12.3 Powerhouse

12.3.1 General

Just as in the case of the waterway, the power station is constructed underground, in order to satisfy the environmental requirement. Furthermore, we avoided watershed classification areas 1A and 2A by minimizing the entrance of access tunnel of powerhouse and the switch-yard area (see DWG. 12-5).

The powerhouse in a large scale cavern underground power station (width 22 m x height 45.7 m x length 117 m) constructed about 300 m under the ground equipped with pump turbine, 250 MW x 4 units, power generator and other accessories. In the transformer room, a large cavern (width 20 m x height 25.5 m x length 108 m) is provided about 70 m apart from the center of turbine, in order to install 4 units of transformer and GMCS. A draft gate room is also arranged directly under this transformer room.
The bird's - eye view of powerhouse are illustrated in DWG. 12-6.
The excavated amount of the powerhouse and the transformer room is about 168,000 m^3.

12.3.2 Geologic Condition

The geologic condition near the underground power house and transformer room is such that the upper part of arch consists of siltstone and fine-grained sandstone and the area under the arch is made up of sandy siltstone and fine-grained sandstone. Both of them are kept horizontal as in the case of the waterway.

It is expected that the arch excavation is carefully done by the drainage, early lining after excavation, use of rock bolts, driving prestressed anchor bolts, etc.

12.3.3 Underground Powerhouse and Transformer Room

The cross-section of underground power house station and transformer room is in the "mushroom shape" which satisfies a wide range of geologic requirements and improves the economic aspect with the minimized cross-sectional shape.

Since both underground powerhouse and transformer room are a large cavern type, there is a possibility that both powerhouse and transformer room may interfere with each other while excavating, thus causing adverse effects such as the displacement or loosening of surrounding rock. To prevent these problems, the distance between the center of turbine and that of transformer is designed 70 m.

The underground powerhouse and the outside on the surface are connected by the access tunnel for powerhouse (total length; about 1,210 m) and power cable tunnel (total length; about 710 m).

The access tunnel for powerhouse passes from the National Highway of EL. 295.00m at a gradient of about 14%, through the transformer room of EL. 214.00m and reaches the erection bay of the powerhouse of EL. 214.00m.

The power cable tunnel is constructed at a gradient of about 20% from the mountain side (Altitude; EL. 350.00 m) to the vicinity of underground powerhouse and the arch base of transformer room (Altitude; EL. 225.00 - EL. 230.50m).

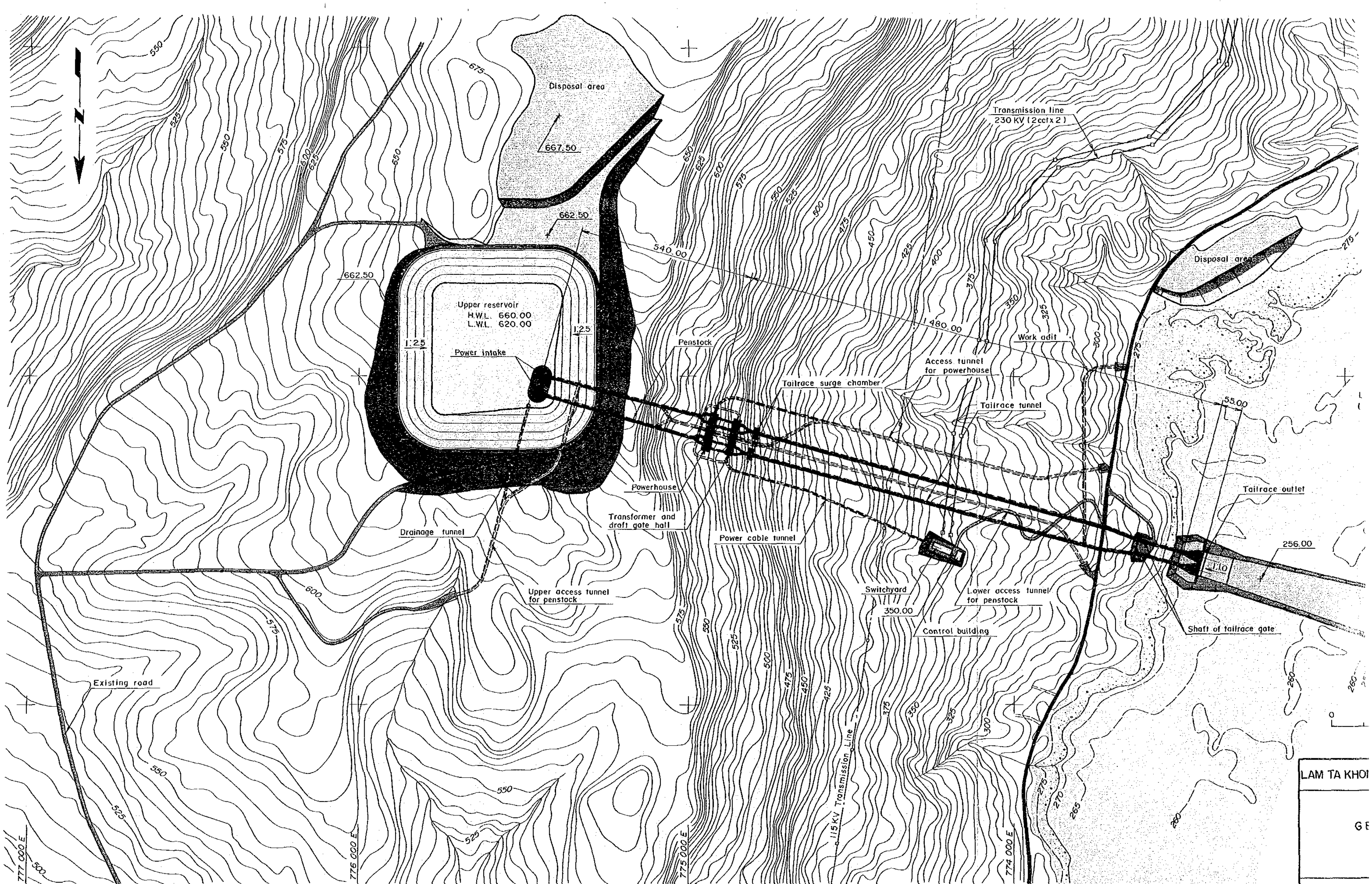
A gallery (Altitude; EL. 214.00 m) is installed in the peripheral area of underground powerhouse, in order to reduce the spring water which springs out in the powerhouse while the construction work is in progress. With this gallery, the curtain grout and water draining boring are carried out in the surrounding area of powerhouse and when completed, water pressure to the arch and side wall concrete is reduced.

The water springing out in the peripheral area of underground powerhouse increases to the maximal level after each tunnel reaches the underground powerhouse and all spring water is converged to the powerhouse. This converged water is removed to the outside of tunnels by pumps installed in each tunnel, but when a power failure should occur, the construction work may have to be stopped. Therefore, designed is the drainage tunnel which is branched from the access tunnel for powerhouse to the powerhouse drainage pit. This drainage tunnel is used for hauling out the excavation muck of the lower inclined tunnel of penstock and of powerhouse cavern. It is also used as the drain tunnel in the future.

12.3.4 Disposal Area

The disposal area for the muck from powerhouse and waterway except the upper horizontal tunnel of penstock is provided along the Lam Ta Khong reservoir on the south side of outlet. This layout is designed by taking into consideration the environmental control in the mountain side of National Highway No. 2. The surface of this disposal area is a very wide area which is on the same level as the elevation of National Highway. This area may be utilized as a park, a resort etc, in the future. When planning this disposal area, it is required to negotiate with Royal Irrigation Department (RID), Lam Ta Khong dam control office, and only 650×10^3 m^3 of the capacity of the Lam Ta Khong reservoir is reduced by this disposal area (reducing only 0.2% of the effective reservoir capacity of $290,000 \times 10^3$ m^3).

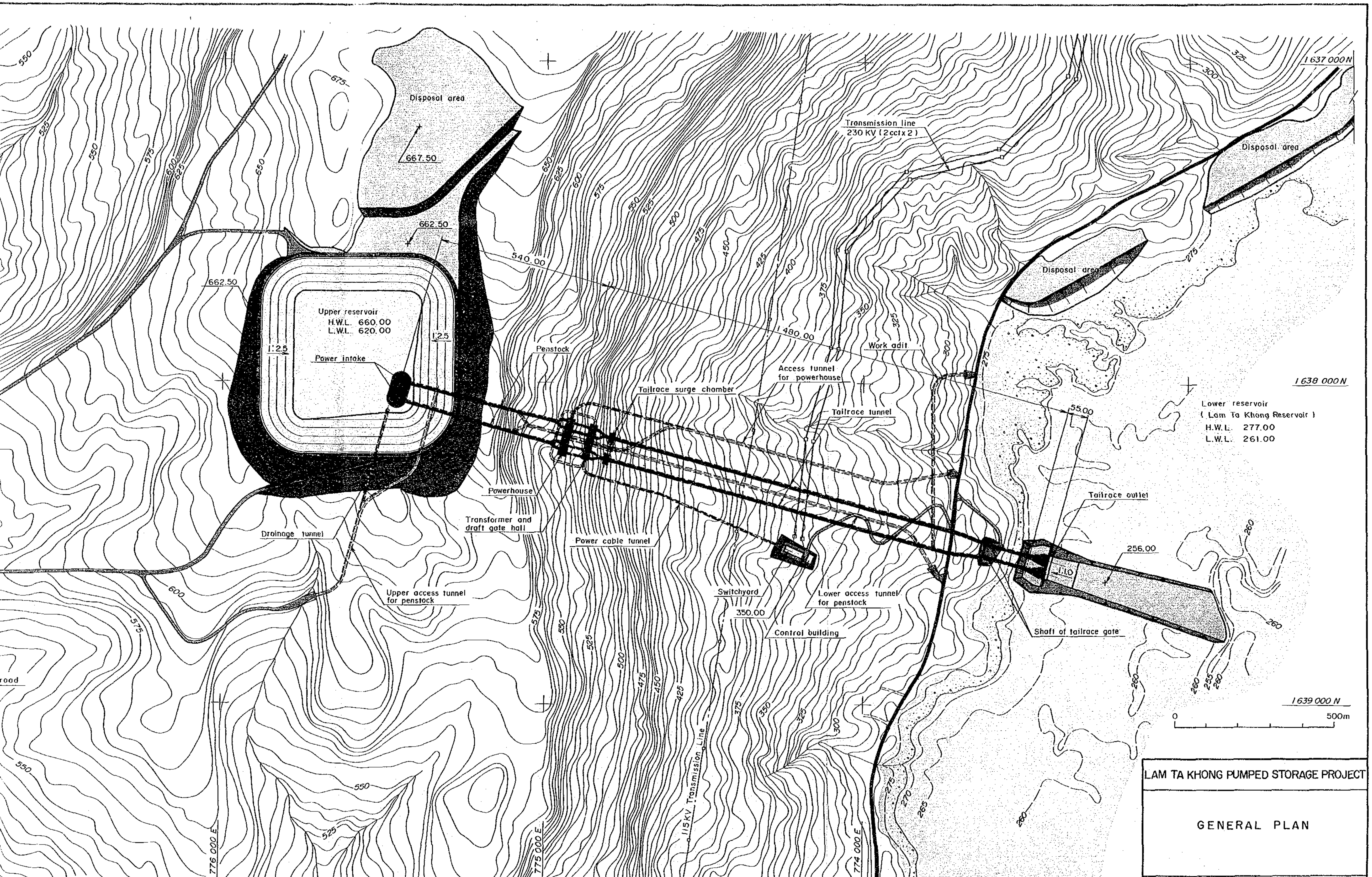
The sloped surfaces of disposal area are covered with rubbles, and the peripheral area is covered with trees to ensure harmony with surrounding or to protect the sloped areas.



