be executed by six parties, each of which shall be in charge of the four to five kilometer long sections for their works.

The summary of the output and the schedule for the pipe works, which have resulted from the graphical method, are shown as follows:

Wet season (August to November)

1.5 P.C.S. x 9 m x 20 days = 270 m/month/crew

Dry season (December to May)

2.5 P.C.S. x 9 m x 28 days = 630 m/month/crew

In the above, expected working hours were estimated at six hours per day in the rainy season, while ten hours in the dry season. The pipe laying by jacking is planned to be carried out for crossing the Route-3 and 36 from November 1983 till February 1984, to avoid interfering the main pipeline works.

5.4 HEAD TANK

The construction period of 18 months involves some slack time for the head tank works. The sequence of the works and time requirements resulting from graphical analysis are as follows:

Mobilization	120 days
Foundation & Base of Tank	50
Tank Concreting	199
Prestressing & Grouting	23
Water-Proof Coating & Others	54
Sub-total	446
Demobilization & Inspection, Test Run	103
Total	549 days

The spillway pipeline works, installation of 426 m R.C. pipeline should be executed after finishing the main pipeline laying from KM 6 + 400 to KM 7 approximately, and is expected to be started on February, 1984.

5.5 OTHER WORKS

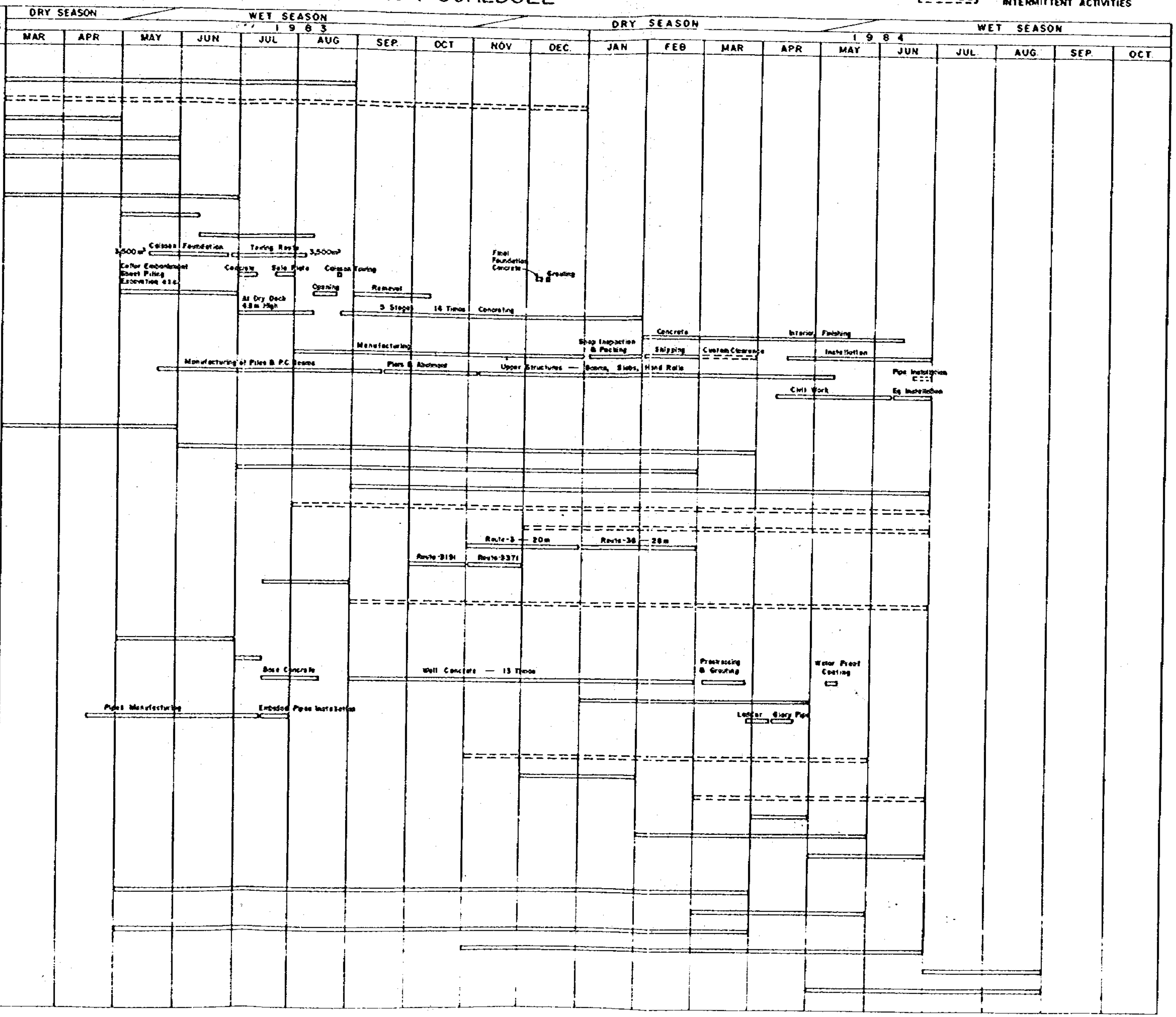
The construction works of the receiving facilities may be carried out in the dry season from December 1983, because the work volume is not so much. One dry season is sufficient to complete the said work.

