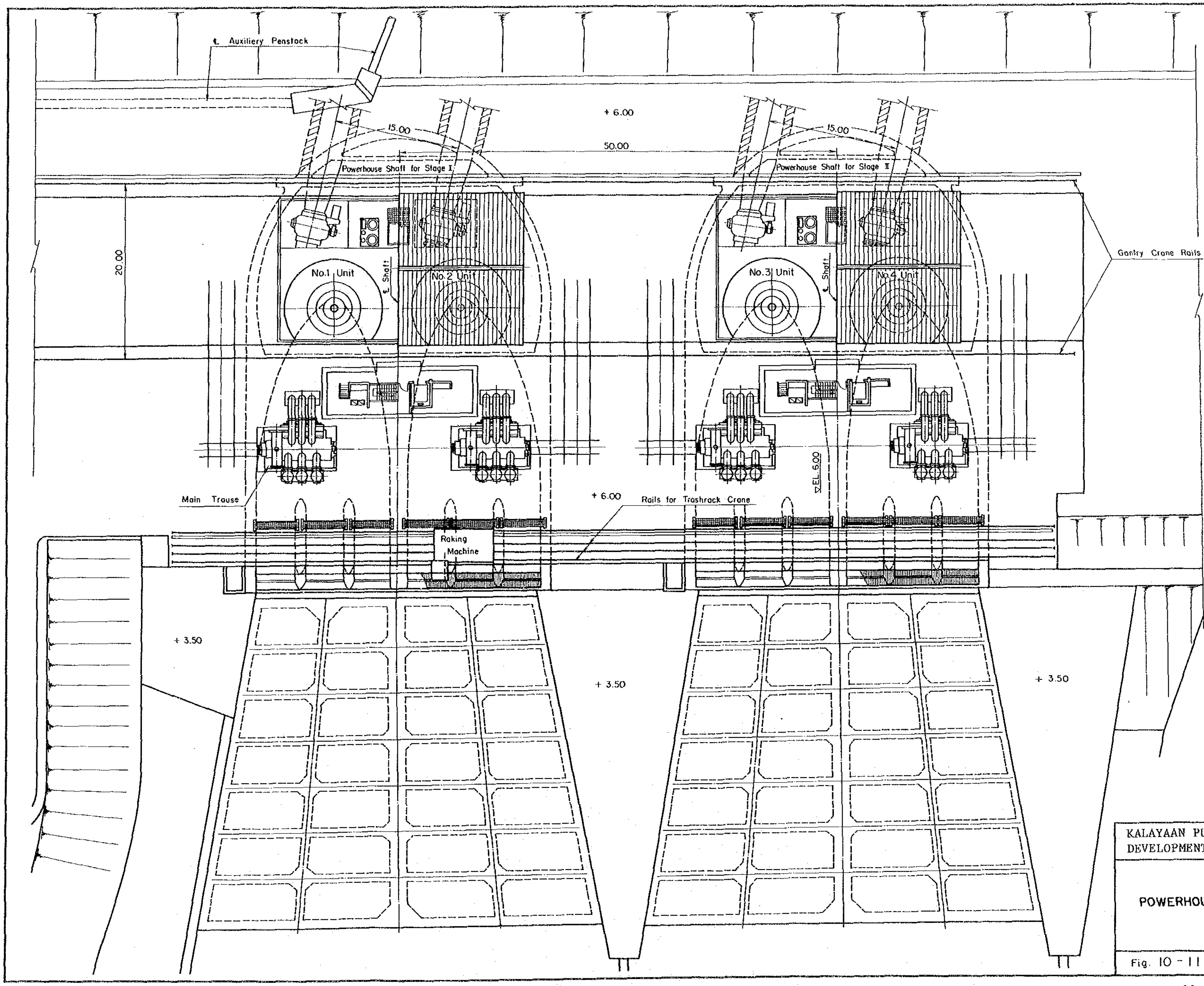
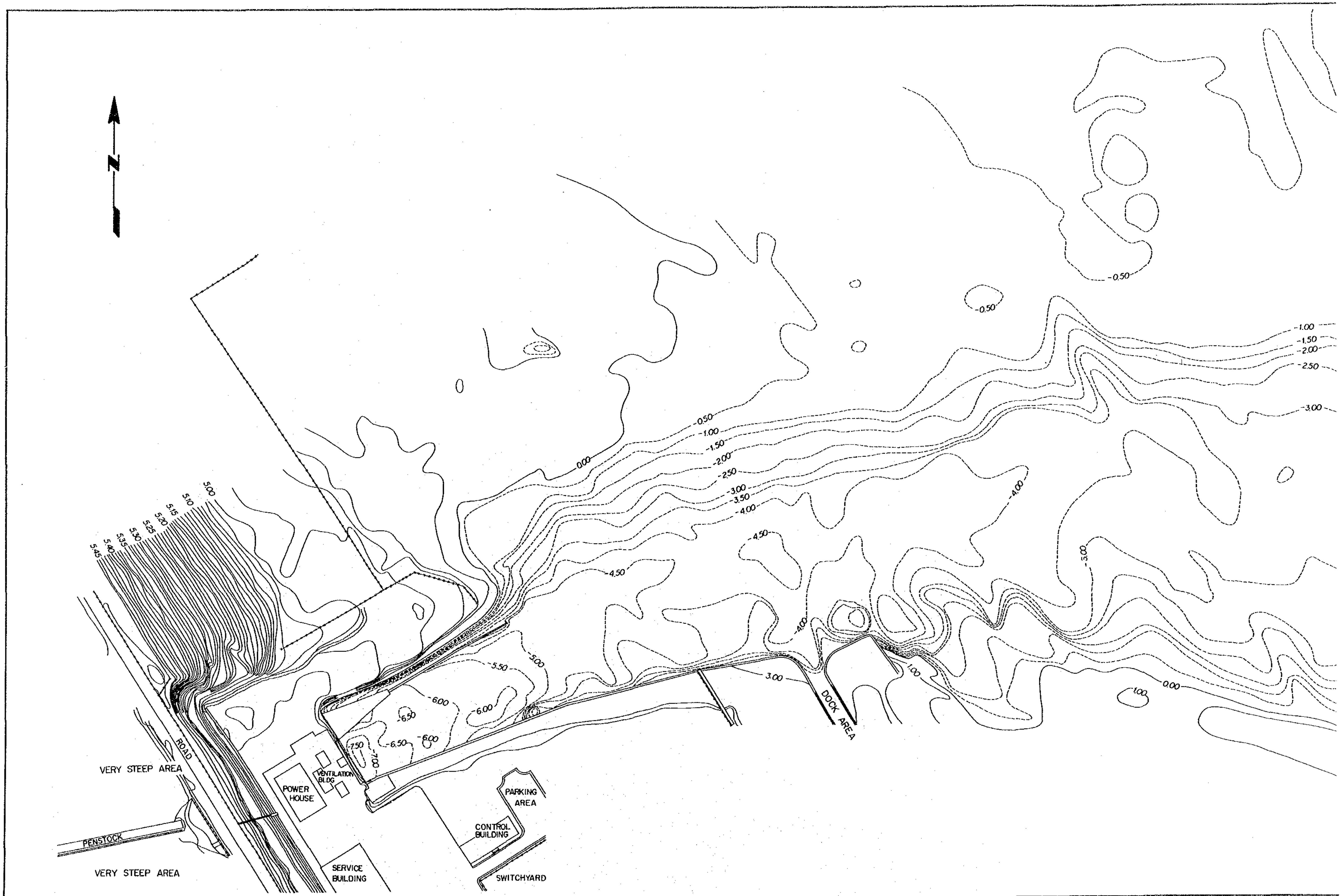
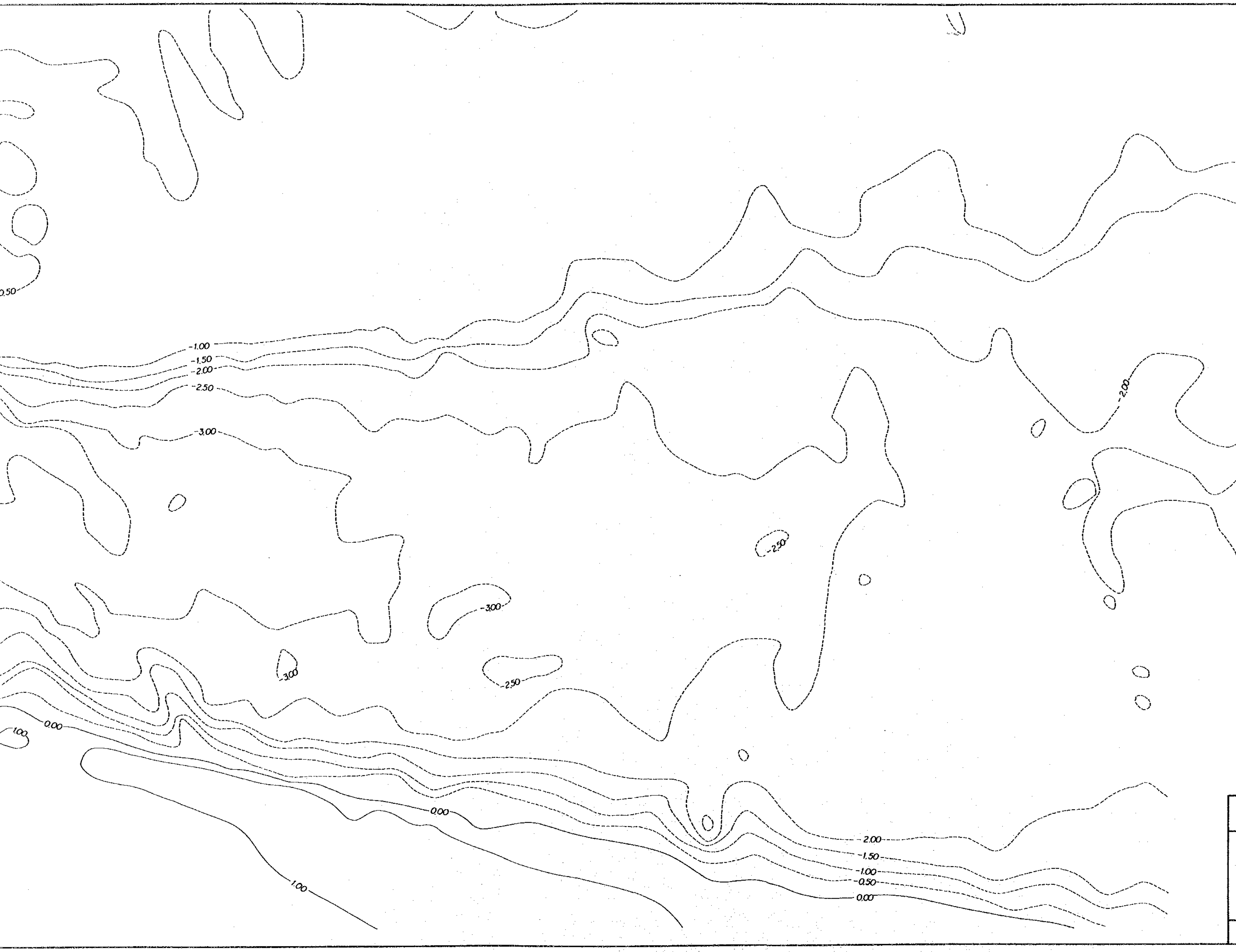


KALAYAAN PUMPED STORAGE PLANT DEVELOPMENT PROJECT (STAGE II)

POWERHOUSE AND TAILRACE PLAN

Fig. 10 - 11


N
ROAD
VERY STEEP AREA
PENSTOCK
VERY STEEP AREA
POWER HOUSE
VENTILATION BLDG
SERVICE BUILDING
PARKING AREA
CONTROL BUILDING
SWITCHYARD
DOCK AREA



KALAYAAN PUMPED STORAGE PLANT
DEVELOPMENT PROJECT (STAGE II)

SURVEYING RESULT
OF
LOWER CANAL

Fig. 10 - 12

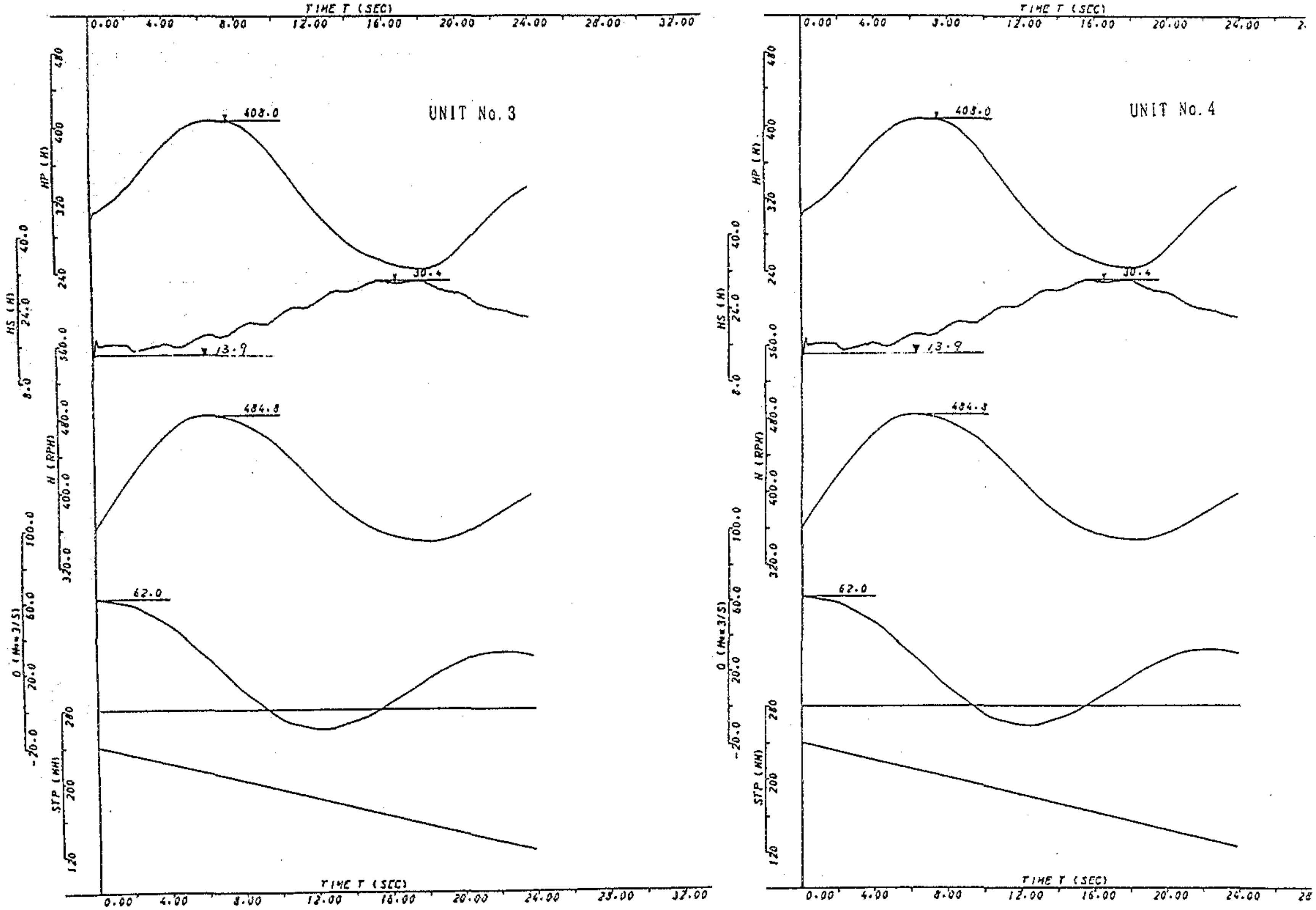


Fig. 10-13 Transient Calculation for Turbine Load Rejection

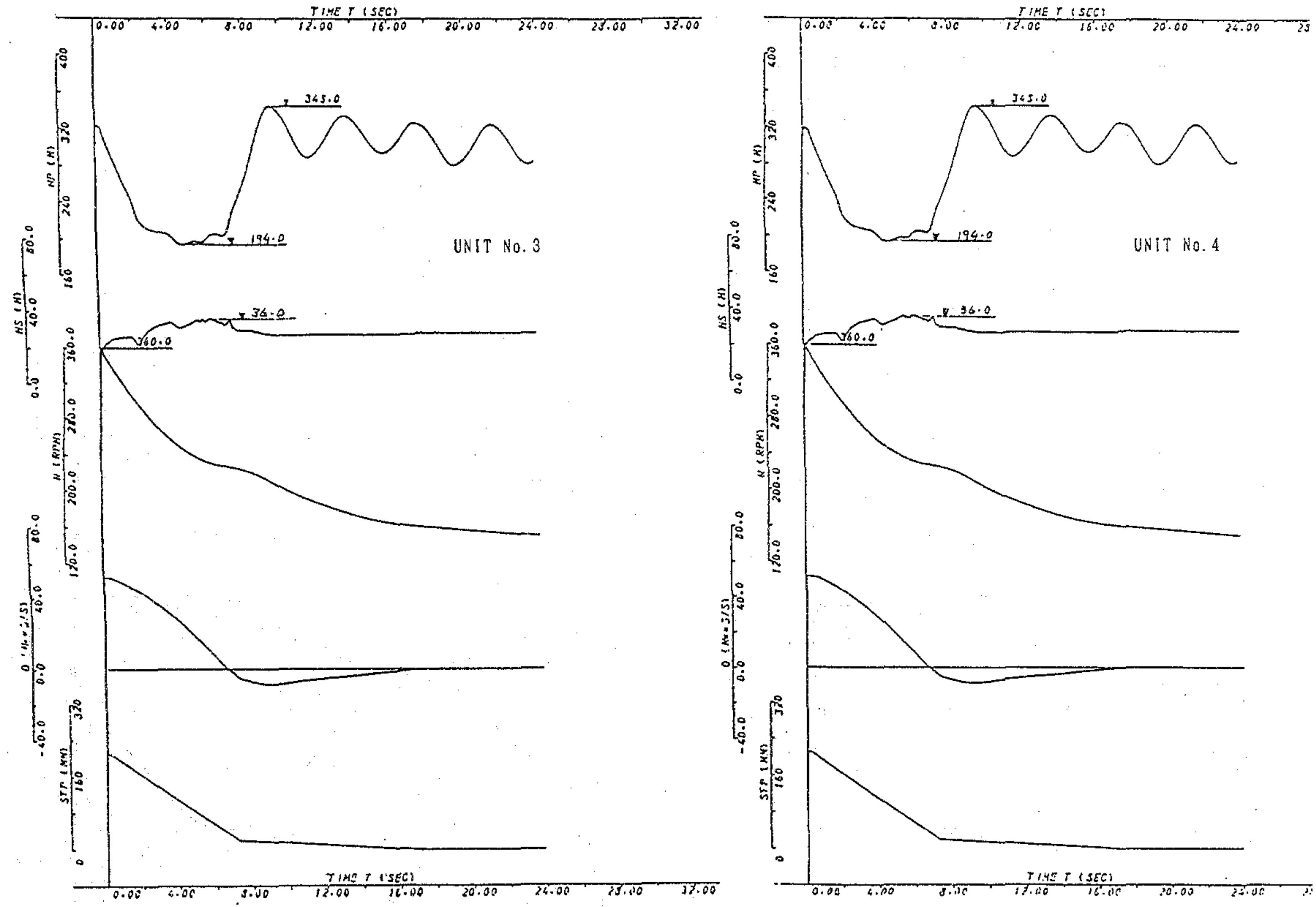
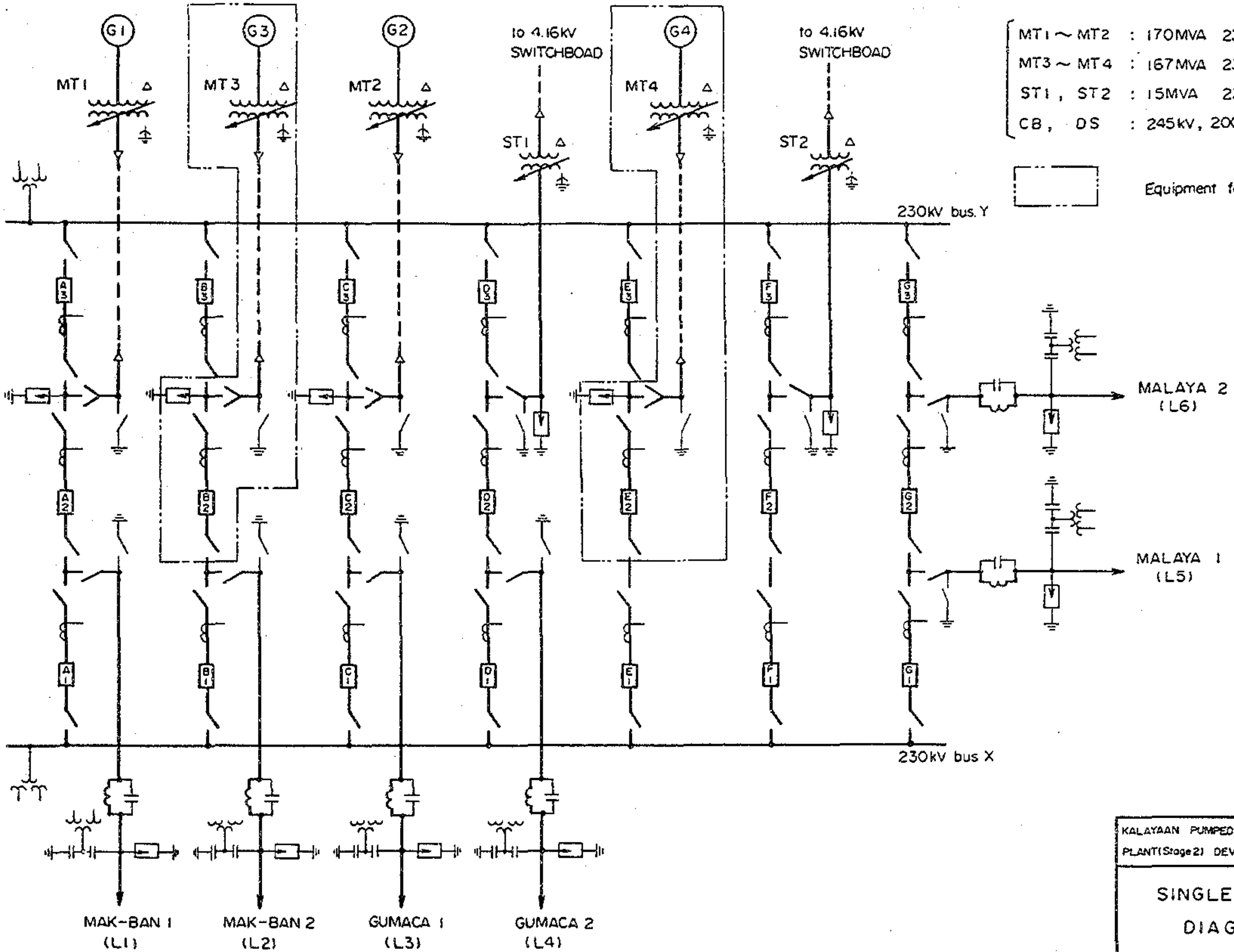


Fig. 10-14 Transient Calculation for Pump Power Failure



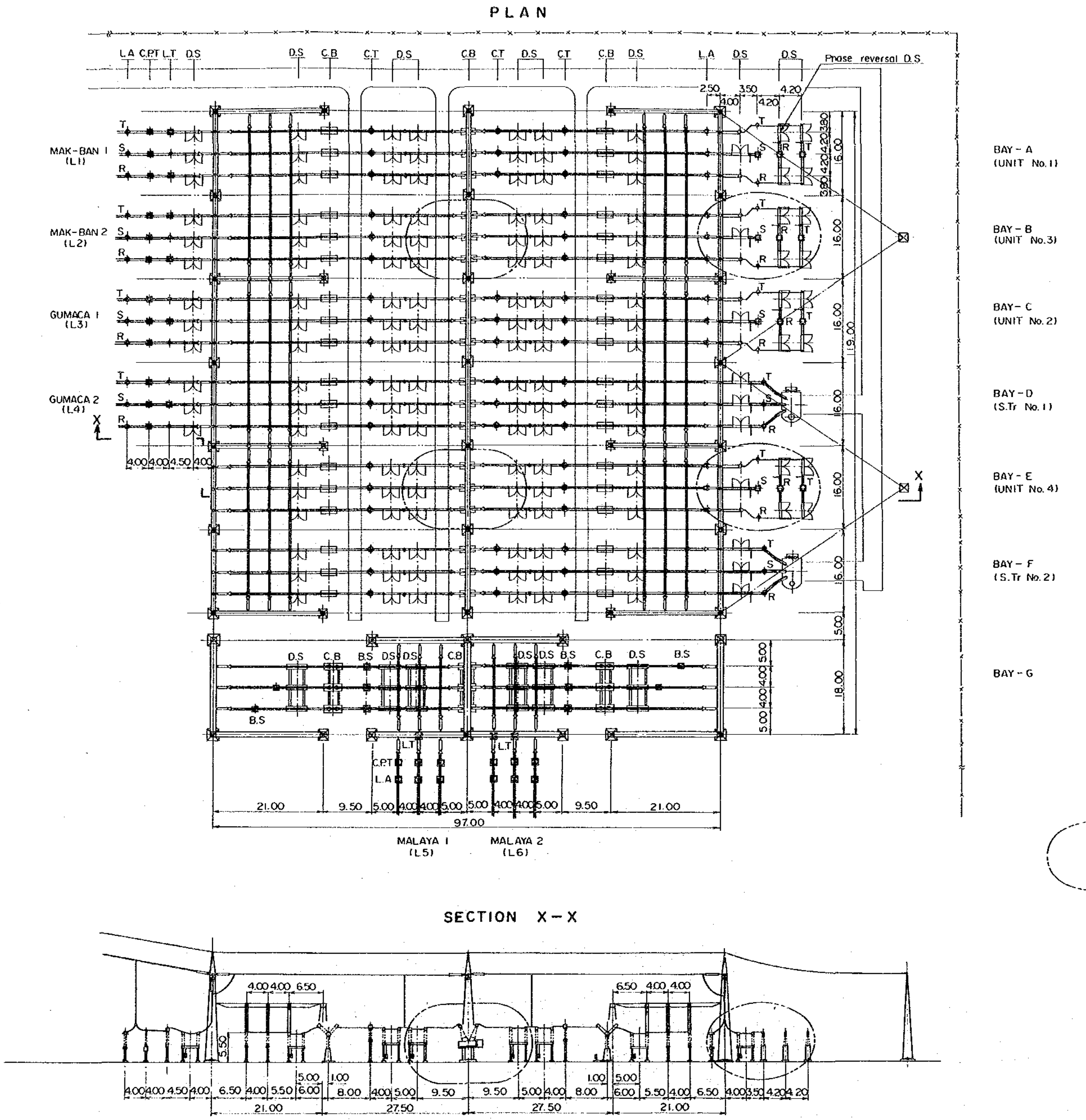
MT1 ~ MT2 : 170MVA 230kV/13.8kV
MT3 ~ MT4 : 167MVA 230kV/13.8kV
ST1 , ST2 : 15MVA 230kV/4.16kV
CB , DS : 245kV, 2000A, 40kA

Equipment for Stage II

KALAYAAN PUMPED STORAGE POWER PLANT(Stage2) DEVELOPMENT PROJECT

SINGLE LINE DIAGRAM

Fig. 10-15



Equipments for Stage II

KALAYAAN PUMPED STORAGE PLANT DEVELOPMENT PROJECT (STAGE II)

230kV SWITCHYARD

GENERAL LAYOUT PLAN

Fig. 10 - 16

Chapter 11 Construction Schedule and Cost

Chapter 11 Construction Schedule and Cost

11.1 Construction Plan and Schedule

11.1.1 Feature of Civil Works

The feature of the Stage II Project is that it is to be carried out extremely close by existing power generation facilities.