LAM TA KHO

G

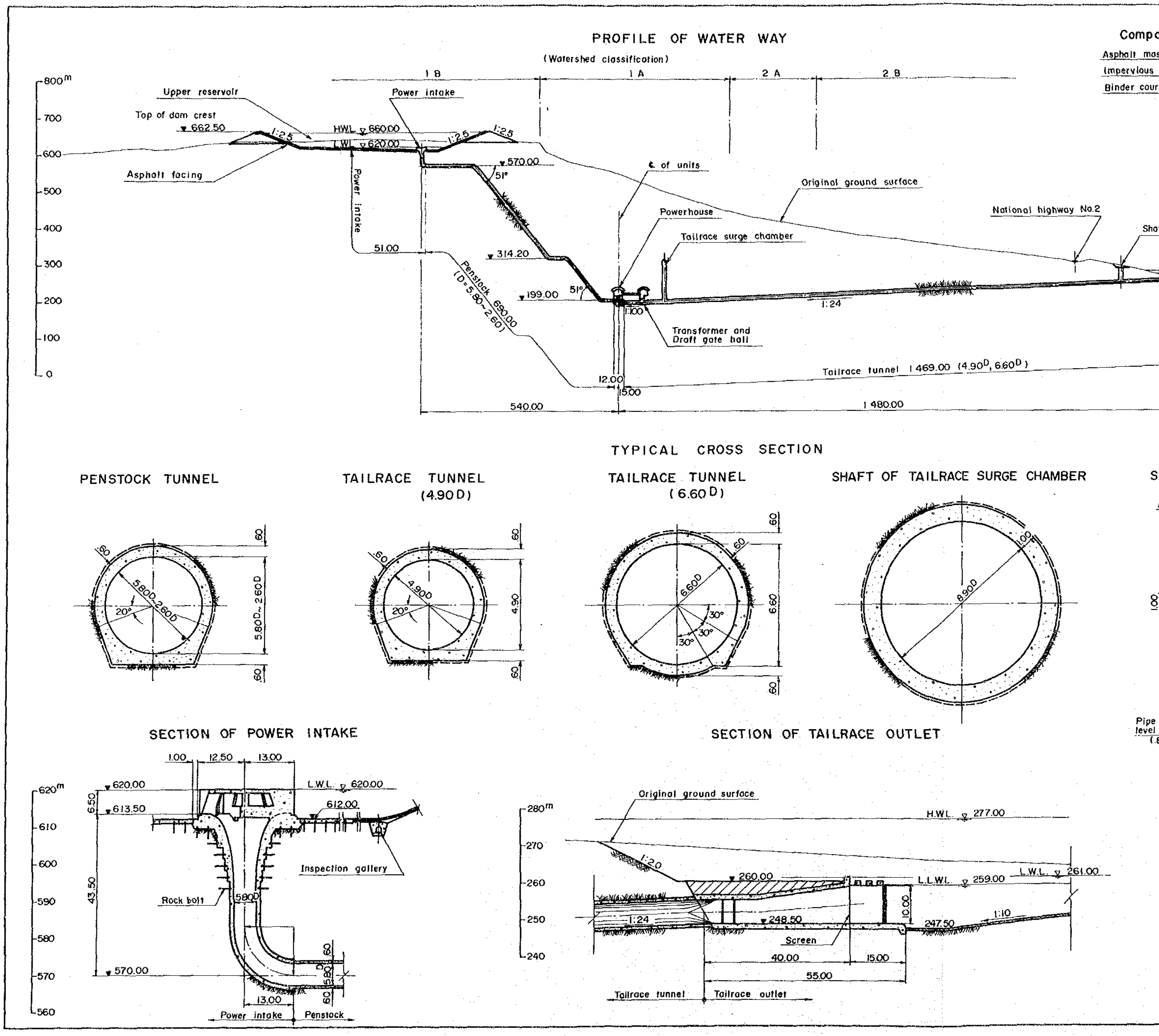
DWG. 1



LAM TA KHONG PUMPED STORAGE PROJECT

GENERAL PLAN

DWG. 12-1

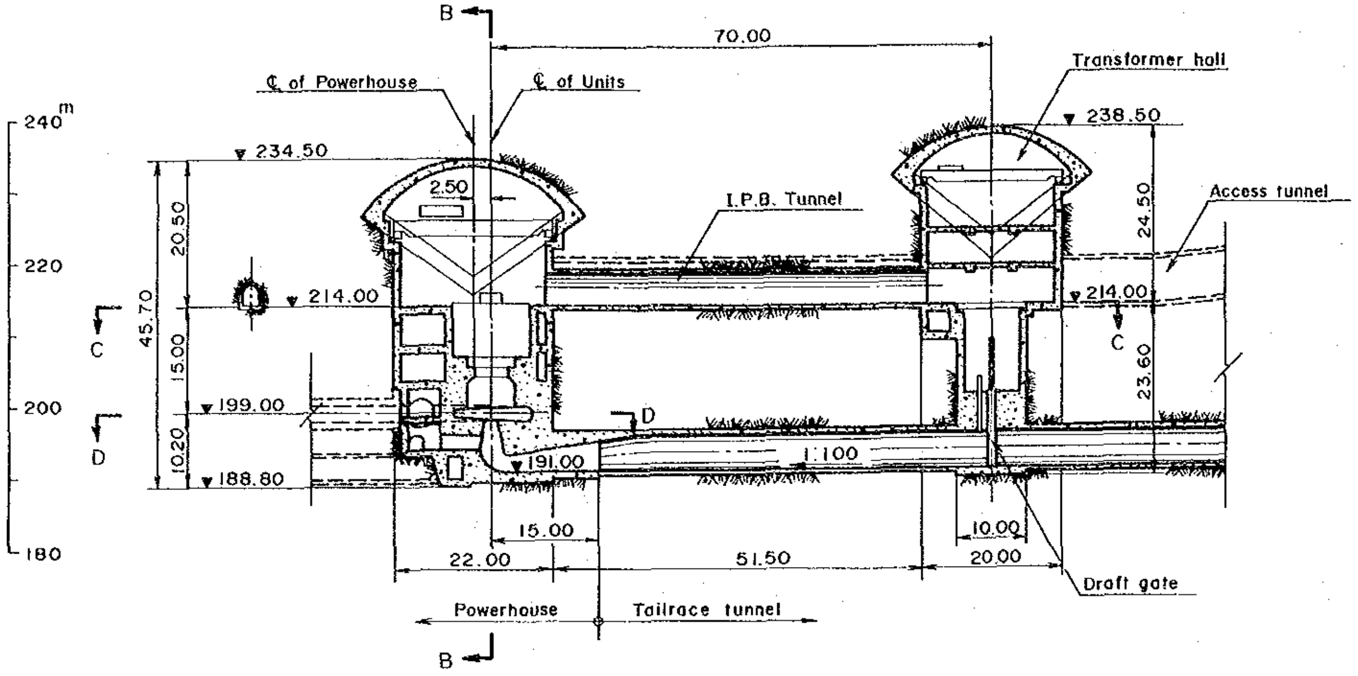


LAM TA KHONG PUMPED STORAGE PROJECT

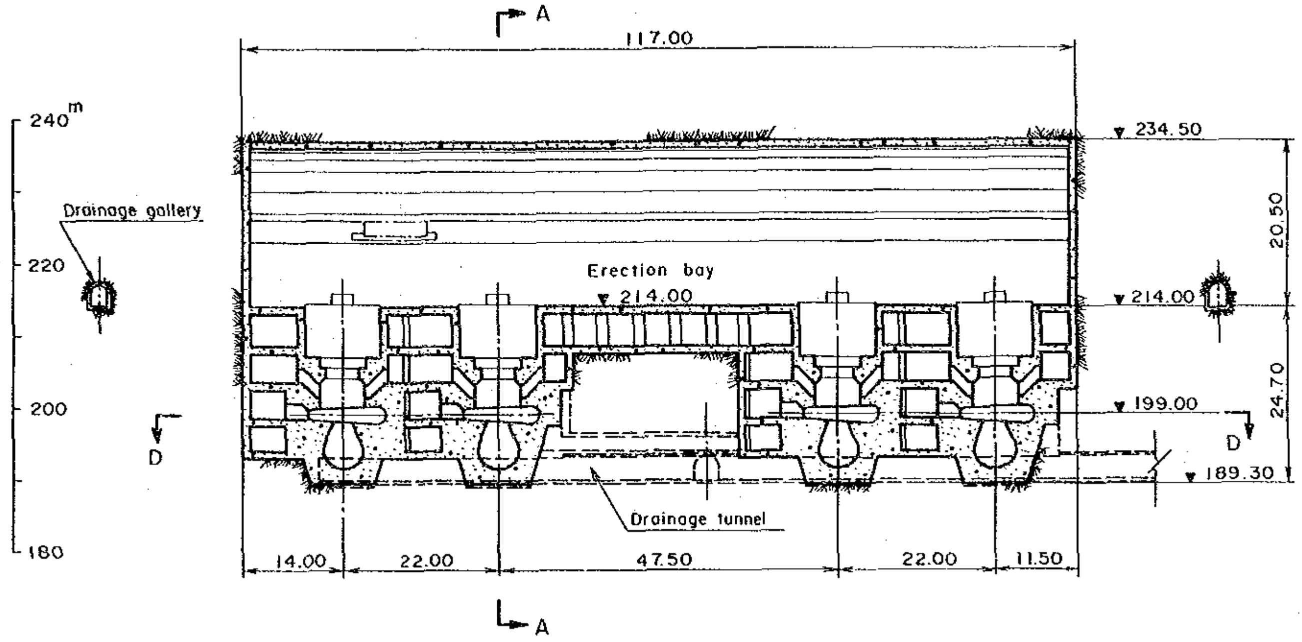
WATER WAY
PROFILE AND SECTION

DWG. 12-2

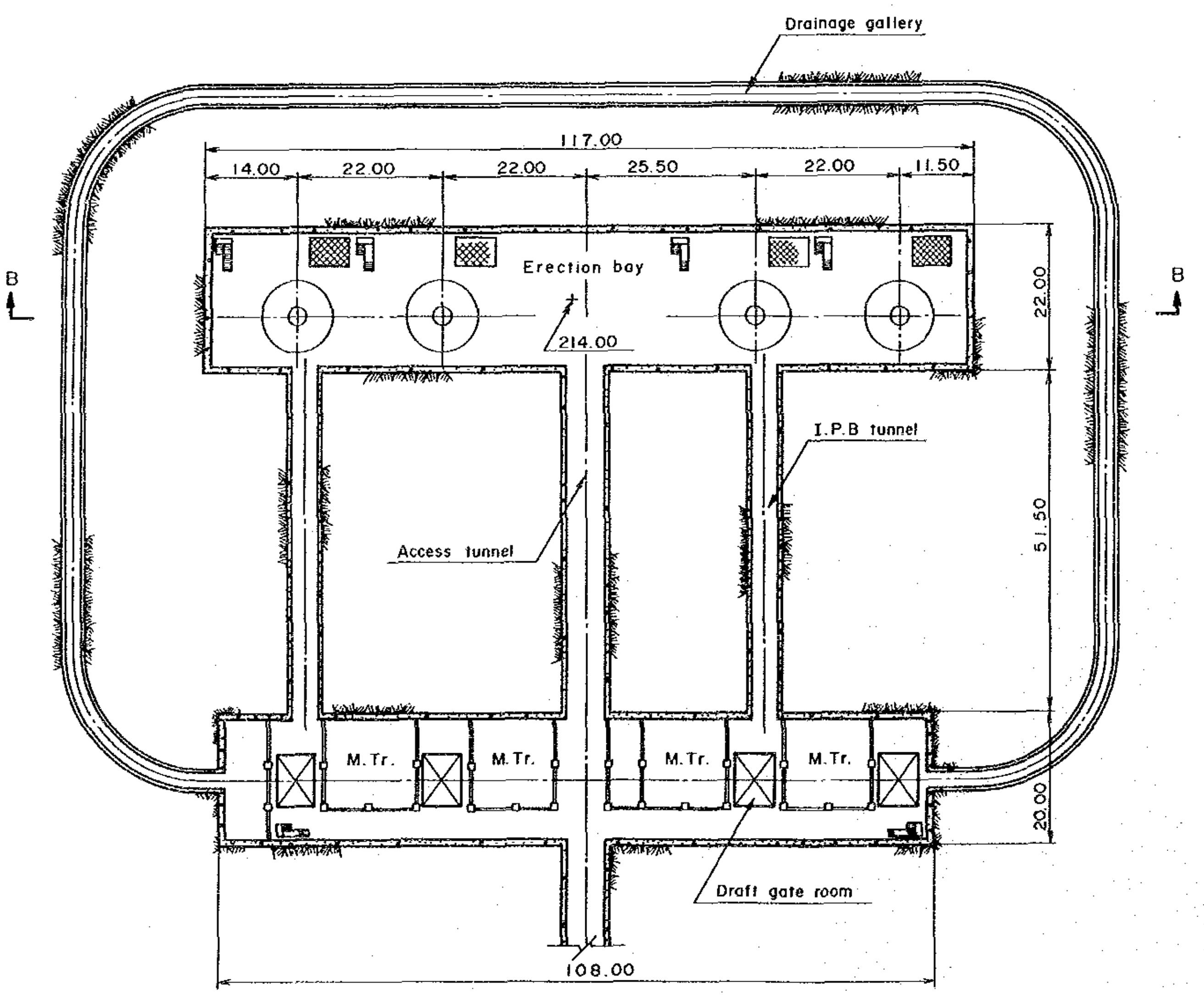
SECTION A — A



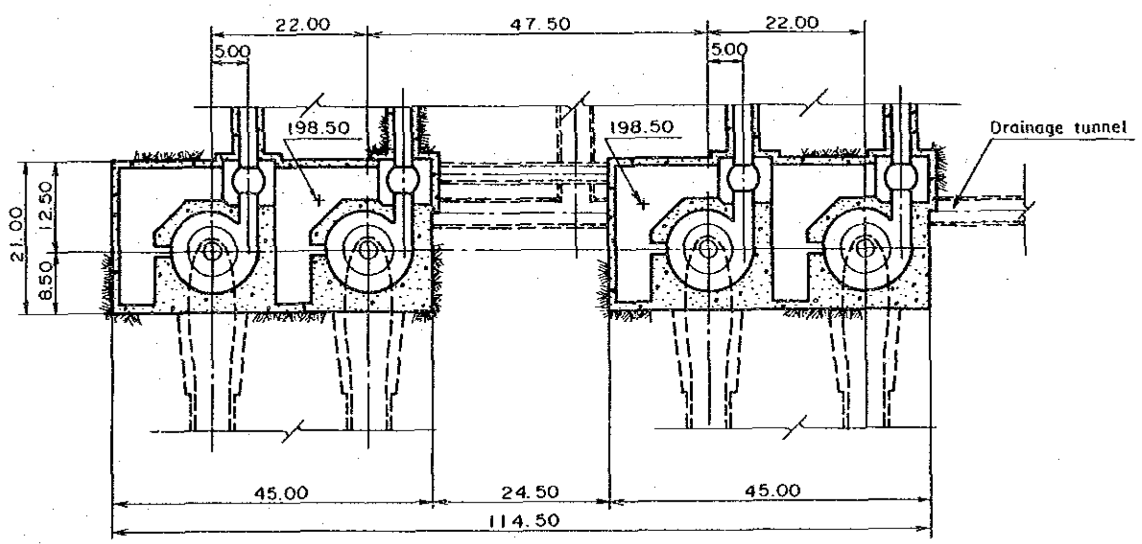
SECTION B — B

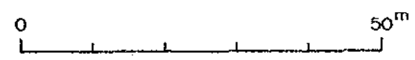


SECTION C — C



SECTION D — D





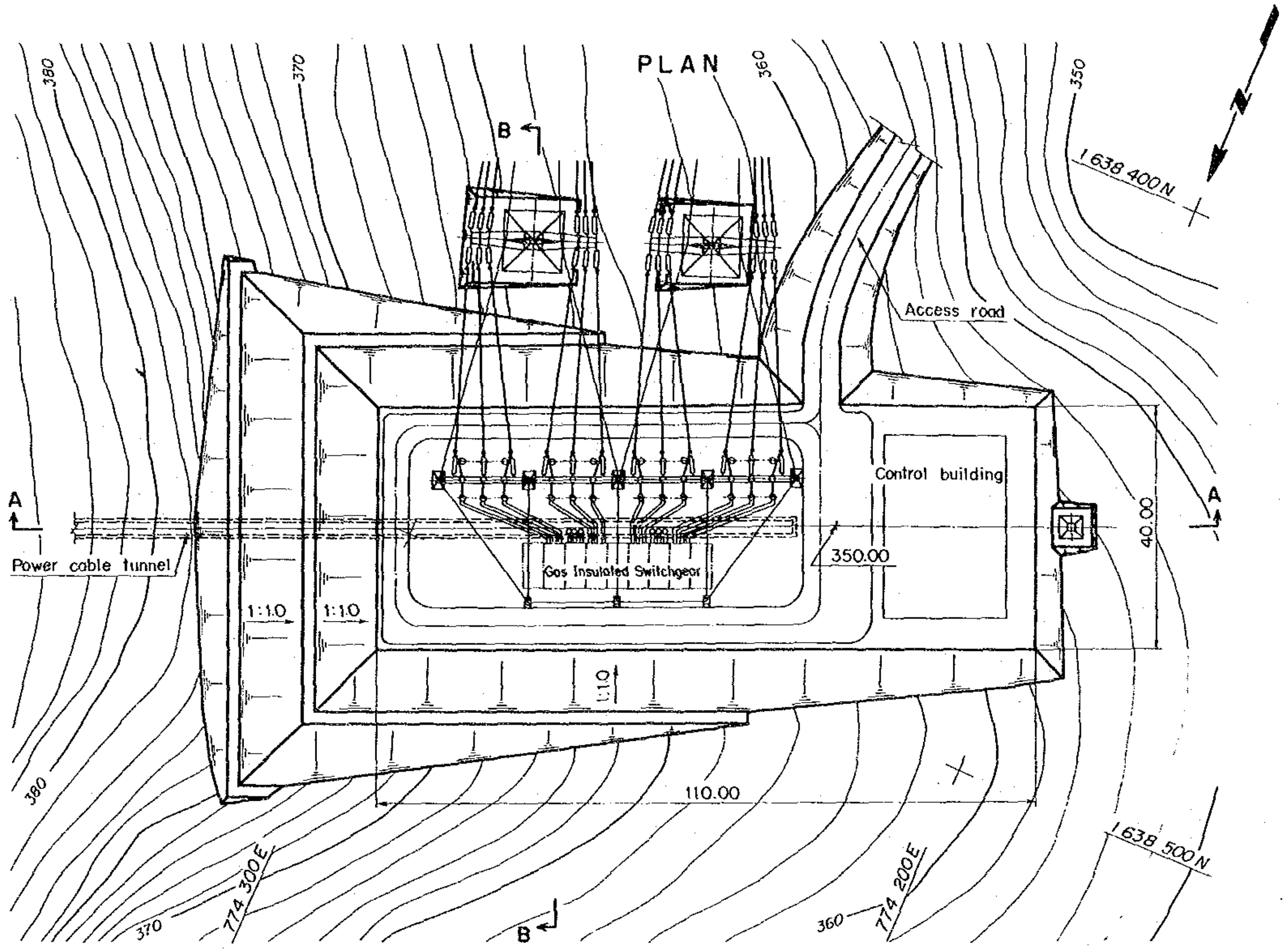
LAM TA KHONG PUMPED STORAGE PROJECT

POWERHOUSE

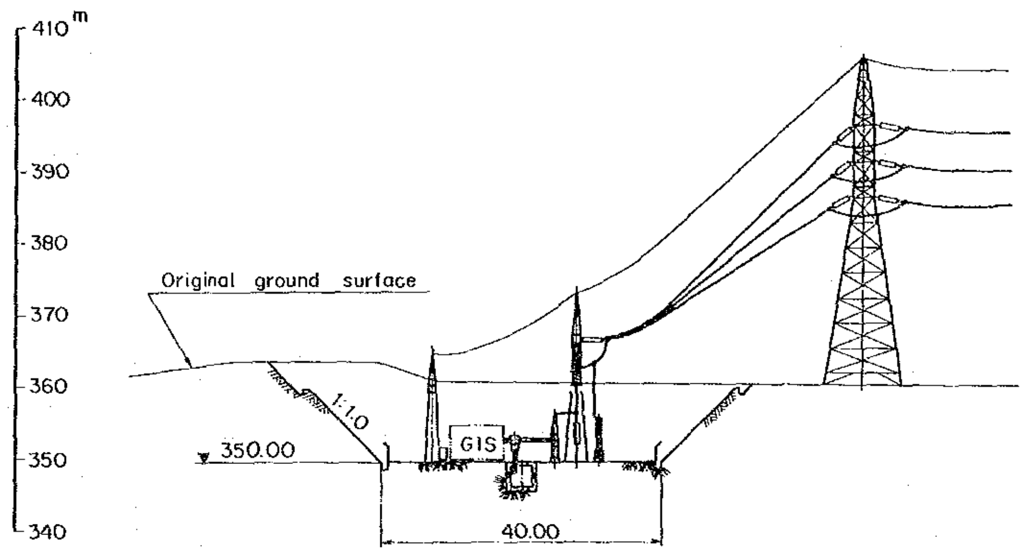
SECTION

DWG. 12-3

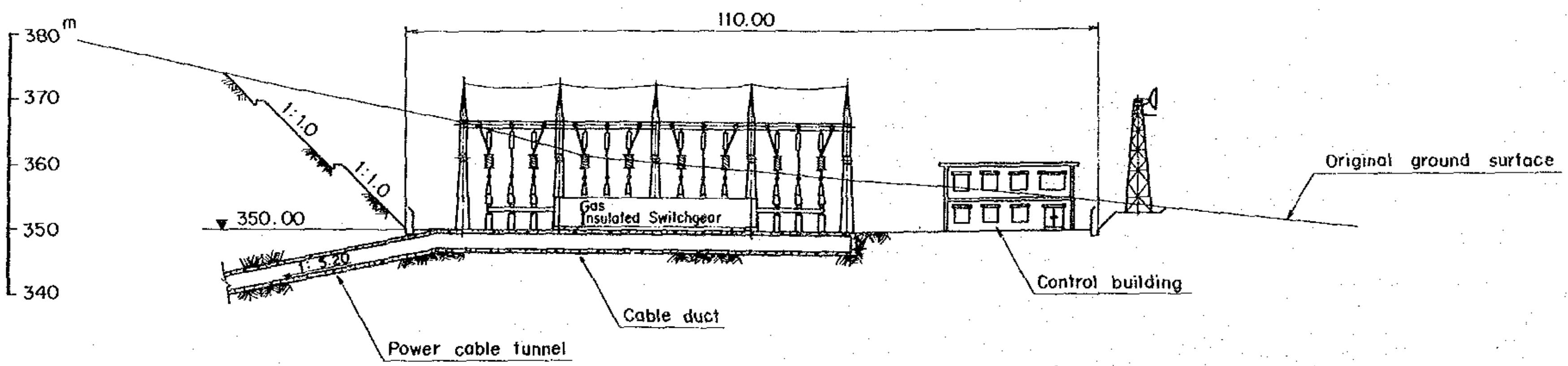
PLAN



SECTION B-B



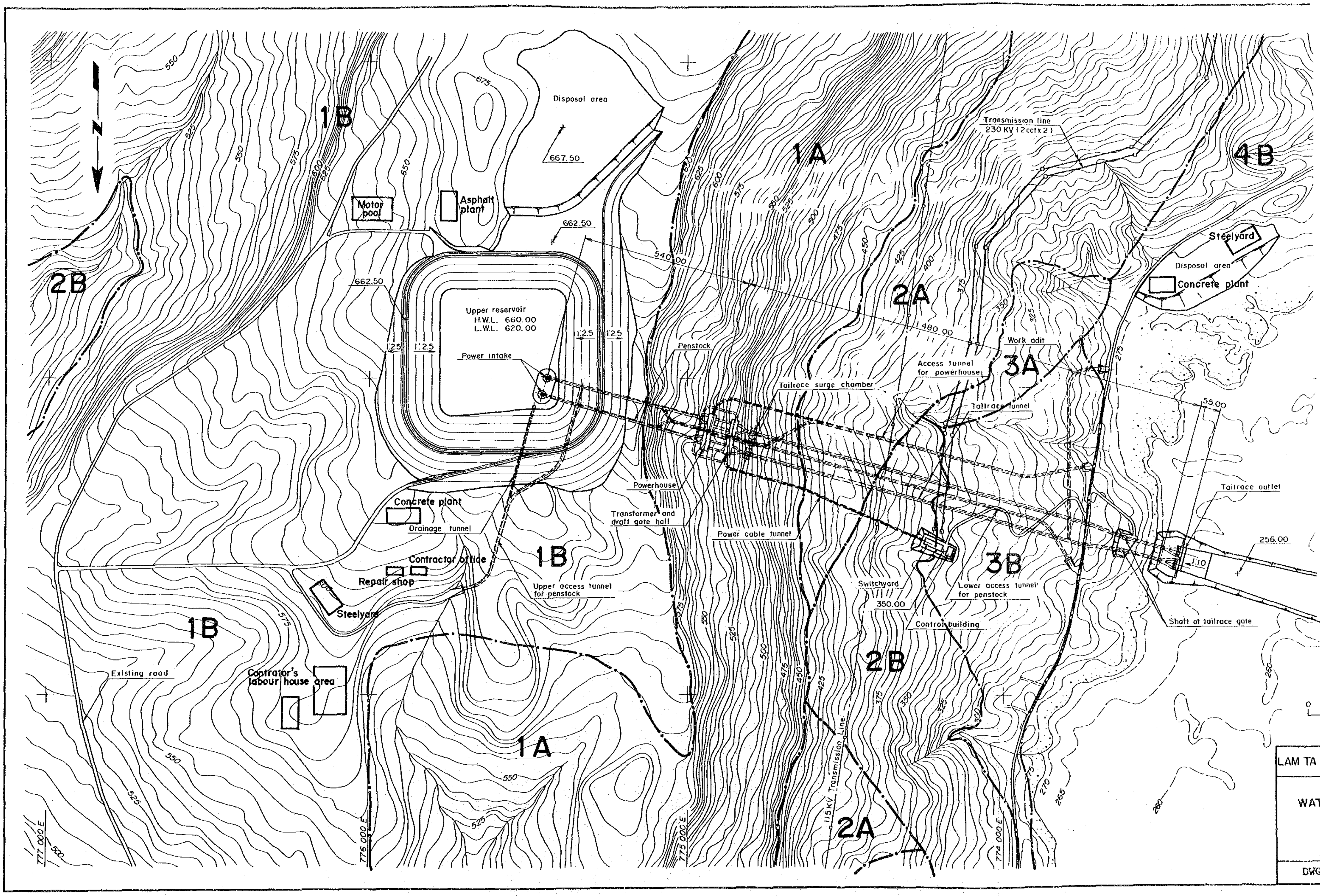
SECTION A-A

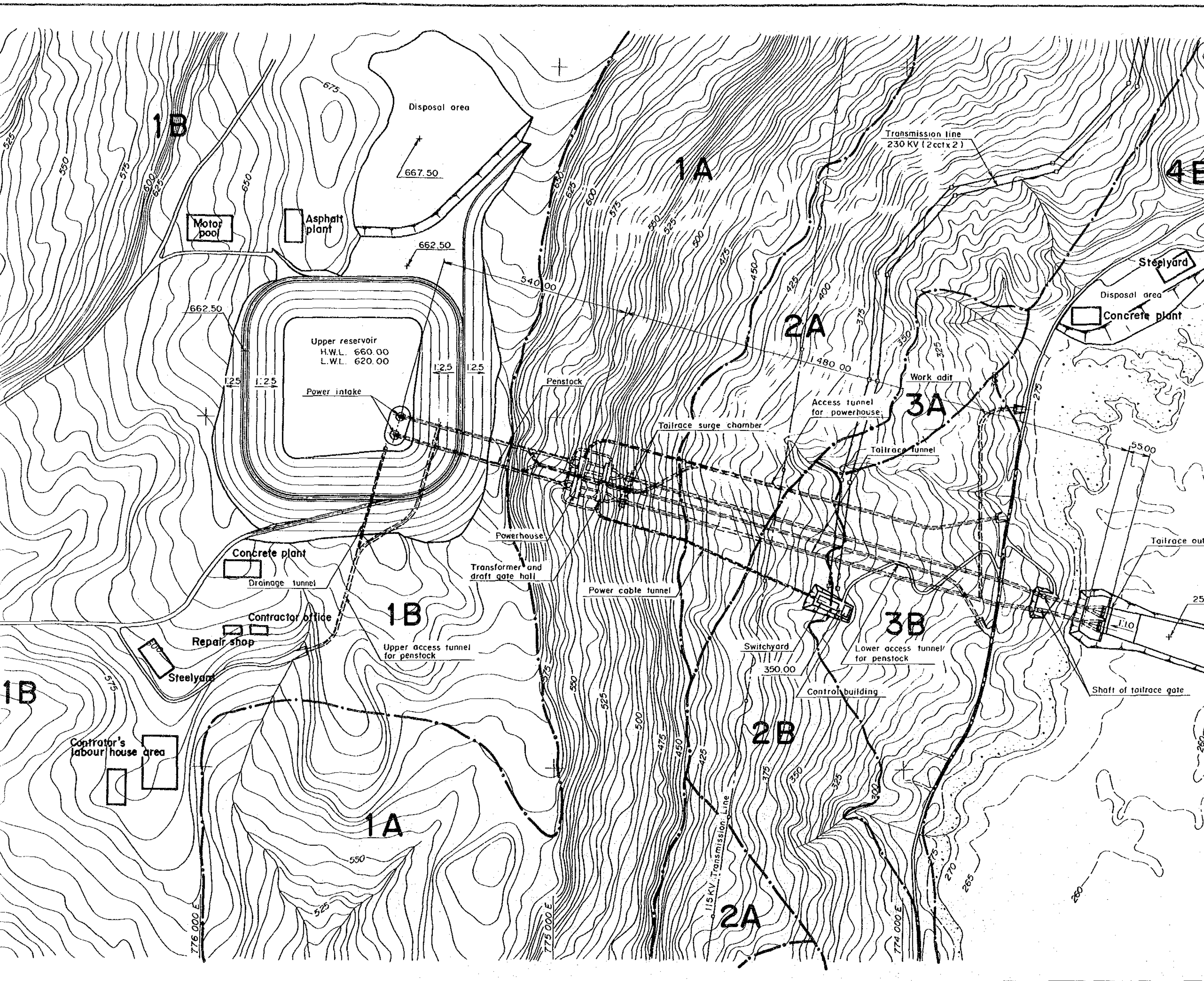


LAM TA KHONG PUMPED STORAGE PROJECT

SWITCHYARD
PLAN AND SECTION

DWG. 12-4

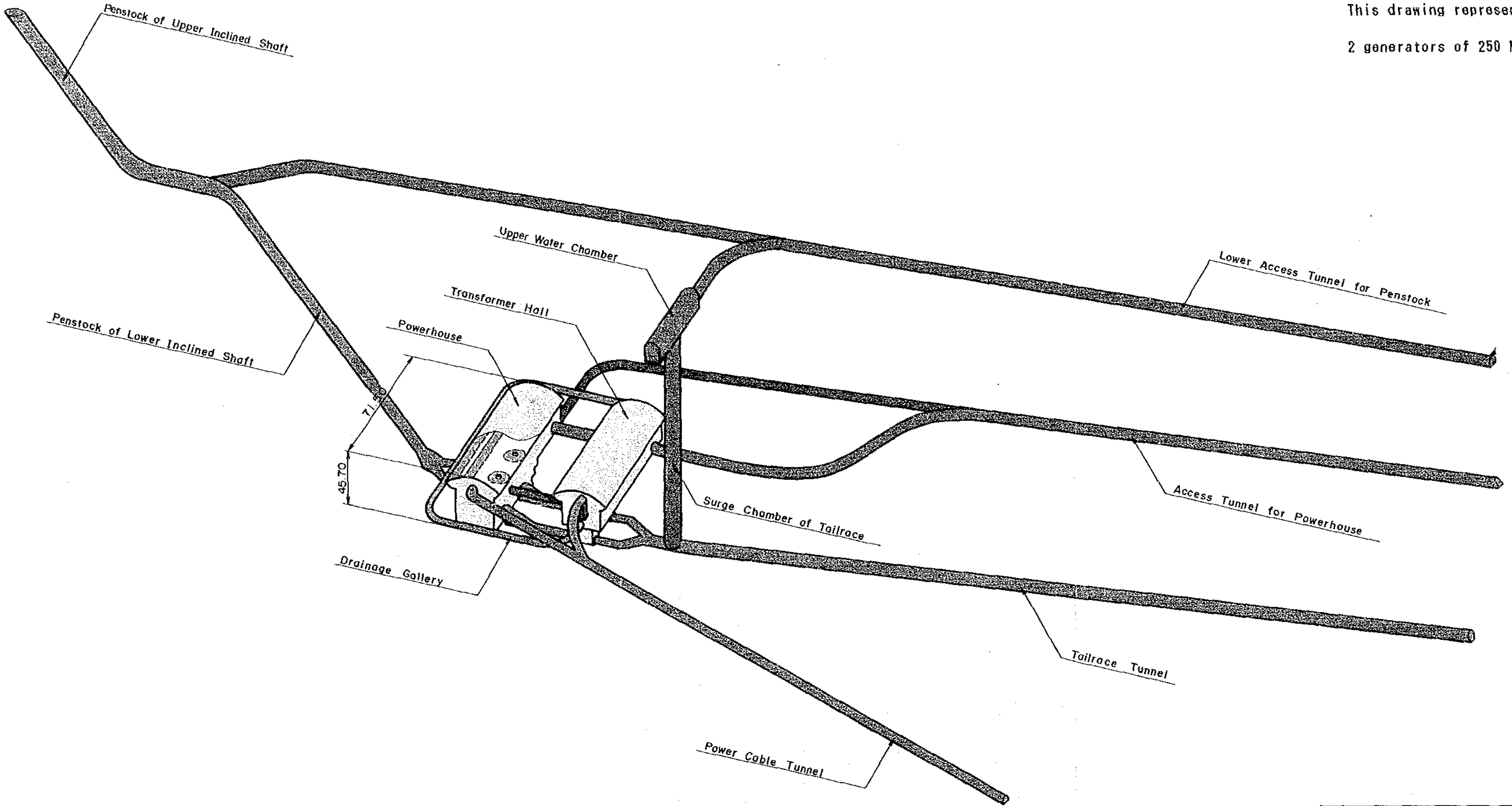

N
Disposal area
667.50
662.50
Motor pool
Asphalt plant
1B
2B
1A
2A
3A
3B
4B
Transmission line 230 KV (2cctx2)
Steelyard
Disposal area
Concrete plant
540.00
Upper reservoir
H.W.L. 660.00
L.W.L. 620.00
Power intake
1:2.5
Penstock
Tailrace surge chamber
Access tunnel for powerhouse
Work adit
1 480.00
Tailrace tunnel
55.00
Powerhouse
Transformer and draft gate hall
Power cable tunnel
Tailrace outlet
256.00
1:10
Concrete plant
Drainage tunnel
Contractor office
Repair shop
Steelyard
Upper access tunnel for penstock
Switchyard
350.00
Control building
Lower access tunnel for penstock
Shaft of tailrace gate
Existing road
Contrator's labour house area
115KV Transmission Line
777.000E
776.000E
775.000E
774.000E
LAM TA
WAT
DWG



LAM TA KHONG PUMPED STORAGE PROJECT

WATERSHED CLASSIFICATION IN PROJECT AREA

DWG. 12-5



Note.

This drawing represents

2 generators of 250 MW.

LAM TA KHONG PUMPED STORAGE PROJECT
POWERHOUSE BIRD'S-EYE VIEW
DWG. 12-6

12.4 Electric Facilities

12.4.1 Power Station

The power station is constructed under ground, about 60 m lower than the highest water level (full water level) of the reservoir, at the right side shore of the existing LAM TAKHONG Reservoir (Lower reservoir).

The underground power station is accessible through the road and tunnel, length about 1200 m, branched from Route No. 2 which runs along the right side shore of reservoir.

The underground power station consists of two caverns; power house and transformer room. Dimensions of power house and transformer room are estimated as shown in the following:

Power house : Length; 115 m, Height; 45 m, Width; 20 m
(See DWG. 12-7, 12-8)

Transformer room: Length; 108 m, Height; 23 m, Width; 18 m
(See DWG. 12-9, 12-10)

(1) Specifications for Equipment

- Pump turbine

  Type: Vertical shaft Francis type reversible pump-turbine.

  Quantity: 4 units

- Generating operation

	(Max.)	(Nor.)	(Min.)
Effective head (m)	397	357	325
Discharge (m^3/S)	73.1	82.5	78.7
Output (MW)	255	255	220
Revolving speed (r.p.m)	375	375	375
Specific speed (m-kW)		122	

- Pumping operation

	(Max.)	(Min.)
Total head (m)	409.2	346.7
Pump discharge (m^3/S)	52.7	71.4
Pump Input (MW)		277
Revolving speed (rpm)	375	375
Specific speed (m-m^3/s)		39.4

- Generator motor

Type	:	3-phase AC synchronous generator-motor
Quantity	:	4 units
Generator output (MVA)	:	278
Motor output (MW)	:	277
Voltage (kV)	:	16.5
Frequency (Hz)	:	50
Revolving speed (r.p.m.)	:	375
No. of pole	:	16
Power factor	:	Generator 0.90 (Lag) Motor 0.98 (Lead)

- Transformer