Building construction works and camping facilities should be implemented from the early stage of the period and all works should be completed as early as possible taking into consideration utilization of the facilities.

5.6 WHOLE CONSTRUCTION SCHEDULE

NOTE: ═══ CONTINUOUS ACTIVITIES; - - - - INTERMITTENT ACTIVITIES

DESCRIPTION	UNIT	QUANTITIES
MOBILIZATION AND GENERAL TEMPORARY WORKS		
Mobilization		
Land Acquisition		
Access to Sites		
Contractor's Camps		
Batcher Plant		
INTAKE FACILITIES		
Site Preparation		
Embankment	Cu.m	23,000
Temporary Bridge & Caisson Setting Rig	L.S.	
Excavation in Reservoir	Cu.m	7,000
Foundation Concrete, Caisson Settlement	Cu.m	1,200
Dry Dock (30 x 24 x 6.6 m)	No.	1
Caisson Concrete	Cu.m	3,800
Control House	Sq.m	
Pumping Equipment	L.S.	1
Intake Bridge (160m Length)	L.S.	1
Air Chamber	L.S.	1
PIPELINE		
Material Arrangement		
Pipe Fabrication	t	10,400
Site Preparation & Temporary Works	L.S.	1
Pipe Installation	Km	26.1
Valve Chambers & Boxes (Main ∅1 350)	Pieces	17
Blow Offs	-do-	23
Highway Crossing (Jacking) (28m+20m)	-do-	2
-do- (By Pass & Reconstruction)	-do-	2
Water Pipelines for Casava Factory (∅150)	Km	2.8
Miscellaneous Works (Branches, Air Valves, etc.)		
HEAD TANK		
Site Preparation		
Excavation	Cu.m	1,000
P. C. Tank (∅16 x 25.1m)	Cu.m	
Spillway (∅900x426m R.C Pipes & 2-Dissipators)	L.S.	
Steel Works (Pipes & Others)	L.S.	
RECEIVING FACILITIES		
Excavation	Cu.m	9,400
Embankment	Cu.m	24,100
Backfill	Cu.m	4,700
Membrane Sheeting	Sq.m	12,400
Concrete	Cu.m	1,300
Pipes, Gates & Valves Installation	L.S.	
BUILDING		
Dok Krai (Administration Office, Camp, Garage, Warehouse, Compressor Room, Sub station)	Sq.m	
Head Tank Site (Maintenance Hut Camp)	Sq.m	
Mab Ta Pud (Main Office, Generator Room, Repairing shop, Garage, Warehouse Camp)	Sq.m	
ELECTRICAL FACILITIES	L.S.	
INSPECTION & TEST RUN		
DEMOBILIZATION		



CHAPTER VI - PROJECT COST

6.1 COMPOSITION OF PROJECT COST

The project cost of Dok Krai-Mab Ta Pud Water Pipeline Project consists of following items.

Construction Cost with Contingency	878,000,000 ฿
Engineering & Administration Expenditures	70,000,000
Cost of Land Expropriation	4,000,000
Compensation Cost of Electrical Pole etc. (assumed)	4,000,000
Total	956,000,000 ฿

6.2 CONSTRUCTION COST

Construction cost is estimated by calculated quantities based on the drawings and the rate for each work.

The summary of construction cost is as follows; The detail content of each work is shown in the Bill of Quantities of Tender Documents.

1.	General Requirement	90,000,000 ฿
2.	Intake Facilities	154,000,000
3.	Pipeline	387,000,000
4.	Head Tank	11,000,000
5.	Receiving Facilities	43,000,000
6.	Control System	4,000,000
7.	Buildings	48,000,000
8.	Test Operation	3,000,000
9.	Contingency	138,000,000
	Total	878,000,000 ฿

6.2.1 General Requirement

General Requirement includes the following works executed by the Contractor's own intention and is estimated as Lump Sum.

