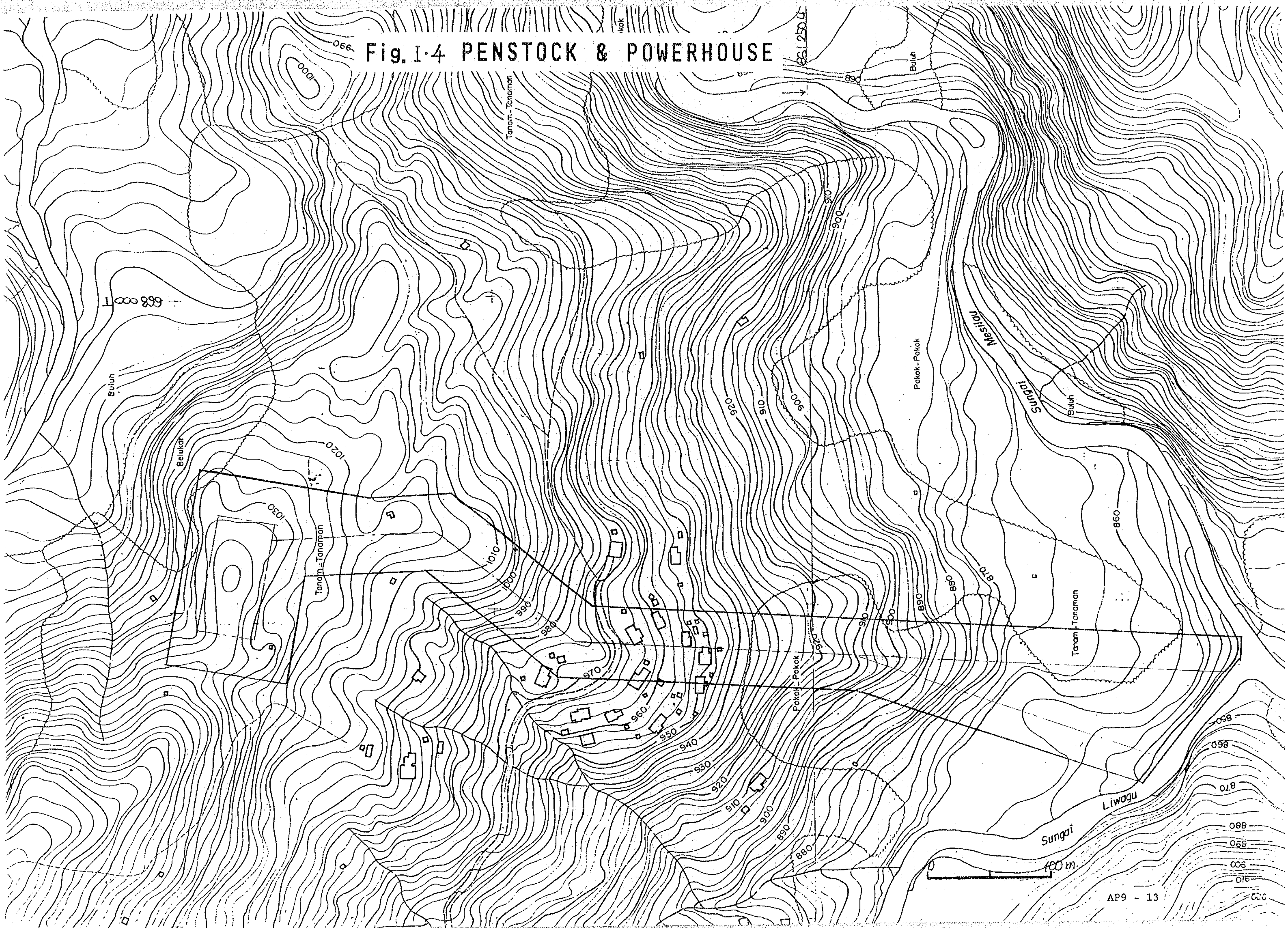
Fig. I·4 PENSTOCK & POWERHOUSE



II. GEOLOGICAL INVESTIGATION

II.1 Core Drilling with Permeability Test and Standard Penetration Test (SPT)

1. General

The Specification shall be applicable to the Core Drilling with Permeability Test and Standard Penetration Test (SPT) to be performed in order to obtain data necessary for the preliminary design of the Feasibility Study of the Small Scale Hydroelectric Power Development Project at Upper Liwagu River Basin in Sabah, Malaysia.

2. Objective and Scope of Work

This Work shall be executed to investigate and confirm the geologic condition of the site and to make various accompanying measurements.

3. Location of Drillholes

The locations of drillholes are as indicated in the attached drawings (see Fig. II.1.1(a) ~ II.1.1(d)), and the detailed locations shall be indicated by the Engineer in the field before the commencement of the work.

4. Type of Work and Work Quantity

The type and quantity of the Work shall be as given in the table below. However, the work quantity may be partially changed after execution of the contract depending on circumstances in the field and other reasons.

4.1 Type of Drilling

The types of drilling shall be classified as indicated in the table below.

Type	Classification
A	Drilling in topsoil and talus layer, gravel layer, weathered bedrock surface layer (final size of hole shall be NX)
B	Drilling in rock (final size of hole shall be NX)

4.2 Work Quantity

Work quantities shall be as indicated in the Table 1.

5. Period of Work

5.1 Period

Start ____________, 19__

Completion ____________, 19__

Completion shall be on the date when the Engineer finishes acceptance of the results of the Work by the Contractor.

5.2 Work Schedule

The Contractor, immediately after execution of the contract, shall submit to the Engineer his work schedule (2 copies) and obtain the approval of the Engineer. In the event after start of the Work delay is produced compared with the work schedule previously approved by the Engineer, the reason shall be explained and a modified work schedule shall be submitted to the Engineer for approval.

6. Daily Work Report

The Contractor shall record the condition of work in a daily report (2 copies) of the format directed by the Engineer, and shall dispatch or deliver the report to the place of the Engineer's designation. The daily report, in addition to the major items according to Chapter 9, shall record in as much detail as possible matters regarding drilling.

7. Safety Supervision

The Contractor, in executing the Work, shall prevent occurrence of accidents throughout, providing necessary safety facilities in accordance with related laws and regulations.

Provision and administration of these safety facilities shall all be the responsibility of the Contractor.

8. Equipment Used

Equipment used for the drillings, permeability tests and the Standard Penetration Test (SPT) shall be of the types or capacities as follows:

8.1 Drilling Machine and its Accessories

Oil-hydraulic high-speed drilling machine capable of drilling to the depth indicated in Table 1, with accessories including core barrel, bit, drill rods, casing pipes, etc. suitable for obtaining maximum core recovery.

8.2 Pump

Discharge capacity of not less than 150 ℓ/min at pressure of 10 kg/cm^2 and with little pulsation in discharging pressure and discharging water.

8.3 Pressure Gauge for Water Supply

Graduation of gauge not more than 0.5 kg/cm^2.

8.4 Flowmeter

An integrating flowmeter of not more than 1 ℓ/min graduation.

8.5 Packer

In principle, extension (mechanical) packers are to be used and air packers shall be used according to rock condition.

8.6 Measuring Instrument for Water Level

The instrument shall be capable of measuring the depth in the borehole with reading accuracy within 1 cm.

8.7 Split-Barrel Sakpler

The sampler for the Standard Penetration Test shall be constructed with the dimensions indicated in Fig. II.1.2.

8.8 Hammer and Knocking Head

The hammer shall weigh 63.5 ±1 kfg and shall be a solid rigid metallic mass. The hammer shall strike the knocking head and make steel on steel contact when it is dropped. A hammer fall guide, which allows free falls, shall be used.

8.9 Hammer Drop System

Rope-cathead, trip, semiautomatic, or automatic hammer drop systems may be used, providing the lifting apparatus will not cause penetration of the sampler while re-engaging and lifting the hammer.

9. Drilling

9.1 Surveying of Drillhole Locations and Installation of Machines

(1) The Contractor shall provide survey control points at drillhole locations in accordance with the directions of the Engineer.

(2) Surveying of drillhole locations shall be done by the Contractor from survey control points according o the method approved by the Engineer. The survey results shall be submitted to the Engineer.

9.2 Prevention against collapse of drillholes shall be taken by using the casing pipe or by cementation where such collapse is anticipated.

9.3 Drilling and Records

9.3.1 In the drilling operation, the types of bit and core barrel used shall be selected in accordance with the rock condition, and maximum effort shall be exerted for 100% core recovery without disturbing the original condition of the rock strata through adjustment of bit pressure, drilling speed, water supply quantity, and the like.