Accordingly, what must be paid utmost attention in construction is to execute work in a manner that no trouble at all will be caused operation and facilities of the existing power plant.

Particularly, it is necessary for attention to be given to operation and handling of heavy equipment in excavation work, and strict care must be exercised regarding vibration and flying of rock fragments caused by blasting. In this respect, facilities for protection against flying rock during blasting operations are to be provided, while concerning vibration, work must be performed keeping to a low vibration rate said to have practically no influence on existing structures.

11.1.2 Basic Conditions

Items which would have influences on the construction program and work schedule of the Stage II Project are the following:

Structures to be constructed in the Stage II Project are a penstock of about 1,300 m in length, tailrace, powerhouse, switchyard and intake gates excluding intake structure constructed in the Stage I.

(1) Meteorology

The meteorological conditions of the Project are as described in 5.2 of Chapter 5.

(2) Transportation Routes

(a) Inland Transportation Routes

Inland transportation from Manila to the Project site can be achieved by two routes: one going east-south around the north side of Laguna de Bay and the other going south-east around the south side of the lake. These routes consist of national highways of widths at least 6.8 m, well-maintained, which form a loop around Laguna de Bay.

The route going around from the north side of Laguna de Bay passes a mountainland of elevation 200 m and higher along the way so that there are stretches with curves and steep gradients.

The route going around from the south side of Laguna de Bay consists of an expressway extending south from Manila which passes an area of low elevation along the lake shore so that there are no sharp curves or steep slopes.

The clearances to the surface of the expressway under overbridges at grade crossings are 4.8 m, whereas the regulations call for 4.5 m.

(b) Ports and Harbors

Manila has a North Port and a South Port. North Port is an international trade port with piers where large vessels can berth, and there are no special obstacles to landing of construction machinery and electrical equipment. On the other hand, South Port is exclusively for domestic purposes, and has piers where medium-size ships can berth.

(c) Water Transportation Routes

As a water transportation route, the existing Kalayaan Pumped Storage Plant can be reached by going upstream of the Pasig River for approximately 24 km between Manila Bay and Laguna de Bay and going approximately 70 km from south-east to northeast of inside Laguna de Bay.

At the right-bank side downstream of the existing Kalayaan Pumped Storage Plant, there is a dock for landing cargo provided at the time of construction of the Stage I, which is equipped with a gantry crane (130 t).

This water route and the dock facilities were used for transportation and landing of heavy articles such as power generating equipment during the Stage I construction work.

For the Stage II Project also, if a part of the dock facilities were to be repaired and depths in the Pasing River and Laguna de Bay investigated and confirmed, it is thought transportation of heavy articles by watercraft will be quite possible. The transportation route is shown in Fig. 11-1.

(d) Existing roads in Project Area

Outlines of the existing roads in the work area of the Stage II Project are as follows:

- To go from the powerhouse to the intake, a route is taken from the existing power plant gate northward on the access road for approximately 350 m to reach National Highway Route 321. Turning around from this point, a route is taken southward along Laguna de Bay for approximately 3 km to a point before the entrance to Lumban. National Highway Route 321 branching off from here and going eastward toward Caliraya Dam is then taken and on climbing approximately 5.2 km, the access road to the intake is reached. (Caliraya Dam is reached at 3.1 km from this point.) The intake is reached going approximately 800 m from here, and this is an unpaved road of width approximately 7 m.

Consequently, the distance from the existing power plant to the intake is approximately 9.3 m.

- There are two existing access roads to the penstock. One is a concrete-paved road of approximately 400 m which branches off to the left from a point approximately 100 m down the access road to the intake. This road was used for installation of the penstock reaching the vicinity of EL. 270 m on the left bank above the upper part of the penstock.

  The other access road is down approximately 2.2 km and turn to the right approximately 300 m on National Highway from the entrance point of the intake access road, where an unpaved road of width approximately 7 m branches off to the right to reach the downstream surface part of the penstock at around EL. 175 m.

  This road will be used frequently for civil works and pipe installation work of the penstock.

- The following are roads that can be used for the Stage II work in the vicinity of the powerhouse:

  - A concrete-paved road of width 6.8 m and length 300 m from the powerhouse entrance gate to the existing control building.

  - An unpaved road of width 7 m and length approximately 400 m from the powerhouse entrance gate to the cargo landing dock through the lake side of the switchyard.

(e) National Highway Detour Road and Safety Countermeasure

National Highway Route 321 passes by the bottom end of the steeply-sloped surface stretch of the penstock. The design excavated gradient of this slope is very steep at approximately 58 deg and the length difference of the slope is as much as 90 m. The volume of rock excavation at this part will be 35,000 m^3, the period of construction including concrete work and penstock installation approximately 20 months, and according to safety measures during construction works, traffic regulation or road blocks of the national highway will become necessary to achieve both traffic safety and construction.

In order to avoid this cutting off of traffic and to secure the overall work schedule for the penstock, it will be necessary for a detour road and safety countermeasure to be provided for the National Highway.

The four cases below are conceivable for the detour road and safety measures. The estimated cost for each case is given in parentheses.

Case A: Detour from National Highway Route 321, pass over the intake access road and get out to the north side of Kalayaan Village by a road of 5 km (US$1,600 thousand).

Case B: Detour by a 1-lane tunnel of 5.5 m diameter approximately 265 m at the mountain side of the penstock area (US$750 thousand).

Case C: Provide a temporary bridge of approximately 90 m at the tailrace downstream of the powerhouse, pass the lake side of the substation, and with a new detour road of 2,500 m (both sides of tailrace) reach the national highway (US$1,200 thousand).

Case D: Traffic regulation on restricted-time basis (US$700 thousand).

The rough estimates of the construction periods and the construction costs of these four cases are as given below.

	Length (m)	Period (mo)	Cost (US$$10^3$)	Remarks
Case A	5,000	12	1,600	Surface, 2 lanes, paved
Case B	265	4	750	Tunnel, 1 lane with signals
Case C	2,800 (incl. bridge 150 m)	3	1,200	Surface, 2 lanes, paved; bridge, 1 lane
Case D	-	1	700	Shelter for falling stone, 50 m

The problematic points, respectively, of the above four cases may be considered to be the following:

Case A: Both construction period and construction cost are problems.

Case B: Since a tunnel would be excavated under the existing penstock, it will be necessary for the construction to be performed carefully giving thorough attention to prevailing conditions.

Case C: The route will cross over the tailrace and construction will conflict with tailrace work.

Case D: The time available for construction will be reduced to pose an influence on the overall construction period for the penstock and it will not be completely safe.

In view of the above, it is thought that Case B will be the most reasonable when taking into overall account degree of difficulty, construction period, construction cost of the detour road, and control of the job site. Accordingly, Case B is to be adopted for the detour road and safety measure concerning the National Highway.

(f) New Access Road

Roads required to be newly constructed to add to the existing roads remaining as a result of the Stage 1 work are the following:

- Access road to intake: The existing road is unpaved and is not well-maintained. A concrete or asphalt paved road of width 7.0 m and length 800 m is necessary for safe transportation of heavy articles such as concrete, gates, and steel pipes during construction, and for maintenance and control of generating facilities after completion of construction.

- Access road for powerhouse and tailrace works: At present, there is an existing powerhouse access road to the powerhouse and tailrace, but this existing road is important for exclusive use in administration of the existing power plant, and basically, cannot be used except for installation of equipment at the new outdoor switchyard.

  Consequently, as a construction road, a 2-lane road 500 m in length arriving from the Pagsanjan side of National Highway Route 321 to the left-bank side of the tailrace will be necessary.

- Other than the above, roads to the Project management office, a road to the reclamation area to be made into a spoil area, and a road to the temporary shop for penstock fabrication will be required.

(3) Construction Materials

(a) Cement

Cement plants near the Project site are the ones at the two towns of Norzagaroy approximately 35 km north of Manila and Binarconan on a peninsula at the west side of the northern part of Laguna de Bay. The distances from the cement plants at these towns to the Project site in case of taking the national highway at the north side of Laguna de Bay are approximately 110 and 55 km, respectively. The demand for cement on Luzon has been large in recent years, and there is a tendency for supply not being able to keep up; it will be necessary for supply of cement for construction in the Project to be made from a plural number of cement plants.

(b) Aggregates

As aggregates for concrete, the sand-gravel deposited in the vicinity of where two tributaries merge at a midstream-to-downstream part of the Balanac River, itself a left-bank tributary of the Pagsanjan River, can be utilized.

At this place, terraces are formed by sand-gravel brought down from the upstream area of the Balanac River. The thicknesses of these terraces are 3 to 5 m upward from the present river bed, the total area covered estimated to be more than 30 ha.

At present, sand-gravel is being collected for aggregates at the river bed of this area by a local firm using heavy equipment for collection and transportation.

An aggregate manufacturing plant of 200 t/h of sand and gravel is under construction by the local firm with start of operation scheduled for February 1990.

As another source of aggregate, there is the deposit of mainly agglomerate disintegrated and deposited at the river bed from the Lumban District at the downstream part of the Pagsanjan River down to the mouth of the river at Laguna de Bay.

This deposited material is slightly coarse-particled for a fine aggregate for concrete, but it can be used blended with sand obtained elsewhere.

This deposited material is presently being collected from the river bottom by a local firm using a dredger and other means.

(c) Reinforcement Steel

A plant manufacturing steel bars for reinforcement is located at Novcliches 15 km northeast of Manila.

Steel bars manufactured at this plant will mainly be used for work in the Stage II Project.

The distance from Novcliches to the Project site is approximately 85 km taking the route passing the north side of Laguna de Bay.

(4) Electric Power for Construction

Electric power for construction will be required at the following locations:

- Penstock site (tunnel work, temporary shop for penstock, field welding)
- Powerhouse site (powerhouse, tailrace)
- Tailrace left bank reclamation area (construction office and lodgings)

The power distribution for construction would be for voltage to be stepped down to 4.16 kV from the 69-kV transformer (50 MVA) installed at the time of Stage 1 work at the right side of a point approximately 2 km toward Caliraya Dam from where National Highway Route 321 branches, and distribution lines newly constructed to the respective sites. The electric facilities to be installed for the works of the Project are estimated to be 1400 kW as a whole, with maximum load about 800 kW. The charge for the electricity supplied from NAPOCOR in this manner would be US$0.0519/kWh (P1.1078/kWh).

11.1.3 Construction Plan and Schedule

The construction work of the Stage II Project must be performed with utmost care giving consideration so as not to be of hindrance to operation or cause trouble to facilities in any way at all since it is extremely close to installations (No. 1 and No.2 units) of the existing Kalayaan Power Plant. As a result of studies made therefore, considering the scale of work, layout of structures, and otherwise, the degree of progress in execution of work to be done by special methods for excavation of rock, it is thought that a construction period of 3 years and 3 months for the No. 3 unit, and 3 years and 9 months for the No. 4 unit will be required.

Assuming that the year of commissioning of the Stage II Project will be 1997, it will be necessary for preparations to be made to start work according to the following schedule:

1990 - 1 - 1990 - 11	Feasibility Study (11 months)
1990 - 11 - 1991 - 3	Provision and Award of Final Design (5 months)
1991 - 4 - 1992 - 9	Final Design (18 months)
1992 - 10 - 1993 - 3	Financing Formalities (6 months)
1993 - 4 - 1993 - 9	Bidding and Award of Contract for Construction (6 months)
1993 - 10	Start of Construction
1997 - 1 & 7	Commissioning (No. 3 unit: 39 months, No. 4 unit: 45 months)

The quantities of the principal civil works in the Stage II Project are as given in Table 11-1. The principal pieces of equipment and facilities expected to be required at the peak of construction in the Project are listed in Table 11-2.

Table 11-1 Principal Civil Works

Item	Description	Civil Works	
Power Intake		Concrete	540 m^3
Penstock	D = 6.0 - 3.3 m L = 1,300 m	Ex. in open Shaft ex. Concrete	266,300 m^3 4,100 m^3 18,500 m^3
Powerhouse	D = 52.1 - 33.8 m H = 45.4 m	Ex. in open Ex. in shaft Concrete Drilling & Grouting	166,000 m^3 46,200 m^3 28,600 m^3 17,000 m
Tailrace		Ex. in open Dredging Concrete Reinf. conc. Diaphragm	41,300 m^3 220,000 m^3 2,000 m^3 2,000 m^2
Switchyard		Ex. in open Concrete	300 m^3 500 m^3

Table 11-2 Principal Construction Machinery

Place	Machinery	Specification	Number
Common Use	Cement Silo	600 t	1
	Concrete Plant	1.6 m^3 x 2	1
Penstock	Boring Machine	ϕ250 - 1,150 mm	1
	Tower Crane	L 50 m, 6.5 t	1
Power Plant	Tower Crane	6.5 t	1
	Crawler Crane	60 t	1
	Pump	ϕ250 mm, H = 50 m	3
Tailrace	Crawler Crane	40 t	1
	Crawler Crane	100 t	1

Regarding the work schedule for the Stage II Project, an outline based on the work schedule according to Fig. 11-3 and the critical path method shown in Fig. 11-4 is given below:

1993:

- Bids are to be accepted in the first third of April on camp facilities for NAPOCOR, civil works, hydraulic equipment, and electromechanical equipment, with awards of contracts aimed to be done six months later during the first third of October.

- Work in 1993 will mainly consist of preparations for the main works, concerning which the timing for starting excavation in the detour road tunnel work for National Highway No. 321 in connection with the penstock project which will be the critical path in the entire schedule for this Stage II Project, in effect, the first third of December, will be especially important in maintaining the work schedule.

1994:

- The start of open excavation at 266,000 m^3 of the upper part of the penstock must be in August of 1994.

- Installation of intake gates is to be from April 1994 followed by start of penstock pipe installation at the intake portions from August.

- With regard to the intakes, pavement work on the access road to the intakes is to be completed by the middle of June in order to deliver intake gates, and installation of the two intake gates is to be completed by the middle of July.

  In succession, removal of the existing concrete bulkheads at the intakes is to be done with the end of July as the target date. This is in preparation for the start of the intake portion penstock pipe installation scheduled for the first third of August. After installation of the penstock pipes, the surroundings of the pipes are to be filled with concrete.

- At the penstocks, the upper open excavation, including preparation of the lot for temporary penstock work is to be completed.

- The temporary detour road tunnel (L = 265 m, effective width B = 5.0 m) for National Highway 321 to allow work to be done on the lower part of the penstock is to be completed by the middle of March, and general traffic is to be switched to the detour road. In succession to this, slope excavation of the lower parts of the penstocks is to be carried out from top to bottom using the low detonation wave-velocity explosive method and the bench-cutting method with the target for completion the end of July. In succession to this, inclined tunnel excavation work is to be done using boring machines such as Big Man and low detonation wave-velocity blasting in combination with this to be completed aiming for the middle of April 1995 as the target.

- Installation of penstock pipes is to be started on the upper parts of the penstocks from the beginning of October following the intake portions.

- At the powerhouse, in succession to this, water springing-prevention boring and grouting works to allow excavation of the vertical shafts to be performed are to be started from the first part of January. Subsequently, excavation of the vertical shafts is to be done from the first third of March using the low detonation wave-velocity blasting method whenever the existing power plant is stopped in order not to cause trouble for the power plant. Along with this, digging down is to be performed providing weep holes to reduce water pressure applied to the vertical shaft walls.

1995: • At the upper parts of the penstocks, installation of pipes is to be continued following construction of anchor blocks and saddles.

At the lower parts of the penstocks, excavation of the inclined tunnels is to be completed by the middle of April, and consolidation grouting is to be performed from inside and outside the tunnels to secure stability of the ground surrounding the tunnels. Installation of pipes for the lower penstock portions is to be started from the middle of June. The surroundings of the pipes inside the tunnel are to be filled with concrete in approximately three months from the first part of December.

• At the powerhouse, excavation of the vertical shafts is to be more or less completed the middle of December 1994, followed by concrete lining of the vertical shaft walls. Further, foundation concrete for generating equipment is to be placed from around the middle of April in preparation for draft tube installation.

• Draft tubes are to be installed in periods of one month each from the first part of June for Unit No. 3, and the first part of July for Unit No. 4.

• After installation of draft tubes, concrete is to be placed around the respective tubes in preparation for installation of spiral casings.

• At the tailrace, the reinforced concrete underground diaphragm walls extending along both banks of the tailrace from the power plant outlet are to be constructed in approximately three months from the first part of May. From the first part of August after this, a cofferdam to allow work on the tailrace bay to be done is to be constructed using soil fill material and other water cut-off material. Since the inside of the cofferdam is to be dewatered following this, reinforcing is to be done with steel struts set against the diaphragm walls to enable water pressure from the outside to be resisted.

- Ordering of a dredging barge for dredging of the lower channel is to be done in the first third of July with completion targeted for the end of December.

1996:
- At the penstocks, the upper penstock pipes are to be finished installing by the end of February, and the lower penstock pipes by the end of September in preparation for trial operation of the No. 3 generating equipment scheduled for start-up from the first part of October.

- At the powerhouse, in parallel with installation of the generating equipment of the No. 3 and No. 4 units to be continued from 1995, concrete placement and architectural work are to be carried out. The civil works related to the No. 3 unit are to be completed by the end of August, and installation of the turbine-generator, installation of distribution board equipment, and installation of outdoor switchyard equipment are to be completed aiming for the end of September, in preparation for trial operation.

  Civil works on the outdoor switchyard are to be started from around the first part of February, and concrete placement is to be finished by the end of May, one month before start of installation of outdoor switchyard equipment.

- At the tailrace, excavation inside the tailrace bay is to be finished by around the middle of March, and along with installing foundation piles, the placement of tailrace bay bottom concrete is to be finished in a period of approximately 2.5 months. Following this, removal of the cofferdam is to be done with completion targeted for the end of August.

- In March, National Highway Route 321, which had been closed for construction of penstocks is to be reopened to traffic, and subsequently, the portals of the detour tunnel are to be plugged for reasons of safety.

1997: . The No. 3 unit, after three months of trial operation, including one month of wet tests, is to commissioning from the first part of January.

. Regarding the No. 4 generator, both civil works and electrical equipment installation are to be completed by the end of March. From the first third of April, tests for a period of three months including a month of wet tests are to be completed, with commissioning to be started from the first part of July.

. All construction works including removal of camp facilities, etc. are to be completed by the end of October.

The layout of temporary facilities for construction are shown in Figs. 11-1 and 11-2, respectively. As for the rehabilitation work on Caliraya Dam, it is thought 2.5 years will be required including preparatory works. The work schedule for the Stage II Project is shown in Fig. 11-3.

11.1.4 Construction Procedures and Methods for Principal Structures

Construction in Stage II will be characterized by the fact that intake, penstock, powerhouse, and tailrace works will be additions to existing structures and will be performed in extremely close proximity to the existing structures.

Accordingly, the following comments are made regarding the special natures in construction of the individual structures, and their methods and procedures of construction:

(1) Intake

The intake work comprises installation of two intake gates, and the subsequent installation of penstock pipe. This work must be performed while the existing No. 1 and No. 2 generating units are in constant operation. The work must be done by the following procedure:

- The existing intake gate guideway hardwares are cleaned and repaired underwater, followed by installation of the two gates.

- Dewatering is done by a method such as pumping out from the spaces between gates and concrete bulkheads provided downstream of the gates in the Stage I Project to remove water pressures acting on the bulkheads.

- The bulkheads are removed using tools such as pick hammers so as not to cause damage to existing permanent facilities.

- The concrete surfaces of the existing cavern are cleaned and repaired, after which penstock pipe installation is performed.

- The gap between penstock pipe and existing concrete is filled with concrete.

- The two intake gates installed must be provided with locking devices to absolutely prevent them being raised until completion of all the Stage II work downstream.

(2) Penstock

(a) Excavation of the surface stretches of the penstocks will be done in extremely close proximity to existing penstock pipe. Particularly, when breaking bedrock, methods that will not cause damage to existing structures due to vibration or flying of rock fragments must be employed. In this regard, the work must be done using an explosive of low detonation wave-velocity (Concrete Cracker), quiet-action chemical disintegrator (Calmmite), or an Giant Breaker.

(b) The topography of the downstream surface portions of the penstocks has a height difference of approximately 90 m, the gradient being about 58 deg to constitute a steep slope, the slope having outcropping of hard bedrock. National Highway Route 321 crosses perpendicularly with a portion corresponding to the bottom end of the slope.

With such a field condition, especially in excavation, rock falls will be of concern, and there is ample possibility of traffic on the national highway being obstructed.

For safety of traffic and smooth execution of work, a detour tunnel (one lane, length 265 m) passing inside the slope is to be provided beforehand for the highway traffic to be detoured, while with regard to excavation of the slope, it is to be by benchcutting from the top with rock broken using low detonation wave-velocity explosive or Giant Breaker, with excavation muck hauled safely by backhoe or bulldozer into a special muck hopper enclosed beforehand by means such as iron fences (see Fig. 11-5).

For installation of penstock pipe, it is necessary for an incline to be temporarily provide on the slope shaped by excavation and concrete placement and using equipment such as cranes.

(c) In construction on the inclined shaft portions of the penstocks, especially in excavation of the tunnels, they will be extremely close to penstock pipe already in place adjacently, and in case ordinary blasting methods are used, vibrations from detonation of explosives will be magnified due to transmission from pipe to bedrock. To avoid this, two vertical shafts through which large-diameter boring machines for inclined shaft excavation can be hauled in from the mountain sides of the powerhouse shafts are to be dug downward beforehand under the horizontal portions of the bottom stretches of the penstock to serve concurrently as drainage pits during excavation of the powerhouse shafts, following which the horizontal portions of the penstocks are to be excavated.