Type	:	Special 3-phase forced oil water cooled indoor type.
Quantity	:	4 units
Capacity (MVA)	:	290
Voltage (kV)	:	230/16.5

On load tap changer is provided.

- Main circuit configuration

The main circuit of this project consists of the following equipment as shown in Fig. 12-1 single line diagram;

(a) Pump-Turbine and generator-motor;
For the specification, refer to the above.

(b) IPB (Isolated phase bus); 16.5 kV, 11,000 A.

This is an isolated phase bus which is used for connecting the generator-motor to transformer and is installed in the bus tunnel connecting the power house and transformer room.

(c) GMCS (Generator-motor main circuit system);
16.5 kV, 11,000 A.

This system consists of a low voltage circuit breaker (3 phase GCB) and enclosed type phase reverse disconnecting switch.

(d) Transformer: For the specification, refer to the above.

(e) Power cable; 230 kV, XLPE cable

Four circuits of three single-core XLPE (cross-linked polyethylene) cables are laid for connection between high tension side of transformer and outdoor GIS switchyard through the cable tunnel with the total length of about 700 m.

(f) Outdoor GIS switchyard; 230 kV GIS (SF_6 gas insulated switchgear.)

GIS (Gas installed switchgear) consisting of 9 bays is installed. Double buses with bus-tie are used. Four circuits of transmission line and four circuits of transformer power cables mentioned in (e) are connected.

(2) Layout of Underground Power Station Facilities

(a) Powerhouse

Provided in the power house are the pump-turbines, generator-motors, auxiliary equipment and various control systems.

The pump-turbines are installed at the position about 60 m lower than the low water level of the lower reservoir (existing Lam Ta Khong Reservoir), thus preventing possible troubles caused by the cavitation made while the pump is operating. The power house is provided with 5 floors. Two power house travelling cranes for election work are installed.

- Floor No. 1 (Assembling floor)

This is the top floor of power house with an election bay at the center. Two of four main units are installed on one side and, other two on the other side of the election bay. An access tunnel is connected to the bay.

Main units and auxiliaries are assembled on the election bay and put in proper positions making use of overhead travelling cranes. On this floor, the unit control board and protection relay board are installed for each unit.

- Floor No. 2 (Generator-motor floor)

Installed on this floor are the generator-motors, PT-CT cubicles for main circuit, NGT (Neutral Grounding Transformer), exciter, short-circuit disconnecting switches for electric brake systems, etc.

The periphery of generator-motor air hood is made of concrete walls. The entrance to inside of generator-motor is provided on this floor.

Installed under the election bay, of this floor are the power supply cubicles for station service and compressed air supply device.

- Floor No. 3 (Pump turbine floor)

The pump turbine control boards, pressurized oil tank, compressed air tanks, thrust bearing lifting devices, bearing oil coolers and motor control centers for auxiliary units are installed on this floor. Also installed is the entrance to the pump turbine pit.

- Floor No. 4 (Auxiliary Floor)

Auxiliary equipment such as the pressurized oil supply system, cooling water strainer, etc. are installed on this floor. Many pipings for cooling water, pressurized oil, etc. are also installed on this floor.