9.3.2 Various data and conditions regarding the drilling shall be accurately recorded in a field book and transferred on an approved daily report specified in Fig. II.1.3. Two copies of the report shall be submitted to the Engineer.

(1) Water springing and leakage

In the event of occurrence of water springing or leakage during drilling the quantity (unit: ℓ/min) and the elevation of rising water level or falling water level (unit: cm) shall be measured.

(2) Temperature measurement

When especially directed by the Engineer the temperature inside the hole shall be measured.

(3) Time of advance (unit: min)

Time shall be entered accurately in units of minutes.

(4) Length of advance (unit: cm)

(5) Color of drainage water and color of rock

(6) Geologic name

(7) Quantity of water pumped (unit: ℓ/min)

(8) Quantity of water discharged (unit: ℓ/min)

(9) Crown (type, No., rpm, applied pressure)

(10) Geologic symbol

(11) Diameter of drillhole

(12) Names of machinery used

(13) Oils and fats, fuel, expendables, etc.

(14) Name of person in charge

(15) Others

9.3.3 When it is evident that poor core recovery is due to poor workmanship of the Contractor or when entries in the daily report are incorrect, the Engineer may require the Contractor to perform redrilling at the Contractor's expense.

9.3.4 Records of the drilling shall be written with C.G.S. units.

9.3.5 RQD (Rock Quality Designation): For each section of 1 meter, a piece of core 10 cm or longer shall be measured and indicated as a percentage in the drilling log of the prescribed form.

9.4 Arrangement of Cores and Delivery

9.4.1 The length of a core recovered from each drilling operation shall be measured in terms of net length in the condition as it is in the core barrel.

9.4.2 The core shall be directly transferred and deposited in the corresponding section in a core box.

9.4.3 The following measures shall be taken for a section where core recovery is not possible.

(1) When collection of slime is possible, the slime shall be put in a vinyl bag and the bag shall be placed in the corresponding section of the core box.

(2) Suitable means shall be provided in the core box to prevent sliding of the adjacent core into the next section.

9.4.4 The core box shall be of inside length of 1 m with 5 or 10 rows to a box.

9.4.5 The outer surface of each core box shall be inscribed with the name of the site, hole number and box number, while the inner surface shall be marked for every 10 cm of depth.

9.4.6 Cores placed in boxes shall be stored at the place designated by the Engineer.

9.5 Drilling Log

The Contractor shall prepare a drilling log based not only upon core inspection results, but also conditions observed during drilling. The log shall be in the form approved by the Engineer.

9.6 Core Photographs

Coloured photographs of cores arranged in each core box shall be taken. The photographs shall be taken in a bright location but shielded from direct rays of the sun. Surfaces of dried cores shall be wetted with water. The size of a photograph shall be approximately 11 cm X 8 cm.

9.7 Measurement of Water Level in Hole

The water level in the hole shall be measured in cm every day before and after work and recorded in the daily report (Fig. II.1.4), data sheet (Fig. II.1.5) and diagram (Fig. II.1.6). Equipment to be used for measuring water levels in the holes shall be approved by the Engineer.

9.8 Installation of Hole Mark

Upon completion of drilling, a steel pipe shall be driven into the hole and the pipe anchored with concrete. The number of the hole shall be inscribed on the concrete.

9.9 Installed observation pipes in drillholes shall be more than 40 mm in inside diameter.

9.10 Inspection of hole length will be done by the Engineer on completion of each hole.

9.11 Classification of types of drilling will be judged by the Engineer after the Work.

9.12 Accounting of quantities shall be based on measured lengths. However, increase or decrease in drilling length for reasons attributable to the Contractor shall not be recognized.

10. Permeability Test

10.1 Scope

This specification describes water tests for determining the approximate values of permeability of individual strata penetrated by core drilling. Permeability test consists of open-end test in unconsolidated deposits and packer test in the bed rock.

10.2 Open-End Test

10.2.1 Outline of Open-End Test

Fig. II.1.7 shows the test through the open end of a pipe casing which has been sunk to the desired depth and which has been carefully cleaned out just to the bottom of the casing.

10.2.2 Location of Tests

(1) The test shall be performed in the topsoil and sand-gravel layer.

(2) Test intervals and locations shall be given by the Engineer in the field.

(3) The test interval shall be in principle 2 m.

10.2.3 Method

(1) When the hole has been drilled to the depth where the test is intended casing pipe shall be installed up to the bottom of the hole. For tight contact of the casing to the deposits in the surroundings the casing shall be larger in diameter than the bore hole. To avoid disturbance of the deposits at the bottom of the hole the casing should not be driven by hammering. The inside of the casing shall be cleared of fallen loose materials up to the bottom by coring and washing with water.

(2) The casing pipe shall be filled with clean water up to near the top, and the water level shall be kept constant by supplying clean water from the top of the casing. Quantity of the supplied water shall be measured and recorded every minute until the difference between two successive measurements falls within the limit of 5% and for twenty minutes.

(3) Depth of groundwater level, if any, shall be recorded.

(4) The depth to the bottom of casing pipe, groundwater level in the hole before the test and height from the top of a hole to the constant water level shall be accurately measured and entered in the respective columns on the recording form (see Fig. II.1.8).

10.2.4 Calculation

The results shall be presented in coefficient of permeability as calculated by the following formula.

$$k = \frac{Q}{5.5rH}$$

where, k = coefficient of permeability (cm/sec)
r = internal radius of casing (cm)
H = differential head of water from the bottom of hole up to the constant water level. If groundwater level is higher than the bottom of hole, this is the head from the groundwater level up to the constant water level (cm)
Q = constant rate of flow into the hole (cm^3/sec)

This Open-End Test shall be carried out in accordance with specification in Earth Manual (1974), Appendix, Designation E-18 unless otherwise instructed by the Engineer.

10.3 Packer Tests

10.3.1 Outline of Packer Test

The test shall be performed by the so called "Single Packer Stage Method" where clean water is injected in the section of the hole between packer and bottom of hole (see Fig. II.1.9).

10.3.2 Test Section

(1) The test shall be performed in bedrock excluding topsoil, sand-gravel and weathered surface zones where setting of packers is difficult.

(2) The test section shall be given by the Engineer in the field.

(3) The length of one test section shall be in principle 5 m, but some variation may result depending on selection of the packer position.

10.3.3 Setting of Packer

(1) When setting a packer in the hole blow the casing pipe, the position shall be selected where few cracks exist at and above the prescribed depth as judged by core observation.

(2) When leakage of water to the part above the packer is observed or is judged to be taking place after start of injection of water the test shall be repeated by moving the packer position upward.

(3) Notwithstanding the above requirement, in the first test on reaching rock, the packer shall be shifted downward step by step and a watertight position selected.

10.3.4 Washing of Hole

After completion of drilling of each test section, the interior of the hole shall be washed by pumping water into a rod inserted to the bottom of the hole, and the washing shall be continued until there is no outflow of muddy water or slime.

10.3.5 Injection Pressure

Injection pressure cycles shall be according to the table below depending on the depth from the top of the hole to the packer position. Injection pressure as used herein shall mean pressure indicated by a pressure gauge set near the top of the hole.

Depth from Rock Surface to Packer	Injection Pressure Cycle kg/cm^2
Less than 5 m	0.5-1-2-3-2-1-0.5
More than 5 m	0.5-1-3-5-3-1-0.5

10.3.6 Measurements of Injecting Amount

(1) Measurements of injecting amount shall be started after 10 minutes of preliminary injection at each injection pressure and upon confirmation that water injecting amount has become stable.

(2) Measurement of injecting amount shall be made for 10 minutes at each injection pressure.

(3) Measurement of injecting amount shall be made at 1 minute intervals and the results shall be entered on a recording form approved by the Engineer.

(4) In case that the injecting amount exceeds the capacity of the pump at a certain pressure, no further tests at higher injection pressure shall be performed. In such case, the position of the packer shall be shifted downward to shorten the

test section, after which the injection test at the prescribed pressure shall be executed.

(5) The depth to bottom of hole, position of packer, water table and height from top of hole to pressure gauge shall be accurately measured and entered in the respective columns on the recording form (see Fig. II.1.10 and II.1.11).