In succession to this, large-diameter boring machines (Big Man) are to be set at the tops of the inclined shafts and primary pilot holes of diameter 250 mm are to be drilled, followed by reaming from the lower horizontal shafts upward to make pilot holes of diameter about 1,150 mm.

From the tops of the inclined shafts where these pilot holes have been completed, the pilot holes are to be utilized to perform cutting for blasting and for mucking. The bedrock must be broken carefully using means such as blasting with a low detonation wave-velocity explosive to excavate the inclined shafts downward (see Fig. 11-6).

Further, for protection of tunnel walls after installation of penstock pipe and until completion of backfilling with concrete, shotcrete or other material is to be applied besides providing steel supports.

(2) Construction of Powerhouse

The topographical and geological features of the vertical shaft portions of this powerhouse are that they almost directly face Laguna de Bay, the lower reservoir. The foundation rock at this site is agglomerate of volcanic ejecta with permeability generally high, a large amount of springing of water having been recorded during Stage I work. The work is to be performed within 20 m of existing structures of the Stage I Project, while a special condition is that the existing power station is to be operated practically unrelated to the Stage II Project.

As a consequence, especially in excavation of the vertical shaft portion, what is of greatest importance besides prevention and handling of water springing, and the accompanying protection of excavated surfaces, is to carry out work in a manner not to cause any trouble for the existing generating facilities, and for this purpose, the following will be the procedure for executing the vertical shaft work (see Fig. 11-7):

- Carry out beforehand grouting with the dual purposes of preventing water from springing at the perimeter of the vertical shaft and consolidating the bedrock.

- Provide grount holes inside the vertical shaft for prevention of water springing at the bottom part of the vertical shaft during excavation.

- For the soil portion close to the ground surface, construct a concrete wall beforehand at the outer periphery of the vertical shaft to prevent water in the existing tailrace leaking out into the vertical shaft.

- During excavation of bedrock inside the vertical shaft, provide stage presplitting beforehand by drilling narrowly-spaced, deep boreholes perpendicular to the excavation lines of existing facilities.

- When blasting is used in breaking rock foundation, the blasting in excavation shall be controlled to limit the vibration velocity to 2 kine or less, with due consideration on the results of blasting test, so that no adverse effect is inflicted on the existing power plant.

- In breaking rock foundations on the side of existing structures, the use of the slowly exploding concerte cracker (CCR), the static cracker (calmmite), iron breaker, etc. shall be considered, and the work shall be implemented with good care to prevent vibration and dispersion of rock pieces.

- With regard to blasting work to be done in breaking bedrock, it is to be carried out exercising care, and performing only when the existing power plant is stopped (twice daily) is thought will be safe in consideration of present circumstances concerning the existing generating facilities.

- As excavation of the vertical shaft progresses, the excavated surface is to be protected by placing shotcrete and, where necessary, providing another bars or rock bolts, and also arranging weep holes at suitable locations aiming to stabilize the excavated surfaces.

(4) Tailrace

Underground concrete diaphragm walls are to be provided at both banks of the tailrace bay.

It will be difficult for these diaphragm walls to stand up by themselves, when in excavation of the tailrace bay and placing of concrete, water in the bay is drained and the walls are subjected to water pressure from the outside.

Accordingly, reinforcing must be done by providing steel braces or the like inside the bay. Removal of these braces must be done carefully after work on the bay has been completed and the bay has become filled with water accompanying removal of cofferdams (see Fig. 11-8).

11.2 Estimated Construction Cost

11.2.1 Fundamental Matters

The construction cost of the Stage II Project was estimated based on the design and construction methods, materials and products in accordance with the technology level that can be expected at the present time, and considering the geological conditions of the Project sites, regional conditions, project scale, etc.

The cost estimate was based on prices as of January 1990, and for the purpose of calculations in this Report, an exchange rate of US$1.00 = P22.50 was used.

The estimated items for the Stage II Project are as listed below. As for the costs of rehabilitation work on Caliraya Dam, in addition to making a review of the amount of increase resulting from inflation from 1986 to January 1990, interest during construction was taken into account and the total construction cost was calculated.

(1) Estimation Items

(a) Civil Works

- Camp Facilities: offices and lodging facilities

- Temporary Facilities: access roads, national highway detour road, electric distribution lines for construction works

- Waterway structures: intake, penstock, tailrace

- Powerhouse and switchyard: civil and building works

(b) Hydraulic Equipment: gates, penstocks, etc.

(c) Electromechanical Equipment: pump-turbine, generator-motor, control device, switchyard equipment, etc.

(d) Dredger: dredger, pumps and soil delivery pipes

(e) Engineering and Administrative Cost: planning, coordination, administration and management, etc.

(f) Interest during Construction: interest during the construction period

(2) Estimating Criteria

(a) Civil Works

For unit price of civil works and hydraulic equipment, comparison studies were made of recent unit construction prices of NAPOCOR, unit construction prices at project sites under construction or for which feasibility studies have been completed in the Philippines, and unit construction prices at similar sites in Japan, and these were broken down according to construction procedures and estimations were made taking into consideration labor costs, construction materials and machinery costs, etc. in the Philippines.

i) Labor Cost and Material Cost

Unit labor cost and unit material cost in the Philippines as of January 1990 are given in Table 11-3 and 11-4.

Table 11-3 Labor Cost

Item	Unit Cost, US$/day (P/day)
Foreman	5.78 (130)
Laborer	3.96 (89)
Carpenter	4.09 (92)
Electrician	5.78 (130)
Mechanic	4.62 (104)
Operator	5.11 (115)
Teamster	4.09 (92)
Steel setter	4.09 (92)
Welder	4.09 (92)
Miner	4.09 (92)
Apprentice	3.82 (86)

Table 11-4 Construction Material Cost

Item	Unit	Unit Cost, US$ (P)
Portland Cement (Bag)	t	94.44 (2,125)
Dynamite	kg	1.56 (35)
ANFO	kg	0.90 (20)
Gassoline	ℓ	0.32 (7.2)
Light Oil	ℓ	0.22 (5)
Reinforcement	t	666.67 (15,000)
Shaped Steel	t	800 (18,000)
Squared Timber	m^3	386.67 (8,700)
Timber (log)	"	297.78 (6,700)

The transportation cost for cement, reinforcing steel, shaped steel, etc., were calculated adapting the unit cost employed by NAPOCOR.

Value added tax (VAT 10%) was not included in material costs.

ii) Construction Machinery

The principal construction machines such as bulldozers, backhoes, large-sized cranes, large-sized boring machines, etc. for unprocurable in the Philippines would be imported and used, and construction machinery costs calculated from CIF Manila port prices.

iii) Access Road

The construction cost of roads for construction purposes is to be calculated based on construction items and their quantities and unit cost.

(b) Hydraulic Equipment

Penstocks, intake gates, tailrace gates, etc., would be imported.

(c) Electrical Equipment

Electrical equipment such as pump-turbines, generator-motors, transformers, etc., are all to be imported. Outdoor steel structures are also to be imported.

The existing gantry crane is to be used for installation of main equipment.

(d) Dredger

Of the dredger and soil delivery pipes required for maintenance of the lower channel of the tailrace, pumps would be imported from abroad and are to be included under foreign currency requirements.

The barge and the delivery pipes are to be domestically produced and thus be covered with local currency.

(e) Engineering and Administrative Cost

Construction management cost is generally around 10 to 15 percent of (a) - (d) costs, but since dam construction, which generally occupies a large portion of project cost is not included in Stage II, 6 percent of (a) - (d) costs was considered to be appropriate in this case.

(f) Compensation Cost

The land for the Project is owned either by NAPOCOR or by the state. According to the results of field investigations there are no water utilization rights or fishery rights in the area which need to be compensated. Consequently, as a result of discussions with NAPOCOR, compensation costs will not be included.

(g) Interest during Construction

As a result of discussions with NAPOCOR, interest during construction is to be calculated at 6.33 percent per annum for foreign currency and 20 percent per annum for local currency.

(h) Import Duties and Various Taxes

Import duties on construction machinery, gates, steel pipes, turbines, generators, etc., which must be imported will not be included in view of the fact that this is a national project. However, amounts corresponding to import duties on the above will be calculated for reference purposes.

(i) Contingencies

As a result of discussions with NAPOCOR, 10 percent of foreign currency requirements and 15 percent of local currency requirements in the civil works construction cost are to be included for contingencies.

With regard to gates, penstock pipes, and electrical equipment, only 5 percent of foreign currency requirements is to be included.

(3) Division of Foreign and Local Currency

(a) Civil Works

Principal materials for civil works such as cement, reinforcing steel, small steel products, and dynamite would be domestic products and are to be included in local currency requirements. As regards construction equipment for civil works, items such as bulldozers and backhoes, and temporary facilities machinery and apparatus such as concrete plant and large-sized cranes are to be imported and construction costs calculated based on foreign currency. Special equipment such as jack hammers, crawler drills, boring machines, grout pumps and air compressors are to be imported and included in foreign currency requirements.

(b) Hydraulic Equipment

Principal materials and manufacturing, fabrication and transportation to be performed outside the country for gates and penstock pipes are to be included in foreign currency requirements. Large-sized cranes, winches, automatic welding machines, welding rods, etc., required for installation are to be procured with foreign currency.

Domestic transportation costs and domestic labor costs for fabrication and installation works are to be included in local currency requirements.

(c) Electrical Equipment

Principal electrical equipment items themselves are to be included in foreign currency requirements. Domestic transportation costs and domestic labor costs for installation works are to be included in local currency requirements.

(d) Engineering and Administrative Costs

Local currency would cover 47 percent and foreign currency 53 percent of engineering and administrative costs.

(e) Interest during Construction

Interest is to be calculated separately for local and foreign currency requirements.

11.2.2 Estimated Construction Cost

Local and foreign currency requirements and construction costs per year of the approximate construction cost for the Stage II Project and the rehabilitation cost for Caliraya Dam are given in Tables 11-5, 11-7, 11-8, and 11-9, respectively.

Table 11-5 Investment Cost

(10^3 US$)

Item	Amount		
	F. C.	L. C.	Total
1. Stage II Project	107,351.9	63,621.3	170,973.2
2. Rehabilitation Works for Caliraya Dam	4,820	5,598	10,418
Total	112,171.9	69,219.3	181,391.2

The total amount of import duties that would ordinarily be levied on materials and equipment imported for the Stage II Project is approximately US$13.71 Million. A breakdown of this amount is given in Table 11-6.

Table 11-6 Amount of Import Duties

Unit: 10^3US$

Item	Amount
Measurement Device for Land Slide	1
Penstock	2,550
Gates and Other	315
Electromechanical Equipment	10,840
Pump for Dredger Boat	4
Total	13,710

Table 11-7 Estimated Construction Cost

Unit: 10^3 US$

Item	Foreign Currency	Local Currency	Total
Preparation Works			
Camp Facilities	100	900	1,000
Access Road	0	300	300
Temporary Detour Road	380	370	750
Sub-total	480	1,570	2,050
Civil Works			
Upper Canal	62.4	7.6	70
Power Intake	20.4	77.9	98.3
Penstock	1,929	5,070	6,999
Powerhouse	5,487.3	10,054.9	15,542.2
Switchyard	21.2	77.8	99.0
Tailrace and Lower Canal	1,741.9	1,885.1	3,627.0
Sub-total	9,262.2	17,173.3	26,435.5
Hydraulic Equipment	16,701	13,749	30,450
Electromechanical Equipment	60,400	5,800	66,200
Dredger Boat	50	700	750
Project Controlling			
Engineering Fee	4,000	150	4,150
Administration Cost	0	3,400	3,400
Sub-total	4,000	3,550	7,550
Physical Contingency			
Preparation Works	48	235.5	283.5
Civil Works	926.2	2,576	3,502.2
Hydraulic Equipment	835	0	835
Electromechanicasl Equipment	3,020	0	3,020
Dredger Boat	2.5	0	2.5
Project Controlling	400	532	932
Sub-total	5,231.7	3,343.5	8,575.2
Total (Project Cost)	96,124.9	45,885.8	142,010.7
Interest during Construction (Interest FC: 6.33%, LC: 20%)	11,227.0	17,735.5	28,902.5
Grand Total (Investment Cost)	107,351.9	63,621.3	170,973.2

Table 11-8 Fund Requirement in Each Year (1/2)

(Unit : 10³US$)

F : Foreign Currency
L : Local Currency
T : Total

Item	Year	1991	1992	1993	1994	1995	1996	1997	Total	Remarks
Preparation Works	F	0	0	167.9	295.5	7.6	0	9	480	
	L	0	0	675.7	805.9	7.4	0	81	1.570	
	T	0	0	843.6	1.101.4	15.0	0	90	2.050	
Civil Works	F	0	0	7.6	15.7	15.7	15.7	7.7	62.4	
Uppar Canal	L	0	0	0.9	1.9	1.9	1.9	1	7.6	
	T	0	0	8.5	17.6	17.6	17.6	8.7	70	
Power Intake	F	0	0	2.08	18.32	0	0	0	20.4	
	L	0	0	8.37	69.53	0	0	0	77.9	
	T	0	0	10.45	87.85	0	0	0	98.3	
Penstock	F	0	0	271.05	992.86	455.15	209.94	0	1.929	
	L	0	0	743.97	2.245.74	1.193.03	887.26	0	5.070	
	T	0	0	1.015.02	3.238.6	1.648.18	1.097.20	0	6.999	
Powerhouse	F	0	0	716.17	3.595.91	910.49	257.31	7.42	5.487.3	
	L	0	0	1.327.66	3.496.26	4.347.49	840.66	42.83	10.054.9	
	T	0	0	2.043.83	7.092.17	5.257.98	1.097.97	50.25	15.542.2	
Switchyard	F	0	0	2.13	0	0	19.07	0	21.2	
	L	0	0	8.38	0	0	69.42	0	77.8	
	T	0	0	10.51	0	0	88.49	0	99	
Tailrace and Lower Canal	F	0	0	174.19	0	860.56	707.15	0	1.741.9	
	L	0	0	188.51	0	929.27	767.32	0	1.885.1	
	T	0	0	362.7	0	1.789.83	1.474.47	0	3.627	
Sub-Total	F	0	0	1.173.22	4.622.79	2.241.9	1.209.17	15.12	9.262.2	
	L	0	0	2.277.79	5.813.43	6.471.69	2.566.56	43.83	17.173.3	
	T	0	0	3.451.01	10.436.22	8.713.59	3.775.73	58.95	26.435.5	

Table 11-8 Fund Requirement in Each Year (2/2)

(Unit : 10^3US$)

F : Foreign Currency
L : Local Currency
T : Total

Item	Year	1991	1992	1993	1994	1995	1996	1997	Total	Remarks
Hydraulic Equipment	F	0	0	2.907	2,211.8	3,823.5	6,393.7	1,365	16.701	
	L	0	0	0	2,049.6	3,969	6,260.4	1,470	13.749	
	T	0	0	2.907	4,261.4	7,792.5	12,654.1	2,835	30,450	
Electromechanical	F	0	0	4,480	5,600	19,600	21,960	8,760	60,400	
Equipment	L	0	0	0	0	0	3,300	2,500	5,800	
	T	0	0	4,480	5,600	19,600	25,260	11,260	66,200	
Dredger Boat	F	0	0	0	0	10	40	0	50	
	L	0	0	0	0	140	560	0	700	
	T	0	0	0	0	150	600	0	750	
Total (Direct Cost)	F	0	0	8,728.12	12,730.09	25,683	29,602.87	10,149.12	86,893.2	
	L	0	0	2,953.49	8,668.93	10,588.09	12,686.96	4,094.83	38,992.3	
	T	0	0	11,681.61	21,399.02	36,271.09	42,289.83	14,243.95	125,885.5	
Project Management	F	572	468	486.3	666	761.1	761.1	285.5	4,000	
	L	0	0	250.6	942.7	942.7	942.7	471.3	3,550	
	T	572	468	736.9	1,608.7	1,703.8	1,703.8	756.8	7,550	
Physical Contingency	F	0	104	165.9	576.9	300.3	1,034.5	3,050.1	5,231.7	
	L	0	0	379.1	1,248.8	1,112.1	526.3	77.2	3,343.5	
	T	0	104	545	1,825.7	1,412.4	1,560.8	3,127.3	8,575.2	
Total (Project Cost)	F	572	572	9,380.32	13,972.99	26,744.4	31,398.47	13,484.72	96,124.9	
	L	0	0	3,583.19	10,860.43	12,642.89	14,155.96	4,643.33	45,885.3	
	T	572	572	12,963.51	24,833.42	39,387.29	45,554.43	18,128.05	142,010.7	
Interest during	F	18.1	54.3	369.3	1,108.4	2,397.1	4,237.4	3,042.4	11,227	
Costruction	L	0	0	358.3	1,802.7	4,153	6,832.9	4,588.6	17,735.5	
	T	18.1	54.3	727.6	2,911.1	6,550.1	11,070.3	7,631	28,962.5	
Grand Total	F	590.1	626.3	9,749.62	15,081.39	29,141.5	35,635.87	16,527.12	107,351.9	
(Investment Cost)	L	0	0	3,941.49	12,663.13	16,795.89	20,988.86	9,231.93	63,621.3	
	T	590.1	626.3	13,691.11	27,744.52	15,937.39	56,624.73	25,759.05	170,973.2	

Table 11-9 Fund Requirement for Rehabilitation Works of Caliraya Dam

Unit : US$

Item \ Year	-1st year			1st year			2nd year			Total			Remarks
	F. C	L. C	Total	F. C	L. C	Total	F. C	L. C	Total	F. C	L. C	Total	
1. Direct Cost Rehabilitation Works for Existing Spillway for Common Use	0	0	0	20,000	159,200	179,200	0	0	0	20,000	159,200	179,200	
Changing of gate	0	0	0	0	0	0	80,000	9,500	89,500	80,000	9,500	89,500	
Build Additional Spillway	0	0	0	875,600	847,800	1,723,400	1,662,400	1,681,100	3,343,500	2,538,000	2,528,900	5,066,900	
Rehabilitation Works for Land-slide Place at East Side	0	0	0	0	91,600	91,600	0	0	0	0	9,160	91,600	
Rehabilitation Works for Down-stream Surface of Dam	0	0	0	313,200	363,700	676,900	0	0	0	702,000	815,100	1,517,100	
Rehabilitation Works for Up-stream Surface of Dam	0	0	0	0	0	0	56,000	305,000	361,000	56,000	305,000	361,000	
Total	0	0	0	1,208,800	1,462,300	2,671,000	2,187,200	2,447,000	4,634,200	3,396,000	3,909,300	7,305,300	
2. Site Investigation Works	0	85,500	85,500	0	0	0	0	0	0	0	85,500	85,500	
3. Compensation Cost	0	0	0	0	190,000	190,000	0	0	0	0	190,000	190,000	Quarry site Area 10ha
4. Engineering Fee	118,000	0	118,000	354,000	0	354,000	354,000	0	354,000	826,000	0	826,000	
5. Administration Cost	0	22,400	22,400	0	67,200	67,200	0	67,200	67,200	0	156,800	156,800	
6. Physical Contingency	0	0	0	2,000	25,000	27,000	337,600	365,900	703,500	339,600	390,900	730,500	
7. Interest during Construction	3,700	10,900	14,600	57,000	196,100	253,100	197,700	658,500	856,200	258,400	865,500	1,123,900	F.C : 6.33%, L.C : 20%
8. Grand Total (Investment Cost)	121,700	118,800	240,500	1,621,800	1,940,600	3,562,400	3,076,500	3,538,600	6,615,100	4,820,000	5,598,000	10,418,000	

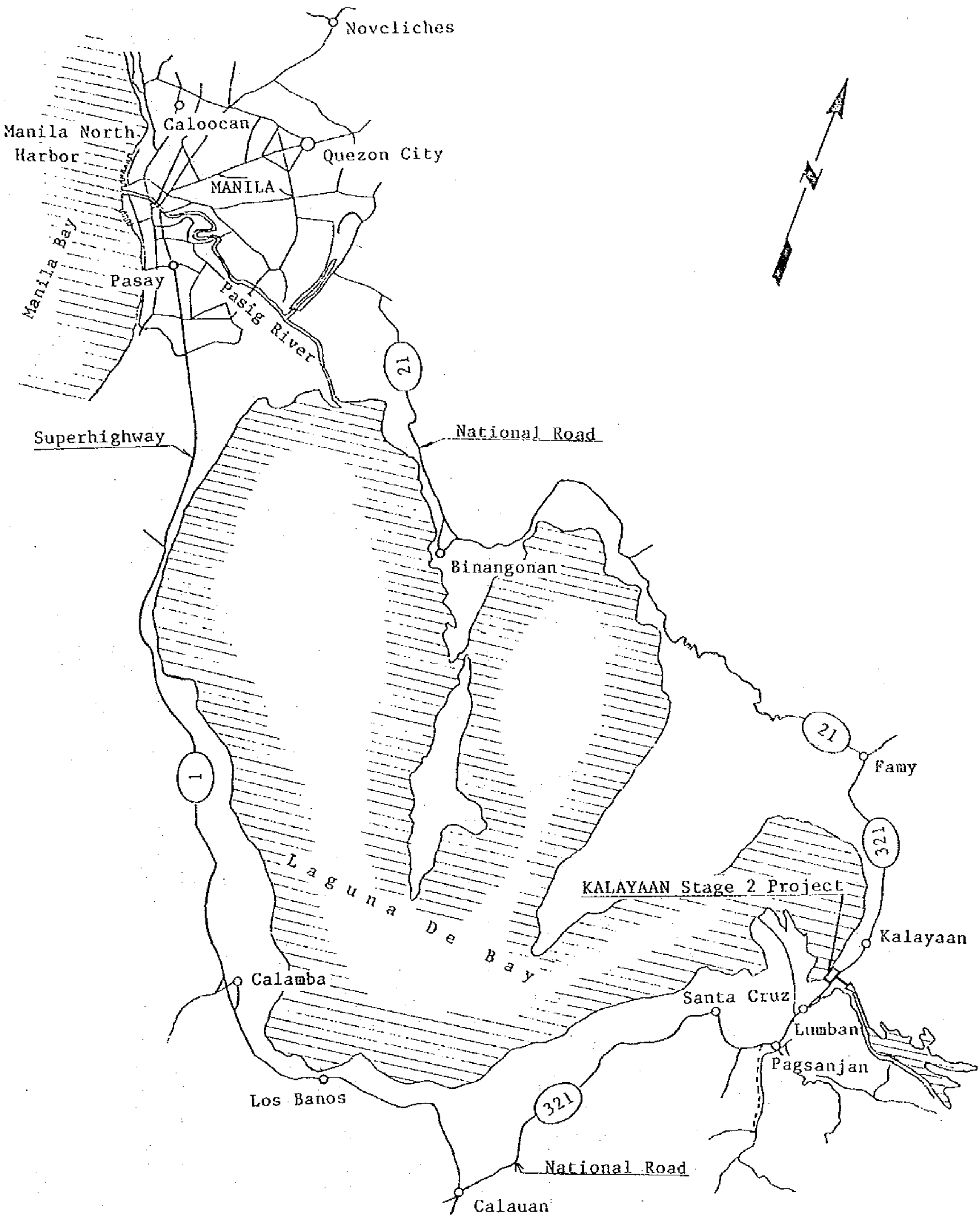
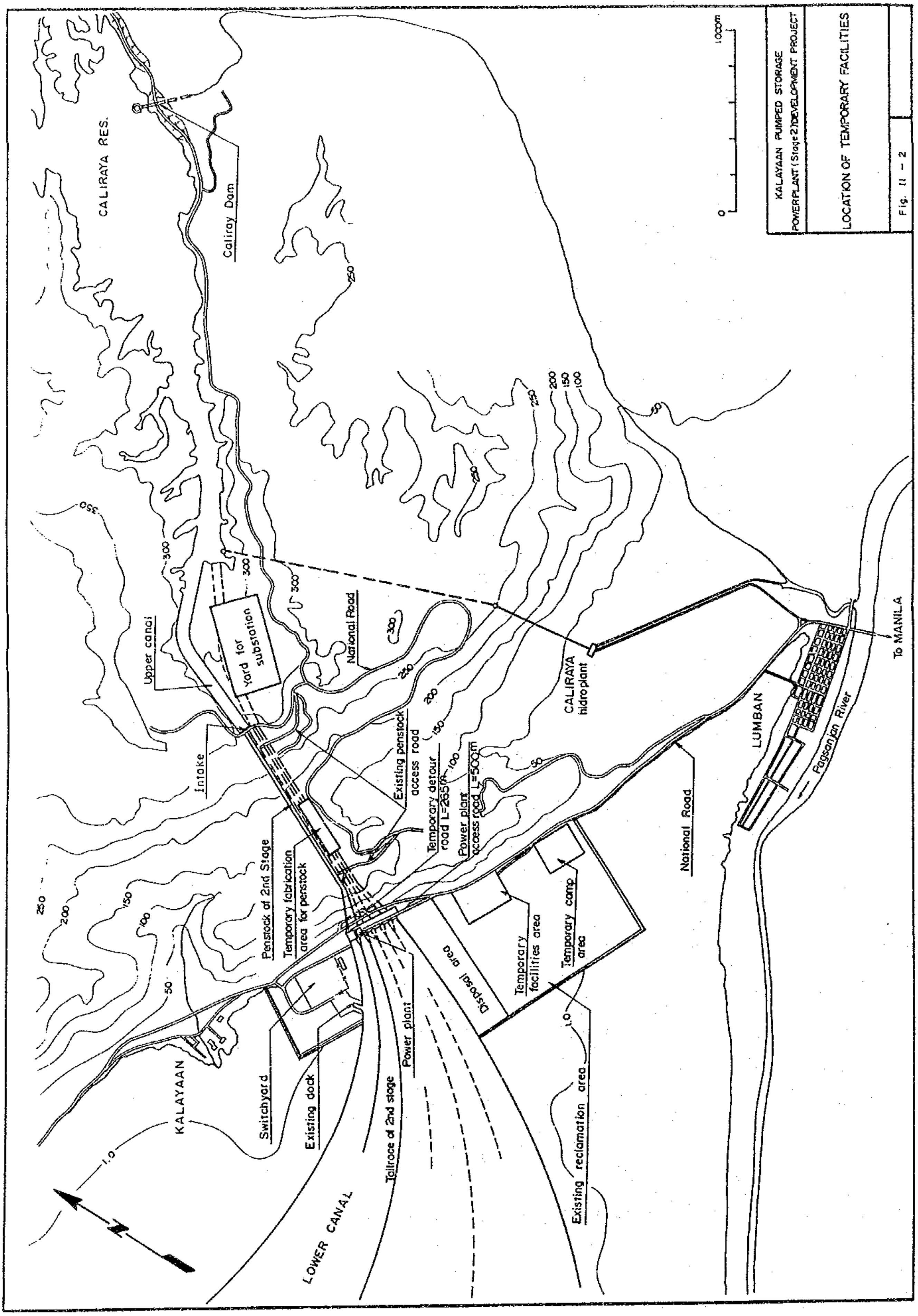