- General preparatory works such as setting out and preparation of shop Drawings and Documents.
- General temporary works such as transportation of construction plant, access road, power & water supply for construction purpose, Contractor's camp and office, maintenance of traffic etc.
- Engineer's facilities such as Engineer's office, camp and transportation.

6.2.2 Intake Facilities

The Intake facilities includes the works of intake tower, intake bridge, air chamber and electrical facilities executed at the Dok Krai site.

6.2.3 Pipeline

The pipeline includes the works of supply of pipes and valves, installation of pipes and valves, and civil works executed at the section between Dok Krai and Mab Ta Pud.

6.2.4 Head Tank

The Head Tank includes the works of head tank and spillway at the station of 7 km from the Dock Krai reservoir.

6.2.5 Receiving Facilities

The Receiving Facilities includes the works of receiving well, receiving reservoir and piping works at the Mab Ta Pud site.

6.2.6 Control System, Buildings and Test Run

These works are executed for purpose of the maintenance and operation after completion of the works.

6.3 COST ESTIMATION

6.3.1 Basic Unit Rates

Labour ...... The unit rates of labour has been decided according to the results of price survey at Rayong and the rates applied for other projects in Thailand.

Material .... Same methods as above are applied.

Machinery ... The recent price quotation for machinery procurement by RID are basically applied.

6.3.2 Rates of Works

Rate of each item of works has been estimated taking the construction plan of the said work into consideration. The hiring rate and the efficiency of machinery are calculated based on the standard prevailing in Japan, with some amendment there to with our own experience. The material cost in the work is estimated with proper percentage of wastage. The labor cost in the work is estimated considering the group of labor and their output in proper duration using machinery and material.

The basical factors applied in those aforementioned estimation are as below:

<u>Working Hour</u>

1) Working hour:

12 hrs/day ..... Intake tower & pipeline in dry season
8 hrs/day ..... Other works

2) Labor cost in 12 hrs/day basis:

$$\text{daily wage} + (\text{daily wage} \times \frac{1}{8} \times 1.25 \times 4)$$

3) Net working hour of machinery:

12 hrs/day basis ..... 10 hrs/day
8 hrs/day basis ..... 6 hrs/day

<u>Power Supply</u>

Electricity is applied for Intake Facilities, but other works are calculated as use of petroleum.

<u>Other Factors</u>

1) Steel pipe & steel pile

The steel plate may be imported and processed in Bangkok.

2) PC Beam & PC pile

To procure from manufacturers in Bangkok.

3) Pumping Facilities, Gates, Valves, etc:

To be imported and unloaded in port of Bangkok. The cost includes custom duties, etc.

4) Other materials

Except those manufactured articles mentioned aboves, other materials are to be procured in Thailand.

5) Construction plant

All constructional plants are provided in Bangkok, and returned thereto after completion of works.

Indirect cost

A part of indirect costs is entered into Bill of Quantities and other indirect expenditures are broken down into each rate of works. Indirect cost to civil works is estimated about 30% and that of manufactured articles is about 10%.

6.4 ENGINEERING & ADMINISTRATION EXPENDITURES

Engineering expenditures usually means the consulting fee for construction supervision. Administration expenditures are the expenses which is used for this project by RID.

Since feasibility and final design study has been made by Japan Inernational Cooperation Agency as grant, Engineering & administration expenditure will be about 10% of the construction cost.

6.5 COST OF LAND ACQUISITION

The total land required for the project is estimated as about 200 Rais and priced of land per Rai estimated as 20,000 Bahts.

6.6 COMPENSATION COST OF REPLACEMENT OF ELECTRICAL POLE, ETC.

The distance of replacement of electrical pole is estimated as about 12 km and per kilometer rate is estimated as 300,000 Bahts.

CHAPTER VII - NOTES ON PROJECT EVALUATION

. The raw water cost at the outlet of the receiving facilities is estimated based on the construction cost after the detailed design. In addition, the raw water cost estimated in the feasibility study is reevaluated using loan conditions employed in the detailed design so that the raw water costs from two studied can be compared. The costs of water purification and distribution are excluded, since they are out of the scope of present detailed design.