Access to the spiral case manhole can be made on this floor.

- Floor No. 5 (Pump floor)

  This is the lowest floor of the underground power house where the cooling water pumps, station water drainage pumps, a penstock filling water pump, etc. are installed. Also installed on this floor is the passage to draft tube manhole.

(b) Layout of transformer room

The transformer room is constructed on the tailrace side of power house in parallel with the power house. This room consists of three floors. The access tunnel to power house crosses the center, and a cable tunnel to outdoor switchyard is connected to one end of the transformer room.

Two IPB tunnels are provided between power house and transformer room for laying generator-motor circuit buses.

- Transformer floor

  Four special 3-phase transformer with on load tap changer are installed on this floor.

  AC and DC reactors and a power transformer for thyristor starter and two station service transformers are also installed on this floor together with cooling and fire extinguishing water supply systems for above oil immersed equipment.

  Installed on the lower section of this floor is an oil disposing pit which is used when the transformer has a trouble. Also installed are the pit with draft gate and the gate operation panel.

- Thyrister starter floor

  On this floor rectifire, inverter and control equipment for thyrister starter are installed, and remaining spaces are used for cable laying and treatment.

- GMCS (Generator-motor main circuit system) floor

  Generator-motor main circuit breakers, phase reverse disconnecting switches and various cubicles (dry type transformer for generator motor excitation, switchgears for thyristor starter, tapping switch to station service circuit, etc.) are installed on this floor.

12.4.2 Outdoor Facilities

(1) Switchyard

When selecting the location of switchyard, two plans were proposed; upper reservoir side plan and tailrace side plan, and the tailrace side plan was finally accepted, from the technical and economical point of view, the tailrace side plan was considered most advantageous for the cable installing work between the main transformer and switchyard. When the cost of civil works is taken into consideration the tailrace side plan was especially meritorious, because the power cable tunnel could be also used as the exploratory adit.

For the switchyard, two different types could be used; the conventional exposed equipment switchyard and the gas insulated switchyard (GIS), but we decided to use GIS, because GIS featured the better reliability, maintenance and economical aspects, it was in the vicinity of environment controlled area and the switchyard of this GIS was rather small.

Comparison of area of switchyard (estimated)

Conventional type (230 kV, 7 bay, double buses)
(See DWG. 12-11) 165 m x 70 m

GIS type (same as above); 110 m x 40 m
(See DWG. 12-4)

(2) Control Building

The latest information transmitting technology (Example; Optical fiber signal transmission) has eliminated the distance-wide restriction between control station and underground power station, thus enabling to decide the location of control facilities by attaching greater importance to the working condition of operators, workers and all other people concerned.

In the case of this project, it is preferable to install control facilities in a building constructed adjacent to outdoor switchyard from view points of environment around operating staff and economy.

Besides control facilities, the control building is designed to accommodate minimum maintenance staff necessary for daily patrol and to cope first with unexpected accident or trouble.

An outline of the control building is expressed DWG. 12-12.

(3) Personnels of Control Station

As this project site is at proximity of an area on which strict environmental conservation regulation is applied, EGAT strongly wishes to make the design of outdoor buildings as inconspicuous as possible. Therefore, we have adopted such a design concept that the floor area within which the minimum function of a control station, such as control room, auxiliary machine room and power supply room, can be accommodated will be approximately 900 m^2 (consisting of two floors each having floor areas of 450 m^2), and it is planned to locate repair shop and warehouse at separate locations. The office space in the building was estimated as 80 m^2 (6 m^2 per person), where it is assumed that 13 personnels of 7 different duties will attend. The breakdown of these personnels to be at the office is described in the table below.

Table of Duties\Personnels

	Duty	No. of Personnel	Form of Duty
1.	Station manager (Electrical Engineer)	1	Day duty
2.	Electrical Engineer	3	Day duty
3.	Mechanical Engineer	2	Day duty
4.	Communication Engineer	2	Day duty
5.	Civil Engineer	2	Day duty
6.	Clerk	1	Day duty
7.	Janitor	1	Day duty
8.	Guard	1 + (1)	Day duty + (night duty)
	Total	13 + (1)	

Dimension of building : W 17 m x L 27 m x H 10 m (two storied)

12.4.3 Operation Control

(1) Mode of Operation

Lam Ta Khong Pumped-storage Power Plant is to operate usually being remotely controlled from, according to EGAT's latest information, EGAT's head quarter dispatching center.

However the plant is also to be able to operate by one-man-control from control room is control building to meet demands for operation when remote control system is not available (troubles, testing, maintenance work, etc.)

(2) Features of Control System

A hierarchical SCADA (supervisory control and data acquisition) system which mainly consist of central computer systems and local plant controllers, is applied as the control system of this plant.

Duplex systems of main supervisory computers supporting man-machine interface equipment (CRTs display, typewriters, control desks, graphic panel, etc.) and remote supervisory equipment to dispatching center compose upper part of the system and, at the lower level, a micro processor based plant controller is provided for each of main units, station service equipment, GIS switchyard, etc.

The central computer systems and plant controllers are linked by means of a optical-fiber loop dataway, through which high speed and reliable data transmissions among them are achieved.

12.4.4 Additional Study

(1) Location of Switch Yard

The three plans shown in the attached figures (Fig. 12-2, Fig. 12-3 and Fig. 12-4) have carefully studied and are ensured that the civil engineering work and electric work can be carried out without problems.

(a) Plan for ground GIS type (Refer to Fig. 12-2)

From the standpoint of civil engineering and electric technology, this design is most acceptable because of the following reasons;

. The area used for construction yard can also be used for the switchyard.

. Transmission line (4 lines/2 routes) can be easily installed.

. Equipment can be easily installed and maintained

This project is located near the environment controlled area, but we do not have to worry about the "exposed scenery" viewed from the national road side, because the difference of elevation from the national road is more than 50 m and the full caution is taken to protect the scenery by planting trees, etc. Protection of environment from air pollution, oil leak noise, etc. is fully ensured by using the gas insulated switchgear (GIS).

(b) Underground GIS type; alternative plan (Refer to Fig. 12-3)

In this design, the GIS in the main plan for ground GIS is installed underground, but the area for cable head connected to the transmission line can not be reduced very much, because the proper space should be provided between electric insulators. Therefore, this alternative plan is not superior to the plan for ground GIS type when the difficulty in civil engineering work and complicated installation\maintenance of GIS are taken into consideration. However, this plan is slightly better in regard to the environment protection measures (especially the protection of scenery).

(c) Alternative plan for the ground GIS type installed along National Road (Refer to Fig. 12-4)

In this design, the location of ground GIS in the main plan is changed to the area located along the national road. The merits of this plan are the excellent access to equipment and separation from environment controlled area. However, in this design, it is very difficult to install the power line, the distance of power line is increased and the length of XLPE cable connected between underground power station and GIS is increased.

In the above study on the 3 alternative plans, the advantages of the main plan are explained and in addition to such advantages, this main plan is also advantageous in the economic evaluation. The following table shows the comparison between construction costs of three plan.

Comparing construction costs of 3 plans

Plan / Name of work	Ground GIS type. This plan	Underground GIS type. Alternative plan	GIS type installed along national road.
Cost of civil engineering work (MB)	15.2	53.1	25.1
Cost of electric work (MB)	221.0	254.2	262.2
Total	236.2 (100%)	307.3 (130.1%)	287.3 (121.6%)

(2) Study of Pump Starting System

LAM TAKHONG Project is a pure pumped-storage hydroelectric plant using a large capacity (250 MW) equipment. an estimated GD^2 is about 6,100/ton-m^2. Approximately 20,000 kW of input is believed to be required to start the pumping operation.

Therefore, it may be appropriate to select a pump starting method from the following two methods;

. Pony motor starting
. Thyristor starting

It is also possible to use the synchronous back to back starting for backing up the thyristor starting.

The following are the characteristics of pony motor starting method and thyristor starting method (static frequency converter);

(a) Pony motor starting method

- Since the pony motor is directly connected to the top of generator-motor, a total shaft length of machine is very long, which is a disadvantage for the shaft vibration stability.

- Operation loss (wind loss) increase.

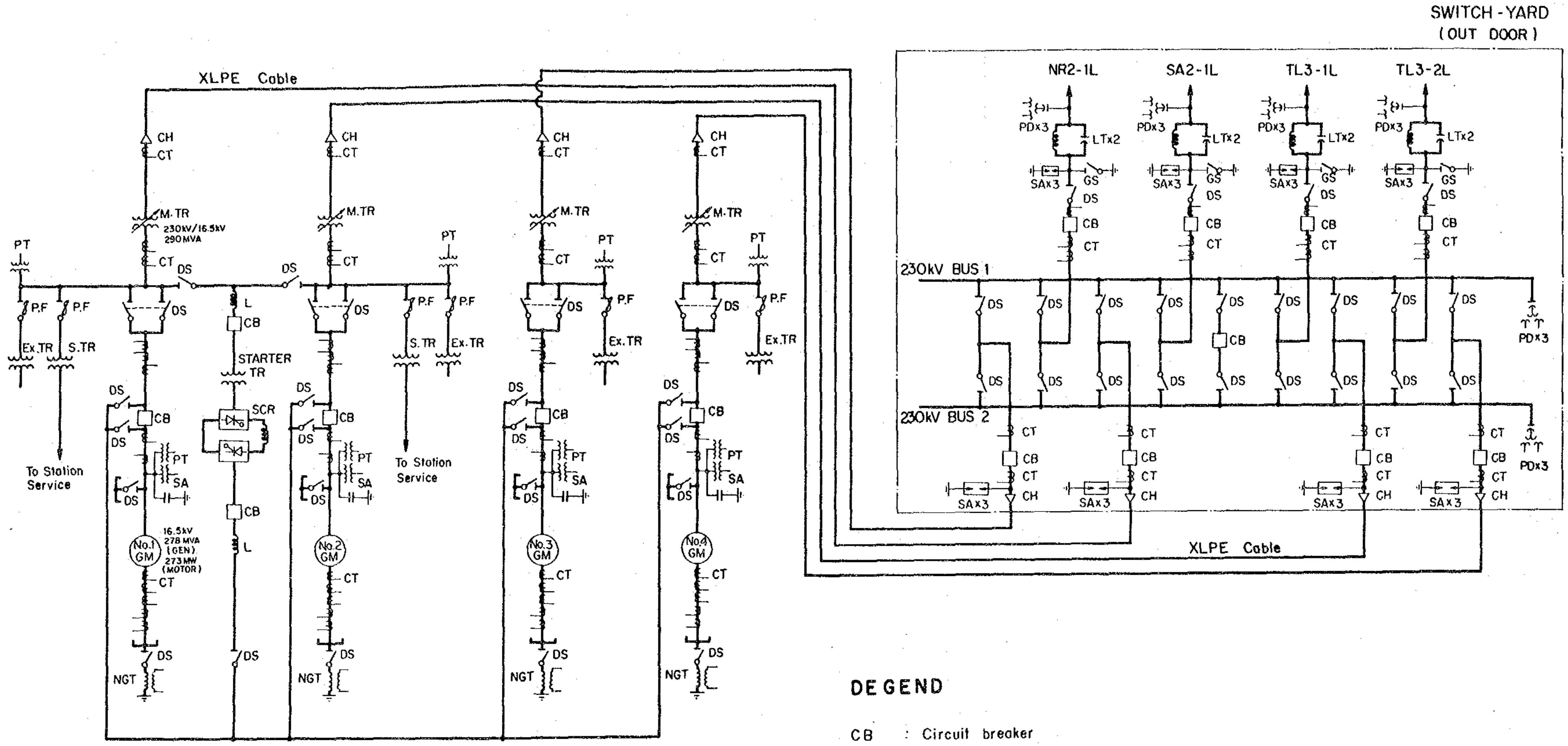
- In addition to the pony motor (revolving unit), the revolving speed controlling liquid resistor, slip rings, brushes, etc. are installed, which are disadvantage for proper maintenance. Reliability is also deteriorated.

- When compared with the thyrister starting method, the cost of this method is less.

(b) Thyrister starting method

- Installation space is wide, but the reliability is excellent, because all the components are stationary. Excellent maintenance can be made.

- Price is high, but unlike the pony motor method, this does not have to be installed for every unit (one set of starting system can be commonly used for more than 1 unit).



DEGEND

CB	:	Circuit breaker
DS	:	Disconnecting switch
GS	:	Grounding switch
PT	:	Potential transformer
PD	:	Coupling capacitor potential device
CT	:	Current transformer
M.TR	:	Main transformer
S.TR	:	Station service transformer
E.TR	:	Excitation transformer
NGT	:	Neutral grounding transformer
SA	:	Surge arrester
LT	:	Line trap
L	:	Reactor
SCR	:	SCR starter
P.F	:	Power fuse
CH	:	Cable head

LAM TA KHONG PUMPED STORAGE PROJECT

SINGLE LINE DIAGRAM

Fig. 12-1

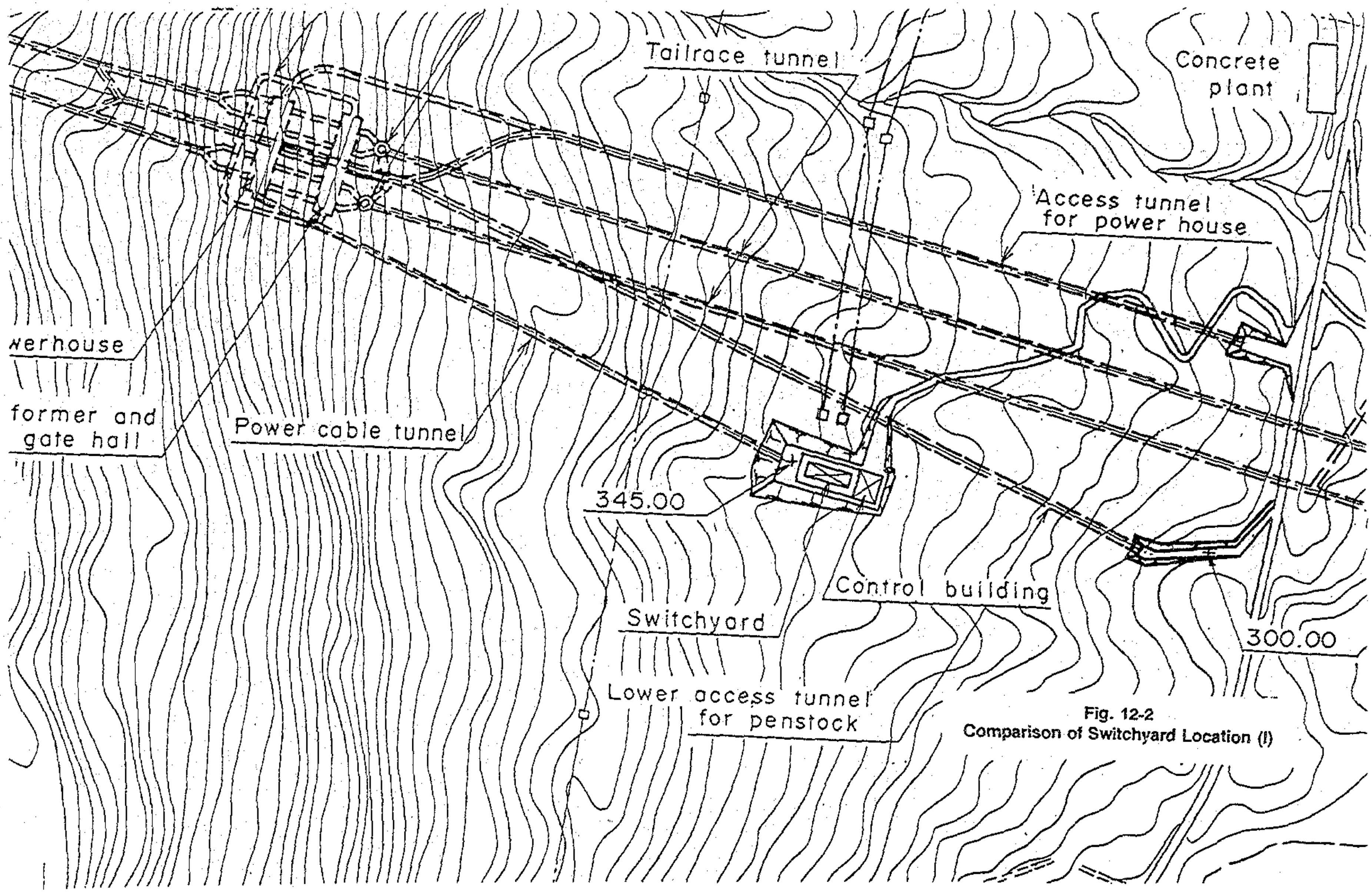


Fig. 12-2
Comparison of Switchyard Location (I)