Fig. 11-1 Transportation Route



KALAYAAN PUMPED STORAGE
POWERPLANT (Stage 2) DEVELOPMENT PROJECT
LOCATION OF TEMPORARY FACILITIES
Fig. 11 - 2
0
1000m
CALIRAYA RES.
Caliray Dam
Upper canal
Yard for substation
National Road
Intake
Existing penstock access road
Temporary detour road L=265m
Power plant access road L=500m
Penstock of 2nd Stage
Temporary fabrication area for penstock
CALIRAYA hidroplant
To MANILA
LUMBAN
Pagsanjan River
National Road
Temporary facilities area
Temporary camp area
Disposal area
Power plant
Switchyard
Existing dock
Tailrace of 2nd stage
Existing reclamation area
KALAYAAN
LOWER CANAL
N

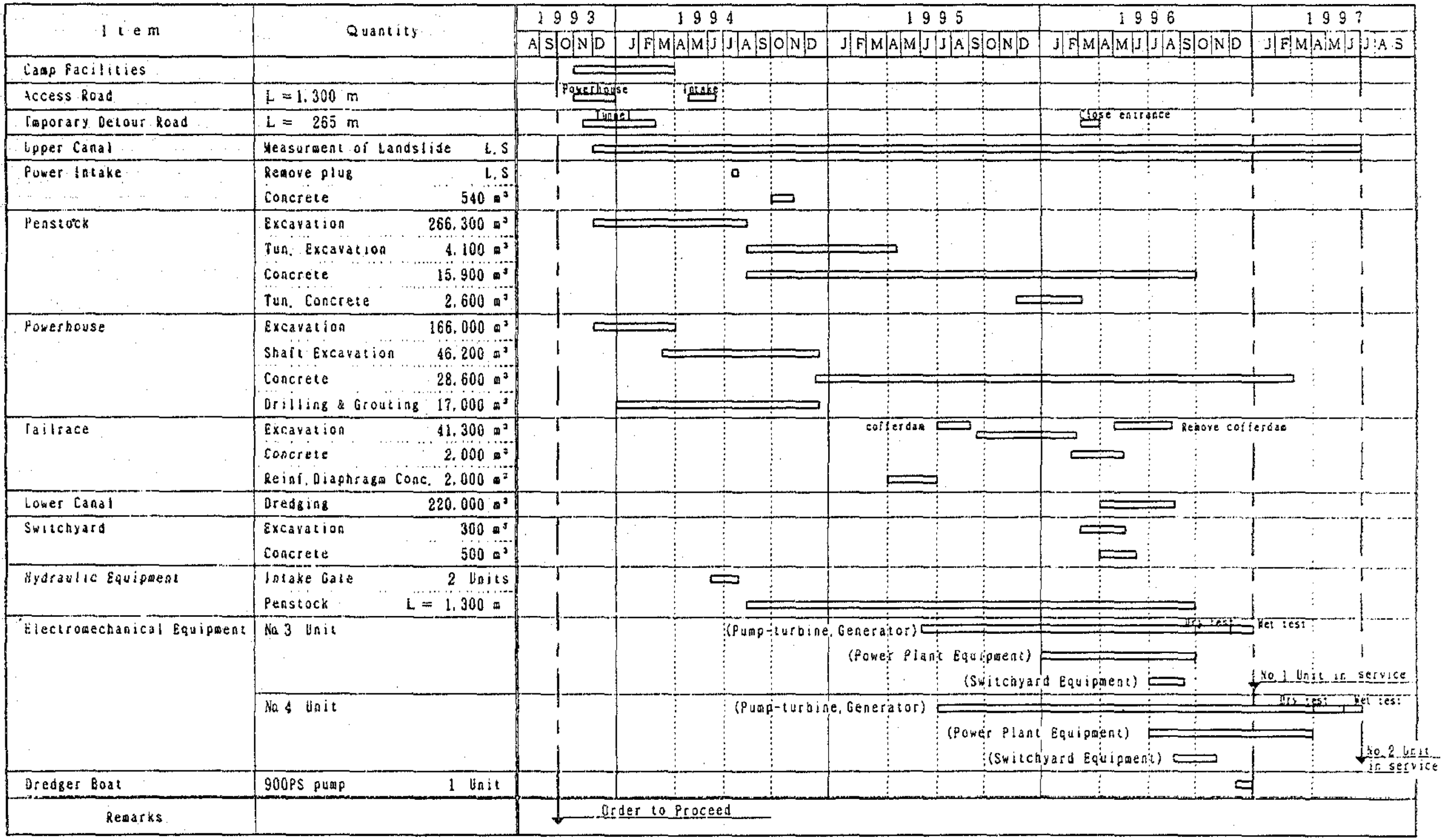


Fig. 11-3 Construction Schedule

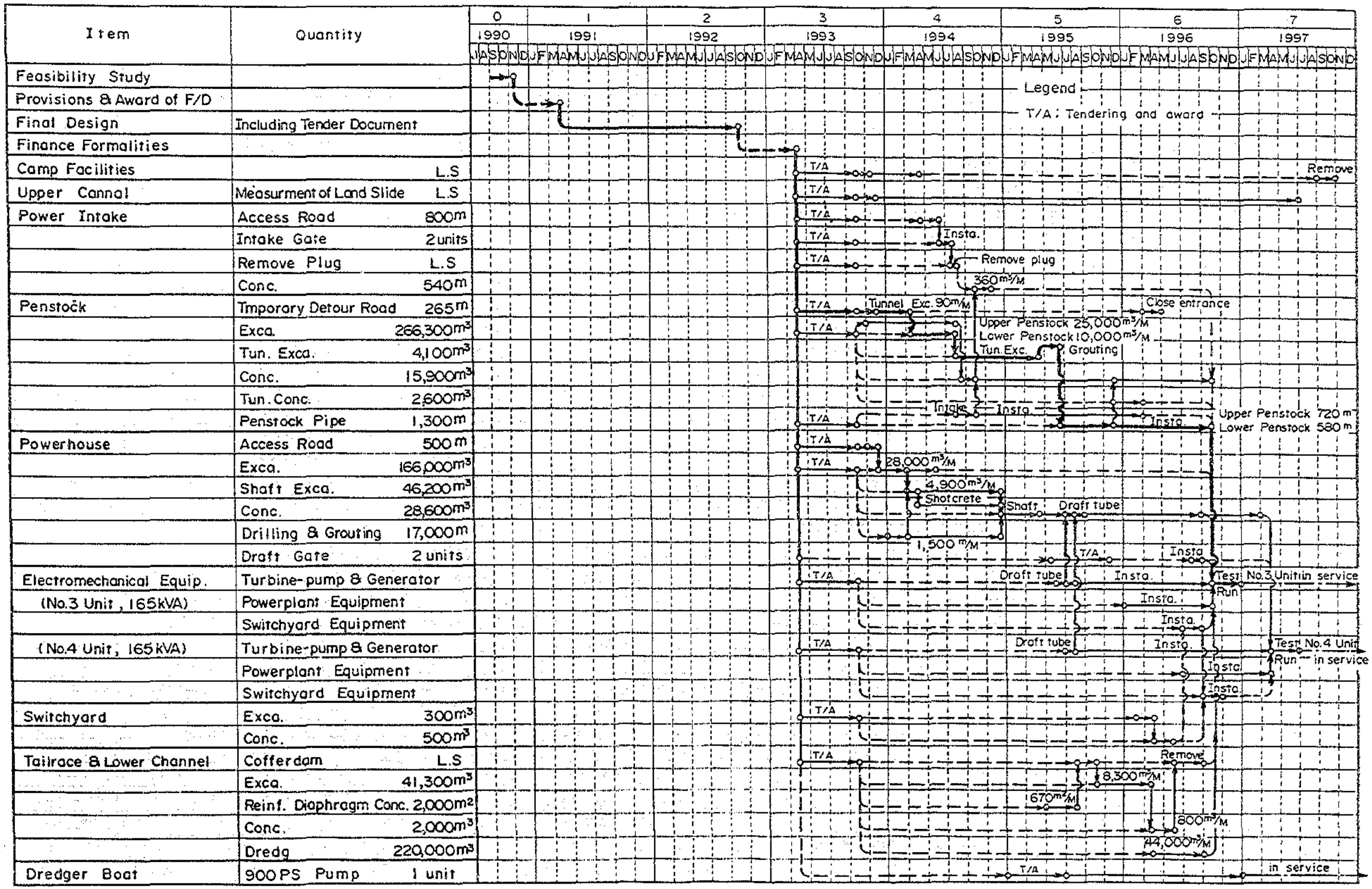


Fig. 11-4 Construction Schedule (Critical Path Method)

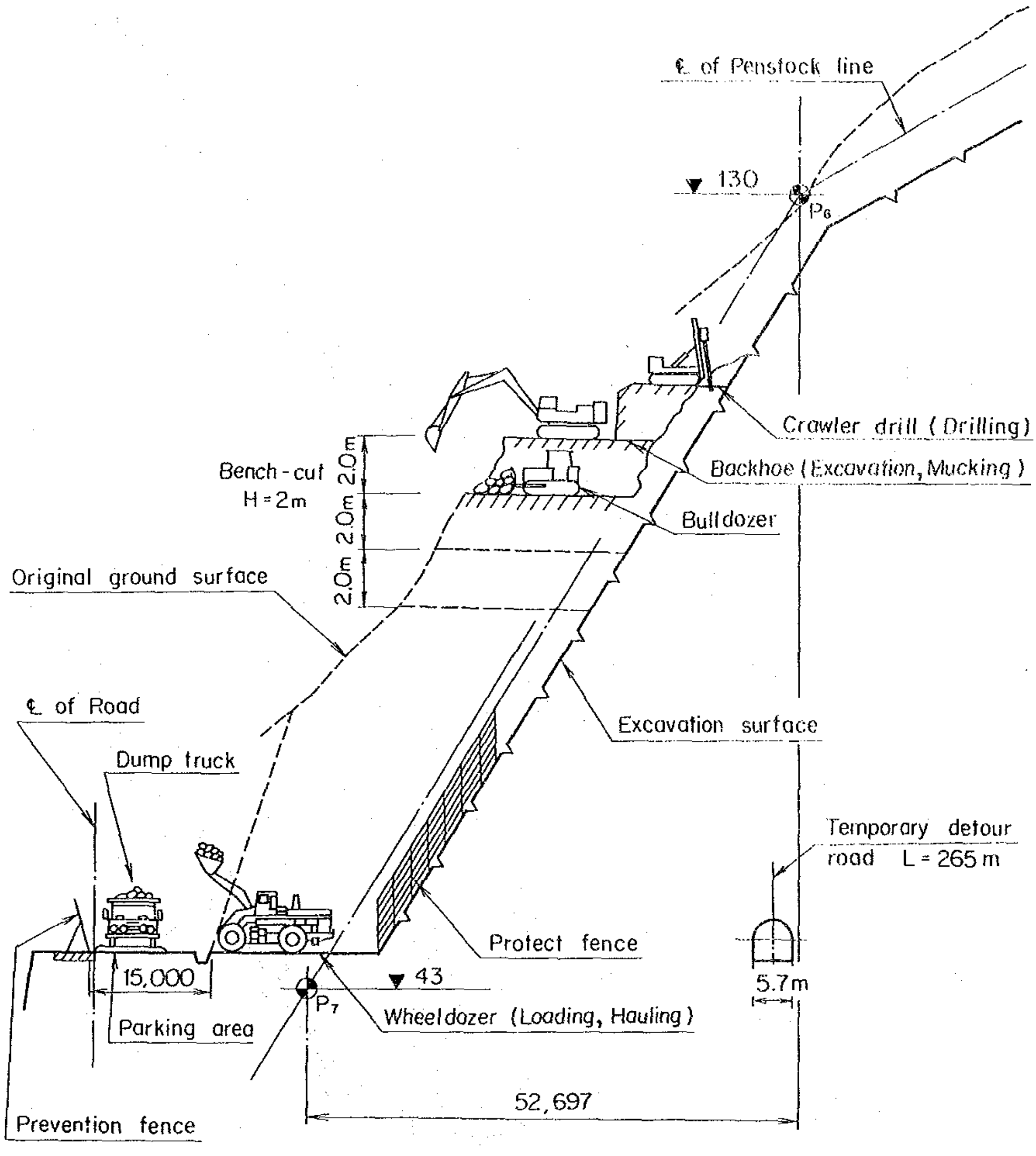


Fig. 11-5 Excavation in Lower Part of Penstock

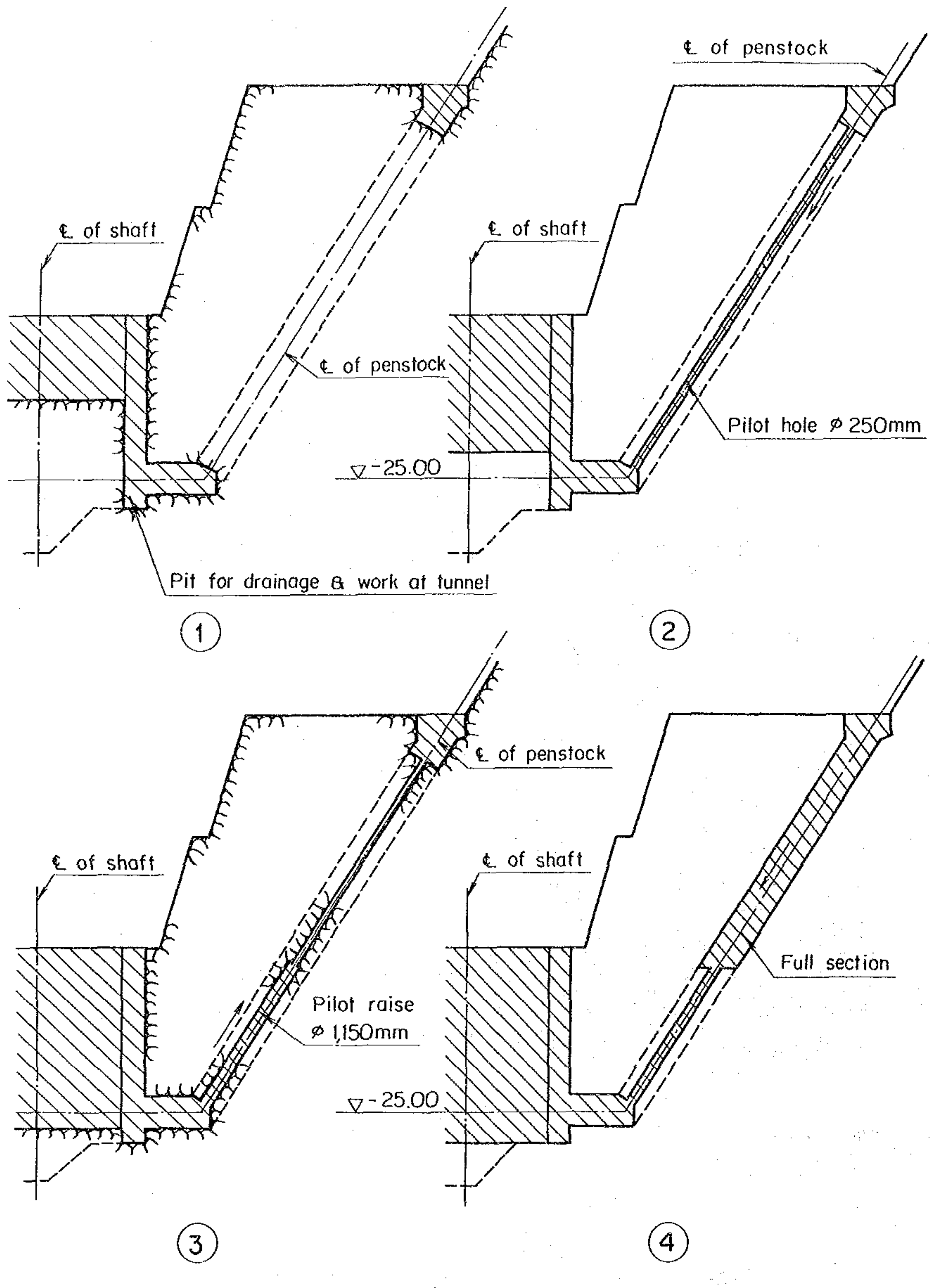


Fig. 11-6 Penstock Tunnel Excavation Sequences

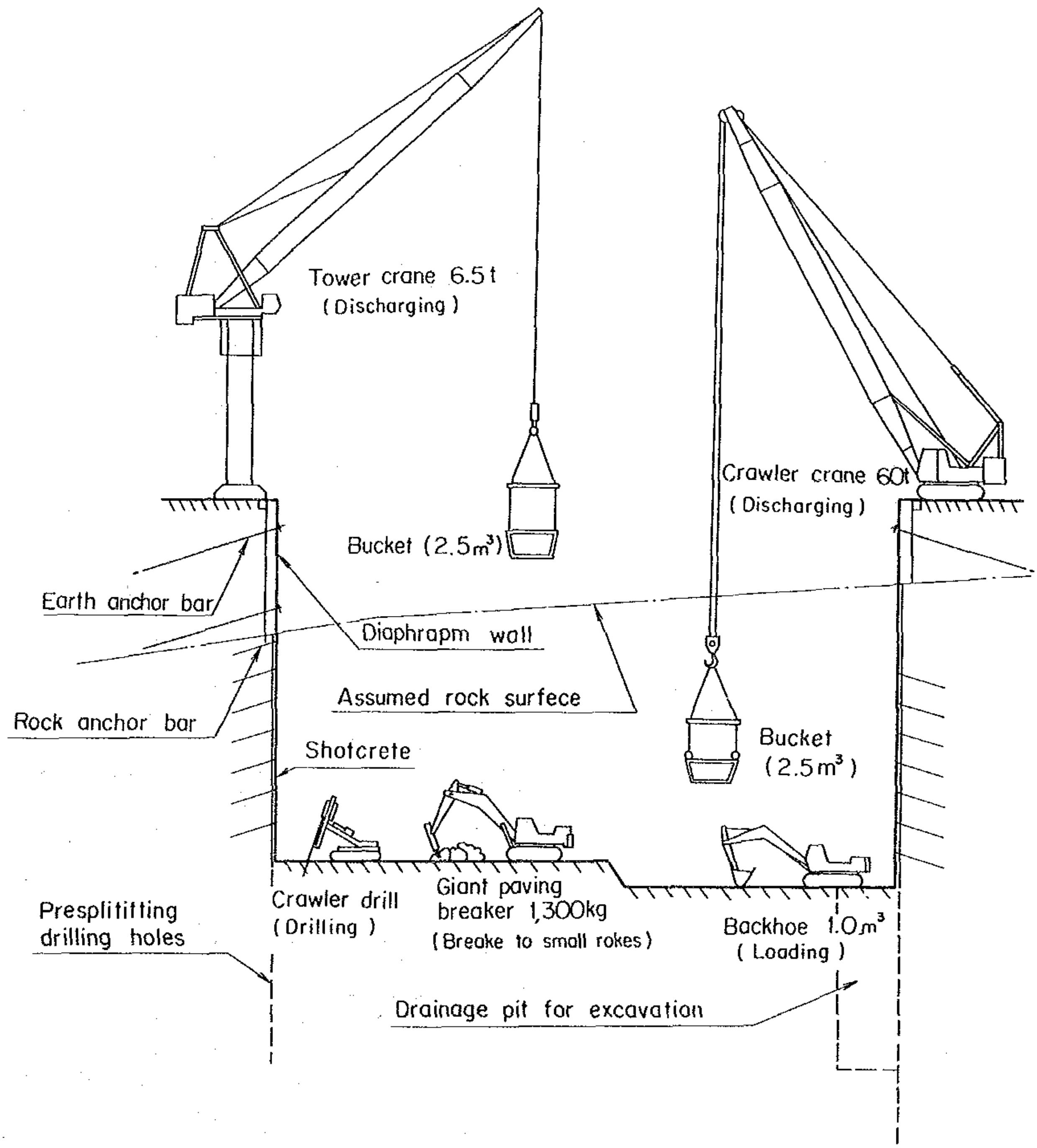
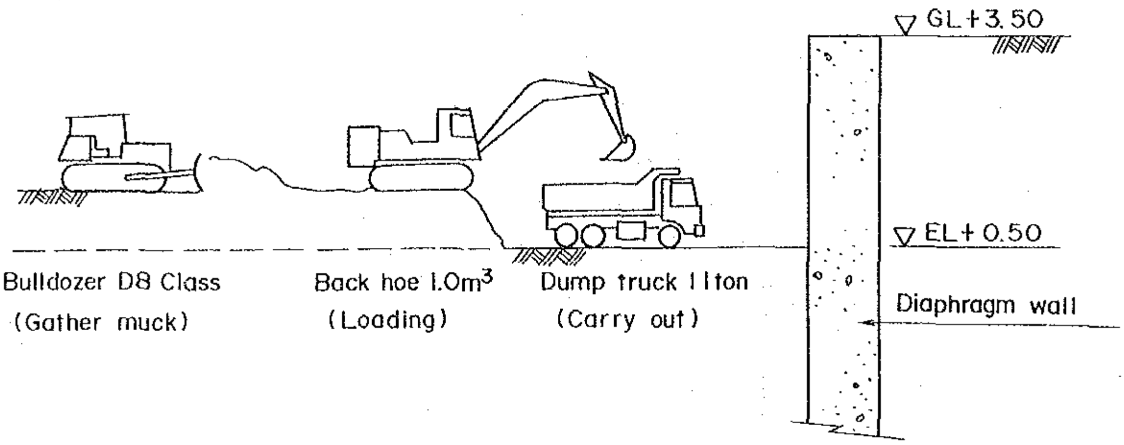