7.1 FINANCIAL COST

The cost of raw water, which should be paid by water users, equitably throughout the life span of the pipeline project consists of 1) construction of the pipeline facilities between Dok Krai and Mab Ta Pud and also the extension between Mab Ta Pud and Sattahip, 2) their maintenance and operation costs, 3) allocated construction cost and operation and maintenance costs of the Nong Pla Lai dam which replaces Dok Krai as the water source for the irrigation water in the existing Dok Krai irrigation area, and 4) construction costs of the Ban Khai head works to collect released water of the Dok Krai reservoir for sending it towards the Rayong municipality.

The cost estimate in the detailed design stage covers only pipleline facilities provided between Dok Krai and Mab Ta Pud, therefore, other related costs are extracted from these prepared in the previous feasibility study.

The allocated construction cost of proposed Nong Pla Lai dam, prepared in the previous feasiblity study, has been estimated by "Separable Cost-Remaining Benefit Method" and it is concluded that 60% of the cost is allocated to the pipeline project including the extension from Mab Ta Pud to Sattahip.

7.2 O&M COSTS

O&M costs are mostly electricity cost to run the pumps, repair cost of the facilities, and remuneration of staff. The O&M costs for the pipeline facility and the allocated O&M costs which should be covered by the project are estimated based on the stage of the full operation.

7.3 PROJECT LIFE

Project life of the pipeline is decided to be 37 years which is equal to the average depreciation period of main facilities involved in the pipeline and related projects.

7.4 LOAN CONDITION OF FOREIGN CAPITAL

The pipeline project as well as the Nong Pla Lai project are already decided to be financed by OECF loan on the conditions below.

Interest rate	:	3.00%
Repayment term	:	30 years
Grace period	:	10 years

The same conditions apply to the financial analysis.

7.5 RAW WATER COST

The raw water cost estimated under cash flow presented is 3.2 ฿/m^3.

The raw water cost in the feasibility study was 3.5 ฿/m^3 under the loan condition of the interest rate of 9%, the terms of repayment of 20 years, and the grace period of 5 years. The same raw water cost would be 3.3 ฿/m^3 under the OECF loan.

CHAPTER VIII - LIST OF CONTRACT DRAWINGS

DRAWING NO.	TITLE OF DRAWING	NO. OF SHEETS	REMARKS
	1. GENERAL		
1001	General Plan of the Project	1	
1002	References for Topographic Survey	1	
1003	Available Land for the Project	1	Subtotal 3
	2. INTAKE FACILITIES		
2001	General Plan of Intake Facilities	1	
	2-1. Intake Tower		
2101	General Plan of Intake Tower	1	
2102	Intake Tower-Structure (1)	4	
2105	Intake Tower-Structure (4)		
2106	Intake Tower-Reinforcing Bar Arrangement (1)	4	
2109	Intake Tower-Reinforcing Bar Arrangement (4)		
	2-2. Intake Bridge		
2201	General Plan & Profile of Intake Bridge	1	
2202	Intake Bridge-Super Structure (1)	1	
2203	Intake Bridge-Super Structure (2)	1	
2204	Intake Bridge-Pipeline on Girder	1	
2205	Intake Bridge-Substructure	1	
2206	Intake Bridge-Lighting Plan	1	
	2-3. Intake Yard		
2301	General Plan of Intake Yard	1	
	2-4. Air Chamber		
2401	Air Chamber-Substructure	1	
2402	Air Chamber-Substructure Reinforcing Bar Arrangement	1	

DRAWING NO.	TITLE OF DRAWING	NO. OF SHEETS	REMARKS
	2-5. Mechanical & Electorical Work		
2501	Electrical Work - Substation & Intake Tower Single Line Diagram	1	
2502	Electrical Work - Dok Krai Dam	1	
2503	Electrical Work - Dok Krai Substation	1	
2504	Electrical Work - Intake Tower	1	
2505	Mechanical Work - Pumping Equipment & Piping; Plan (1F,2F)	1	
2506	Mechanical Work - Pumping Equipment & Piping; Plan (3F,4F)	1	
2507	Mechanical Work - Pumping Equipment & Piping; Section	1	
2508	Mechanical Work - Air Chamber Equipment & Piping; Plan & Section	1	Subtotal 27
	3. PIPELINE		
3001	Schematic Plan of Pipeline	1	
	3-1. Plan & Profile of Pipeline		
3101	Pipeline-Plan & Profile (1)	24	
3124	Pipeline-Plan & Profile (24)		
	3-2. Pipeline Details		
3201	Pipeline-River Crossing R-19; Details	1	
3202	Pipeline-Marking Post and Branch; Details	1	
3203	Pipeline-Standard (1) Earth Work and Road & River Crossing	1	
3204	Pipeline-Standard (2) Valve Chamber & Box	1	
3205	Pipeline-Standard (3) Blow-off	1	
3206	Pipeline-Standard (4) Pipe Manufacturing	1	Subtotal 31