10.3.7 Calculation of Permeability

The formulas for this test are:

$$k = \frac{Q}{2\pi LH}\log_e\frac{L}{r}\,;\,L \geq 10r$$

where, k = coefficient of permeability (cm/sec)
Q = constant rate of flow into the hole (cm^3/sec)
L = length of the portion of the hole tested (cm)
H = differential head of water (cm)
r = radius of hole tested (cm)
$\log_e$ = natural logarithm

10.3.8 Calculation of Lugeon Value

(1) The Lugeon value for each injection pressure shall be proportionally calculated by the equation below using test values.

$$L_u = \frac{10Q}{PL}$$

where, L_u = Lugeon value
Q = quantity of water injected (ℓ/min)
P = effective injection pressure (kg/cm^2)
L = length of test section (m)

Effective injection pressure (P) shall be obtained by applying compensations for hydrostatic head between the position of the pressure gauge and the center of test section or water table.

$$P = P_0 + 0.1(H_1 - H_2)$$

where, P_0 = indicated pressure at pressure gauge (kg/cm^2)
H_1 = hydrostatic head between pressure gauge and center of test section (m)
H_2 = hydrostatic head from water table to center of test section (m)
(in case water table is lower than test section, $H_2 = 0$)

(2) Lugeon values shall be entered in the appropriate columns on recording forms and boring logs, and arranged in tabular form.

11. Standard Penetration Test (SPT)

11.1 Scope

This test is a penetration test for determining the N value of soil indicating the relative value of hardness or softness, and degree of compaction of soil in situ.

The N value shall be the number of blows required for pounding in a sampler for standard penetration tests 30 cm by allowing a hammer weighing 63.5 kgf to fall freely from a height of 75 cm as shown in Fig. II.1.3.

11.2 Location of Tests

11.2.1 The SPT shall be performed in the topsoil, sand-gravel layer and weathered bedrock layer.

11.2.2 Test intervals and locations shall be given by the Engineer in the field.

11.2.3 The test interval shall be in principle 1 m.

11.3 Method of Test

11.3.1 Prior to testing, the Contractor shall completely remove slime accumulated at the bottom of the drillhole while exercising care not to disturb the ground below the bottom of the hole.

11.3.2 The penetration test shall be performed placing the hammer on the knocking head (with any subsidence at this time to be recorded). The first 15 cm of drive with the hammer shall be considered a seating drive followed by the main drive of 30 cm, and a finishing drive of 5 cm.

11.3.3 The main drive shall be with the hammer falling 75 cm and it shall be a free fall. While performing the main drive, the cumulative penetration shall be measured and recorded after each blow. However, if the penetration from one blow is less than 2 cm, the number of blows for every 10 cm shall be recorded.

11.3.4 The number of blows for the main drive shall be limited to fifty (50), and the cumulative penetration at that time shall be measured.

11.3.5 After completion of the main drive, 5 cm of finishing drive shall be performed as a rule.

11.4 Observation and Storage of Sample

The sampler shall be withdrawn and the sample taken out with the following observed and recorded:

11.4.1 Depth

11.4.2 Soil Identification

11.4.3 Color

11.4.4 Existence of Organic Materials

11.4.5 Existence of Slime

Samples shall be stored sealed in airtight condition and used for the physical tests.

12. Report

The Contractor shall submit 6 copies of a report in English to the Engineer. The report shall contain the following information and shall be prepared in accordance with the prescribed form.

12.1 Map Indicating Locations of Drillholes

12.2 List of Drillholes

12.3 Drilling Logs (See Fig. II.1.12 and 11.1.14)

12.4 Core Photographs

12.5 Permeability Test Records and Results of Calculation (Fig. II.1.13)

12.6 Pressure-water take curve for each Test Section of the Packer Test (Fig. II.1.13)

12.7 Standard Penetration Test Records

Table 1 Work Quantity

Hole No.	Angle	Depth (m)	Permeability test		S.P.T. (times)	Remarks
			Open-end t. (times)	Packer t. (times)		
LI-1	Vertical	15	5	1	10	
LI-2	Vertical	15	5	1	10	
LI-3	Vertical	15	5	1	10	
LI-4	Vertical	15	5	1	10	
LT-1	Vertical	20	5	2	10	
LT-2	Vertical	20	5	2	10	
LP-1	Vertical	20	5	2	10	
LP-2	Vertical	20	5	2	10	
LP-3	Vertical	20	-	-	10	
Total		160	40	12	10	