Fig. 11-7 Excavation of Powerhouse Shaft

① GL+3.50 ~ EL+0.50



② EL+0.50 ~ EL-4.50

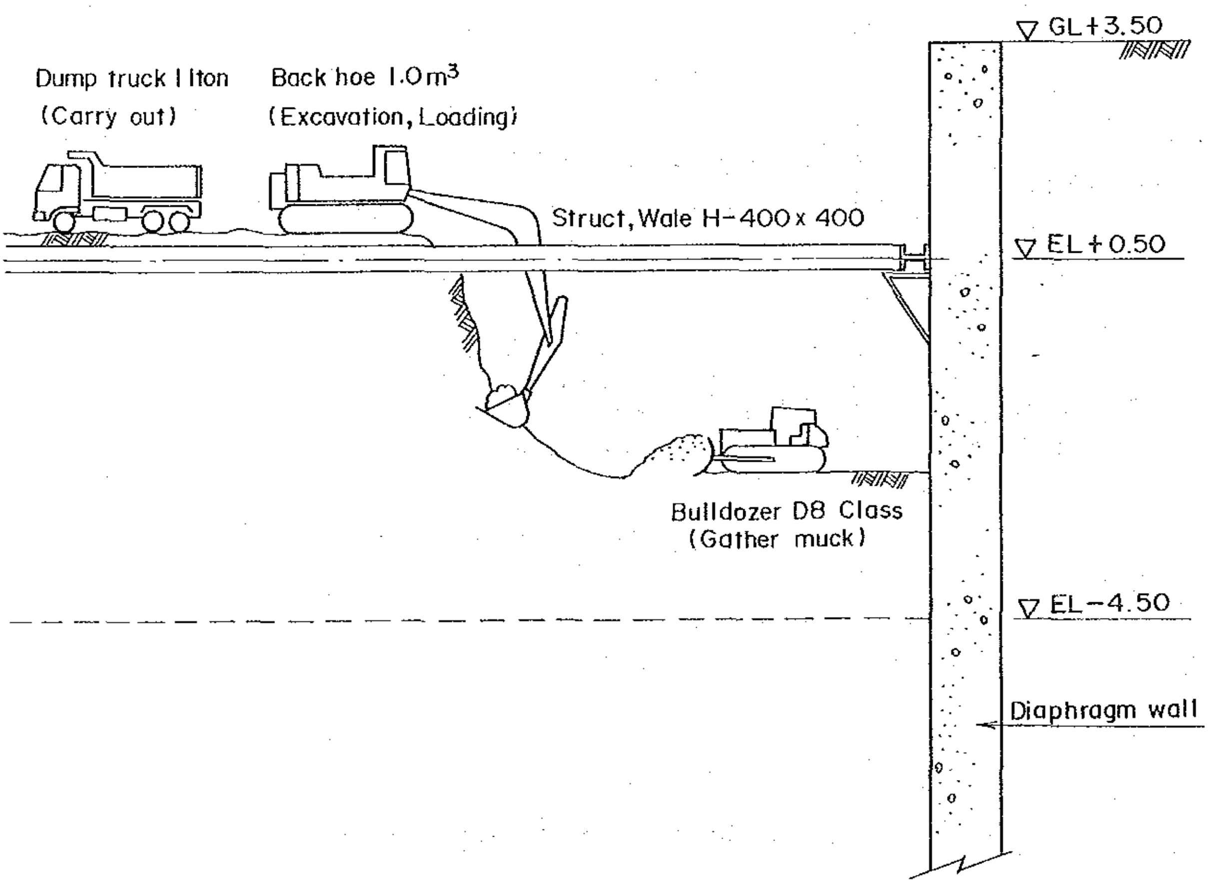


Fig. 11-8 (1) Tailrace Excavation

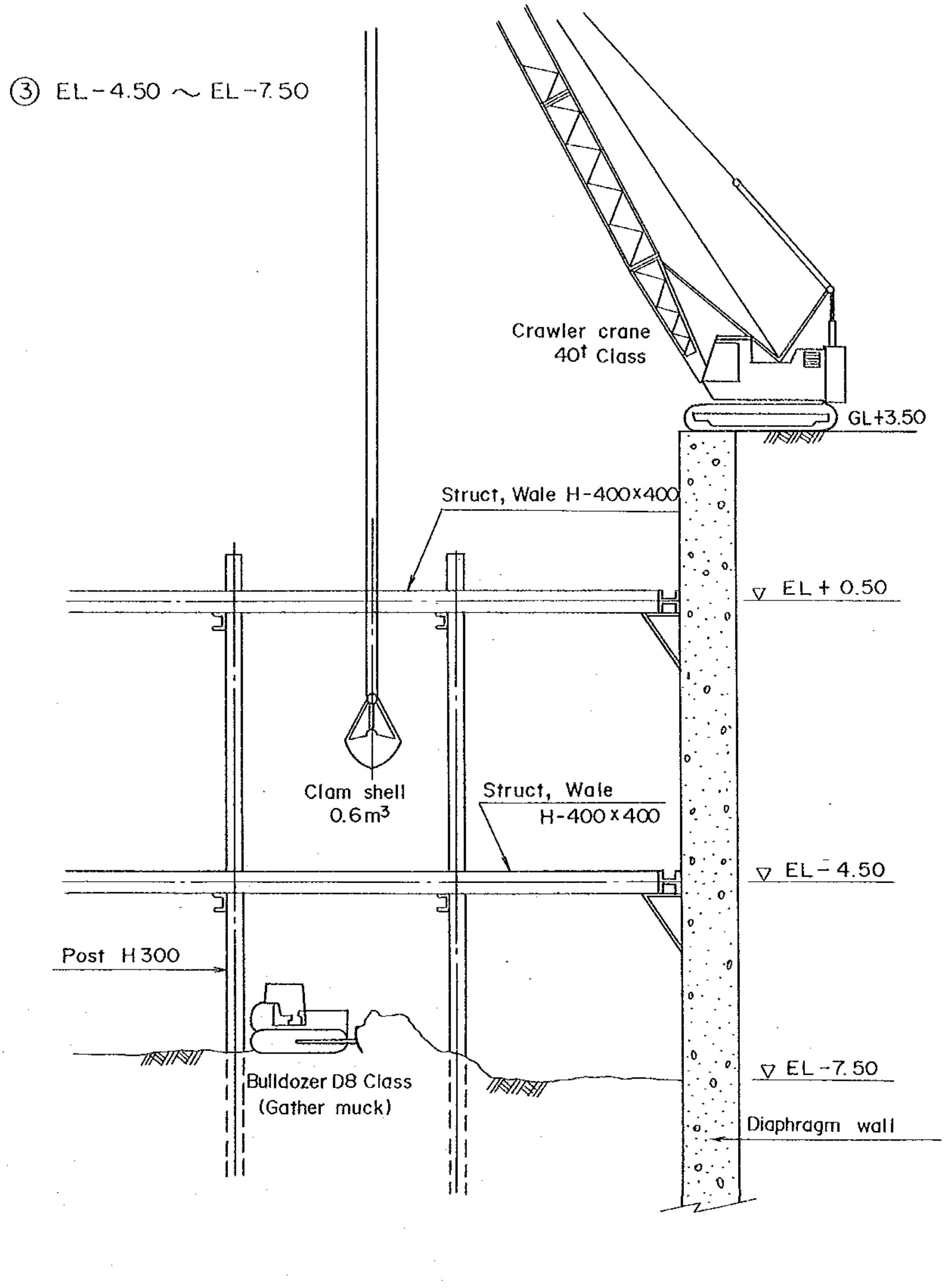


Fig. 11-8 (2) Tailrace Excavation

Chapter 12 Environmental Assessment

Chapter 12 Environment Assessment

12.1 Targets of the Environmental Impact Assessment (E.I.A.)

The original Scope of Work of the present E.I.A. study can be summarized as follows:

- Identification and description of the principal effects produced on the existing environment as a consequence of the implementation of the Kalayaan Stage II Project (two 150 MW additional units)

- Indication of basic mitigation measures to be adopted, in order to reduce the negative impacts, either during construction or in the operation stage

As discussed above, the objective of this measure is to alleviate the negative effect of Stage II Project.

The major environmental impact of this Project is the transfer of water pollution in Laguna de Bay to Carilaya Lake. It must be noted that this transfer of pollution is already going on by the operation of the power plant of Stage I, and the effect of construction of Stage II power plant is only marginal. Stage II only changes the amount of water that is exchanged between the two lakes, and the variation of water level of Carilaya reservoir remains the same as before. Considering the fact that the existing power plant is not producing a serious environmental problem, it can be reasoned that Stage II Project will not cause a substantial effect.

The traffic of the national road, which is affected by the Project during the construction period, can also be resolved by providing the diversion tunnel.

Although there is no serious environmental impact of Stage II Project as discussed above, the Mission hereby propose the measures to alleviate the general environmental effects which are more or less related to the pumped storage plant operation of Kalayaan Project (with total capacity of 600 MW including Stage I and Stage II).

12.2 General Approach

12.2.1 The Environment Related to Kalayaan Project

The general term "Environment" is normally interpreted as "the whole complex of physical, social, cultural, economic and aesthetic factors, which affect individuals and communities". Environmental Impact is therefore any alteration (positive or negative) produced on the above factors, as a consequence of human intervention.

In our case, the physical Environment of KPSPP can be considered as the complex formed by Laguna Lake (LL), Caliraya Lake (CL), the intermediate mountains and all infrastructures existing in the proximity and between the lakes.

The socioeconomic Environment is represented by all individuals living in this area, and/or performing social or economic activities on or related to it.

Defined as above, the KPSPP's area of influence is extremely wide, covering an area that can be estimated at about 150,000 ha (90,000 of which corresponding to LL), and inhabited by nearly 1,000,000 people.

The basic environmental problem of this area is the increasing pollution of Laguna de Bay, caused by human and industrial settlements and by the agricultural activities in all catchment area. In this framework, the main environmental impact of KPSPP operation is the "transfer of pollution" from Laguna to Caliraya lake.

A significant reduction of the pollution of Laguna de Bay would require a global control of all pollution sources in the entire catchment. This is certainly out of the scope of the present Study: this goal is being pursued by a medium and long term program, not related to Kalayaan project, being considered by Laguna Lake Development Authority (LLDA).

If a solution of the main environmental problem caused by the KPSPP's operation: the mixing of polluted water from Laguna de Bay with the originally clean water of Caliraya lake is to be attempted, the first target will be reducing the KPSPP's area of influence to a manageable system, where effective mitigation measures may be produced.

The only possibility to create such a manageable system seems to be to bound a portion of LL, which will be then acting as the lower reservoir of KPSPP, and operate on it.

In this area water quality reclamation measures could be adopted, thus arriving to an interchange of clean waters between LL and CL.

Of course, positive and negative aspects of this idea needs to be carefully studied before implementation, assessing in depth the consequences of the isolation of a portion of LL on the global physical and socioeconomic environment.

The other environmental effects related to Stage II will also be discussed in this chapter, but their importance if far less significant when compared with water quality in CL.

12.2.2 Present and Planned Operating Conditions

With the implementation of Stage II, Kalayaan generating discharge will increase from the present 120 m^3/s (2 x 60), up to 240 m^3/s, and pump-up quantity will pass from about 100 to 200 m^3/s.

The effective storage capacity of Caliraya and Lumot reservoirs will not change, thus the total weekly amount of interchanged waters will remain essentially the same. Only the "frequency" of the interchanges and the daily volumes of water pumped and turbined will be modified.

The exact response of CL to the modified hydrodynamic conditions is not predictable without a proper hydrodynamic model, but considering the importance of the discharges when compared with CL overall storage capacity (79.2 million m^3), it's easy to understand that equilibrium will be reached rapidly, possibly in 6 - 8 weeks (according to a simplified transport model performed by EBASCO in 1980, for Stage I equilibrium should have been reached in 4 months).

12.2.3 Priorities in E.I.A.

The T.O.R of the Study mention a long list of environmental effects to be analyzed. nevertheless not all of them have the same importance and a categorization is necessary to meet the targets of the Study.

In principle, secondary impacts, or changes induced by associated investments will not be considered. The studies will be limited to primary impacts, related to KPSPP's construction and operation activities only.

Concerning E.I. after construction, as already mentioned, priority will be given to water quality, considering that improvements on CL are strictly related to the actions undertaken in LL.

Socioeconomic impact is also of utmost importance, because of the many activities related to water, either in LL or CL.

Noise, plant safety and physical impact (including aesthetic) will be briefly discussed. Other items will receive minor attention.

During construction, priority will be given to transportation and public facilities aspects, followed by some socioeconomic considerations.

12.3 Present Environmental Conditions

In this section the present environmental situation will be described, assessing in particular the impact already generated by Stage I.

12.3.1 Physical Environment

The physical environment, intended as the geographic, geological, soil, and climatological conditions of the area has already been described in Chapters 5 and 6.

The following adverse effects, produced by the KPSPP (either Stage I or II), must be mentioned:

- Restriction on land and water use, especially in the area where the powerhouse and the penstocks are located

- Soil and slope alteration, especially along the penstocks alignment and in the powerhouse area. Consequences are evident on removal of vegetation covering;

- Soil erosion along the shore of CL, due to the daily water level variations, and consequent increase of sedimentation in the reservoir;

- Impact on aesthetics all along CL shores: to be considered important in the most popular resort area in the vicinity of Manila

The potentially more dangerous adverse physical effects, consisting in erosion of the LL bottom in the plant area, due to the high water velocities, and consequent sedimentation elsewhere, either in the lower tailrace or the upper intake canals, are controlled by existing concrete retention walls, sufficient canals width and periodical dredging operations.

12.3.2 Water Quality

(1) Monitoring and Studies

In order to determine the impact of KPSPP on water quality, monitoring activities have been conducted prior and during plant operation (from 1979 to 1988) by NAPOCOR Environmental Service Division - Environmental Management Department, both in LL and in CL.

Seven sample stations where established in CL, named from CL1 to CL7: 3 in the proximity of the intake canal and the others scattered along the reservoir. Two stations (LL1 and LL2) where established in LL: the first nearby the KPSPP tailrace and the other at some two hundred meters distance.

Sampling was generally taken at three different depths: surface, mid-depth and bottom, and the following parameters were analyzed:

- temperature
- conductivity
- total suspended solids
- total dissolved solids
- PH
- total alkalinity
- dissolved oxygen
- chloride
- ammonium
- nitrate/nitrite
- phosphate

NAPOCOR reported, among others, the following remarks: "The aforementioned monitoring results tend to indicate that no significant changes in the water quality of LL was brought about by the operation of KPSPP. The reverse, however, is seen to be happening in Lake Caliraya" (see: KPSPP - Operation and Trends of Water Quality - Pollution Monitoring Section - NAPOCOR - September 1989).

A short field survey on water quality was conducted during the first appraisal Mission for the Project, in January 1990. Results are attached in appendix 3.

(2) Comments

No statistical analysis of NAPOCOR monitoring data has been done, due to the shortness of the assignment.

Anyhow, a wide spread of range is evident, concerning both the data relevant to CL and the measurements taken in the proximity of the tailrace.

Reasons should possibly be found in the sampling hour, considering that, immediately after pumping, in the upper canal the same waters of LL should be found. On the contrary, at the end of generation clearer waters coming from the upstream part of the reservoir will be present.

There is anyhow a clear correspondence between LL and CL parameters, at least up to CL3 station and with some peaks also in the other stations.

This correspondence seems to indicate that water mixing is complete at least up to the spillway of Caliraya reservoir, with strong influence up to the aqueduct arriving from Lumot reservoir. The influence rapidly decreases in the upstream part of the lake.

Those data are partially contradictory with the results of the mathematical mixing model performed by EBASCO in 1980, that on the other hand was based on quite simplified equations.

The turbidity in CL is also clearly visible when crossing the lake from the upper canal up to the end (CL7 station). The transparency of waters increases steadily from some 10 or 15 cm (referring to a "Secchi Disk" analysis), up to 1.5 or possibly 2.0 meters when approaching the lake's terminal part.

It clearly indicate that CL's turbidity is essentially due to the effect of pumping LL's waters.

Finally, we remark that all data normally fit in the standards for Class "C" waters (for fishery), but are quite far from Class "A" (human consumption). In fact LL is classified as Class "C" and CL as Class "B" (fresh inland waters).

12.3.3 Biological Environment

(1) Monitoring of the Lakes and General Features

Informations relevant to LL biological environment are available mainly from previous LLDA studies.

Laguna de Bay inhabits a total of some 65 algal species, of which only two groups are of importance; blue-green algae and diatoms. Blue-green algae show a pronounced seasonal growth (during the hottest season), where diatoms are present all year long.

Dense algal blooms, caused by microcystis or filamentous blue-green algae, used to occur in past years, endangering the fishery production.

This phenomena seems to have been decreasing in the recent past, due to reasons discussed in the next paragraph.

Macrophytes are normally represented by floating, submerged and marginal aquatic plants.

Floating aquatic plants shows a predominance of the well known "Eichornia Crassipes" (water lilium), found almost everywhere in the tropics, and whose rapid growth often causes disturbances to the water's users.

Eichornia is often accompanied by other species of water weeds, such as waterlattuce (Pista Stratiotes) and waterfern (Salvinia Cucullata), which have an infestation capacity similar to water lilium.

Submersed aquatic plants are also capable of rapid vegetative propagation, and are easily dispersed by water currents. More common species are Hydrilla Verticellata (florida elodea), Ceratophyllum dimersum (Coontail) and Najas Graminea (grassy naiad).

They are likely to predominate in shallow areas and in the distribution channels, sometime completely impeding water flow and thus causing serious troubles.

Emerged and marginal aquatic plants are of minor importance in our case, not interrelating at all with KPSPP.

As animal life is concerned, at least 15 species of fishes are reported in Caliraya Lake, and it's likely that more than that are living in the Lagoons' waters.

LLDA reports a potential fishery production up to 2.90 t/ha per year, over an extension of some 31,000 ha. For this study, no statistical data have been made available on this matter, but such a production seems unlikely, since it would require a so large amount of nutrients (nitrogen), possibly not compatible with the entire biological equilibrium of the Lake.

NAPOCOR conducted two biological studies on Laguna de Bay, the first related to the thermal power plant of SUCAT, and the second for the thermal PP of PILILLA.

Both studies are only considering the environmental conditions in the vicinity of the plant, but it is likely that the biological condition of the whole Laguna are similar, and the results of those studies can therefore be translated also to the eastern part and Kalayaan area.

This last consideration can also be confirmed by the conclusions of the Water Quality study on Laguna de Bay and tributary rivers, conducted in 1988 by Manila University of Life (see water quality index for western, middle and eastern Lagoon).

Caliraya lake has never been monitored as far as biological environment is concerned (algal species, aquatic plants and animals, zooplankton, phytoplankton, bacteria). In any case, following the opinion of NAPOCOR environmental experts, it can be assumed that biological conditions of the lake are stable, and no significant variations have been generated by the operation of KPSPP.

It is considered that informations and data made available are sufficient for the purposes of the present analysis, and that the conditions existing in LL will be entirely "transferred" to CL (of course it doesn't mean that CL will react on the same way).

(2) Basic Ecological Considerations

Either blue-green algae or macrophytes seems to be decreasing during recent years. Water lilium, as reported by NAPOCOR, is not representing a problem for the plant operation.

This phenomena should be carefully investigated, since it may be a consequence of the appearance of limiting factors, influencing the ecological equilibrium of the Lagoon.

According to not confirmed fishermen's declarations, even fishery production is decreasing in the last years. The fishermen accuse Kalayaan plant of spreading poisonous substances (which is without fundamentals), as before they where accusing the Napindan Control Structure, located at the outlet of the lagoon, of lowering the salinity level in the lake, thus compromising the fishes habitat (which was partially true).

In reality, this phenomena is possibly due to the concourse of several factors, namely:

- Nitrogen removal operated by fishpen fishery;

- Possible introduction in the lake of herbicides coming from agricultural drainage (rice crops along the lake shore are especially dangerous);

- Increasing turbidity of the waters, with consequent reduced photosynthesis activity;

- Decreasing of dissolved oxygen at eutrophication levels, even if it may happen only in some area of the lake;

- Possible increased concentration of heavy metals and inorganic salts, coming from industrial pollution, and affecting the osmoregulation of aquatic plants and animals.

Other minor factors may also occur, and following the "Liebig's low of the minimum" (an organism is no stronger than the weakest link in its ecological chain of requirements), they may have a determinant influence on the equilibrium of biota.

The present situation is nevertheless not critical at all, and the Laguna shows a strong ecological dynamic. In fact, in spite of the turbidity and shallowness of the waters, the Dissolved Oxygen (DO) is still sufficient for the evolution of the ecosystem, thus indicating that vertical and horizontal hydrodynamic interchanges are well acting.

This is possibly due to the winds' action, provoking not only waves movements, but (of major importance), a cooling effect of the water surface, with high oxygen content, thus engendering a vertical flow and oxygen transfer to the lowest water layers.

Considering the high presence of organic substances, the effect of water turbidity is certainly not only due to suspended solids, but is caused by the presence of mineralized organic sediments, normally deposited in the benthos (organism attached or resting on the bottom or living in the bottom sediments), which could become an eutrophic or ipertrophic zone, thus modifying the whole limnological equilibrim.

12.3.4 Social and Economic Environment

The socioeconomic environment of Kalayaan is mainly represented by the following communities:

- The fishermen associations, representing from the point of view of the study the most important community, whilst a large part of lake's related economic activities is and will be based on fishery;

- The peasants communities, especially those living in the neighboring of the plant and the rice croppers;

- All people directly or indirectly living on tourist development of Caliraya Lake.

To appreciate the importance of the socioeconomic environment, it can be mentioned that Laguna de Bay Region is comprehensive of 54 municipalities and 6 cities, with a total population around 8.5 million people, 1.4 of which is estimated to live in the 28 lake shore municipalities.

Even limiting the environment related to KPSPP to the communities scattered along the road from Santa Cruz to Mabita and around Caliraya Lake, we found at least 13 municipalities and the city of Santa Cruz itself. It means a total population certainly between 0.5 and 1 million people, and even if a small percentage of it is developing activities in some way related to KPSPP, figures in the order of some tenths of thousand persons are easily reached.

The importance of fishery is well emphasized considering that in 1983, 1.0 billion pesos have been devoted to fishpen industry by the Philippine's Government, generating more than 100,000 job opportunities (LLDA source).

12.4 Expected Environmental Impact of Stage II

12.4.1 Water Quality

(1) E.I. during Construction

The main primary impacts associated with construction activities are temporary, and normally consist in increased erosion from the construction site and consequent increased sedimentation in the downstream waters.

Simple mitigation measures can generally be implemented in order to minimize erosion, as:

- Limiting the area denuded from vegetation;
- Limiting the time of exposure in a denuded state;
- Creating retention basins to trap the sediments;
- Diverting the upstream runoff (hardly applicable for this case).

(2) E.I. during Operation

A slight effect of soil erosion may continue during the plant operation, especially on the enlarged slopes of the powerhouse area and along the new penstock alignment. Easy mitigation measure can be adopted, restoring as much as possible the permanent vegetative cover.

The operation of KPSPP's second stage, as already mentioned, will increase the rate of water mixing between LL and CL's waters, and it's not possible, at this study level, to make any accurate prediction of the related ecosystems interactions.

A reliable forecast can only be made trough a modeling process, which is largely used and relatively low-costing. A brief description of those models, whose application is strongly recommended before the starting-up of the Stage II, will be given hereafter.

Among the possible effects induced by the Plant operation on the whole water system related to it, the following should be mentioned:

- Increased sedimentation, especially in CL, due to the erosion of the lake shores caused by the continuous water level fluctuations and to the erosion effect of the strong velocity in the intake channel and tailrace;
- Increased water turbidity, due to suspended or dissolved solids
- Modification of the surface water temperature in the proximity of the canals (it could be a positive effect, while increasing water's interchange with bottom layers)
- In general, modification of water quality parameters, as DO, PH, Nitrogen, Phosphorous

Sedimentation and turbidity should be considered of major importance, due to their influence on limnological equilibrim, and carefully monitored.

12.4.2 Aquatic Organisms and Plants Life

The natural complexity of aquatic ecosystems makes very difficult any prediction on biotic equilibrium modifications that may be induced by changed water parameters, especially when the new water quality specifications are not known. The following considerations must therefore be considered only as basic guidelines.

As for the water quality data, better answers may be obtained trough the application of appropriate ecological models, and trough a continuous monitoring of both lakes.

(1) E.I. during Construction

The environmental impact expected on aquatic biota during construction in mainly related to the increased water turbidity.

In the vicinity of the plant the high turbidity might strongly interfere with photosynthesis, leading to local eutrophication and thus generating algal blooms and fish killings.

Aquatic vegetation along the lake shore will also be affected and partially destroyed because of high turbidity, with adverse effect on deposed fish eggs, generating an additional decrease of fish population.

In any case, these effects will be limited to the construction period and to the close neighboring of the plant, and will probably not leave any permanent consequence to the lake.

(2) E.I. during Operation

As mentioned, the impact of Stage II will result in an increasing of water mixing rate, leading Caliraya lake to the same pollution level of Laguna de Bay.

Even if Caliraya will not give the same limological answer as Laguna de Bay, similar phenomena might occur, at different times, in both lakes.

The increasing of nutrient concentration (nitrogen and phosphorous) might in particular result in the appearance of eutrophication areas in some parts of the reservoir, where the waters are shallower and the exchange is limited.

This phenomena, as already happened in Laguna de Bay, will enhance algal growth (blue green and green algal) and possible algal blooms during the hottest season, as well as the appearance of islands of macrophytes (water lilium or other species).