DRAWING NO.	TITLE OF DRAWING	NO. OF SHEETS	REMARKS
	4. HEAD TANK		
4001	General Plan of Head Tank	1	
	4-1. Head Tank & Spillway		
4101	Head Tank - Structure (1)	1	
4102	Head Tank - Structure (2)	1	
4103	Head Tank - Reinforcing Bar Arrangement of Footing	1	
4104	Head Tank - Energy Dissipator I	1	
4105	Head Tank - Energy Dissipator II	1	
	4-2. Electrical Work		
4201	Head Tank - Electrical Work	1	Subtotal 7
	5. RECEIVING FACILITIES		
5001	General Plan of Receiving Facilities	1	
	5-1. Receiving Well		
5101	Receiving Well - Plan & Section	1	
5102	Receiving Well - Section	1	
5103	Receiving Well - Reinforcing Bar Arrangement (1)	1	
5104	Receiving Well - Reinforcing Bar Arrangement (2)	1	
5105	Receiving Well - Appurtenances; Details	1	
	5-2. Receiving Reservoir		
5201	Receiving Reservoir - Plan & Section	1	
5202	Receiving Reservoir - Spillway; Details	1	
5203	Receiving Reservoir - Inlet & Outlet pipe; Details	1	

DRAWING NO.	TITLE OF DRAWING	NO. OF SHEETS	REMARKS
	5-3. Receiving Yard		
5301	Receiving Yard - Yard Piping; Plan & Profile(1)	1	
5302	Receiving Yard - Yard Piping; Profile(2)	1	
5303	Receiving Yard - Yard Piping; Material List	1	
5304	Receiving Yard - Yard Piping; Details of Fittings	1	
5305	Receiving Yard - Yard Piping; Details of Valve Box & Flow Meter Box	1	
5306	Receiving Yard - Yard Piping; Details of Energy Dissipator & Manhole	1	
5307	Receiving Yard - Road Layout & Rain Drainage; Plan	1	
	5-4. Electrical Work		
5401	Electrical Work - Receiving Well Single Line Diagram	1	
5402	Electrical Work - Receiving Well (1)	1	
5403	Electrical Work - Receiving Well (2)	1	Subtotal 19
	6. CONTROL SYSTEM		
6001	Instrumentation Diagram	1	Subtotal 1

DRAWING NO.	TITLE OF DRAWING	NO. OF SHEETS	REMARKS
	7. BUILDINGS		
7001	List of Buildings	1	
	7-1. Control House		
7101	Control House - Architectural Work ; Plan	1	
7102	Control House - Architectural Work ; Elevation	1	
7103	Control House - Architectural Work ; Section	1	
7104	Control House - Architectural Work ; Details	1	
7105	Control House - Structural Work (1)	3	
7107	Control House - Structural Work (3)		
7108	Control House - Electrical Work (1)	1	
7109	Control House - Electrical Work (2)	1	
7110	Control House - Water Supply & Sewage Work	1	
	7-2. Dok Krai Substation		
7201	Dok Krai Substation - Architectural Work ; Plan & Details	1	
7202	Dok Krai Substation - Architectural Work ; Elevation & Section	1	
7203	Dok Krai Substation - Architectural Work ; Elevation	1	
7204	Dok Krai Substation - Structural Work	1	
7205	Dok Krai Substation - Electrical Work	1	
	7-3. Dok Krai Administration Office		
7301	Dok Krai Administration Office - Architectural Work ; Plan	1	
7302	Dok Krai Administration Office - Architectural Work ; Elevation & Section	1	
7303	Dok Krai Administration Office - Architectural Work ; Elevation	1	
7304	Dok Krai Administration Office - Structural Work	1	
7305	Dok Krai Administration Office - Electrical Work	1	
7306	Dok Krai Administration Office - Water Supply & Sewage Work	1	