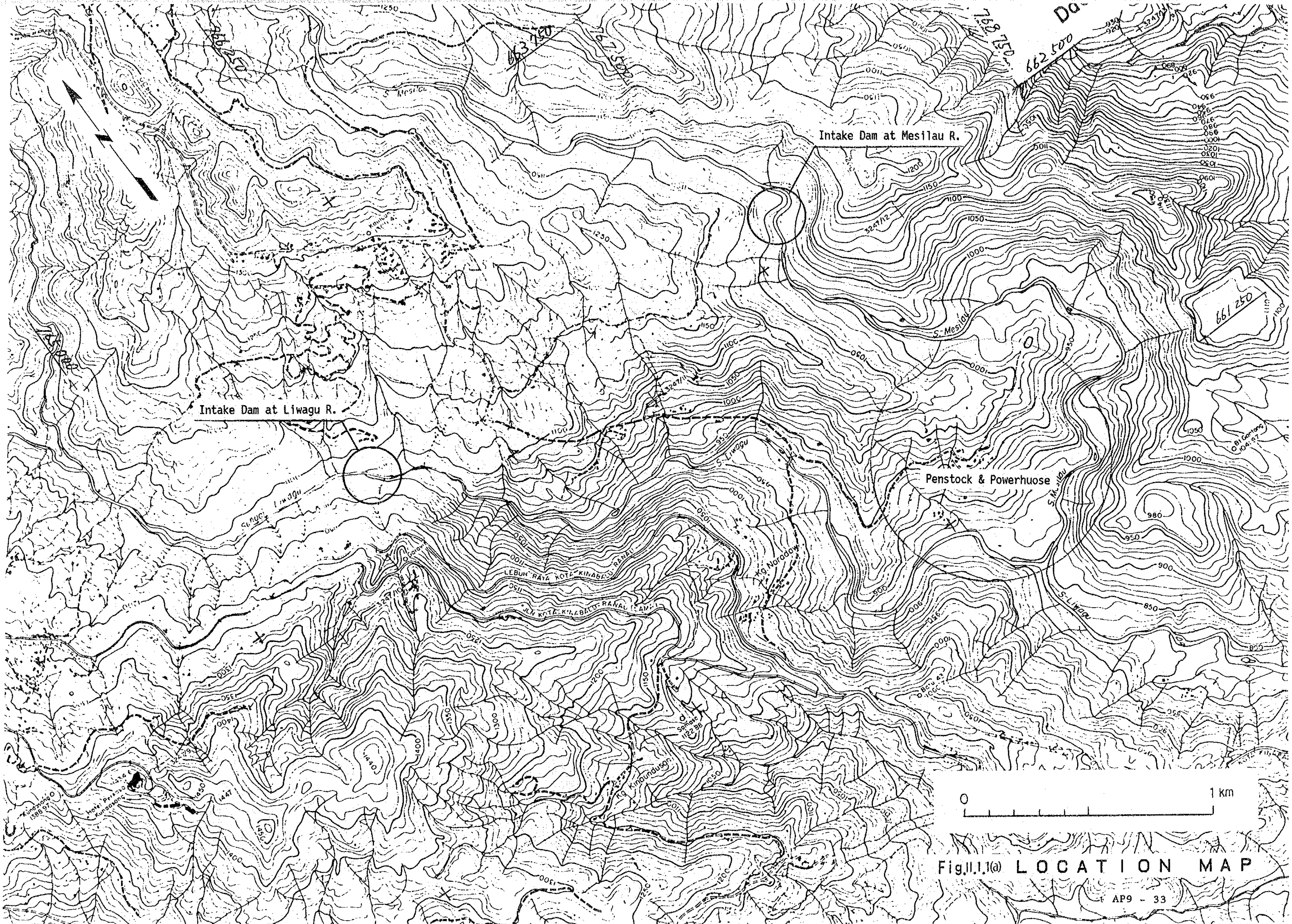


Fig.II.1.1(a) LOCATION MAP

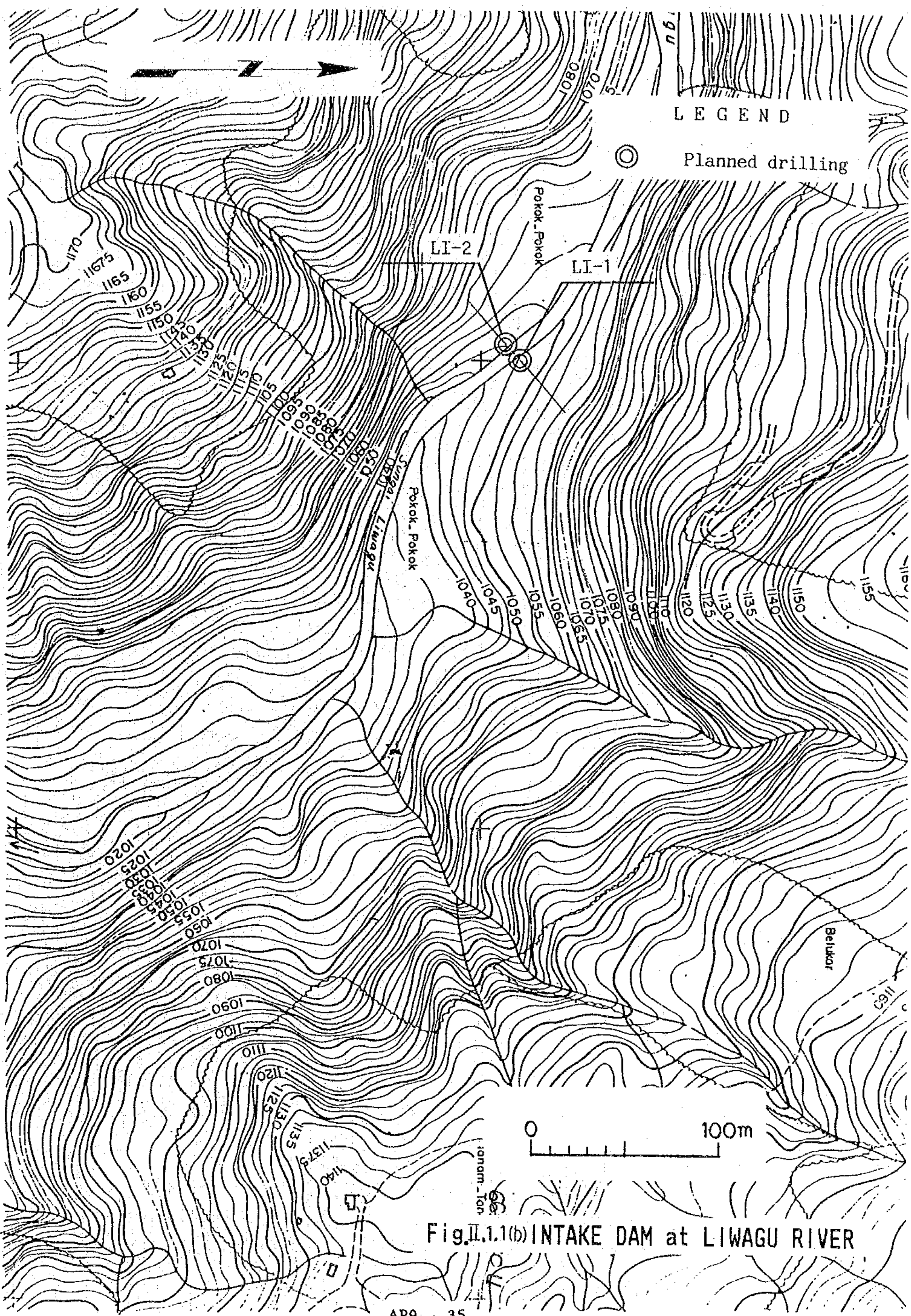


Fig.II.1.1(b) INTAKE DAM at LIWAGU RIVER

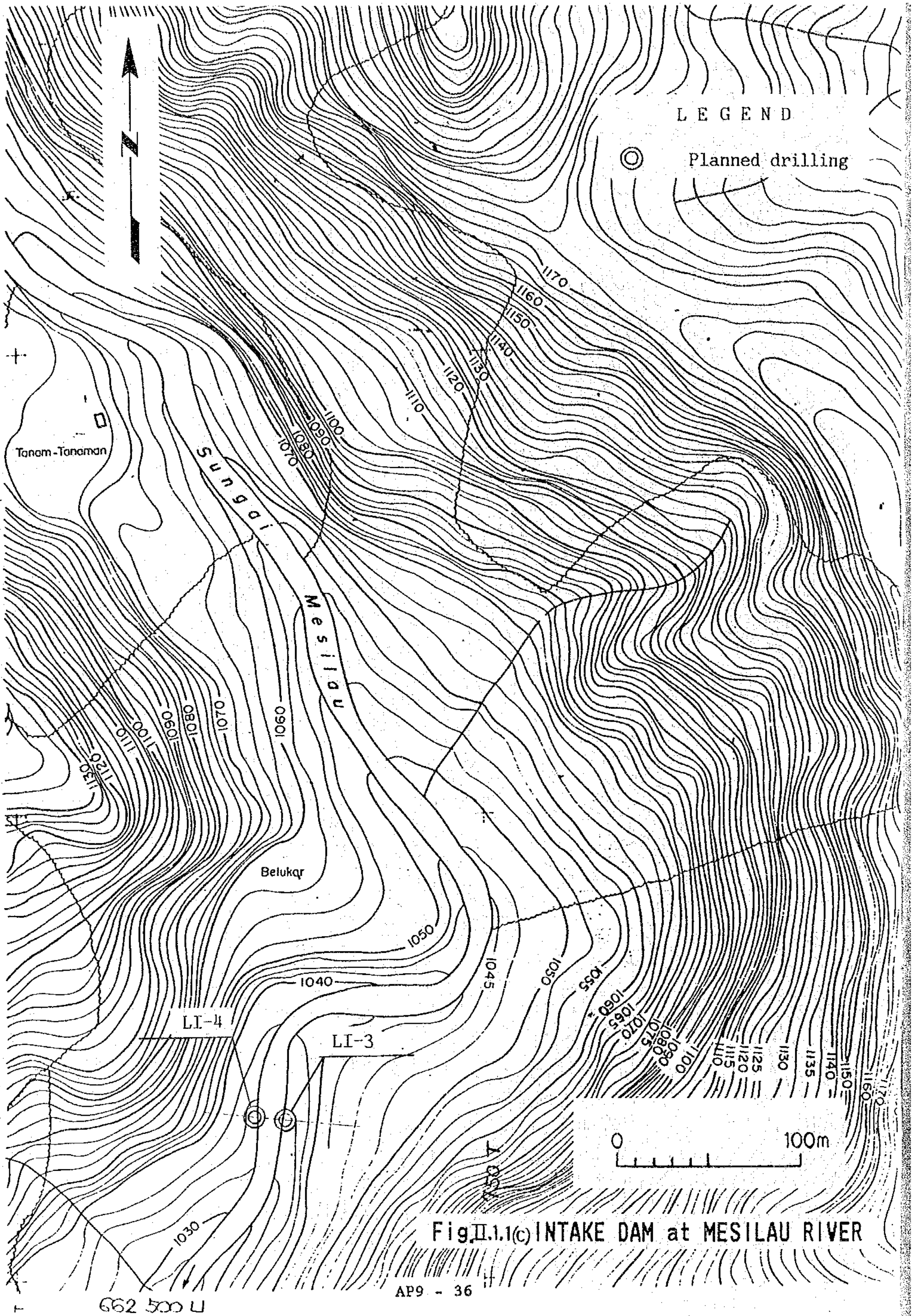


Fig.II.1.1(c) INTAKE DAM at MESILAU RIVER

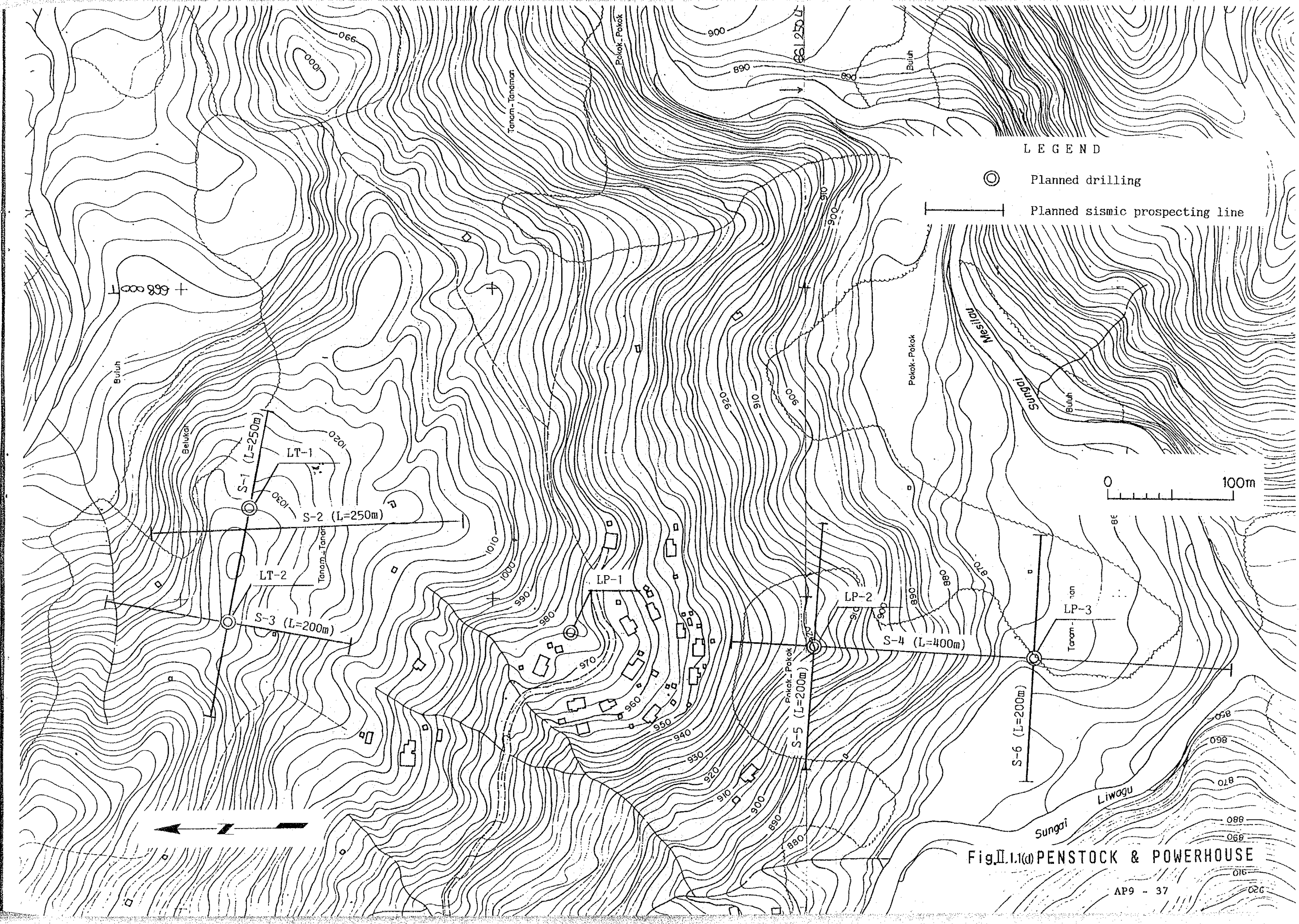
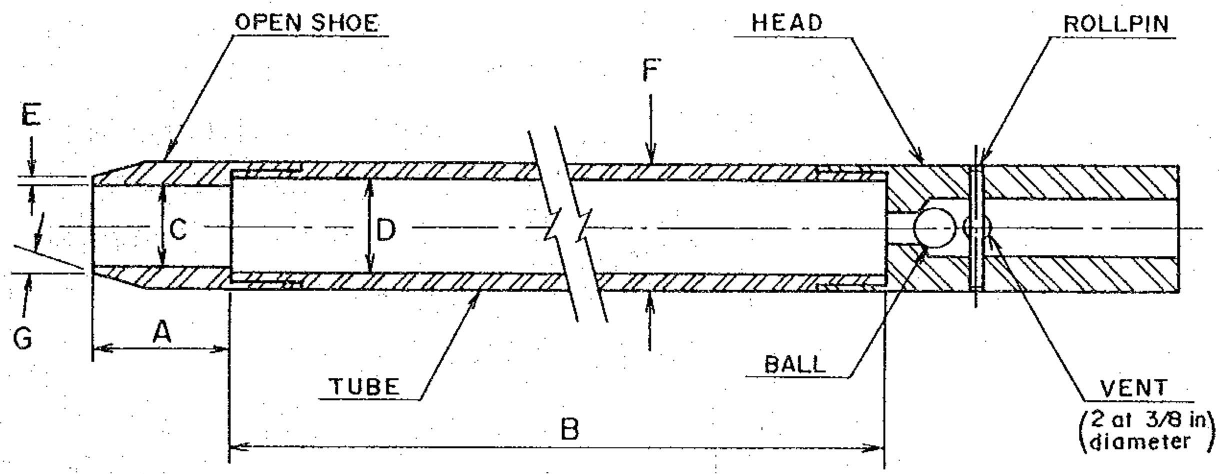


Fig.II.1.1(d) PENSTOCK & POWERHOUSE



A = 25 to 50mm
B = 0.457 to 0.762m
C = 34.93 ± 0.13mm
D = 38.1±1.3 − 0.0mm
E = 2.54±0.25mm
F = 50.8±1.3 − 0.0mm
G = 16.0° to 23.0°

Fig. Ⅱ.1.2 Split-Barrel Sampler (From ASTM Standards D1586-84)