It must anyhow be noted that no algal blooms or uncommon macrophytes growth has been remarked in CL until now, due to the operation of Stage I, even if it was expected.

In fact, contrary to Laguna de Bay, in Caliraya the vertical circulation should be normally assured by the thermal stratification, at least in the epilimnion layer.

In the areas where the lake is deeper, the formation of an intermediate thermocline zone is nevertheless possible, characterized by a rapid change in temperature and oxygen and strongly reducing the oxygen transfer to the bottom layers (hypolimnion).

The increased presence of suspended solids will, on its turn, increase the bottom muds and animal benthos that, for the lack of oxygen, will be rapidly corrupted, forming ipertrophic "pools", with consequences unpredictable on the basis of the present knowledge.

As far as fishes are concerned, several species (as tilapia) are easily adaptable to changed conditions, because they are omnivorous. The increased concentration of nutrients might produce, at least during a first period, a corresponding increase of population, opposed after sometime by the unfavorable effect of turbidity.

The reaction of Caliraya lake to changed ecological conditions is anyhow not easy to predict, considering the complex hydrodynamics of the catchment area and the altered batimetry of the lake itself. It's therefore of primary importance the application of reliable ecological models, before the start-up of the Stage II plant.

12.4.3 Socioeconomic Environment

The socioeconomic impact analysis normally concerns the physical, social, economic and aesthetic environment.

In general, the negative effects on socioeconomic environment due to the implementation of Stage II will be marginal, considering the existence and long-standing operation of Stage I.

These affects will be, in any case, mainly related to the changing water conditions in Caliraya lake, and will be negligible if, with appropriate mitigation measures, a further degradation of the water quality could be avoided.

On the contrary, the benefits of the project for the neighboring communities might be remarkable, because of the creation of labor opportunities and increased development of induced activities, especially during the construction phase.

(1) Physical Environment

During construction, the more important problem will be represented by the transport and disposal of excavation and construction materials, for which suitable areas shall be found.

The utilization of already existing disposal areas is normally recommendable, when still available and suitable for the project. In any case, it should be checked that the disposal areas do not interfere with the usual social and economic activities. Their re-conversion after completion of work is suggested.

Another important aspect to be checked before construction concerns the risks, either for the workers or for local inhabitants, related with construction activities. The more frequent risk factors should be pointed out and effective protection measures adopted.

As permanent adverse physical effects, it is only worthwhile to mention the partial removal of vegetation cover along the penstock alignment, slightly increasing the soil erosion.

The land use will not be affected at all, while the powerhouse and penstock areas are already available, and certainly not suitable for different economic utilization.

(2) Social Environment

Minor social disturbances will be suffered by the populations living in the surroundings of Kalayaan area during the construction phase, originated from the movement of heavy trucks, the interference with the road, the disposal of construction materials, and so on.

Fishermen will be affected because of the increased waters turbidity, even if the strongest effects will be limited to the plant's very close vicinity, and only the nearer fishpens could be partially affected.

Actions of fishermen's associations against the implementation of Stage II are anyhow possible, while they are already accusing the plant for fish killing, and will therefore deduce that doubling the plant capacity will provoke a double fish dying.

It's therefore strongly recommended to carry on a specific information campaign among the fishermen, aimed to explain the purpose of the plant and the reasons why no disturbances to the lagoons' animal life could be expected by the plant operation.

LLDA is well accustomed and aware of this problem, and may give helpful suggestions and support to this campaign.

During plant operation, negative social effects will arrive to the tourist operators around Caliraya lake because of the expected reduction of water's transparency and, in general, for the poorer water conditions.

In fact, the aesthetic of the lake and the touristic attractiveness of the several resort areas existing along the shores are strictly depending on the water quality and especially on transparency. Sport-fishing and water-sky activities might also be affected, with unfavorable economic consequences for the local operators.

The use of the by-pass tunnel with one lane capacity instead of the standard width road, during the excavation and erection of the inclined stretch of the penstock, could generate some disturbance to the traffic along the Lumban - Kalayaan road.

On the other hand, the positive social effects linked to such a big investment in the area are evident and might also be remarkable.

Direct and indirect employment opportunities will arise (even if in a limited number), new infrastructures will be created, as well as improved health, social, educational and recreational services; public transport facilities will be improved and land value increased.

The new investments might also induce new migratory trends, with adverse effects that should be mitigated.

(3) Aesthetic Environment

The most important aesthetic negative effects, as already mentioned, will be related to the further decrease of water transparency in Caliraya lake, with the consequences discussed here above.

Aesthetic of terrestrial environment is somehow already affected by the existing open air penstock, in particular in its subvertical stretch crossing the national road.

From this point of view, the new penstock will not introduce any significant change to the present conditions.

The location and design of the powerhouse is of minimum aesthetic disturbance, either looking from the lake or from the ground.

(4) Noise and Vibrations

Noise resulting from the operation of KPSPP, even after the construction of Stage II, will remain confined within the plant's limits, without affecting the public.

No specific noise measurements was taken during the appraisal mission, but noise and vibration levels reported by NAPOCOR are within or under the normal range for power or industrial plants.

Inside the powerhouse, turbines and pumps represent the main noise and vibration source, whose effects are felt by individual workers. Continuous noise monitoring is presently performed by NPC and shall be also applied to the new units.

Noise problems will be more significant during construction, due to the operation of cranes and hoisting equipment, air compressors, concrete mixers, bulldozers, etc.

In general, the following mitigation measures can be adopted:

- Assure that equipment is designed and manufactured conforming with existing noise control regulations

- Assure adequate operation and maintenance

- Limit the time of day during which the most noisy equipment and engines can be operated

(5) Plant Safety

Plant safety is another essential aspect to be analyzed and carefully engineered during detailed design.

In this respect, the more critical area is the penstock alignment, where surveillance is difficult and the communication cables between the powerhouse and the intake have already been stolen in the past.

Independent from the implementation of Stage II, a complete new fencing of the subhorizontal stretch and increased watch personnel will be highly recommendable.

12.5 Proposed Actions to Reduce E.I. Effects

12.5.1 Foreword

The present chapter will describe the most important engineering measures suggested in order to minimize the adverse impacts of KPSPP, intended as Stage I plus Stage II.

The main target of those interventions is to restore as much as possible the original water quality of Caliraya lake, by improving the water quality in the portion of Laguna de Bay strictly related to the plant operation.

Simple low cost non-engineering measures, not previously mentioned, will be also described, to mitigate the secondary environmental impacts of the plant.

12.5.2 Downstream Reservoir

To meet the target of obtaining a manageable environmental system related to KPSPP, the partial isolation of the portion of Laguna de Bay nearest to the plant would be necessary, thus creating a downstream reservoir for the plant operation.

This can be obtained with the construction of a dike across LL. The location of this dike should be governed by the following two factors:

- The resulting lower KPSPP reservoir shall be wide enough, to keep the daily and weekly water level fluctuations within reasonable limits;

- At the same time, the total area shall be small enough, to allow the implementation of a manageable and controllable water purification program.

Considering the morphology of LL, a suitable location can be found east of the axis formed by Jalajala Promontry and Pila river outlet (see Fig. 12-1).

With this location, the lower reservoir will have a surface of about 11 km^2. Thus the maximum weekly water level fluctuation, corresponding to the total live volume of Caliraya reservoir, will not exceed 0.2 m.

The dike will not form a continuous structure, but will be interrupted, for a breach of 250 m, by a mobile barrage, made by floating elements, whose purpose will be the evacuation of the floods that may come from the Pagsanjan and other inflowing rivers and streams, and allowing the passage of large barges.

The structure and main characteristics of the proposed dike and mobile barrage are shown in the attached Fig. 12-2.

The mobile barrage should normally be closed (floating), and opened only when strictly necessary. in this case the upper tank will be filled with water by means of a small pump, and all mobile structure will sink. Pumping out the water from the tank, the barrage will rise again. The pumps will be housed in a proper location obtained in the main dike's body.

Mobile barrages of similar kind (even if much more sophisticated) have been largely studied and applied in Italy, to prevent floods in the Venice Lagoon and for other purposes.

The whole structure, because of the existence of the mobile barrage, will not guarantee a complete closure to the interchange of waters between the two lake bodies, which is anyhow not required and not even desirable. The "leakage" from the main Lagoons' body to the KPSPP downstream reservoir or vice-versa wouldn't in any case exceed some percentage of the overall amount of pumped waters.

To allow the normal passage of the fisherman's boats, two navigation channels, by-passing the dike's abutments on the two opposite shores, are foreseen.

Under a water head of 0.2 m, a water velocity of 2.0 m/s will be generated, which is quite strong for the usual fisherman boats. Therefore, the navigation channels will be equipped with a double very simple gate system (wood-made will probably be sufficient), operated like a navigation lock, permitting the passage of the boats in both directions even with the maximum level difference between the two lake's bodies (Fig. 12-1).

12.5.3 Creation of "Wetlands" Areas in the Downstream Reservoir

(1) General Concepts

The second step for the solution of KPSPP's main environmental problem is the upgrading of the downstream reservoir's water quality.

This target is not easy to be accomplished, due to the extension of the reservoir and the many pollutants discharged from the various domestic, agricultural and industrial sources.

The reservoir, anyhow, seems to have the proper characteristics to implement a successful Phyto-Bio-Depuration program (wetlands).

This is an application of the "Eco-Technology", or Ecological Engineering, based on the property of some aquatic plant or weed to remove nutrients (nitrogen an phosphorous) from polluted waters.

The most suitable areas for this technology are in fact polluted river estuaries, out-flowing in shallow basins with limited stream effects, normally with high sediment transport and thus generating swampy areas. Tropical climates are also favorable to the growth of aquatic plants.

The sedimentation occur in the swampy areas outstanding the river outlet (wetlands). Most of nutrients remain adsorbed or dissolved in the bottom mud, and are subsequently removed trough organic-decay and assimilation process, performed by certain species of bacteria living in the plant's roots apparatus (rizo-sphere).

Those "wetlands" represent therefore, from the ecological point of view, a natural treatment system, able to reduce the nutrient's content of polluted waters, and trapping an important part of sediments in a precise and delimited area, from where if necessary they can be removed.

(2) Principles of Wetlands Biochemistry

The pollutants removal in wetlands is essentially based on bacteria metabolism and physical sedimentation.

The nitrogen removal occurs trough the biologically mediated process of Nitrification and De-nitrification.

Nitrification is the process leading from dissolved ammonia (NH_4^+) to nitrite/nitrate equilibrium, with the following stechiometry:

$$2NH_4^+ + 3O_2 \text{ ------ } 2NO_2^- + 4H^+ + 2H_2O \quad \text{(nitrosomonas)}$$

$$2NO_2^- + O_2 \text{ ------ } 2NO_3^- \quad \text{(nitrobacter)}$$

De-nitrification, on its turn, leads from nitrate to molecular nitrogen (gaseous), water and carbon dioxide:

$$2NO_3^- + 2H^+ + 2(CH) \text{ ----- } 2H_2O + N_2 + 2CO_2$$

According to recent experiences, nitrification and de-nitrification occur simultaneously, with a significant oxygen demand (1.7 g of oxygen are needed to remove 1 g of nitrogen). The Biochemical Oxygen Demand thus increases.

The most important oxygen source for the phyto-bacteria living in the roots apparatus will be the oxygen transmitted from the vegetation to the roots.

Phytoplankton, microalgae and specific bacteria metabolism are also among the principal responsibles for the Biochemical Oxygen Demand (BOD) reduction, and then for the restoration of the original oxygen equilibrium.

The bacterial activity is dependent on temperature and retention time, which are helping the biochemical process.

(3) Wetland's Engineering

The aquatic environments where the above described biochemical process take place are classified as:

- natural wetlands
- artificial wetlands
- phyto-depuration ponds (or swamps).

Natural wetlands are encountered along the shores of very shallow lakes or lagoons (like the Venice lagoon in Italy), and are characterized by typical vegetation and tidal water regime.

The tidal movement is very important to help the re-oxygenation process of the benthic zone (roots apparatus), while the water level is lower.

The efficiency of natural wetlands in nutrient's removal is related to various factors, among which the species of aquatic plants living on it, the wetland's extension and the plants "lay-out".

Among the artificial wetlands, two main systems are known and employed: Free Water System (FWS) and Subsurface Flow System (SFS).

FWS can be considered as an intermediate level between natural and artificial wetlands. They are in fact developed in natural swampy areas, where some engineering activity to obtain optimum hydraulic conditions and proper soil preparation is performed.

FWS, as natural wetlands, require areas of considerable extension (at least some tenth of Ha), depending on the pollutants concentration in the inflowing waters, and initial installation costs may be relatively important.

Maintenance costs are on the contrary low and can easily be repaid trough the utilization of the harvested plants.

Several examples of FWS exist all over the world, namely in United Stages and Italy. The efficiency is reported up to 70% for Phosphorus, 90% for sediments and 60% for nitrogen.

FWS also show some effectiveness in the removal of heavy metals and pesticides.

Sub-Superficial Flow Systems require more complex engineering, higher investments and more sophisticated maintenance.

They are operated not in natural areas but in artificial percolation beds, where waters are pumped, and with especially designed prefiltering and drainage apparatuses. The required surface is of course less than with FWS.

Principal application field is the preliminary treatment of urban liquid wastes or agriculture drainage waters.

Phyto-depuration ponds, on its turn, may utilize the capacity of floating or semi-submerged aquatic plants, to metabolize nutrients and reduce BOD. Their use can advantageously be coupled with the above mentioned systems.

(4) Creation of Wetlands in the Lower Reservoir

The downstream Kalayaan reservoir area has most of the characteristics required to experiment and implement a successful wetlands project, including the tidal regime created by the plant operation.

Only the use of the Free Water System, other than the simple creation of natural wetlands, can be suggested at the moment.

As the most suitable plant species to be utilized, "Canna palustris" (Phragmetis Australis) certainly presents interesting characteristics and performance. It grows in a temperature range between 12 and 23°C, germinating between 10 and 30°C. The maximum tolerated salinity in the waters is 45 - 50/1000, within a Ph range between 2 and 8.

Following informations presently available over the results obtained in ongoing projects and experimental fields, it can be estimated that 1 Ha of canes is able to utilize, for its growth, 300 kg of nitrogen and 40 kg of phosphorous.

Also the oxygen transfer to the benthic zone is highly effective, because the roots penetrate vertical and deeply in the bottom muds and in the soil.

The canes should be harvested every 2 - 3 years, and it will not be difficult to find an economic utilization for them.

At preliminary level, the most suitable areas where such a project could be previously experimented and then located are the ones shown in Fig. 12-3, encountering the estuaries of Pagsanjan and Santa Cruz rivers, both discharging in the lower Kalayaan reservoir.

As Pagsanjan river is concerned, the covered area should mostly be developed west of the river's axis, in order to avoid interferences with KPSPP. Some canalization works, to operate a partial diversion of the river's waters, spreading them over the whole project areas, will be necessary.

For the Santa Cruz river, more complex problems might be expected, related to the high population density of the area.

At least one river diversion channel, with a length of some km will be needed, and its construction could arise difficulties of different nature, disturbing the peasants and rice croppers.

Other problems could also arrive from the fishermen associations, which will see the fishing surface reduced.

Fishermen should anyhow be made conscious that the lower Kalayaan reservoir, once the water quality improve, might be suitable for selected fish breeding, resulting in increased revenues for the sector.

It is worthwhile to underline that a project of this kind may have a remarkable importance, at experimental level, for the future implementation of LLDA programs, envisaging the water quality upgrading of the whole Laguna.

Furthermore, the works which are mentioned in this chapter should be implemented step by step, after feasibility studies, considering not only technical but also environmental aspects, and detailed engineering studies have been completed, and after an experimental period of at least two years.

It is important to mention that the overall program (dike and wetlands) should be implemented jointly, while the dike itself, without the water quality restoration program, will be useless.

12.5.4 Other Mitigation Measures

Some other minor additional mitigation measure is mentioned hereafter as general indications, subject to further evaluation:

- Tree planting on the slopes all along the subhorizontal part of the penstock alignment, to improve visual impact and minimize soil erosion.

  The possibility and opportunity of concealing the part of the penstock above the national road with prefabricated and pre-inherbed panels (similar to the ones frequently employed along the highways, to prevent erosion and improve aesthetic), could also be studied, depending on cost;

- To improve safety measures and guard watching along the penstock;

- To extend the existing protection net in the tailrace canal up to the bottom, to avoid racks obstructions by submersed or semi-submerged plants, debris, etc.;

  Not to allow fishpens to be located too close to the plant could also be suggestible, considering that they are trapping aquatic plants that could be released at once (especially during pumping), and for safety reasons;

- Tree or bush planting along the shores of Caliraya lake, where the ground slope is smooth (5 - 10%), to reduce soil erosion due to continuous water level variations.

12.6 Recommended Studies, Investigations and Monitoring

12.6.1 Foreword

The key of the proposed environment control program is the split-up of a portion of Laguna de Bay, to be used as lower reservoir for the plant, and the implementation of a water purification program in this part of LL. This will allow to pump clean water in CL, thus solving the main environmental problem of the Project itself (both Stage I and Stage II).

While it is clear that such a program is not designed to solve the overall pollution control of the entire LL, the success of the water purification program in the lower reservoir may represent an important contribution and a pilot experience for the medium and long term programs of LLDA.

On the other hand, the proposed splitting of LL will raise environmental problems of its own, which must be fully studied and solved before the program is actually implemented.

In this respect, main aspects where additional studies will be required are:

- Hydrodynamic behavior and possible modifications of the water quality of the entire LL once the separation dike is built, with all related consequences on the physical and biological environment.

- Socioeconomic problems raised by the proposed splitting of the lake. Given the importance of the fishing industry and of the navigation, and the sometime conflicting interests involved, a comprehensive study, followed by an adequate information campaign will be necessary.

- A review of the existing institutional structures incharged of LL will be also advisable, identifying the improvements possibly required to assure an adequate operation of the dike structures and auxiliary facilities and the proper management of the overall program.

- The design of the dike itself and of its appurtenant structures deserves all required field and laboratory investigations, and a careful consideration of the expected construction and operation conditions.

In addition, the specialized technology to be applied for the water purification program shall be studied and optimized through extensive field experiments.

The following paragraphs illustrate the additional studies, related to the physical aspects mentioned above, that will be required before a decision on the actual implementation of the proposed environment control program is taken.

12.6.2 Hydrodynamic and Ecological Modeling

The application of hydrodynamic and ecological models to predict the variations induced by the program both in Caliraya lake and in Laguna de Bay is suggested.

The applications of system analysis to ecology (system ecology), is becoming of utmost importance in environmental sciences, due to the increasing diffusion of powerful and sophisticated formal tools (mathematical theory, electronic data processing, etc.), and to the availability of highly specialized software.

In "Fundamentals of Ecology", Eugine P. Odum states: "mathematical models provide a useful shorthand for describing a complex ecological system, and equations permit formal statement of how ecosystem is likely to interact. The process of translating physical or biological concepts ... into a set of mathematical relationships, and the manipulation of the mathematical system thus derived, is called System Analysis".

The basic goal of System Analysis is the prediction of dynamic and ecological changes that will occur over time, with or without the influence of human actions.

A mathematical model suitable to describe a complex ecological system is formed by a set of basic elements, called "system variables", normally ordered into a list of "state variables" or "system state vectors", representing under a set of complex mathematical (vectorial) formulas, the "way of reacting" of our system.

Sophisticated modeling systems are available, for the prediction of numerous natural or induced phenomena. As environmental hydraulics and water quality are concerned, available models range from "tsunamis" prediction, to algal blooms, tidal circulation, oxygen depletion, dam break, eutrophication, and so forth.

To set the specific modeling system able to describe specific hydrodynamics and environmental conditions and to make appropriate predictions, proper model engineering, site investigations and data collection are requested.

For the Project, a model engineering should consider the following "segments" (modules):

- Hydrodynamics: representing continuity and conservation of momentum on x, y and z directions; bi or three-dimensional water mixing

- Advection-dispersion: representing mass conservation, sediment erosion, transport and deposition;

- Water quality: describing BOD and DO modifications, oxygen depletion and bacterial decay balances; organic nitrogen, ammonia, nitrite and nitrate balances;

- Eutrophication: describing phytoplankton, benthic algae, zooplankton, oxygen balance and mineralization estimate; dependence on nutrient availability, light and temperature.

The eutrophication model segment, as an example, may consider the following state variables and processes (ref.: Danish Hydraulic institute, DK):

- phytoplankton production, sedimentation and extinction;
- grazing;
- zooplankton excretion, respiration and extinction;
- mineralization of suspended detritus;

- sedimentation and mineralization of detritus;
- accumulation in sediments;
- production and extinction of benthic vegetation;
- exchange with surrounding waters.

The Water Quality model, on its turn, may consider the following (ref.: Hydraulic Research LTD, UK):

- BOD for slow and fast dissolved carbonaceous;
- slow and fast organic nitrogen;
- ammonia nitrogen and nitrate;
- DO, salinity, temperature;
- suspended solids and inert particulate;
- fast and slow particulate BOD;
- algal and benthal carbon;
- orthophosphate;
- silica.

The most expensive part for the application of those models is normally data collection and field survey, when data are not available. In this case it seems that most data, even if in discontinuous historical series, could be available either from NAPOCOR monitoring campaign, or trough LLDA, and only a short field survey would be sufficient to set-up a reliable data entry.

12.6.3 Retention Dike for the Lower Reservoir

The easiest and cheapest way to build this dike would be by the hydraulic fill technique, dredging the bottom of the lake along a strip parallel to the dike and using the dredged material to build the body of the dike itself. Adequate layers of sand, gravel and possibly rockfill should then be added on both faces to protect the dike from the water and waves action (Fig. 12-4).

The technical feasibility of this concept and the design of the embankment and its foundations will depend on the geotechnical characteristics of the lake's bottom material, which shall be determined through adequate field and laboratory investigations.

Should the bottom material be unsuitable, then a completely different design should be developed, possibly applying the end dumping construction method, with the dike material (tout-venant) possibly coming from the excavations required for Stage II of the plant itself. In this case, foundation problems are likely, and the cost will be substantially higher.

In addition to the dike itself, attention shall also be devoted to the design of the mobile barrage, where emphasis shall be given to simplicity of construction and easy of operation and maintenance.

The design of the fishing boats navigation canals will not represent a significant problem. Given the water velocities expected, a double gates system, operating like a very simple navigation lock shall be foreseen, to allow an easy passage to the boats in all hydraulic conditions. In any case, it will be necessary to investigate with the local fishermen the more suitable location and operation characteristics of these canals.

Of course, the consequences of the activities related to the dike construction on the overall hydraulic behavior and environmental conditions of LL shall be fully assessed.

12.6.4 Wetlands

The implementation of the wetlands program should be planned and studied carefully, because investment costs are relatively high and benefits are strictly depending on project choices and design accuracy.

The following stages are foreseen:

a) Information campaign to assess results already obtained in other countries, where similar programs have been successfully conducted;

b) Precise chemico-physical and biological data gathering and analysis, in the areas suitable for future wetlands development, as: soil composition, sediment, phytoplankton and zooplankton, benthos, nekton (fish and swimming invertebrates), and so on;

c) Accurate monitoring of the content in nutrients and other elements in the rivers and streams inflowing in future wetland areas (namely Pagsanjan and Santa Cruz rivers);

d) Selection of a limited number of species, suitable of successful results in our biota;

e) Preliminary system design, establishing the basic design parameters;

f) Small scale field experiments with selected species, varying plants layout, water depth, stream effect, and other project parameters;

g) On the basis of the results obtained during the small scale experiments, final design will be prepared, including:

- Sizing of wetlands,
- Selection of optimum plant species (a mixing of various species should not be excluded);
- Design of the necessary river diversion works (side channels);
- Final definition of other project parameters, including planning of maintenance activities, definition of cropping cycles, use of cropped plants, etc.

This program could be strongly helped by the parallel implementation of the previously described hydrodynamic and ecological model.

Stages from a) to f) correspond to the feasibility study level, and they are extended in terms of time, but not excessively costly.

During the same period, the social feasibility of the whole program should also be assessed, before entering in the final design and construction stages.

12.6.5 Limnological and Water Quality Monitoring

Considering the importance of the aquatic environment directly subject to the influence of KPSPP after the implementation of Stage II and when the lower retention dike will be constructed, a continuous monitoring program of the two lakes is suggested.

The program could be managed and conducted by NAPOCOR personnel in charge of the plant, under the supervision on NPC Environmental Division.

As far as the lower lake is concerned, strict accordance and cooperation with LLDA will be necessary and helpful.

The NAPOCOR Environmental Division has all necessary competence to establish and lead such a program (as they have already done), even if the lack of operation personnel may raise some difficulty. Therefore, it is not necessary to indicate a detail water quality monitoring program.