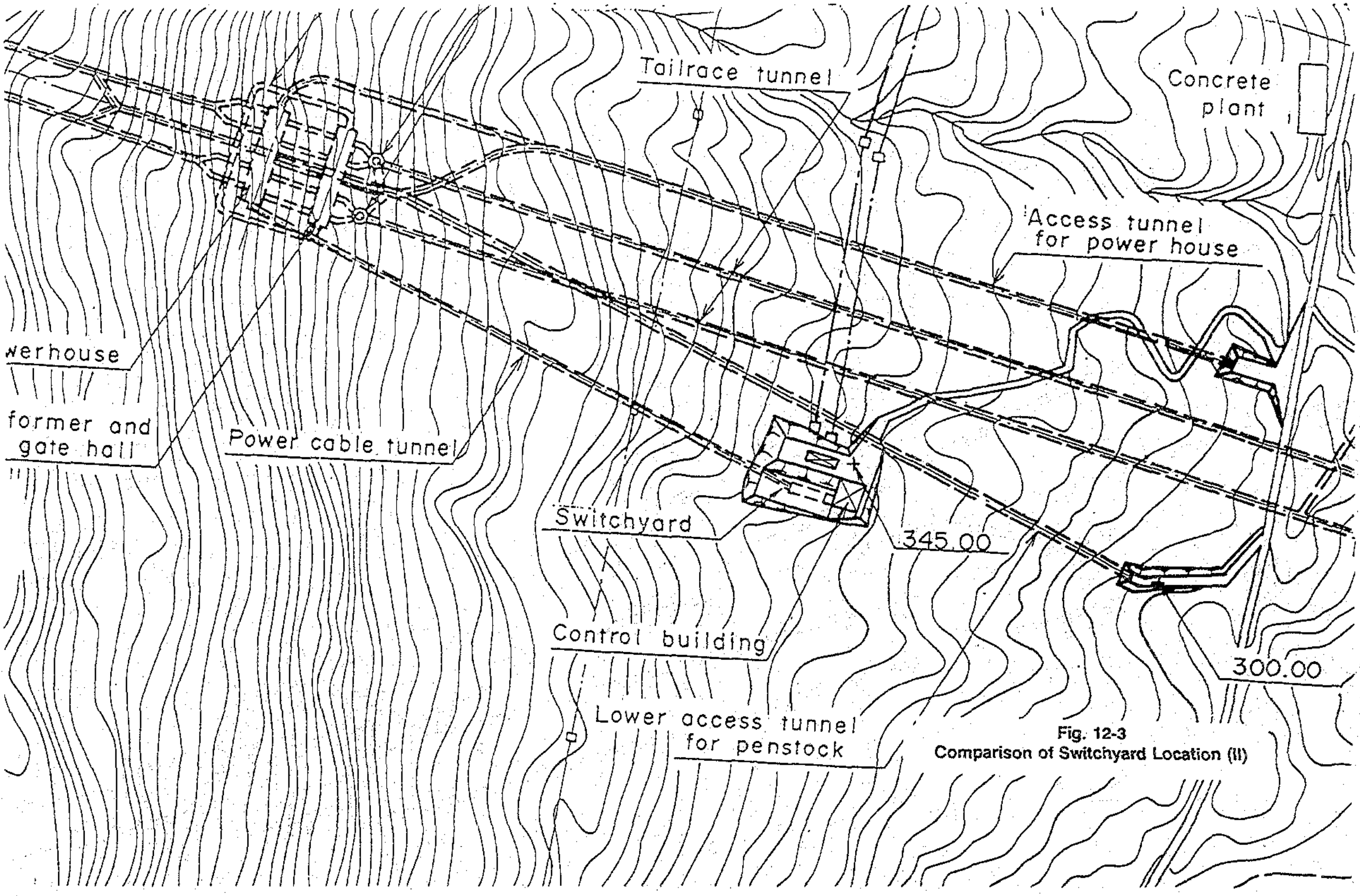


Fig. 12-3
Comparison of Switchyard Location (II)

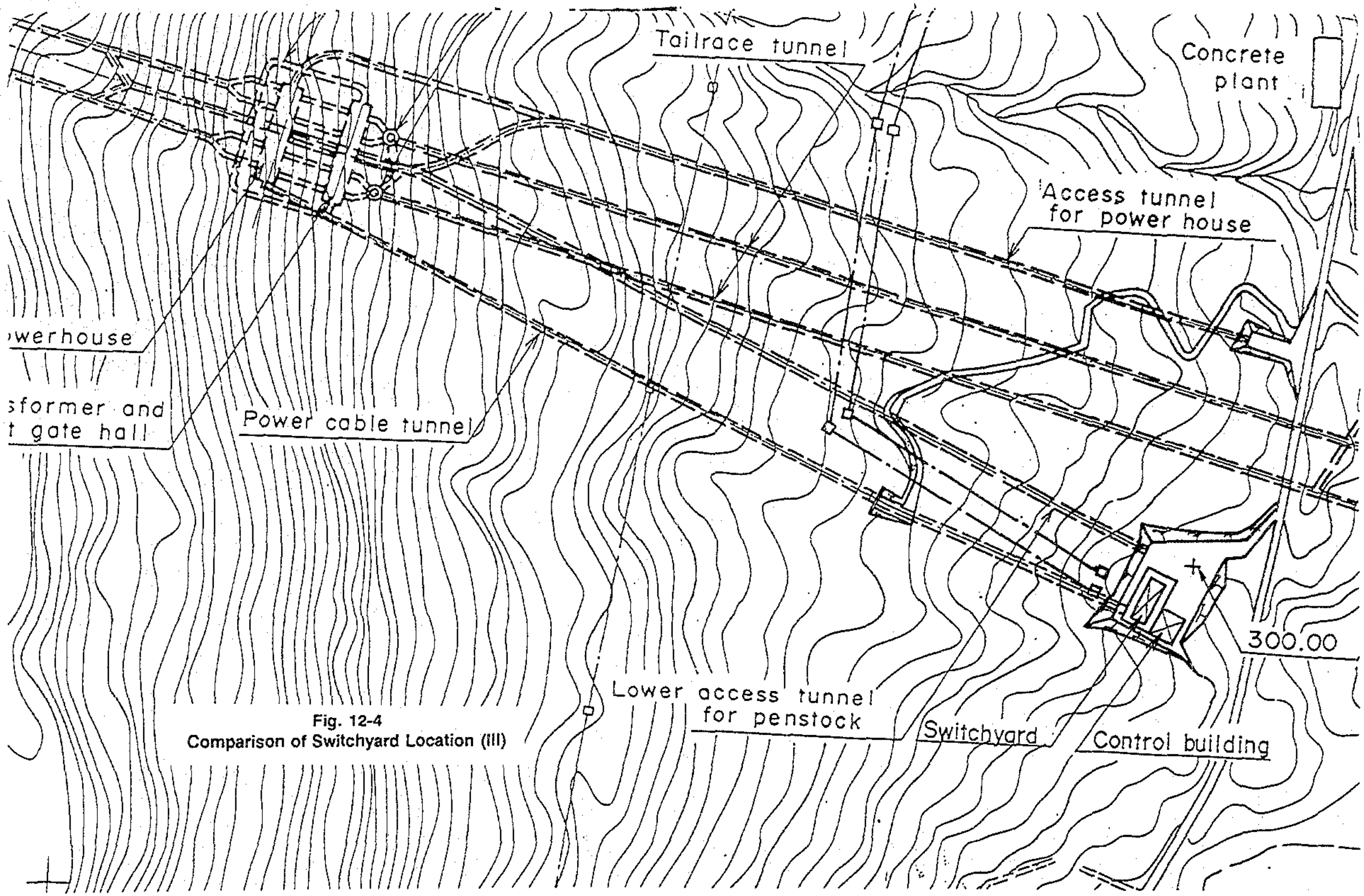
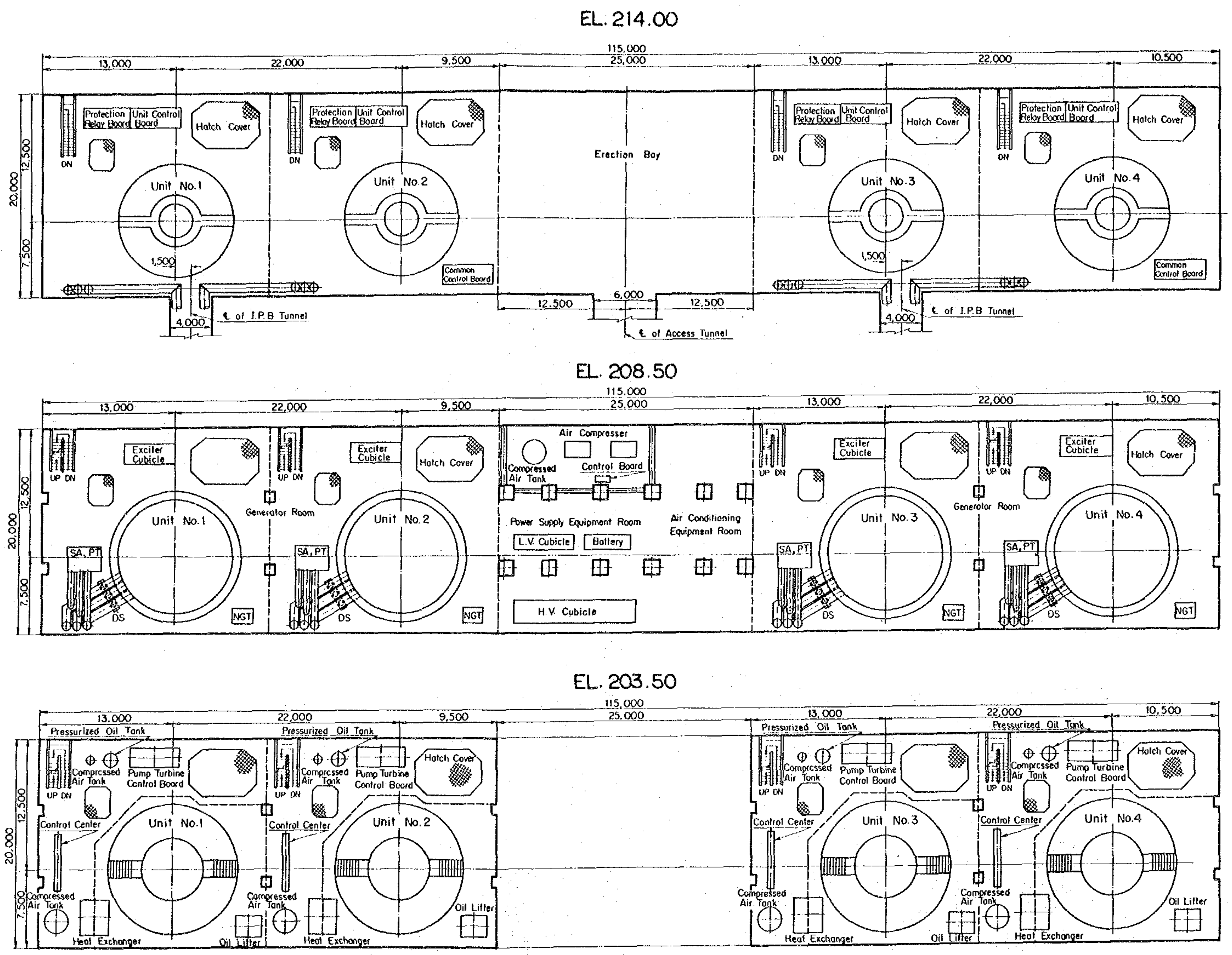


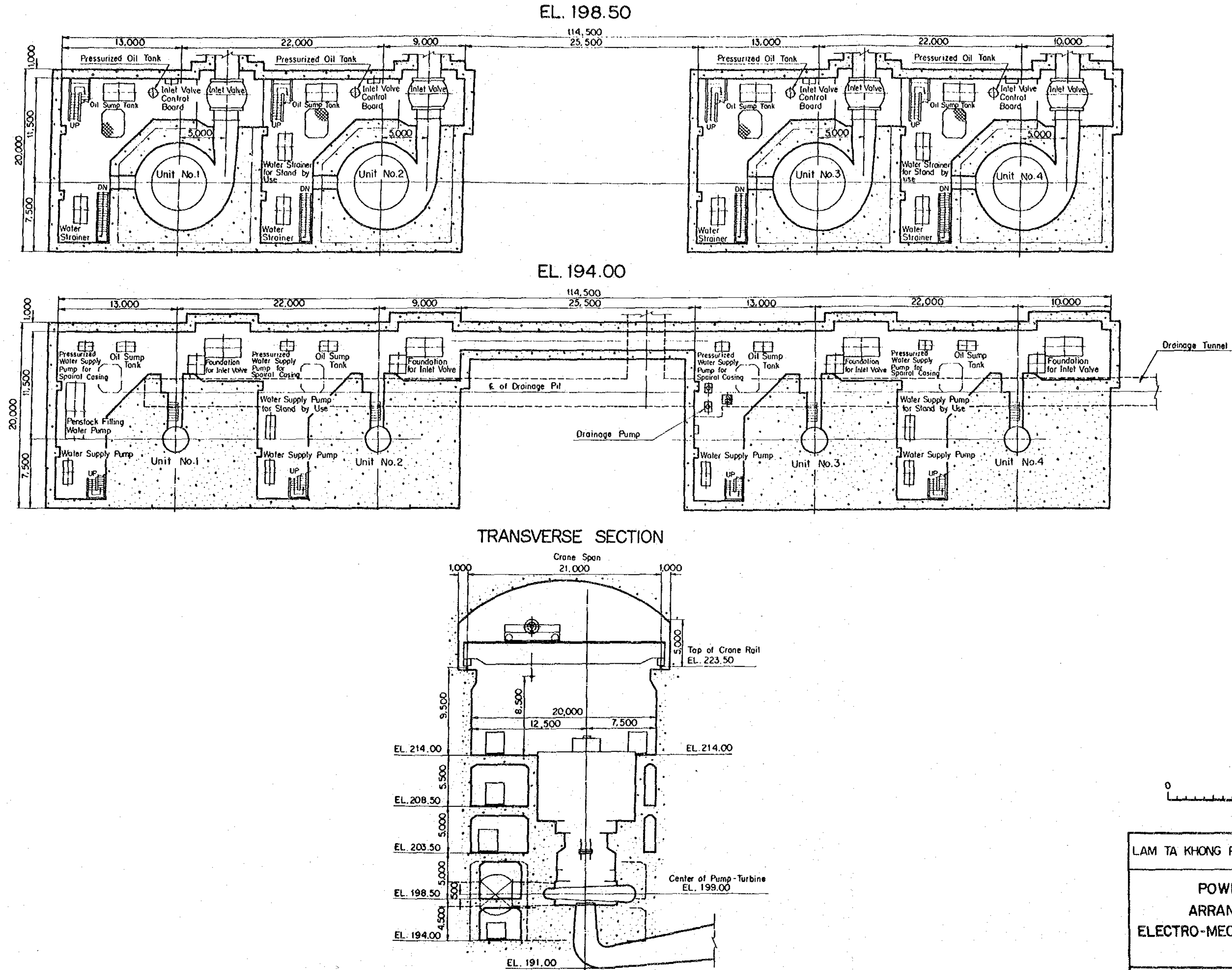
Fig. 12-4
Comparison of Switchyard Location (III)



LAM TA KHONG PUMPED STORAGE PROJECT

POWER HOUSE
ARRANGEMENT OF
ELECTRO-MECHANICAL EQUIPMENT
(1/2)

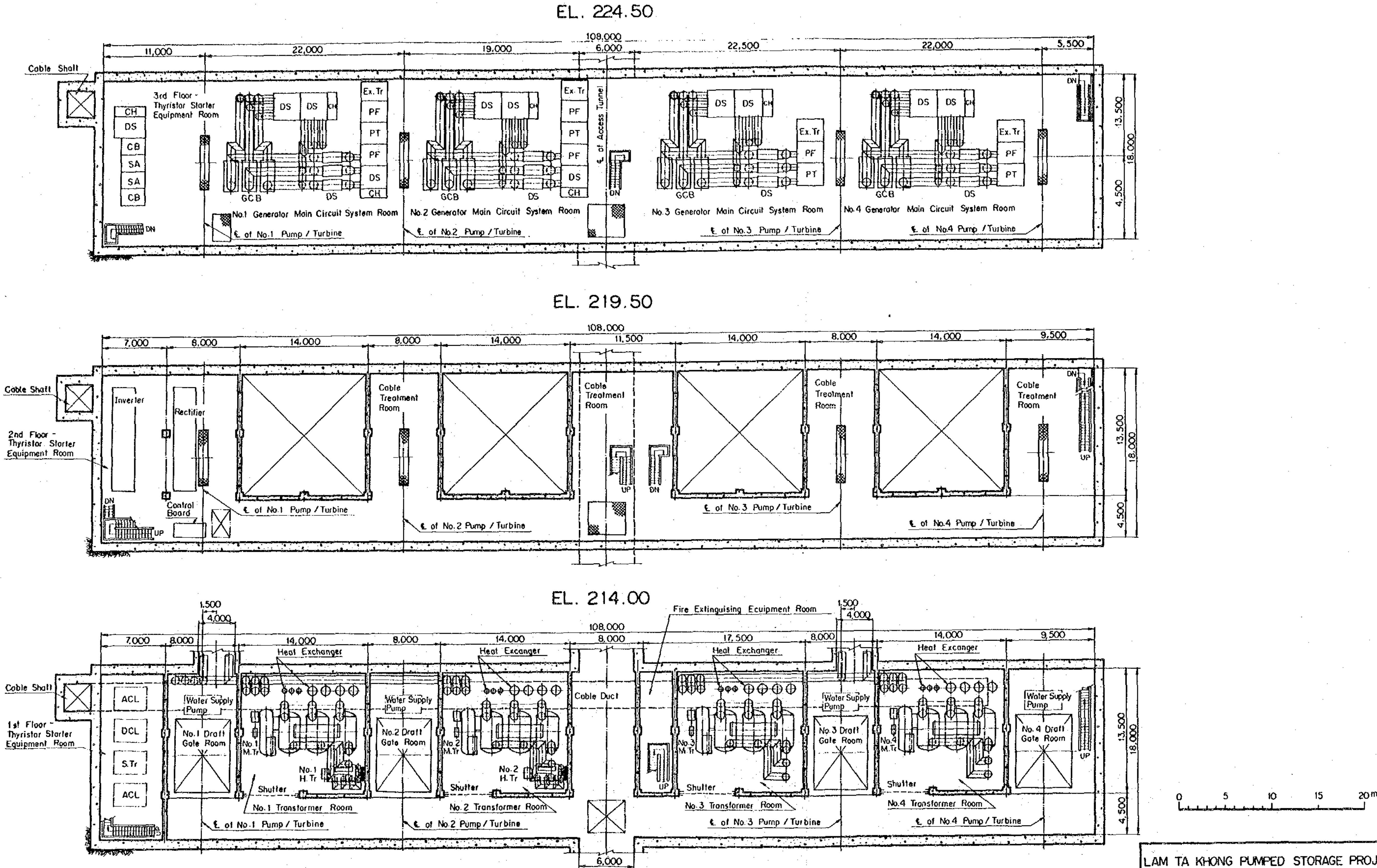
DWG. 12-7



LAM TA KHONG PUMPED STORAGE PROJECT

POWER HOUSE ARRANGEMENT OF ELECTRO-MECHANICAL EQUIPMENT (2/2)