DRAWING NO.	TITLE OF DRAWING	NO. OF SHEETS	REMARKS
	7-4. Other Buildings at Dok Krai		
7401	Garage & Warehouse at Dok Krai - Architectural Work ; Plan & Section	1	
7402	Garage & Warehouse at Dok Krai - Architectural Work ; Elevation	1	
7403	Garage & Warehouse at Dok Krai - Electrical Work	1	
7404	Dok Krai Compressor Room & Nab Ta Pud DEG Room - Plan, Section & Elevation	1	
7405	Dok Krai Compressor Room & Nab Ta Pud DEG Room - Electrical Work	1	
7406	General Plan of Dok Krai Camp	1	
	7-5. Head Tank Maintenance Hut		
7501	Head Tank Maintenance Hut - Architectural Work ; Plan, Section & Elevation	1	
7502	Head Tank Maintenance Hut - Structural Work	1	
7503	Head Tank Maintenance Hut - Electrical Work	1	
7504	Head Tank Maintenance Hut - Water Supply & Sewage Work	1	
7505	General Plan of Head Tank Camp	1	
	7-6. Nab Ta Pud Administration Office		
7601	Nab Ta Pud Administration Office - Architectural Work ; Plan	1	
7602	Nab Ta Pud Administration Office - Architectural Work ; Elevation & Section	1	
7603	Nab Ta Pud Administration Office - Architectural Work ; Elevation	1	
7604	Nab Ta Pud Administration Office - Structural Work (1)	1	
7605	Nab Ta Pud Administration Office - Structural Work (2)	1	
7606	Nab Ta Pud Administration Office - Electrical Work	1	
7607	Nab Ta Pud Administration Office - Water Supply & Sewage Work	1	

DRAWING NO.	TITLE OF DRAWING	NO. OF SHEETS	REMARKS
	7-7. Other Buildings at Mab Ta Pud		
7701	Repairing Shop, Warehouse & Garage at Mab Ta Pud - Architectural Work ; Plan & Section	1	
7702	Repairing Shop, Warehouse & Garage at Mab Ta Pud - Architectural Work ; Elevation	1	
7703	Repairing Shop, Warehouse & Garage at Mab Ta Pud - Structural Work	1	
7704	Repairing Shop, Warehouse & Garage at Mab Ta Pud - Electrical Work	1	
7705	General Plan of Mab Ta Pud Camp	1	Subtotal 45
			Grand Total 133

CHAPTER IX - RECOMMENDATIONS

In executing the construction of the Project and operating the facilities for the intended water supply, it is recommended the following should receive due consideration.

1. Importance is to strictly observe the fixed deadline set for the completion of the construction in 18 months to supply industrial water to the gas separation plant of PTT, operation of which is scheduled for the first half of 1984. In this connection, the following should be paid attention to.

1.1 The construction of the Project demands an advanced technique and a large scale construction execution capability, therefore, it is recommended that the contract be awarded to a reliable and experienced contractor in a lot basis.

1.2 Preliminary transactions, such as land acquisition, house evacuation etc., shall be completed prior to the commencement of the execution of the Project construction, so as to allow a smoother execution of all the specified works immediately upon award of the contract. To successfully achieve the above, speedy business routine in budget allocation, and in licensing and permission is desirable at all agencies concerned of the government.

1.3 As for the environmental aspects, the utmost protective measures may have to be taken to eliminate any possibility of the deterioration during the construction and a careful consideration shall be given to avoid the environmental deterioration after the completeion of the Project construction.

1.4 To cope with possible deterioration of the reservoir water by an anticipated increase in sewage from future development in the upstream area of Dok Krai dam, certain countermeasures such as obligatory construction sewerage systems and enforcement of regulations for land utilization must be put into effect.

1.5 With regard to the construction contract, the "Bill of Quantity" procedure should be adopted in accordance with the accepted international bid requirements. To comply with the particulars of the subject project construction and to the special circumstances in Thailand, a lump sum method may be adopted in certain work items.

2. The water supply system of this project covers only up to the construction of the receiving basin. To achieve the intended purpose of the water supply, a purification plant and water distribution system is prerequisite. Therefore, both the purification plant and water distribution system shoud be constructed by the time the Project is completed.

3. In the design stage of the Project, no jurisdiction over the operation and administration of the pipeline system has been determined, therefore, an administration system was proposed which in general is considered the most suitable under given conditions.

The jurisdiction has to be determined the soonest and the proposed administration system may be revised to suit the organization and to optimize its efficiency. The followings are recommended to undertake effective management and O & M.

3.1 A newborn administrative organization should endeavor to train the personnel so that they acquire the knowledge required for the proper operation and administration of the pipeline system prior to the completion of the Project.

3.2 An operation rule of the pipeline system for water supply is required to be established after thorough conference with water recipients.

3.3 An additional rain-gauge and water-gauge stations may have to be established in the future to attain high order of accuracy in operation and administration.