It is anyhow suggested not to limit the monitoring to a simple data collection and analysis, but to use the available data to determine a "Lake Evaluation Index (LEI)", which will provide a concise and helpful information to understand the "steps forward" made in the improvement of the water quality and limnological conditions of the two lakes (lake restoration).

The LEI methodology has been set up in the 1960s. It was officially adopted by the Environmental Protection Agency (EPA) of the U.S. in 1972, and subsequently used to evaluate results of specific restoration techniques, applied on different lakes.

Among the various approaches, the one based on "target variables" (Donald B. Porcella & others, 1980), seems to be adequate to this specific case.

Selected target variables, to represent general water quality and limnological lake's conditions, are set either independently or combined in a manner to provide a single index number (LEI).

The following "Target Variables" can be considered:

1) Secchi depth (SD);

2) Total phosphorous (TP);

3) Total nitrogen (TN);

4) Chlorophill-a (CA);

5) DO;

6) Macrophytes (MAC).

These variables span most of the main water quality problems affecting either Laguna de Bay or Caliraya lake, and are commonly and easily measured. Other "target variables" may in any case be added, without any conceptual complication for the proposed methodology, when deemed useful.

Each variable is then defined and transformed to a scalar range (linear or logarithmic), in order to facilitate combination and comparison between different variables.

A "Trophic Stage Index" (TSI) is then established and related to each variable.

To give an example, for Secchi Depth (SD) it can be assumed that light intensity (I) disappearance decreases with depth (Z), according to the Beer-Lambert Law:

$$\ln I/Io = -nZ,$$

where n is the extinction coefficient, and Io the reference value for light intensity.

if SDo is the maximum limit (target) for Secchi Disk (could be 3 m for Laguna de Bay and 14 m for Caliraya), the following TSI is obtained (Carlson):

$$TSI = 10 [\log (SDo) - \log (SD)]$$

Carlson's TSI is then equated with the scalar rating value (XSD), for use in the final LEI formula, giving an expression such as:

$$XSD = a - b*\ln (SD),$$

with XSD ranging 0 - 100.

Similar methods are established for the other variables, computing the correspondent XTP, XTN, XCA, XDO, XMAC.

Although each target variables can be used by itself to evaluate a Trophic Stage Index (thus lake response to restoration program), the formulation of a compound index (LEI) give a more expressive global response.

The LEI can be formulated case by case, and normally a formulation already used for other lakes (to have a base of comparison), may be adopted.

The LEI has a range between 0 (minimal impact) and 100 (maximum impact), and is expressed as a function of the various adopted single target variables:

$$LEI = f(XSD, XTP, XCA, XDO, XMAC)$$

Either the LEI or other variables are graphically represented, giving the immediate perception if the values fall in the Oligotrophic ($0 < LEI < 40$), Mesotrophic ($40 < LEI < 60$), Eutrophic ($60 < LEI < 80$), or Ipertrophic ($80 < LEI < 100$) zone (ranges are given as example only).

It shall be mentioned that an overall Water Quality Index (that gives a different information than LEI), has already been elaborated by LLDA, and is reported in the "Water Quality Data on Laguna de Bay and Tributary Rivers - Vol. 5", edited by the Manila's University of Life, on 1988.

Therefore, the elaboration of the proposed lake restoration index will not pose any problem, and the method is possibly already known.

12.7 Implementation Program and Cost Evaluation

The suggested time schedule for the engineering and implementation of all envisaged environmental interventions, is shown in Fig. 12-5.

The time schedule is self-explanatory. We only note that the proposed environmental program is not necessarily linked to the engineering and construction of Stage II, considering also that KPSPP is already producing its environmental effects, trough the operation of Stage I.

A preliminary cost evaluation, not including interests during construction, has been developed, with the following results:

Item	Foreign C.	Local C.	Total
	(Thousand U.S.$)		
Retention Dike	400	1,800	2,200
Wetlands	1,200	2,000	3,200
Other Interventions	100	200	300
Total	1,700	4,000	5,700

Pending more precise studies and analyses, the figures given above should be considered as orders of magnitude, to be precisely evaluated at a more advanced stage of the design. In particular, the cost of the retention dike is estimated on the assumption that the hydraulic fill technique will be applicable.

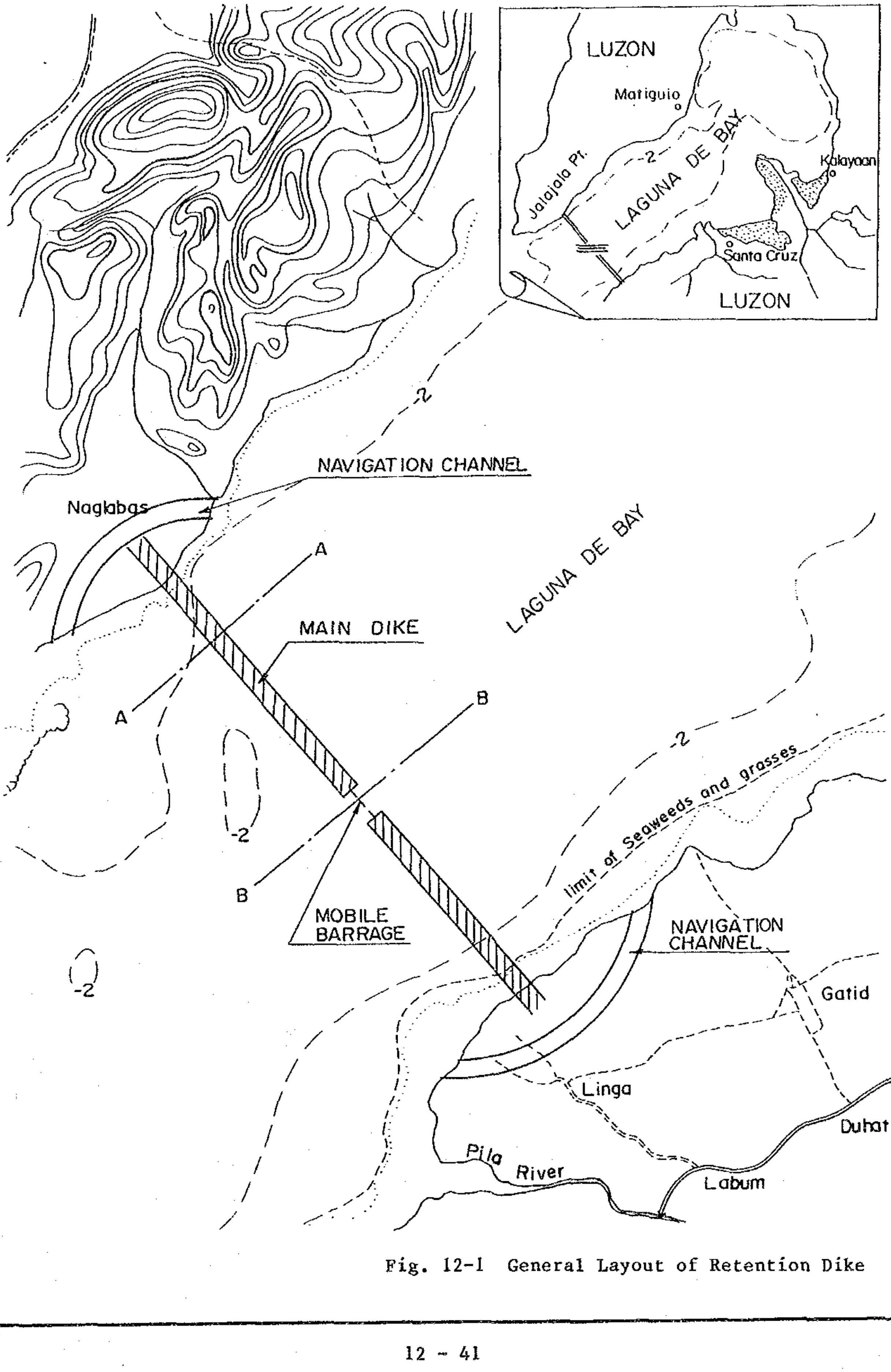


Fig. 12-1 General Layout of Retention Dike

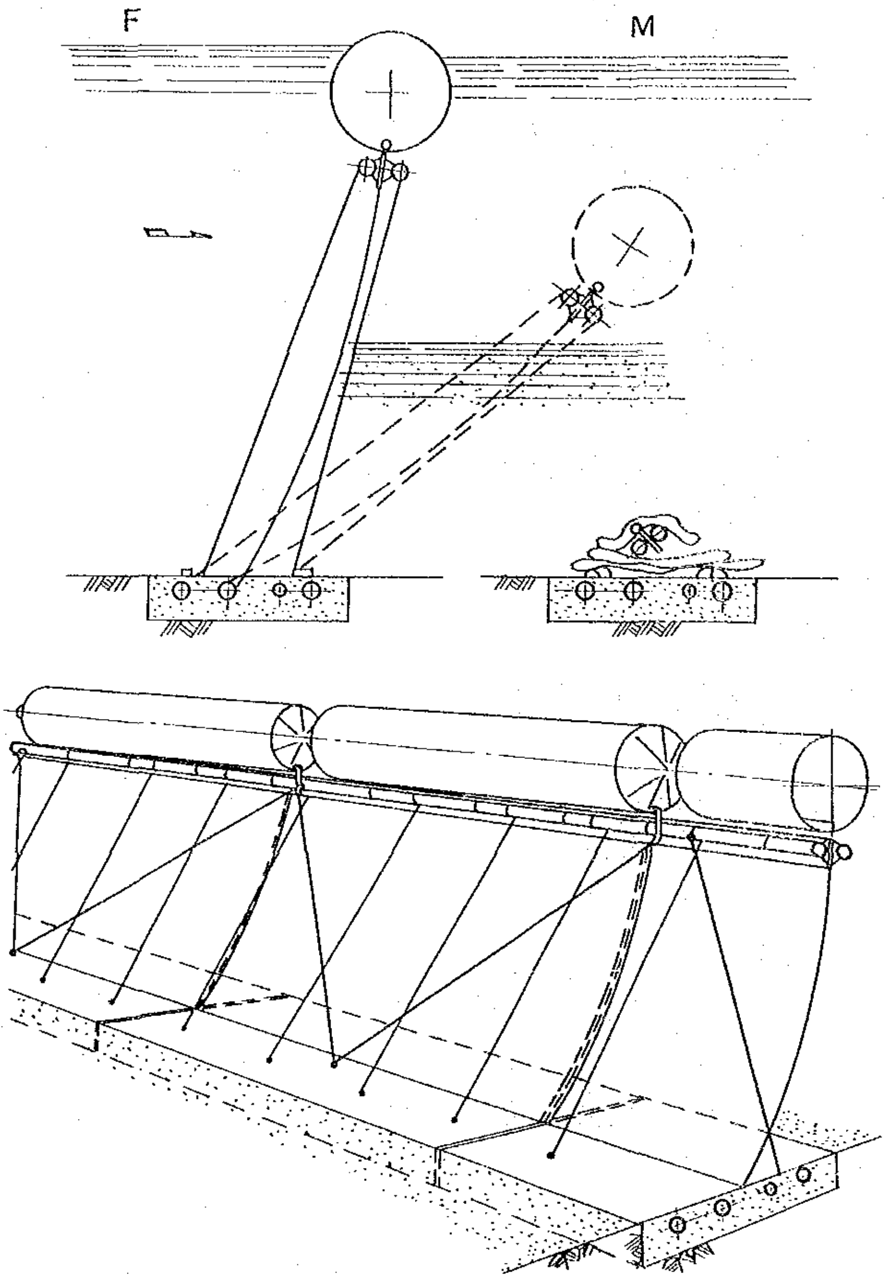


Fig. 12-2 Structure of Dike and Mobile Barrage

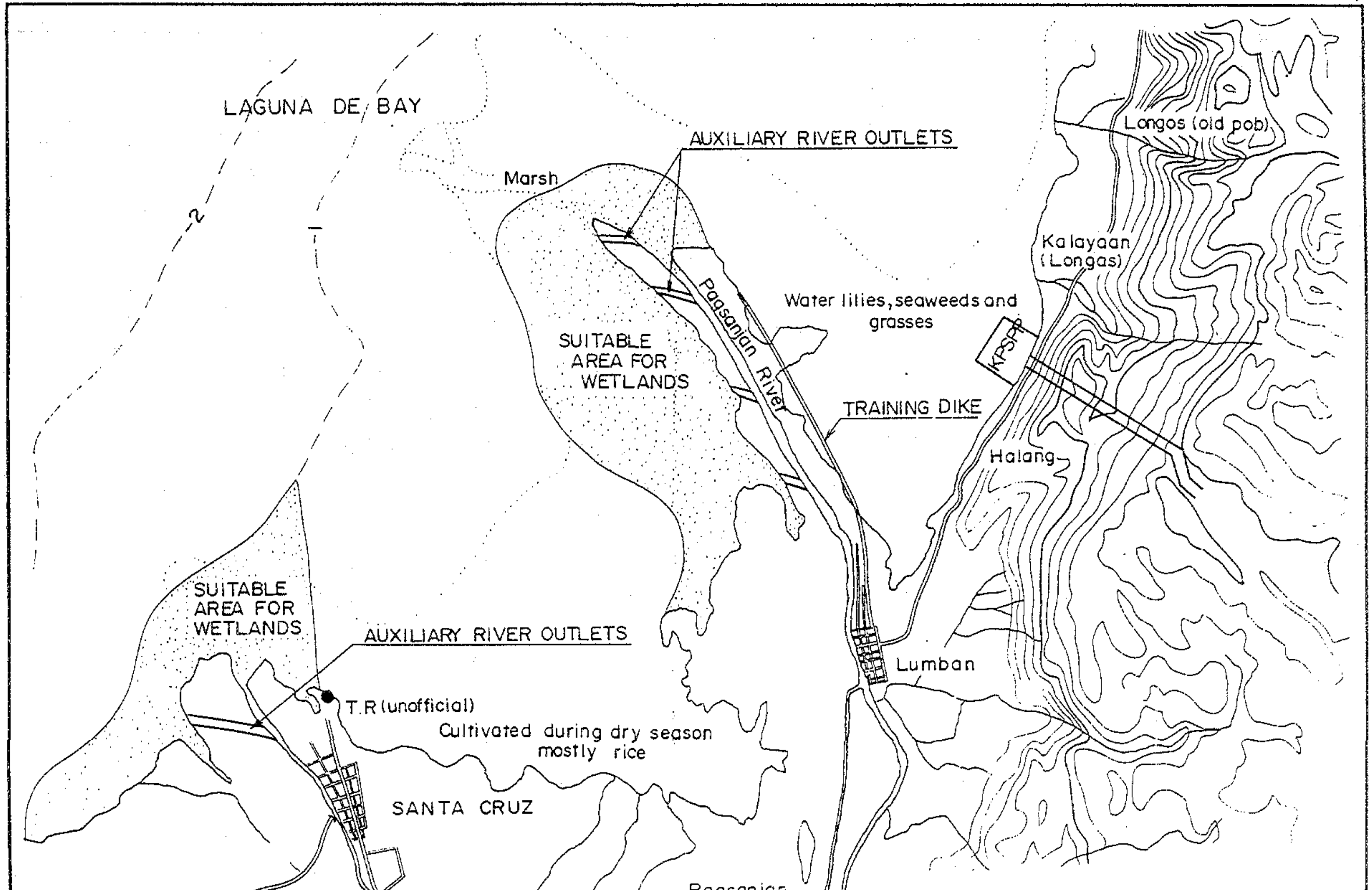


Fig. 12-3 Recommended Location of Wetlands

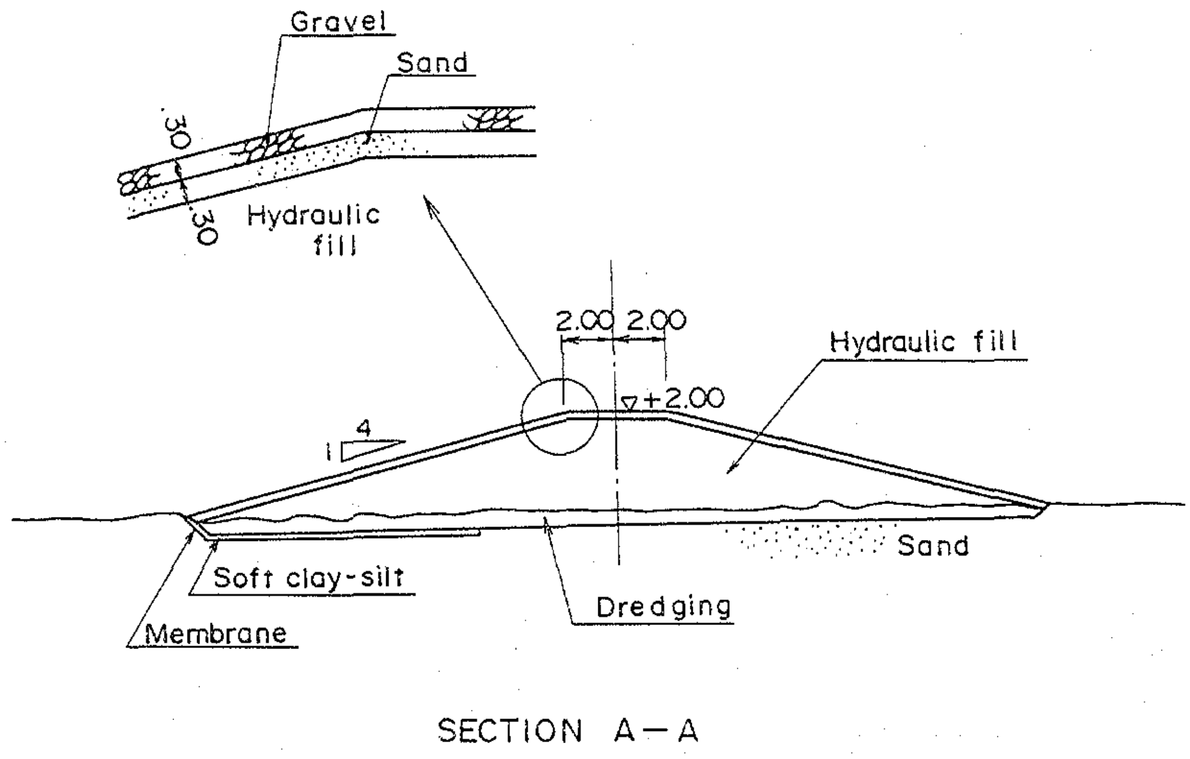


Fig. 12-4 Barrage Cross Section

Engineering and Implementation Program

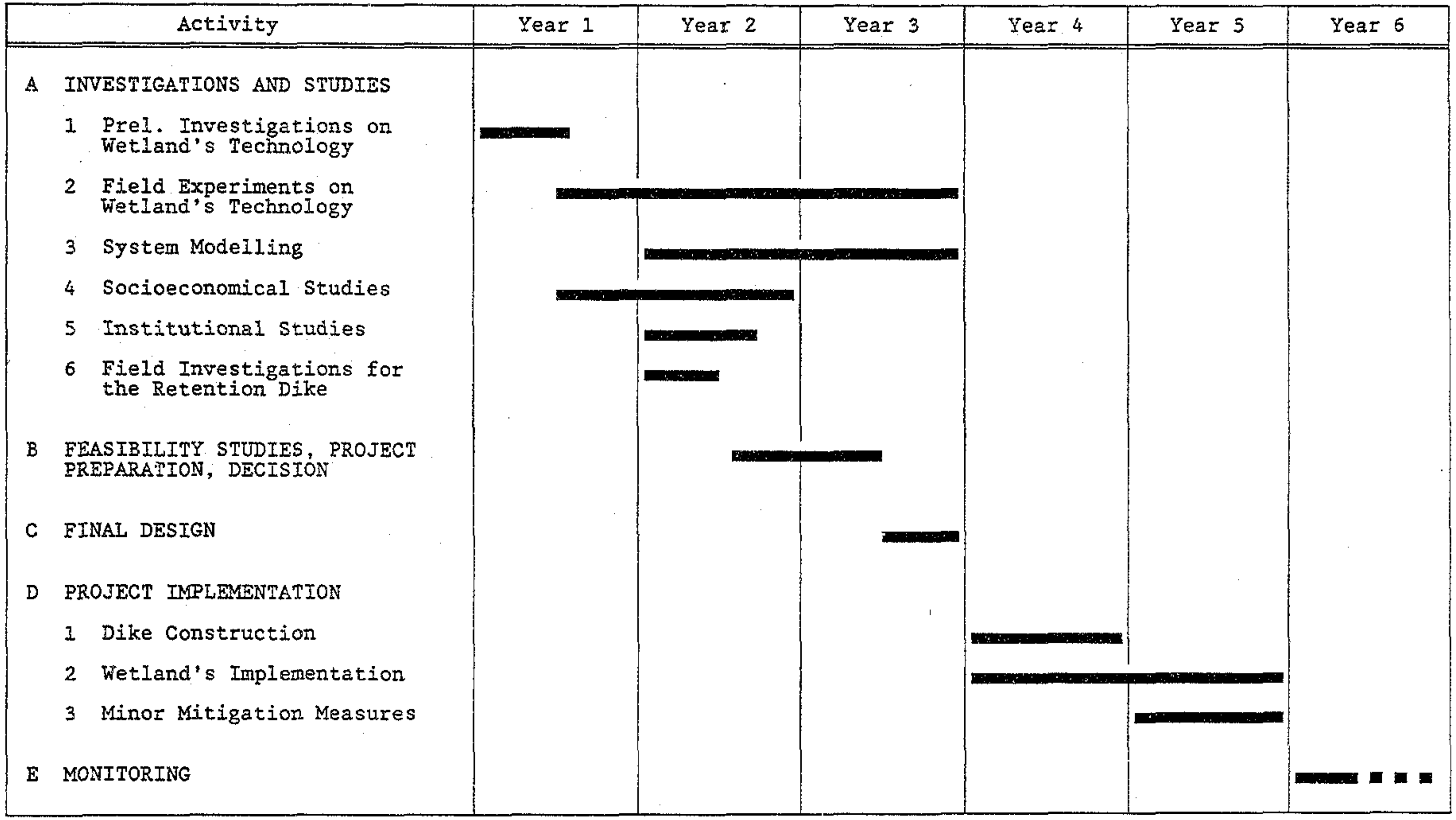
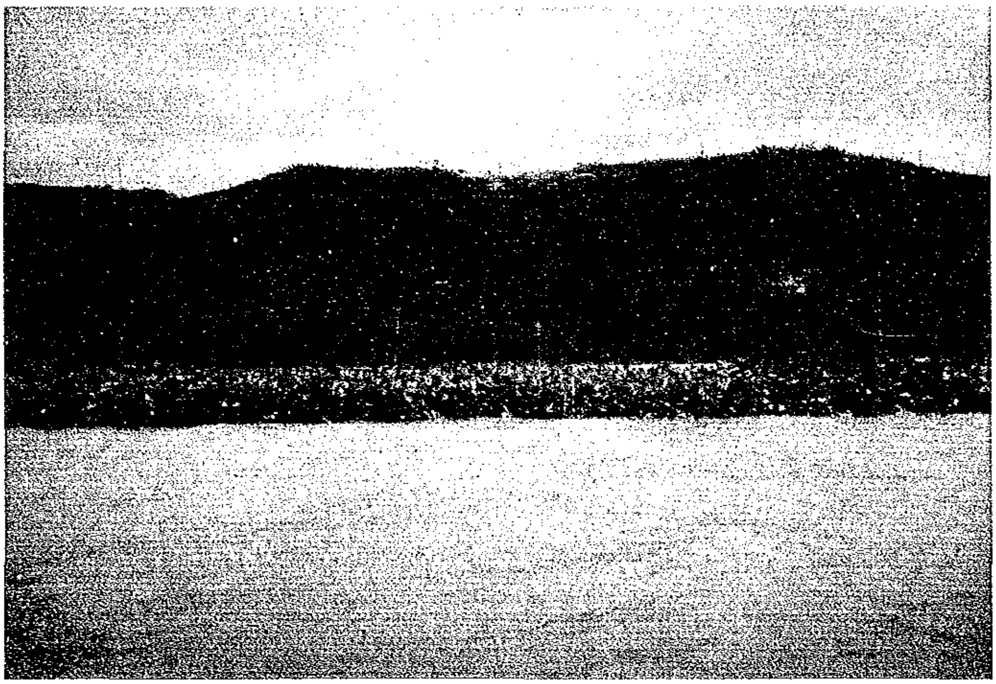
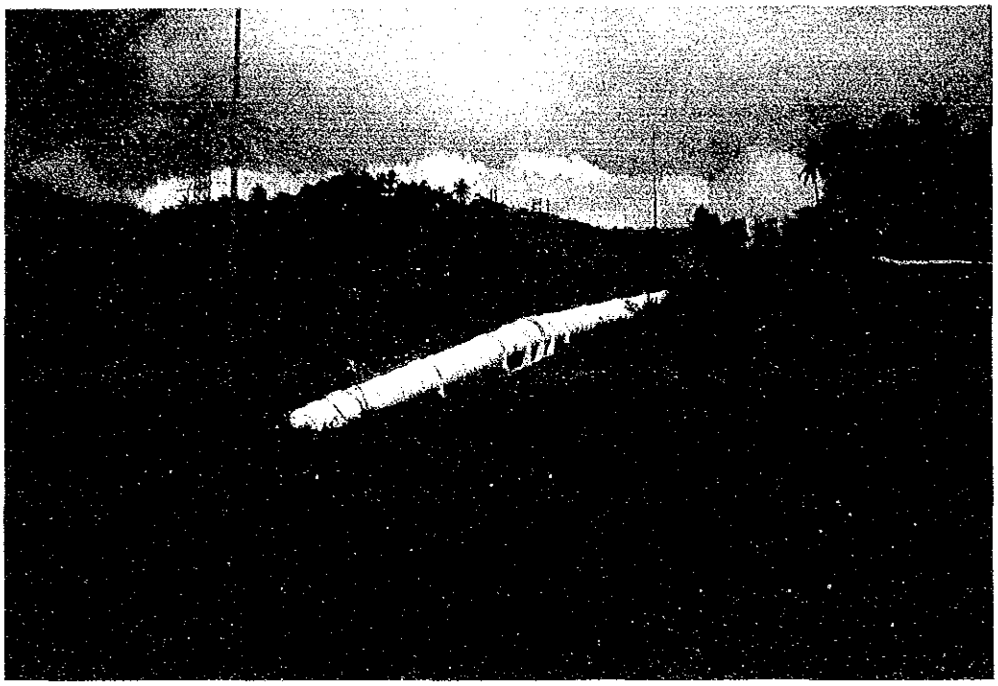