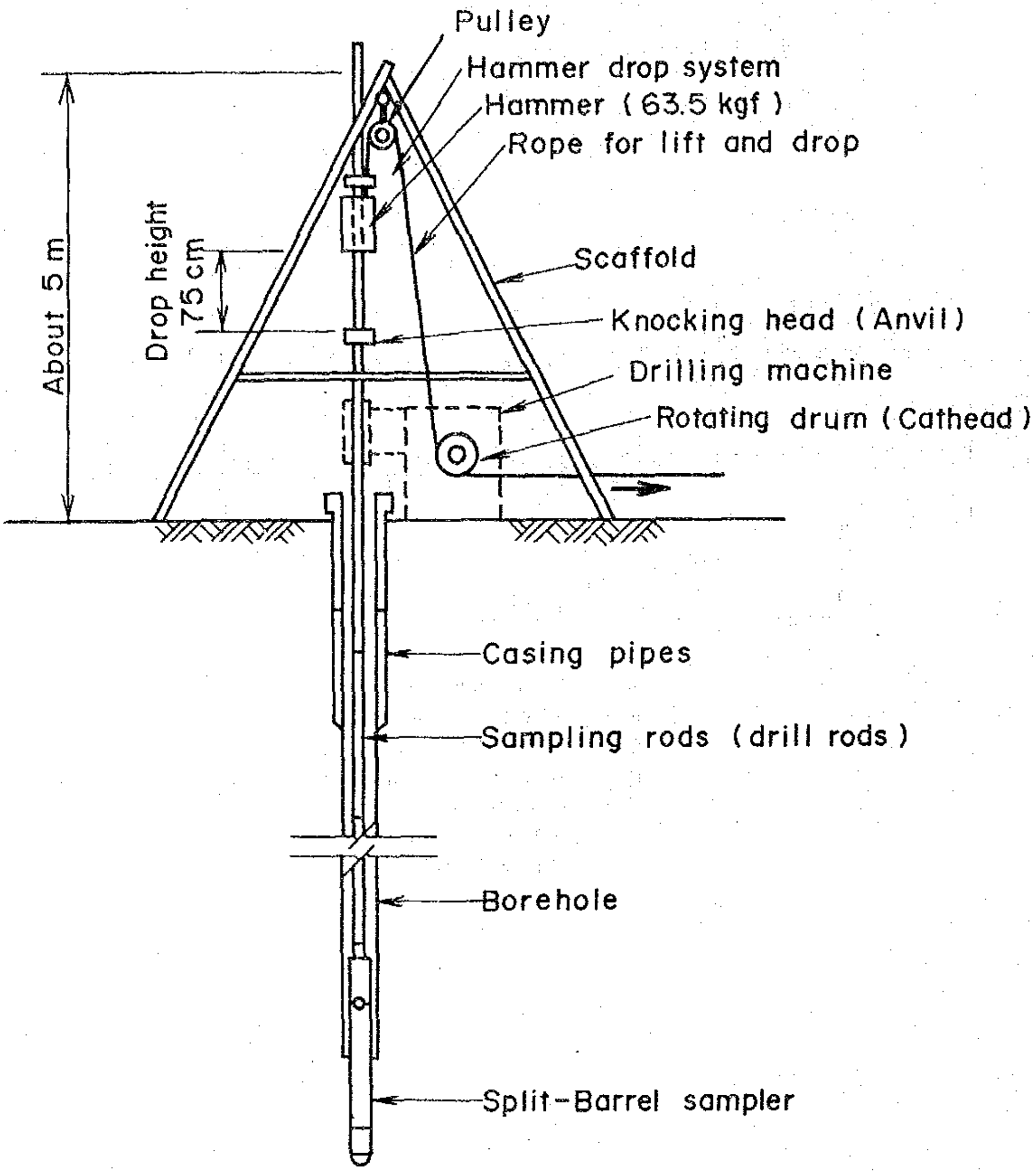


Fig. Ⅱ.1.3 Standard Penetration Test System

Checked By

Bearing and Angle of Hole

CORE DRILLING DAILY REPORT

Site ______ Hole NO. ______

Daily Report NO. ______ Date ______ (Weather ______) Hole Top EL. ______ m

Drilling time			Length of	Depth of	Core recovery		Hardness	Color of drained water or rock	Geology	Water pumped in	Water drained	Leakage	Remarks	Crown				Log	
From	To	Time	drilling	hole bottom	Length	%								Type	NO.	rpm	Pressure applied	Geologic symbol	Elevation
h	h	min								l/min	l/min	l/min					kg/cm²		m