DWG. 12-8

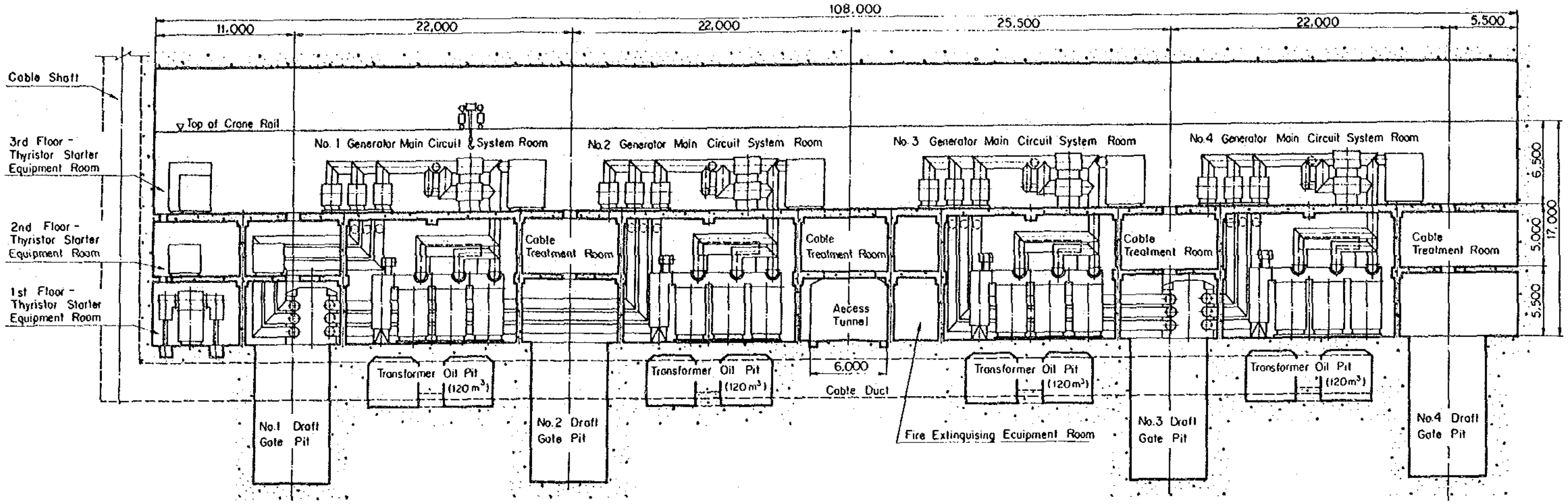


LAM TA KHONG PUMPED STORAGE PROJECT

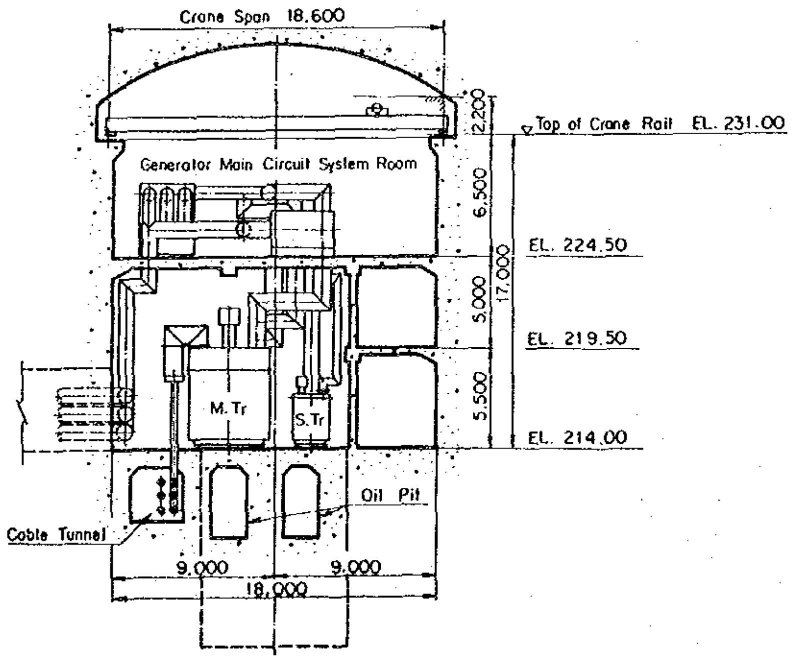
TRANSFORMER ROOM ARRANGEMENT OF ELECTRO-MECHANICAL EQUIPMENT (1/2)

DWG. 12-9

LONGITUDINAL SECTION



TRANSVERSE SECTION

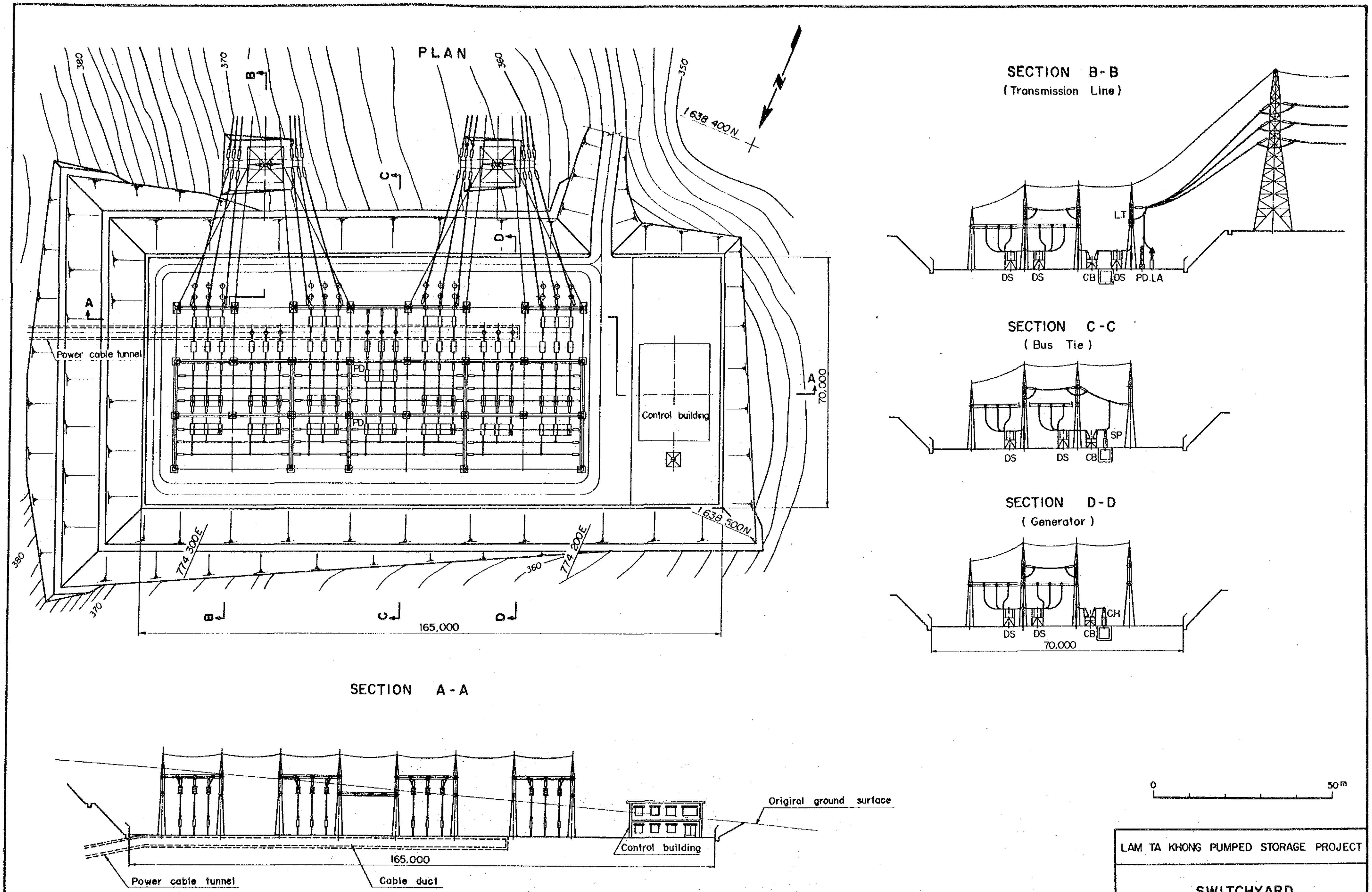


0 5 10 15 20 m

LAM TA KHONG PUMPED STORAGE PROJECT

TRANSFORMER ROOM ARRANGEMENT OF ELECTRO-MECHANICAL EQUIPMENT (2 / 2)

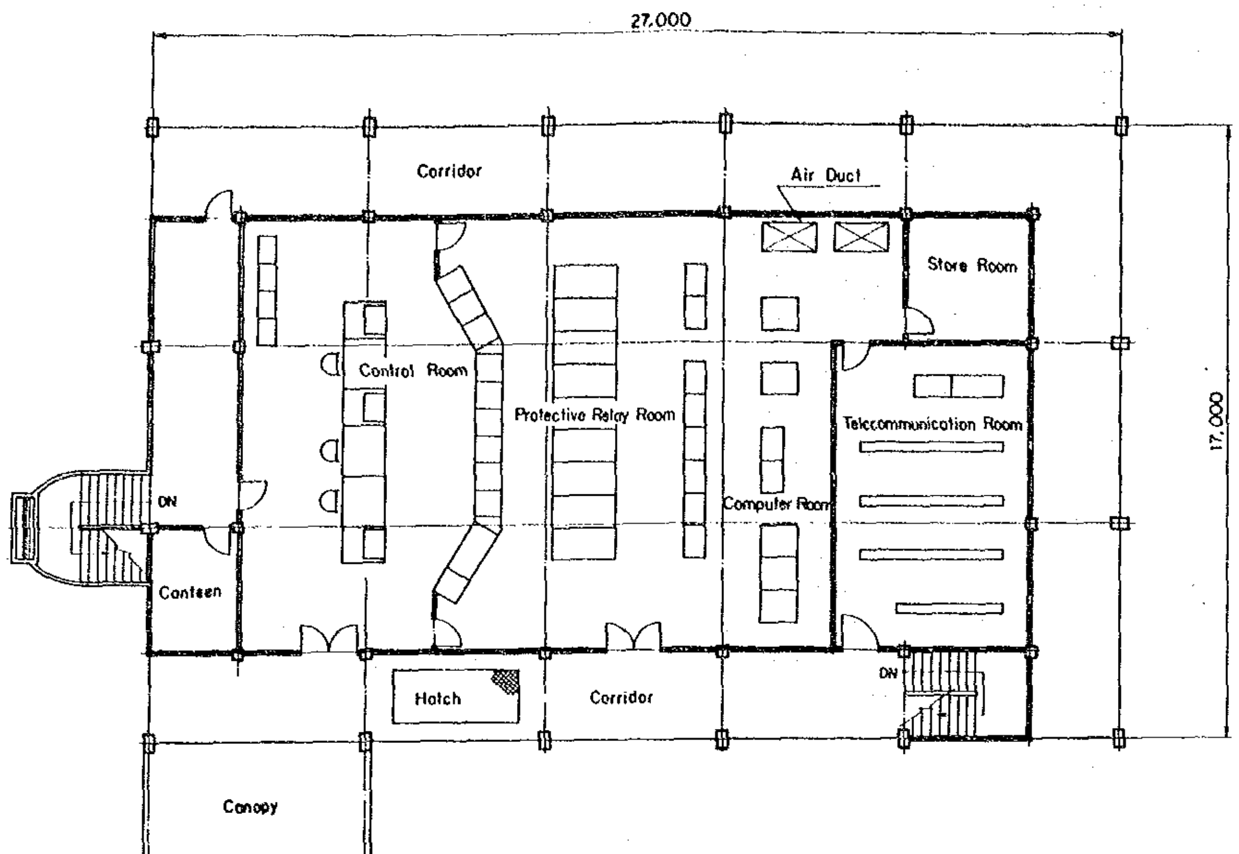
DWG. 12-10



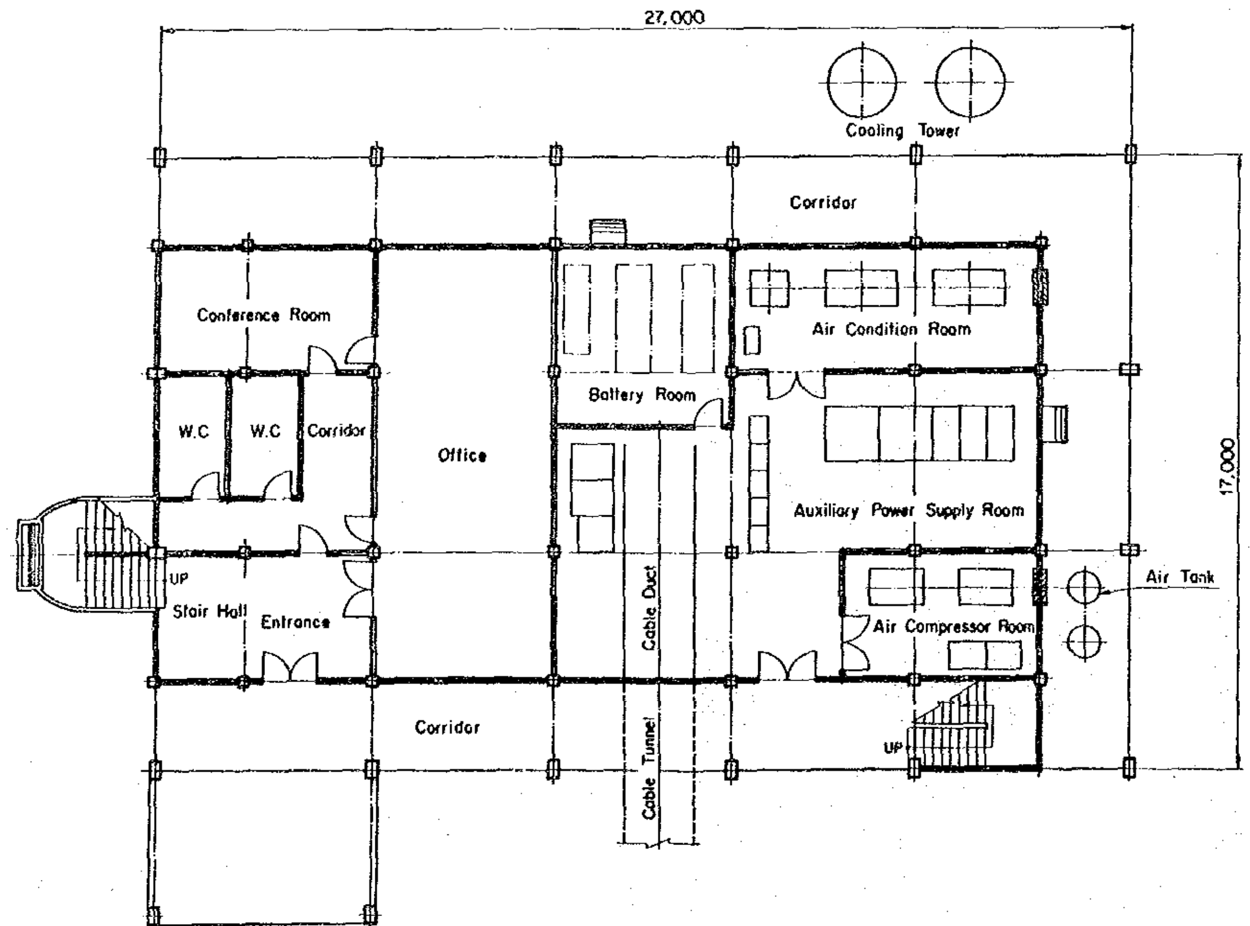
LAM TA KHONG PUMPED STORAGE PROJECT

SWITCHYARD
PLAN AND SECTION
(CONVENTIONAL TYPE)