Fig. 12-5 Environmental Impact Mitigation Measures



Pict. 12.1 : Aquatic plants (water yacynts) floating
nearby the KPSPP tailrace

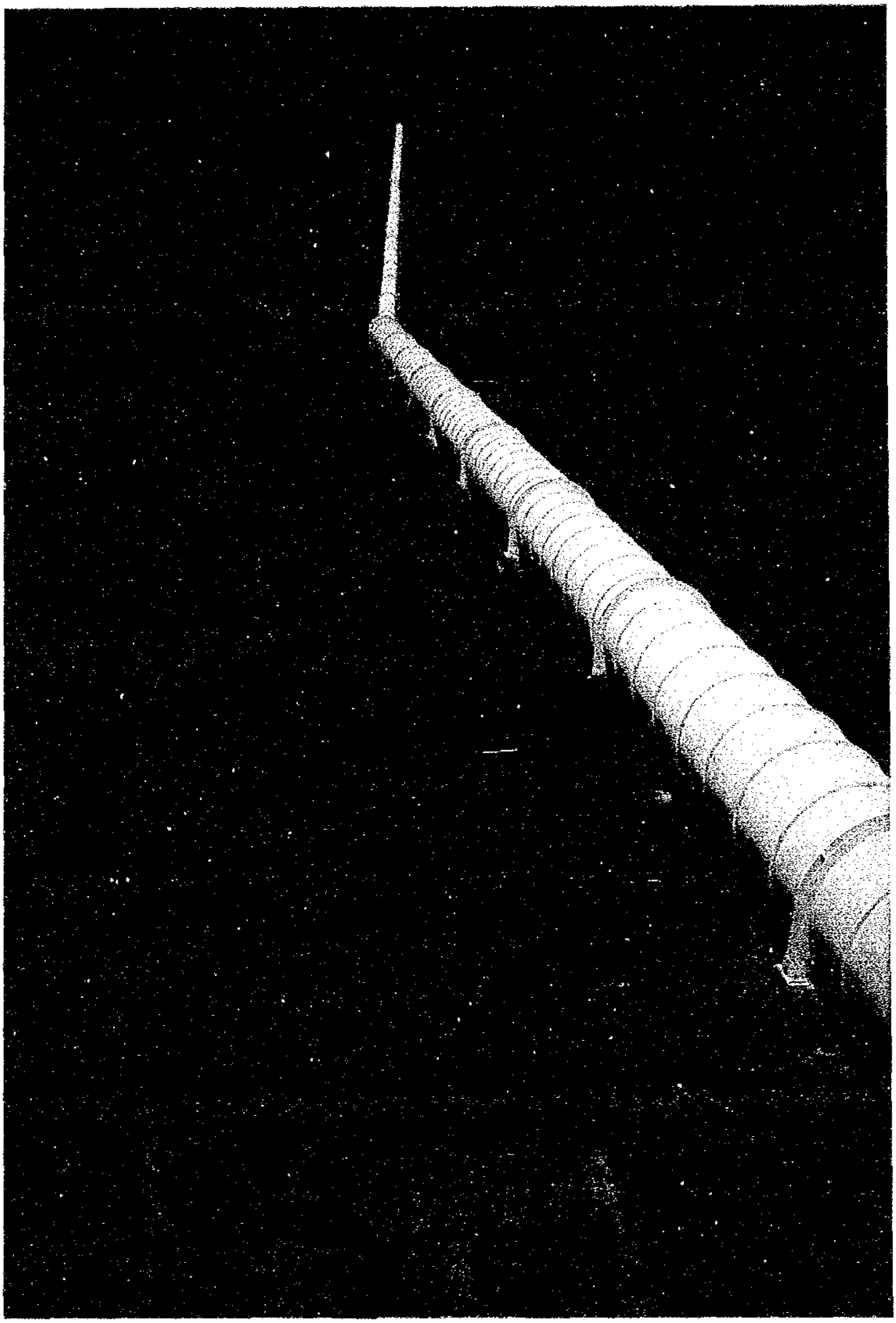
Pict. 12.2 : Macrophyte bloom beside the tailrace



Pict. 12.3 : Intermediate stretch of penstock, easily accesible from the road

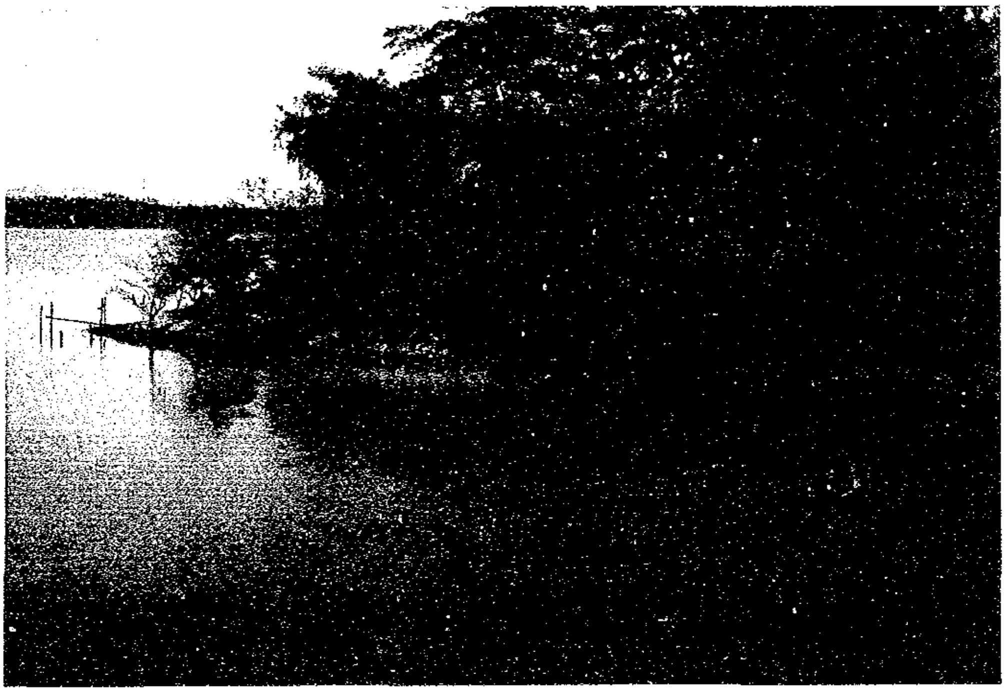
Pict. 12.4 : Suitable area for WETLANDS at the Pagsanjan river estuary

Pict. 12.5 : Closer view of Pagsanjan river estuary



Pict. 12.6 : Tree planting on the slopes along the penstock alignement is suggested, against soil erosion

Pict. 12.7 : Pishpens located very close to the tailrace



Pict. 12.8 : Soil erosion along the Caliraya Lake shores is clearly visible

Chapter 13 Economic Evaluation

Chapter 13. Economic Evaluation

13.1 Methods of Economic Evaluation

The economic evaluation for the Stage II Project has been made according to;

1) Benefit/Cost Method
2) Equalizing Discount Rate Method.

The total costs of the Stage II Project and its alternative project were calculated respectively for their specified time periods from the beginning of work to the last year of the depreciation period of operation. Then conversion was made from the said total costs into their cumulative present values. The Benefit/Cost Method was used for finding whether a ratio of benefit/cost of the Stage II Project exceeds 1.0 or not.

The other method is to obtain an "Equalizing Discount Rate" which equalizes the present values of cumulative costs to be incurred during the specified time period of operation of the pumped storage power project and that of its alternative project counted from the commencement of work of the Stage II Project. This method was also used to know if the discount rate obtained in the above manner exceeds a social discount rate of 15% which reflects an "opportunity cost of capital" prevailingly applied to economic evaluation of projects in the power sector in the Philippines.

Besides, social discount rate(s) for project evaluation are determined mostly by a planning agency of a country. In the Philippines, the government agency responsible for planning sets up social discount rates as national parameters applicable to respective categories of projects. A social discount rate for project evaluation in the power sector is determined to be 15%. In this context, the Mission decided to use this rate (15%) for economic evaluation of the Stage II Project, based on the results of discussion with NAPOCOR.

13.2 Total Cost of the Stage II Project

The total cost of the Stage II Project includes, construction cost, operation and maintenance cost and fuel cost for pumping. The figures of the construction cost were referred to the figures given in Chapter 11 and the annual operation hours were calculated to be 1,500 hrs (6 hr/day x 250 days).

(1) Construction Cost

As shown in "Construction Cost" of Chapter 11, the total construction cost (without interest during construction) of the Stage II Project amounts to US$142.01 Million. Nevertheless, the amounts of US$0.507 Millions of VAT and other taxes are included in the local currency portion. The Construction Cost referred to herein amounting to US$141.50 Millions, which has been obtained by deduction of the amount of various taxes including VAT from the total, has been taken up for the economic evaluation.

It is estimated that the commencement year of work for the Stage II Project and the completion year thereof will be 1991 and 1997, respectively.

(2) Operation and Maintenance Cost

The operation and maintenance cost includes mainly salaries for personnel engaged in operation and maintenance of the pumped storage power plant and expenditure to be incurred in repair of the said plant for maintenance purposes. The percentage of the operation and maintenance cost occupied in the construction cost is to be 1.2% by reference to data furnished by NAPOCOR.

(3) Fuel Cost for Pumping per Kilowatt-hour of Base-Load Thermal Power Plant

(a) Electric power for pumping-up energy for the Stage II Project is to be supplied by advanced coal-fired thermal power plants which will be commissioned in 1997 and subsequent years. Coal for the "incremental fuelling" at such coal-fired thermal power plants at midnight is assumed to be imported. The cost of this imported coal and the heat rate thereof, according to NAPOCOR, are as follows:

C&F	48.06	(US$/MT)
Land	54.58	(US$/MT)
H. Rate	11,160 = 6,200	(BTU/LB) (Kcal/kg)
Ex. Rate	22.5	(Peso/US$)

For pumped storage purposes, operation of the coal-fired thermal power plant is assumed to be improved from a level of a plant factor of 50% with a thermal efficiency of 33.8% and a calory of 2,544 Kcal/kWh to that of a plant factor of 100% with a thermal efficiency of 36% and a calory of 2,389 Kcal/kWh. Then the thermal efficiency to correspond to the incremental power generation can be expressed by the following formula;

$$\frac{(2,389 \times 100) - (2,544 \times 50)}{50} = 2,234 \text{ Kcal/kWh}$$

Consequently, the fuel cost per kWh is;

$$\frac{54.58 \text{ (\$/kg)}}{1,000} \times \frac{2,234 \text{ (Kcal/kWh)}}{6,200 \text{ (Kcal/kg)}} = 0.0197 \text{ (\$/kWh)}$$

(b) Pumping-up Energy

Pumping-up energy as shown below has been obtained on the assumption that a maximum overall efficiency of the pumped storage power plant is 70%, station service rate for incremental generation of coal-fired thermal power plants 1.3%, transmission loss rate 2%, and station service rate of the pumped storage plant 0.6%.

Pumping-up Energy

$$= \text{Annual Energy Generation} \times \frac{1}{0.7 \times (1-0.013) \times (1-0.02) \times (1-0.006)}$$

$$= A.E.G. \times \frac{1}{0.673}$$

$$= A.E.G. \times 1.486$$

(c) Fuel Cost

The fuel cost is obtained by multiplying the fuel unit cost of US$0.0197 per kWh stated in (a) above by the quantity of energy for pumped storage.

(4) Annual Cost

The annual cost (expenditure) for the pumped storage plant was obtained by totalling the figures stated in Sections of (2) and (3).

13.3 Total Cost of Alternative Gas Turbine Project

It is assumed that a gas turbine plant corresponding to the output of the Stage II Project is to be constructed in the suburbs of Manila close to a load center. The total cost of the alternative gas turbine plant is to include the construction cost, operation and maintenance cost and fuel cost.

(1) Construction Cost

By reference to data provided by NAPOCOR and according to practical experience, the construction cost (= without interest during construction) per kW of a gas turbine in the order of 50 MW is estimated at US$365. The construction cost of the gas turbine project is obtained by multiplying 376 MW of the gas turbine plant later described.

(2) Operation and Maintenance Cost

The operation and maintenance cost includes salaries of personnel of the gas turbine plant as well as expenses for repair of the plant for maintenance purposes. Reference was made to an actual record of operation and maintenance of the gas turbine plants located in the Luzon Grid area of NAPOCOR. Namely, the annual fixed cost is US$0.5/kW, while the annual variable cost is US$0.0032/kWh. These figures were multiplied by the generating output and energy generation of the gas turbine plant to find the operation and maintenance cost.

(3) Fuel Cost

Diesel oil is to be used for the gas turbine plant. According to the latest data furnished by NAPOCOR, fuel per Million BTU costs US$3.5/MBTU. Therefore, the fuel unit cost has been calculated to be US$0.0392/kWh.

Thus the figure of US$0.0392/kWh was multiplied by the annual energy generation of the gas turbine to obtain the fuel cost.

(4) Annual Cost

The cost given in Section (2) was added to that in Section (3) in order to obtain the annual cost.

13.4 Adjustment Factor of Construction Cost and Present Value Factor for Cumulative Annual Cost

(1) Adjustment Factor of Construction Cost

The service life of the Stage II Project is 50 years whereas its alternative gas turbine project has a service life of 15 years. There exists a difference in the service lives between both projects. Project evaluation should be made on the same comparable level so that the projects with different service lives can be properly evaluated.

In this economic evaluation, computations were made for 15 years which is identical with the service life of the gas turbine plant.

In case the capital cost (construction cost) of the pumped storage power plant is expressed as Ph and the interest rate (discount rate) is r, the capital cost; Ah to be recovered equally per year during the entire period of 50 years is expressed by the following equation.

$$Ah = Ph \times (\text{Capital Recovery Factor})$$

$$= Ph \times \frac{r(1 + r)^{50}}{(1 + r)^{50} - 1}$$

In other words, Ah is obtainable by multiplying the capital cost of the pumped storage power plant by a capital recovery factor for 50 years.

The next step is to calculate the present value; Sh of a sum to obtain a recovery amount; Ah of the capital cost of the pumped storage power plant over 15 years by means of a present value of annuity.

For this purpose, the following equation is used:

$$Sh = Ah \times (\text{Present Value Factor of Annuity})$$

$$= Ah \times \frac{(1 + r)^{15} - 1}{r(1 + r)^{15}}$$

Accordingly, the following is the adjustment equation of the Construction Cost of the Stage II Project.

$$\text{Adjustment Factor of Construction Cost} = \frac{r(1 + r)^{50}}{(1 + r)^{50} - 1} \times \frac{(1 + r)^{15} - 1}{r(1 + r)^{15}}$$

Where r is 0.15, the adjustment factor becomes 0.878.

(2) Present Value Factor of Cumulative Annual Cost

The work for the Stage II Project is to commence in 1991 and to be completed in 1997 (commissioned in July of the same year). On the other hand, work for the gas turbine project is also to begin in 1995 and assumed to be completed at the same time when the Stage II Project is expected to be completed. The annual cost to be incurred per year during the entire period of operation is assumed to be constant.

The cumulative annual cost covering 15 years is to be converted to the present value thereof at the first generation time of such annual cost. The present value is obtainable by multiplication of the annual cost by the present value of annuity factor provided by the following equation.

$$\text{Present Value Factor of Annuity} = \frac{(1 + r)^n - 1}{r(1 + r)^n}$$

r = discount rate, n = service life

In order to further convert the value obtained by the equation given above into a present value at the beginning of the commencement year of the Stage II Project, the present value of the cumulative annual cost can be obtained through multiplication of the amount of such present value by the present value factor obtained from the equation given hereunder:

$$\text{Present Value Factor} = \frac{1}{(1 + r)^n}$$

r = discount rate, n = time period

In sum, the following equation gives the conversion factor for obtaining the present value of cumulative annual cost at the beginning of the commencement year of the Stage II Project.

$$\text{Present Value Conversionr Factor of Cumulative Annual Cost} = \frac{(1 + r)^{15} - 1}{r(1 + r)^{15}} \times \frac{1}{(1 + r)^{6.5}}$$

Where r is 0.15, the present value factor of the cumulative annual cost arrives at 2.357.

13.5 Salient Features for Benefit/Cost Calculations

The assumptions taken up for necessary calculations made in Sections 13.2 through 13.4 are as follows:

Table 13-1 Salient Features for B/C Calculations

Description	Stage II Project	Gas Turbine Plant Project
Output	300 MW (150 MW x 2)	376 MW (Note 1)
Annual Operation Hours	1,500 hrs.	1,500 hrs.
Annual Energy Generation	450 GWh	441 GWh (Note 2)
Station Service Rate		
- Power (kW)	0.5%	0.6%
- Energy Loss (kWh)	0.6%	0.7%
Transmission Loss Rate		
- Pumped Storage	2%	0%
- Generation	2%	0%
Forced Outage Rate	0%	8%
Scheduled Outage Rate (for Repair)	3.8%	3.8%
Max. Overall Efficiency	70%	
Decrease in Output due to Ambient Temperature	0%	13.2% (Design ambient temperature 37°C)
Service Life	50 years	15 years
Total Construction Cost (US$M)	141.50	137.24
Outflow of Construction Cost (US$M)		
1991	0.57	
1992	0.57	
1993	12.91	
1994	24.75	
1995	39.12	54.90
1996	45.46	61.76
1997	18.13	20.58

(Note 1) kW Adjustment Factor

	Station Service Loss Factor		Forced Outage Rate		Scheduled Outage Rate		Output Decrease Rate

$$\frac{\text{Pumped Storage Plant}}{\text{Gas Turbine Plant}} = \frac{(1 - 0.005)}{(1 - 0.006)} \times \frac{(1 - 0)}{(1 - 0.08)} \times \frac{(1 - 0.038)}{(1 - 0.038)} \times \frac{(1 - 0)}{(1 - 0.132)}$$

$$= 1.254$$

Output of Alternative Gas Turbine Plant : 300 MW x 1.254 = 376 MW

(Note 2) kWh Adjustment Factor

	Station Service Loss Factor		Transmission Loss Factor

$$\frac{\text{Pumped Storage Plant}}{\text{Gas Turbine Plant}} = \frac{(1 - 0.006)}{(1 - 0.007)} \times \frac{(1 - 0.02)}{(1 - 0)}$$

$$= 0.981$$

Energy Generation of Alternative Gas Turbine Plant:

450.0 GWh x 0.981 = 441 GWh

13.6 Benefit/Cost Ratio (Discount Rate: 15%)

The discount rate applicable for economic evaluation of projects in the power sector of the Philippines is 15%. If necessary calculations are made at this discount rate, a Benefit/Cost ratio is obtained as follows:

Table 13-2 Computation of Benefit and Cost

(In US$M)

Item	Stage II Project	Gas Turbine Project
(1) Daily Operation Hours	6.0 hrs.	6.0 hrs.
(2) Annual Generation Hours	1,500 hrs.	1,500 hrs.
(3) Annual Energy Generation	450.0 GWh	441.0 GWh
(4) Construction Cost	141.50	137.24
(5) Annual Operation & Maintenance Cost	1.70	1.60
(6) Annual Fuel Cost	13.17	17.30
(7) Annual Cost (= (5) + (6))	14.87	18.91
(8) Present Value of Cumulative Annual Cost (= (7) x 2.357)	35.05	44.56
(9) Present Value of Construction Cost	74.77	66.50
(10) Adjusted Present Value of Construction Cost for Stage II Project (= (9) x 0.878)	65.65	-
(11) Total Cost	(8) + (10) 100.70	(8) + (9) 111.06

As seen from Table 13-2, Benefit (B)/Cost (C) and Benefit (B) - Cost (C) are as follows:

B/C = 111.06/100.70 = 1.10

B-C = 111.06 - 100.70 = 10.36 (US$M)

The B/C ratio exceeds 1.0 at a social discount rate of 15% reflecting the opportunity cost of capital which is applied in the Philippines. Accordingly, the Stage II Project is found to be economically feasible.

It is said that official exchange rates do not always reflect substantial values of foreign exchange in developing countries. If such exchange rates are used, it is feared that costs of imported materials and equipment might be regarded as lowerer artificially.

In evaluating prices of imported goods, somewhat certain adjustment is needed. In other words, another rate becomes necessary for maintaining a balance of demand and supply of foreign exchange. Practically speaking, an official exchange rate is multiplied uniformly by a certain numerical factor in order that appropriate economic evaluation can be done. A figure obtained through the above-mentioned procedure is used for economic calculation of costs.

In fact, the planning agency of the Philippine Government has decided to multiply each amount of imported goods by 1.2 as a shadow rate in order to get its economic (accounting) price. For reference, Table 13-3 illustrates comparisons between the Stage II Project and its alternative gas turbine project in terms of economic evaluation, utilizing the said numeraire.

Table 13-3 Economic Evaluation (w/ and w/o Shadow Pricing)

(単位：US$M)

Item	Stage 2 Project						Gas Turbine Proroject					
	Market Price			Economic Price			Market Price			Economic Price		
	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total
(1) Construction Cost	96.12	45.38	141.50	115.35	45.38	160.73	116.65	20.59	137.24	139.98	20.59	160.57
(2) Annual Operation & Maintenance Cost	0.51	1.19	1.70	0.61	1.19	1.80	0.48	1.12	1.60	0.58	1.12	1.70
(3) Annual Fuel Cost	13.17	0.00	13.17	15.81	0.00	15.81	17.30	0.00	17.30	20.77	0.00	20.77
(4) Annual Cost (=(2)+(3))	13.68	1.19	14.87	16.42	1.19	17.61	17.78	1.12	18.91	21.34	1.12	22.46
(5) PV of Cumul. Annu. Cost (=(4)×2.357)	32.25	2.80	35.05	38.70	2.80	41.50	41.92	2.64	44.56	50.30	2.64	52.94
(6) PV of Const. Cost	50.79	23.98	74.77	60.95	23.98	84.93	56.52	9.97	66.50	67.83	9.97	77.80
(7) Adj. PV of Const. Cost (=(6)×0.878)	44.60	21.05	65.65	53.52	21.05	74.57						
(8) Total Cost	76.84	23.86	100.70	92.21	23.86	116.07	98.44	12.62	111.06	118.13	12.62	130.74

B/C 1.10
B/C 1.13 (W/ Shadow Pricing)

13.7 Equalizing Discount Rate (EIRR)

The equalizing discount rate was obtained by calculation of the total costs of the Stage II Project and its alternative gas turbine project. As shown in the following table, the equalizing discount rate is found to be 21.15%. This rate exceeds 15% which is established as a social discount rate to reflect an opportunity cost of capital for project evaluation in the power sector in the Philippines. Accordingly, this indicates the economic viability of the Stage II Project.

Table 13-4 Equalizing Discount Rate

(In US$M)

Discount Rate (%)	Stage II Project (C)	Gas Turbine Plant Project (B)	(B) - (C)
15	100.70	111.06	+10.36
20	79.16	80.43	+1.27
21	75.61	75.76	+0.15
22	72.28	71.46	-0.82
21.15	75.10	75.10	0