Miscellaneous work conditions

Borehole dia.		Machine used	

Borehole water level m( )

Operating time ~

Drilling superintendent

Name	
Firm	

Category	Engineer	Technician	Laborer	Length advanced	Core length	Drilling time	Miscellaneous work time	Fuel	Supplies						
Today	Man-day	Man-day	Man-day	m	m	h	h								
Cumulative															

Note … "Daily Report No." shall be put separately by each hole.

"Drilling time means actual drilling time, and time for inserting and lifting is not included.

Fig. II.1.4 Core Drilling Daily Report

Fig. Ⅱ.1.5

FORMAT-1: RECORD OF WATER LEVEL IN DRILLHOLE DURING DRILLING (DATA SHEET)

PROJECT　　　　HOLE No.　　　　(SHEET　　OF　　)

LOCATION ________________　　DEPTH OF HOLE ________ m　　COMMENCED ________

ELEAVTION ________________　　DIAMETER OF HOLE ________ mm　　COMPLETED ________

COORDINATE ________________

ANGLE FROM HORIZONTAL ______ °　　MEASURED BY ________

BEARING OF ANGLE HOLE ______

EQUIPMENT FOR WATER LEVEL MEASUREMENT ________________

DATE MEASURED	TIME MEASURED	DEPTH OF HOLE AT MEASURMENT	DEPTH OF WATER LEVEL (*-1)	ELAPSED TIME (*-2)	CEMENTING CASING	REMARKS

(*-1) Mark "None" when water level exists under the bottom of hole
(*-2) Elapsed time from shutting off of drilling water

Fig. Ⅱ.1.6

FORMAT–2: RECORD OF WATER LEVEL IN DRILLHOLE DURING DRILLNG (DIAGRAM)

PROJECT ______ HOLE No. ______ (SHEET ___ OF ___)

LOCATION ______ DEPTH OF HOLE ______ m COMMENCED ______

ELEVATION ______ DIAMETER OF HOLE ______ mm COMPLETED ______

COORDINATE ______

ANGLE FROM HORIZONTAL ______ MEASURED BY ______

DIAMTER OF HOLE	SECTION USING MUD	DEPTH OF HOLE (m)	DEPTH OF WATER LEVEL AND CASING

O—O—O Depth of water level before drilling

●—●—● Depth of water level after drilling

×—×—× Depth of casing pipe

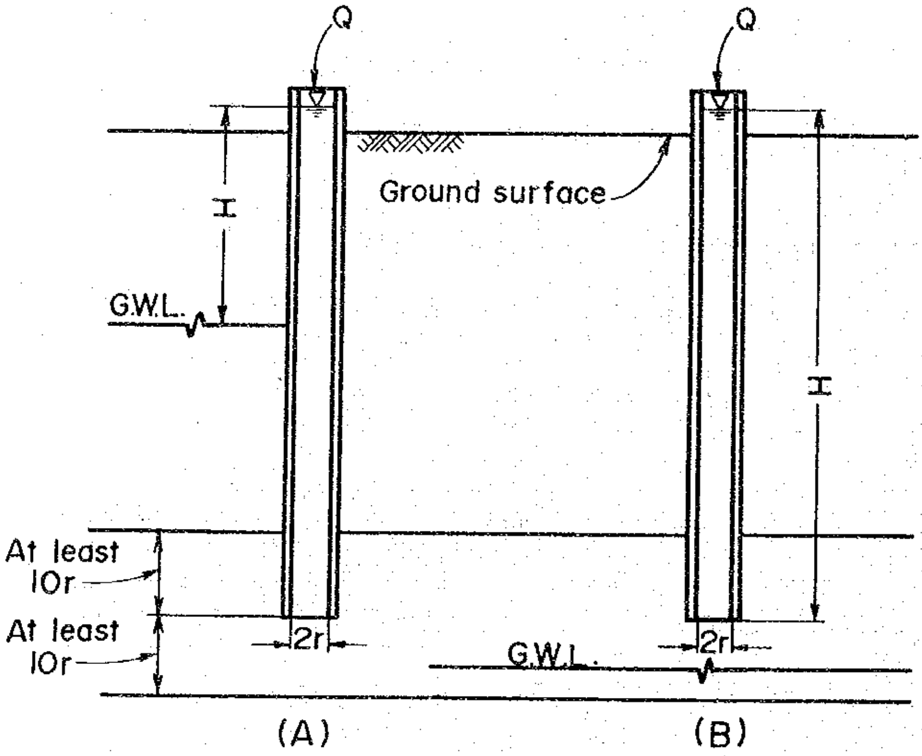


Fig. II.1.7 Open-End Test

Fig. II.1.8

OPEN-END PERMEABILITY TEST (SHEET OF)

PROJECT HOLE No.

Location ______ Date of Test ______ Tested by ______
Ground elevation ______ m Size of casing pipe ______ Checked by ______
Geologic condition of the bottom of drill hole ______

Depth from ground surface to the bottom of casing pipe ______ cm
Height from ground surface to the top of casing pipe ______ cm
Internal radius of casing : r = ______ cm
Ground temperature ______ ~ ______ ℃ Water temperture ______ ℃
Depth from ground surface to water surface in the drill hole before test ______ cm
Depth from ground surface to water surface in the drill hole after test ______ cm

Time		Differential head of water	Water volume			Coefficient of permeability
Clock hr min	min	H (cm)	Accum. flow (l)	Diff. flow (l/min)	Constant rate of flow Q (cm³/sec)	k (cm/sec)
	0			――	――	――
	5					
	10					
	15					
	20					
	25					
	30					
	35					
	40					
	45					
	50					
	55					
	60					

Constant rate of flow for steady state condition Q = ______ cm^3/sec
Coefficient of permeability for steady state condition k = ______ cm/sec