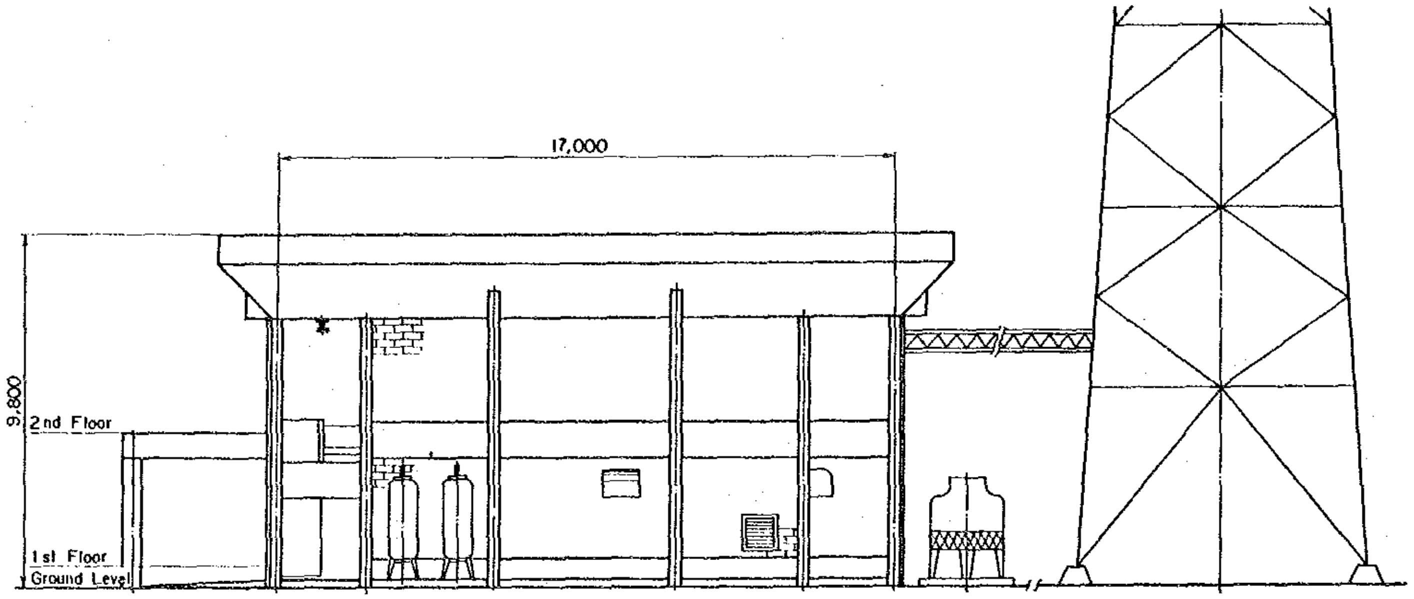
DWG. 12-11



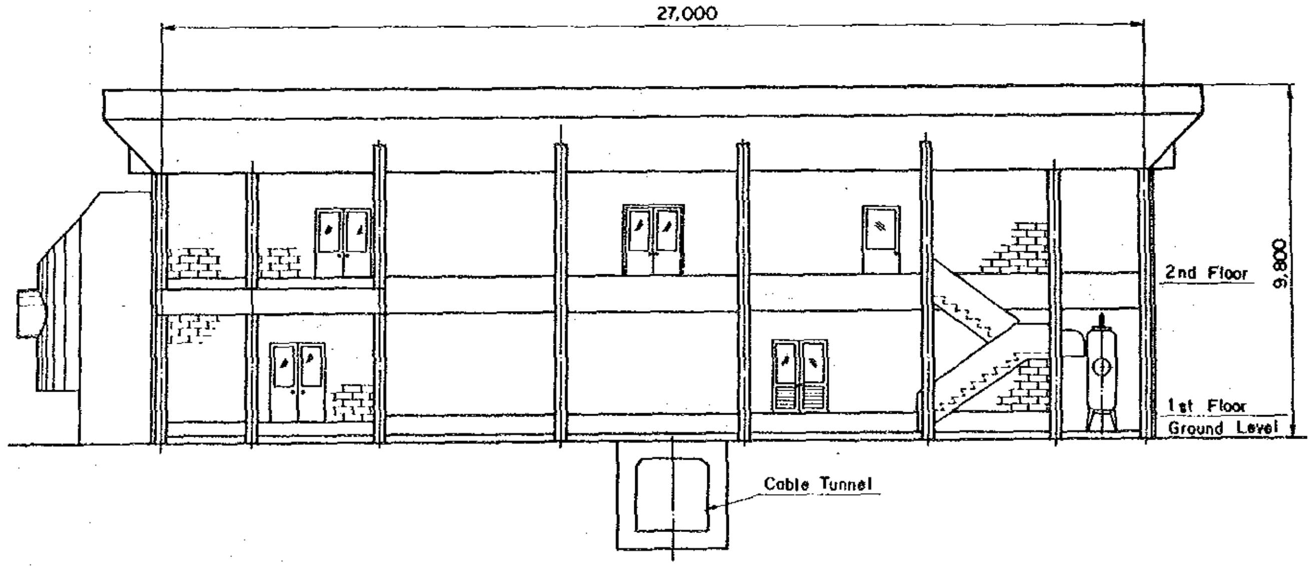
2nd FLOOR



1st FLOOR



SIDE VIEW



FRONT VIEW

LAM TA KHONG PUMPED STORAGE PROJECT
CONTROL BUILDING ARRANGEMENT OF ELECTRO-MECHANICAL EQUIPMENT
DWG. 12-12

12.5 Transmission Line

12.5.1 Transmission Line Plan

In the vicinity of this projected area, two 230 kV circuits (between Saraburi 2 substation and Nakong Rachasima 2 substation) and two 115 kV circuits (between Pakchon substation and Sikkiu substation) are installed.

A new substation named Thalan 3 is scheduled to be commissioned in 1993. The station is to be connected with Tha Tako substation and Saraburi 2 substation by means of 230 kV transmission lines.

The Lam Ta Khong power plant should be connected to the existing 230 kV transmission line (Saraburi 2 - Nakhon Ratchasima 2, double-circuit) by 1 π connection and the above new substation Thalan 3.

Therefore, two 230 kV double-circuit transmission lines are to be constructed, one is between Lam Ta Khong project site and the point where the existing 230 kV Saraburi 2 - Nakhon Ratchasima 2 line lies and the other is between the project site and Thalan 3 substation.

To avoid an area controlled under the environmental regulations, the new transmission lines have to be installed from the plant southward about ten kilometers along Route 2.

One transmission lien is to turn the direction eastward to be connected to the existing transmission line above mentioned. The total length of the newly constructed line is approximately 15 km.

The other transmission line is to be constructed in parallel with the route of the existing 115 kV line between Saraburi 2 and Nakhon Ratchasima 2 and the route of the 230 kV line which is to lie between Saraburi 2 and Thalan 3. The total length of the line constructed is approximately 95 km.

Towers for the transmission lines to be newly constructed shall be standard transmission towers for 230 kV double-circuit transmission lines of EGAT.

12.5.2 Basic Requirement

The following matters should be taken into consideration when studying the transmission line for this project:

(1) The voltage of line should be 230 kV.

(2) Standard double-circuit steel tower is used.

(3) The conductor used shall be ACSR 1272 MCM which is consistent with the standard of existing transmission lines of EGAT.

Thermal capacity of one circuit of the transmission line is as follows:

1078A, 429 MVA (at 230 kV)

Conditions:	Maximum cable temperature	75°C
	Wind velocity	2.2 km/hr
	Ambient temperature	35°C
	Intensity of solar radiation	0.06 W/cm^2

(4) Follow the standard specifications of EGAT.

12.5.3 Transmission Line Route

Two double-current transmission lines shall go southward about ten kilometers along the national road from the location of this project. One of the lines shall turn the direction to east crossing the existing 115 kV transmission line and connect to the existing 230 kV transmission line.

The other shall go in parallel with the existing 115 kV transmission line to Thalan 3 substation which is about 15 km to the northwest of Saraburi city.

Since it is possible to install the transmission line along the national road over almost entire length between the site of the project and Thalan 3 substation, material needed for transmission line construction will be able to be easily transported.

The land for transmission line will be able to be acquired with little trouble, because there are not many houses around the probable routes for the transmission lines.

The area stretching 2 km from Lam Ta Khong switch yard toward south along the Route 2 will be rather difficult area in construction work of the line, because this 2 km zone is located very close to the environment control area and the distance between towers, that is, the distance between the parallel two lines will be restricted. Therefore, when deciding the position of each tower, the geological survey of the foundation of tower should be carefully carried out to ensure the optimum positioning.

There is a hilly area over 500 m high on the route of the proposed transmission line between the site of the project and Saraburi city, but the construction work, including transportation of materials, can be done without much trouble, because national Road No. 2 is running across this area.

Fig. 12-5 shows the standard cross section of a 230 kV double-circuit steel tower. Fig. 12-6 shows the plan of transmission lines for the project.

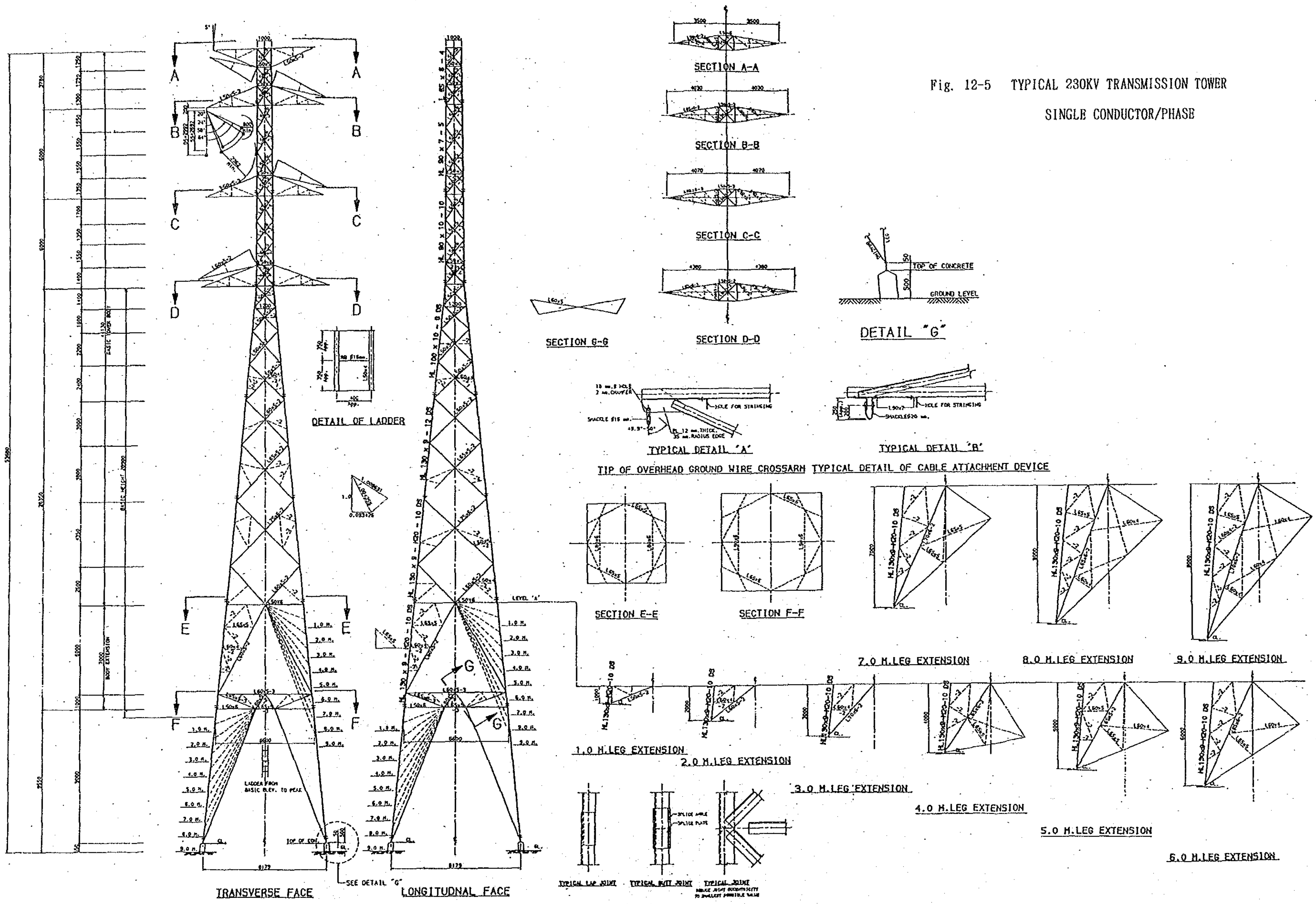
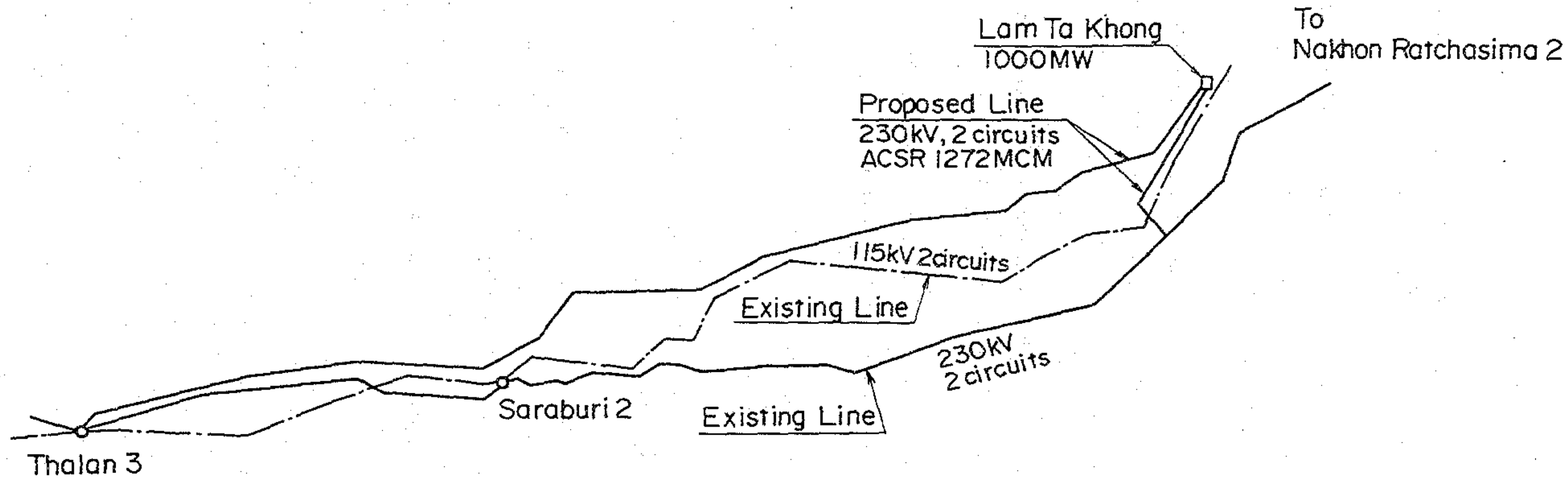


Fig. 12-5 TYPICAL 230KV TRANSMISSION TOWER

SINGLE CONDUCTOR/PHASE

Fig. 12-6 Plan of Transmission Lines for the Lam Ta Khong Power Plant



12.6 Communication Facilities

Communication facilities are designed in such a way that they properly conform to the existing EGAT method.

(1) Microwave circuit is newly installed between this project area and EGAT's headquarter dispatching center and to both Saraburi 2, Nakong Rachasima 2 substations.

A total microwave repeater stations are at 5 stations for the circuit for headquarter, and each 2 stations for both Saraburi 2, Nakong Rachasima 2 substation.

(2) The microwave is the main means of communication, but the power line carrier system is used as the back-up.

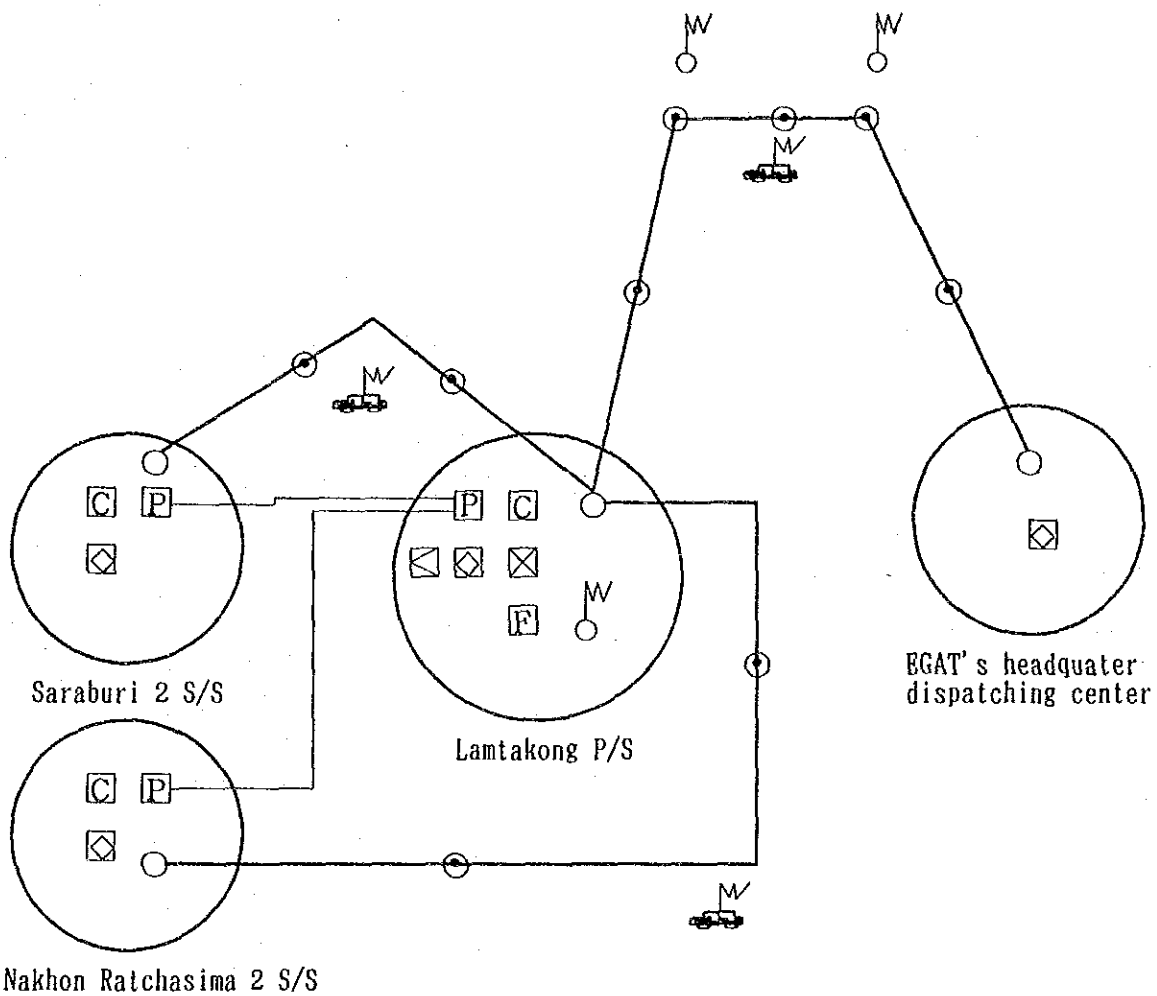
(3) For the power line protection system, both power line carrier method and microwave method are used together.