Remarks

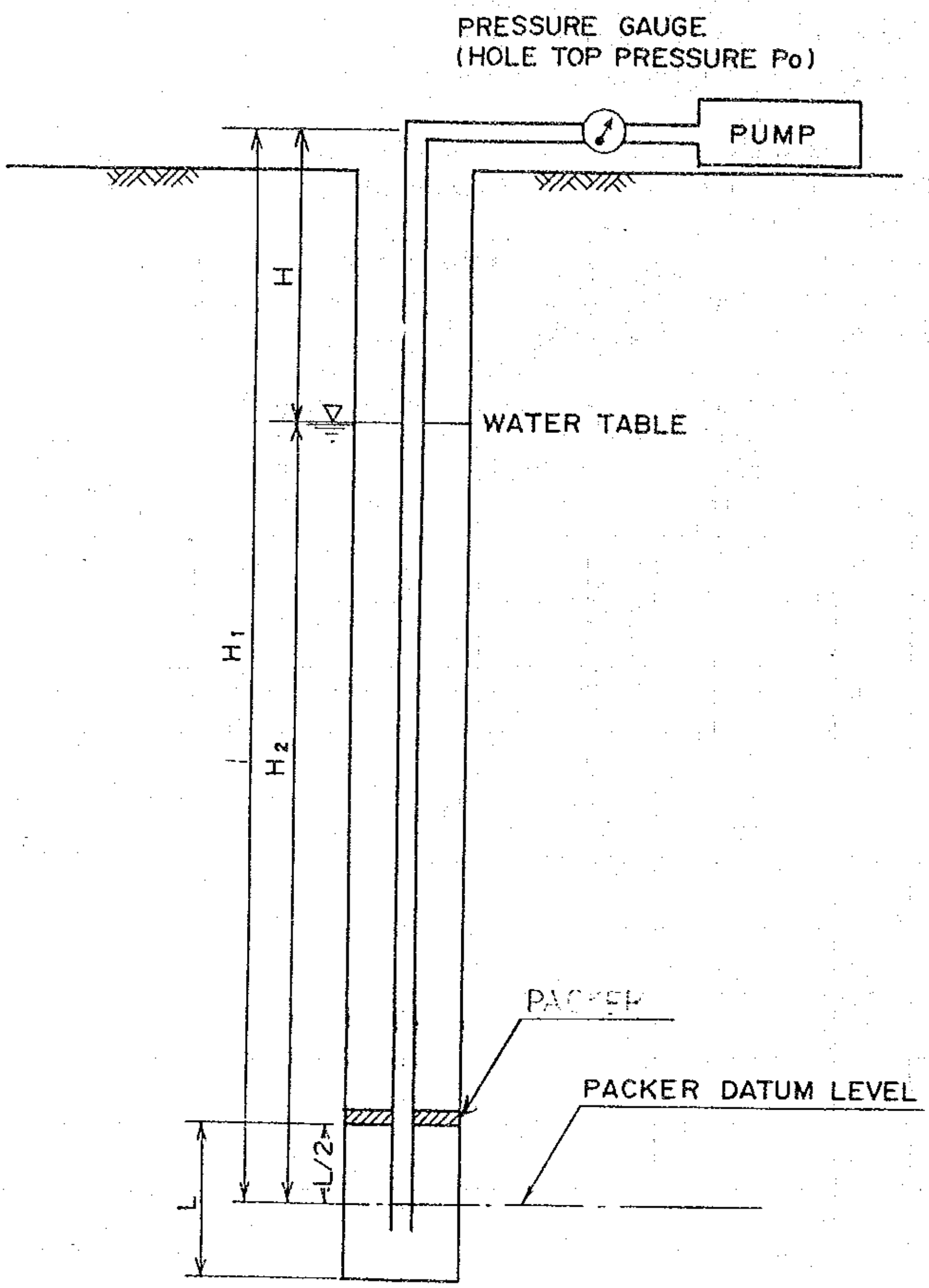


Fig. II.1.9 Packer Test

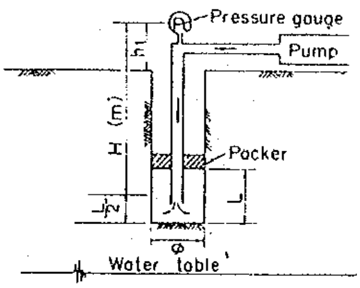
Fig. Ⅱ.1.10

PERMEABILITY TEST IN DRILLHOLE   HOLE NO.   Sheet NO. of

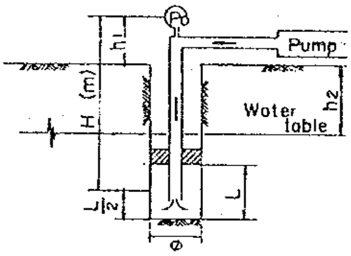
Feature	Project	Country
Location	Coordinates	Reporter
	Date of test – -19	Firm name ( )

Drill hole	Elevation of top	m	Diameter (φ) mm; Size	
	Dip	°	Bearing	
Test section	Stage NO.		Geology	
	Depth of packer & hole bottom	m– m		
	Elev. of packer & hole bottom	m– m		
	Length (L)	m		
Height of gauge (h1)				
Water table (h2)			Temperature of injected water	°C
Pump: Mfr. model			Flow meter: Type	
Pump: Max. discharge	l/min		Flow meter: Min. graduation	l
Pump: Max. pressure	kg/cm²		Pressure gauge Graduation: Min	kg/cm²
Type of packer	kg/cm²		Pressure gauge Graduation: Max.	kg/cm²

Unsaturated strata



Saturated strata



* Effective pressure (kg/cm²); $P = Po + H/10$

** Lugeon value (Lu) to be calculated by following equation

Lugeon value (l/min/m/10kg/cm²); $Lu = 10\ Q/P \cdot L$

Time: hr	Time: min	Elapsed min	Gauge pressure Po(kg/cm²)	Effective pressure P(kg/cm²)	Water pumped-in: Integrated (l)	Water pumped-in: Sectional flow(l/min)	Water pumped-in: Const. rate of flow(l/min)	Lugeon value (Lu)	Remarks

Form A

ELECTRIC POWER DEVELOPMENT CO. Tokyo, JAPAN

Fig. II.1.11

PERMEABILITY TEST IN DRILLHOLE HOLE NO. Sheet NO. of

Stage NO.		Depth of packer & hole bottom	m - m	Test length	m	Reporter

Time			Gauge pressure	Effective pressure	Water pumped-in			Lugeon value	Remarks
hr	min	Elapsed min	Po(kg/cm²)	P(kg/cm²)	Integrated (l)	Sectional flow(l/min)	Const. rate of flow(l/min)	(Lu)	

Form B

ELECTRIC POWER DEVELOPMENT CO, Tokyo, JAPAN

Fig. II.1.12 GEOLOGIC LOG OF DRILL HOLE

PROJECT HOLE No. (SHEET OF)

LOCATION		DEPTH OF HOLE	m	COMMENCED	– –
ELEVATION	m	DEPTH OF OVERBURDEN	m	COMPLETED	– –
COORDINATE		LENGTH OF ROCK DRILLING	m	DRILLED BY	
ANGLE FROM HOLIZONTAL	°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF BIT CASING	OBSERVATION OF CORE					N-VALUE (SPT)	PERMEABILITY k (cm/sec)	DEPTH	ELEVATION
					COLOR	WEATHERING	HARDNESS	CRACK SPACING	DESCRIPTION				
0m			0 → 100 %							0 → 50		0m	m ↓
1												1	
2												2	
3												3	
4												4	
5												5	
6												6	
7												7	
8												8	
9												9	
0												0	
1												1	
2												2	
3												3	
4												4	
5												5	
6												6	
7												7	
8												8	
9												9	
0												0	

core loss

RQD

1 (fresh) ~ 5 (decomposed)

1 (hard) – 5 (soft)

1 (stick), 2 (substick), 3 (piece), 4 (fragment), 5 grain

▶ driller's note 4

WATER TABLE

ELECTRIC POWER DEVELOPMENT CO., LTD.
TOKYO, JAPAN

Fig. II.1.13 PERMEABILITY TEST IN DRILL HOLE (SHEET OF)

PROJECT HOLE No.

LOCATION ____________ DEPTH OF HOLE ________ m TEST DATE ________

ELEVATION ________ m DIAMETER OF HOLE ________ cm TESTED BY ________

COORDINATE ________ DRILLED DEPTH ________ m DRILLED BY ________

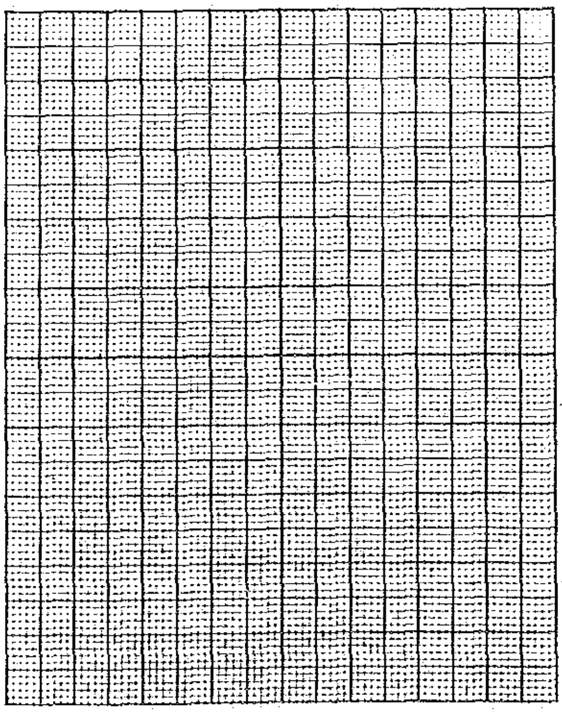
ANGLE FROM HOLIZONTAL ________ ° LEVEL OF WATER TABLE CHECKED BY ________

BEARING OF ANGLE HOLE ________ BEFORE.T.______ m AFTER.T.______ m

TEST SECTION FROM ________ m TO ________ m

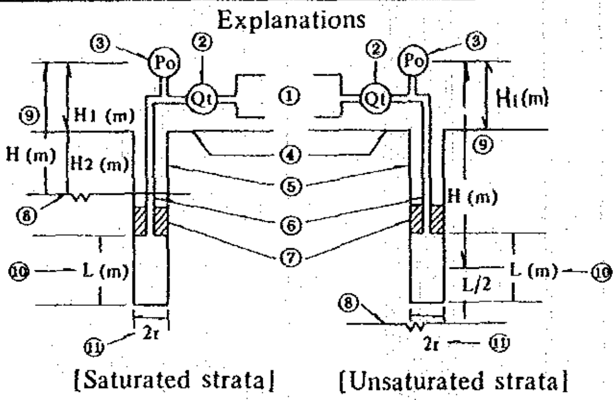
L (m)	H_1 (m)	H_2 (m)	H (m)	Po (kg/cm²)	P (kg/cm²)	t (min)	Qt (ℓ)	Qo (ℓ/min)	Q (ℓ/min/m)	Lu (Lugeon)	K (cm/sec)