(4) Pulse radar system is used for the fault locating system of transmission line.

(5) Telephone switchboard and paging system are installed at Lamtakong control building.

(6) Mobile station is provided for power line maintenance and it's base station is established at the micro relay stations and Lamtakong control building.

Fig. 12-7 shows an outline of communication facilities.



LEGEND

- ○——○ 2 GHz Microwave Radio Link
- —⊙— 2 GHz Microwave Radio Link Repeator Station
- [P]—[P] Power Line Carrier System
- [C] Power Line Carrier Teleprotection Signalling Equipment
- [⊠] Private Automatic Telephone Exchange
- [◇] Data Transnmission Equipment
- [◁] Paging System
- [F] Line Fault Locator
- VHF Communication System. Base Station
- VHF Communication System. Mobile Station

Fig.12-7 TELECOMMUNICATION SYSTEM

CHAPTER 13

CONSTRUCTION PLANNING & COST ESTIAMTE

CHAPTER 13 CONSTRUCTION PLANNING AND COST ESTIMATE

CONTENTS

List of Tables and Figures

CHAPTER 13 CONSTRUCTION PLANNING AND COST ESTIMATE

13.1 Construction Planning and Construction Schedule

13.1.1 Basic Conditions

(1) Hydrology

Hydrological conditions for the project are described in Chapter 6. The construction schedule was prepared considering these hydrological conditions. The rainy season period which affects the construction schedule is generally 6 months from May to October.

(2) Transportation

It is possible to use National Highway of Route 1 and 2 for the access road to the project site, and the access road to the upper reservoir site constructed by EGAT branches from the Route 2.

(3) Construction Materials

- Cement

Cement is to be supplied by the cement mill at Saraburi, about 80 km away from the project site.

- Reinforcement Bars, Steel Materials and Other Construction Materials

Principal construction materials such as reinforcement bars, steel materials, explosives and so on are supplied from Bangkok, about 160 km away from the project site.

- Concrete Aggregates

Concrete aggregates are manufactured from quarries in the vicinity of the project site and/or purchased from the existing aggregate plant 25 km away from the project site.

- Embankment Materials

The excavation debris from the upper reservoir and/or quarries in the vicinity of the upper reservoir are to be used for rock materials of the upper reservoir embankment. The transition material is supplied in the same way as concrete aggregate.

- Site Electricity

The temporary electricity during construction is to be supplied by receiving the 115 kV transmission line passing through in the vicinity of the project site.

13.1.2 Construction Planning and Construction Schedule

The construction schedule was formulated based on the abovementioned basic conditions and work quantities. The construction schedule is shown in Fig. 13-1.

(1) Preliminary Works

As preliminary works, access roads to the upper reservoir and various tunnel portals, temporary facilities (concrete plant facilities, aggregate plant facilities, asphalt concrete manufacturing facilities, temporary power supply facilities), camp and office facilities are to be constructed. (See Dwg. 12-5 for the Temporary Works Program.)
Concrete and aggregate plant facilities are to be provided at two locations, in the vicinities of the upper reservoir site and the tailrace work adit.

(2) Upper Reservoir

After completion of temporary works around the upper reservoir, excavation and rock embankment works are to be started from the second year. Part of the excavation muck is to be utilized as rock embankment material, with the remainder disposed of at a spoil area adjacent to the upper reservoir at its east side. Rock embankment material, other than the diverted excavation muck, is to be obtained from a quarry at a hill area south of the upper reservoir site. Transition material, besides what is diverted from excavation muck, is to be collected from the aggregate quarry and manufactured, or is to be purchased from an existing aggregate plant. The asphalt concrete manufacturing plant is to be provided adjacent to the upper reservoir site at the north side. The asphalt facing work is to be started in the third year and completed in the fourth year after requiring 15 months.

(3) Intake

Excavation of the vertical shaft of the intake is to be commenced in the third year after excavation work of the upper reservoir has reached the intake bed height. The vertical shaft excavation muck is to be disposed of in the spoil area adjacent to the upper reservoir at the east side. Assembly and installation of liner pipe and placing of filling concrete are to be done after completing excavation of the vertical shaft. After completion of filling concrete placement, bed concrete around the intake and concrete of the intake proper are to be placed, and the intake screen is to be installed in the end.

(4) Penstock

Excavation of the upper (800 m) and the lower (1,200 m) access tunnels for penstocks is to be started from the second year. The upper access tunnel is to be also utilized as a work adit for hauling out excavation muck from the upper horizontal penstock portion. The lower access tunnel is to pass the upper part of the vertical surge chamber shaft of the tailrace, connect to the middle horizontal penstock portion, and be also utilized as a work adit for hauling out excavation muck of the middle horizontal penstock portion and the middle inclined portion. The powerhouse drainage tunnel and powerhouse access tunnel are to be also utilized as work adits for hauling out excavation muck of the lower inclined portion.

Installation of penstock pipe is to be done from the third year divided into an upper penstock and a lower penstock with the middle horizontal portion as the boundary and these two parts are to be worked on simultaneously. Temporary field workshops for penstock pipe are to be provided at two places, the south side of the upper reservoir site and the spoil area site south of the outlet. Penstock pipes are to be hauled from the workshops to the portals of the upper and the lower access tunnels by trailer trucks. Installation of penstock pipe and placement of filling concrete are to be done in parallel, and these are to be completed at the end of the fourth year going by a schedule of 15 months.

(5) Tailrace

The work adit for tailrace tunnel excavation is to be of a length of approximately 700 m with its portal adjacent to National Highway No. 2. Excavation of the work adit is to be started from the first year, with excavation muck disposed of at a spoil area at the west side of National Highway No. 2. Excavation work of tailrace tunnel is to be started from the second year after completing excavation of the work adit. Tunnel excavation of approximately 300 m on the downstream tailrace side is to be done at the beginning, followed by tunnel excavation on the upstream powerhouse side. Excavation muck is to be hauled out through the work adit and disposed of at the spoil area on the west side of National Highway No. 2.

Excavation of the vertical shaft of the tailrace gate chamber is to be commenced from the second year, and the tailrace gate is to be installed so that the upstream-side works for the powerhouse and tailrace tunnel will not be hindered by floods.

For the outlet works, a cofferdam is to be built in the dry season of the second year with an embankment of earth and steel sheet piles, and concrete structure is to be constructed.

(6) Powerhouse

Excavation of the powerhouse access tunnel and the power cable tunnel is to be started in the second year. The power cable tunnel (700 m, gradient 20%) is to connect to the arch portions of the underground powerhouse and transformer hall and is to be utilized as a work adit for hauling out muck from arch excavation of the powerhouse and transformer hall. The excavation muck is to be disposed of in the the spoil area at the west side of National Highway No. 2. The arch portions, after providing temporary support with shotcrete and rock bolts immediately upon excavation, are to have arch concrete placed as early as possible. It will be a 7-month work schedule from the start of excavation of the arch drift heading to completion of arch concrete placement.

The construction of the powerhouse proper is to be done in cycles of bench-cut excavation, primary shotcrete placement, rock bolt installation, secondary shotcrete placement, and prestressed anchor installation - drilling holes, inserting rods, and tensioning. For stability of the cavern, provision of supports is to be completed as soon as possible after excavation. For hauling out excavation muck, the power cable tunnel, the powerhouse access tunnel, and powerhouse drainage tunnel are to be utilized in successive order in step with cutting down of the bottom level of the powerhouse. The order of construction of the powerhouse and surroundings is shown in Fig. 13-2.

Side wall concrete is to be placed from the bottom on providing a temporary overhead travelling crane after the excavation the powerhouse cavern has reached the level of the turbine hall.

Assembly and installation of the overhead travelling crane will be started at the assembly hall. Installation of turbines and generators is to be done using this overhead travelling crane.

(7) Turbines and Generators

Installation of draft tubes is to be done from the end of the third year using a temporary overhead travelling crane for civil works. Subsequently, assembly and installation of turbines and generators will be done from the fourth year using the overhead travelling crane for electrical equipment installation. After completion of installation, water is to be impounded in the upper reservoir and wet tests performed, and Unit No. 1 ~ No. 4 is to start operation in 1997 successively.

(8) Transmission Line

Construction of the new 230 kV transmission line (2 cct, ℓ = 15 km) between the Lam Ta Khong Power Station and the existing 230-kV transmission line and of the new 230 kV transmission line (2 cct, ℓ = 95 km) between the Lam Ta Khong Power Station and the existing Thalan 3 substation, and installation of line-equipment for 230 kV - 2 cct at the Thalan 3 substation are to be started from the third year with the work completed at the end of the fourth year.

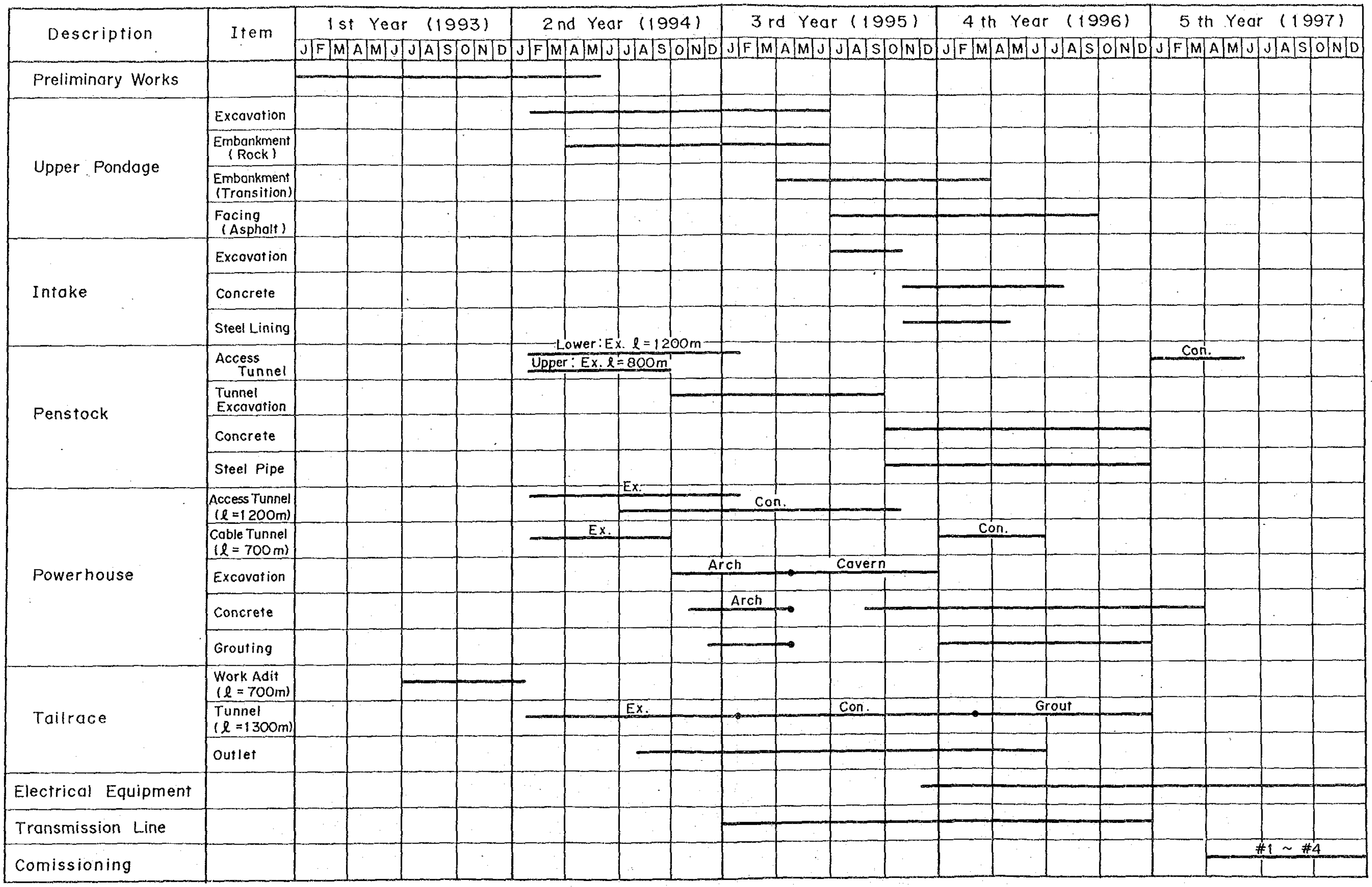


Fig. 13-1 Construction Schedule of Lam Ta Khong Project

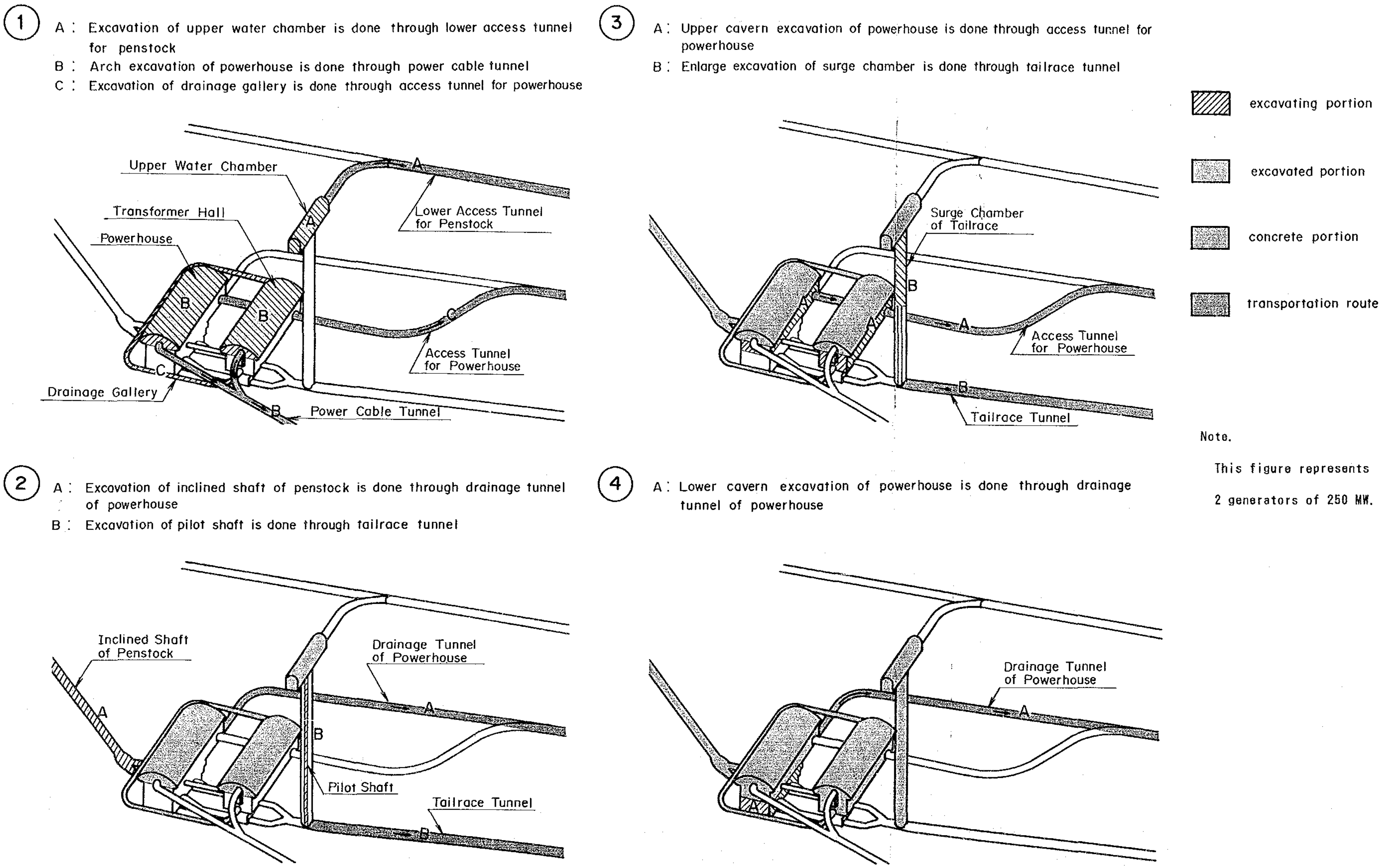


Fig. 13-2 Construction Procedure Surrounding Powerhouse