P (kg/cm²)



Q (ℓ/min/m)

Explanations



[Saturated strata] [Unsaturated strata]

①: Pump
②: Flow meter
③: Pressure gauge
④: Ground surface
⑤: Drill hole
⑥: Injection pipe
⑦: Packer
⑧: Water table
⑨: Hydrostatic head
⑩: Length of test section
⑪: Diameter of hole

Po: Gauge pressure
H_1: Height of Pressure gauge
H_2: Depth of Ground water (Saturated Strata)
P : Effective pressure $P=P_0+H^{(m)}/10$, $H=H_1+H_2$
t : Injected time
Qt: Water volume during time in "t"
Qo: Water volume per one min.
Lu: Lugeon value in ℓ/min/m/10kg/cm²
K : Coefficient of permeability

Table II.1.14 Rock Classification for Drilled Core

Weathering		Hardness		Crack Spacing	
1	Very fresh. No weathering of mineral component.	1	Very hard. Broken into Knifeedged pieces by strong hammer blow.	1	Over 30 cm
2	Fresh. Some minerals are weathered slightly. Usually no brown crack.	2	Hard. Broken into pieces by strong hammer blow.	2	10 - 30 cm
3	Fairly fresh. Some minerals are weathered. Cracks are stained and with weathered material.	3	Brittle. Broken into pieces by medium hammer blow.	3	3 - 10 cm
4	Weathered. Fresh portions still remain partially.	4	Very brittle. Easy broken into pieces by medium hammer blow.	4	1 - 3 cm
5	Strongly weathered. Most are weathered and altered to second minerals.	5	Soft. Able to dig with hammer.	5	Under 1 cm

II.2 SEISMIC PROSPECTING SURVEY

1. General

The Specification shall be applicable to the Seismic Prospecting Survey to be performed in order to obtain data necessary for the preliminary design of the Feasibility Study of the Small Scale Hydroelectric Power Development Project at Upper Liwagu River Basin in Sabah, Malaysia.

2. Location of Work

The location of the Work shall be as shown in the Fig. II.2.1 with detailed locations to be directed by the Engineer at the site prior to commencement of Works.

3. Type of Work, Quantity and Equipment Used

3.1 The Work shall be performed by the refraction method of seismic prospecting.

3.2 The work quantity shall be as shown in the Table II.2.1, provided that a part of the work quantity may be subject to change after award of the contract depending on circumstances at the site.

3.3 Equipment Used

The equipment to be used shall possess adequate capacity for achieving the purpose of the Work. The Contractor, immediately upon award of the contract, shall submit the names, models, types, specifications, and photographs of the equipment to be used for approval of the Engineer.

4. Period of Work

4.1 Period of Work

Commencement: ____________________

Completion : ____________________

4.2 Work Schedule and Work Execution Program

The Contractor, immediately upon award of the contract, shall submit two (2) copies each of his work schedule and a measurement and blasting work execution program for approval of the Engineer.

In the event after commencement of work a delay should occur compared with the work schedule previously approved by the Engineer, the reason for such delay shall be explained, in addition to which subsequent measures to be taken shall be clearly indicated, and a modified work schedule submitted for approval of the Engineer.

5. Field Representative and Engineer-in-Charge

5.1 Field Representative

The Contractor shall cause a Field Representative to be resident at the site for the duration of the Work. A field representative notice shall be submitted prior to commencement of work for approval of the Engineer.

5.2 Engineer-in-Charge

Prior to commencement of work the Contractor shall submit the curriculum vitae of his Engineer-in-Charge for approval of the Engineer.

In the event permitted by the Engineer, the Field Representative may serve concurrently as the Engineer-in-Charge.

6. Daily Work Report

The Contractor shall record the condition of work in a daily report and deliver two (2) copies to the place designated by the Engineer.

The format of the daily report shall be subject to approval of the Engineer.

7. Safety Supervision

The Contractor, in execution of the Works, shall comply with the laws and regulations of the Sabah State, provide necessary safety facilities, and otherwise do the utmost to prevent occurrence of accidents.

Provision of such safety facilities and their management shall all be the responsibility of the Contractor.

8. Handling of Explosives

Special care shall be exercised with regard to handling of gunpowder and explosives to be used in the Works. All procedures as required by laws and regulations, safekeeping, and handling shall be at the responsibility of the Contractor, and the slightest trouble shall not be caused the Engineer.

9. Inspection

9.1 Field Inspection

When measurement operations in the field (in the event there are separate areas of work, operations in each area) have ended, the Contractor shall notify the Engineer of its completion, and submit inspection to them.

9.2 Inspection of Report

Prior to final printing and binding of the report designated by the Engineer, the Contractor shall present and explain the report to the Engineer and submit inspection to them.

10. Report

The Contractor shall submit five (5) copies of the report in English to the Engineer.

The report shall include the following contents and the format shall comply with the directions of the Engineer.

10.1 Report

Explanations of the analysis procedure, seismic wave velocity distribution, and geological structure shall be given in the report.

10.2 Annexed Drawings

(1) Prospecting line layout (scale: 1/1000)

The locations of prospecting lines, blasting points and receiving points shall be clearly indicated.

(2) Prospecting line profile and travel-time curve (Scale: 1/1000)

Prospecting line ends, intersections of prospecting lines, blasting points, receiving points, hole depths, quantities of explosives used shall be clearly indicated, while seismic wave velocities shall be entered in unit of m/sec.

The reduction scale to be used in analyses shall be 1/500. The basement or the velocity layer designated by the Engineer shall be clearly indicated.

(3) The measurement results according to Chapter 12.

(4) Measurement records (bromides).

11. Reconnaissances, Surveying

11.1 Reconnaissances

In carrying out measurements, reconnaissances shall be made of the topography, condition of vegetation, existence of reads, and outline of geological conditions in the area of Works and its surroundings, and these conditions shall be amply reflected in performing analyses of the measurement results.

11.2 Surveying

(1) The Contractor shall survey the locations of prospecting lines and blasting points from surveying datum points on the annexed drawings in accordance with the controls designated by the Engineer.

After completion of surveying the results shall be delivered to the Engineer for approval.

(2) Wooden stakes shall be provided at both ends of each prospecting line, intersections of prospecting lines, and at intervals of 50 m on prospecting lines, and these stakes shall be left in place after measurements.

In the event directed by the Engineer regarding details, the Contractor shall comply with these directions.

(3) In the event a necessity should arise to change locations due to ground surface conditions and other conditions when carrying out surveying of prospecting lines and blasting points, the Contractor shall contact the Engineer and await instructions.

12. Measurement

12.1 Receiving Point

Receiving points shall in principle be laid out on prospecting lines at 5 m intervals (including ends of prospecting lines).
However, in the event of difficulty in laying out according to the above because of ground surface conditions and in the event deemed necessary by the Supervisor, changes may be made at the direction of the Engineer.

12.2 Measurement

In making measurements, the Contractor shall be careful in the method of installing seismometers and adjustment of measuring devices, and endeavor at all times to obtain satisfactory measurement records. In the event the Engineer should deem the measuring conditions or the measurement results to be unsuitable and order remeasuring to be done, the Contractor shall comply without delay. The cost of remeasurement in such case shall be borne by the Contractor.

12.3 Blasting Point

The layout of blasting points shall be for a minimum of three (3) points on each spread with the maximum spacing between points 50 m. Blasting points shall be provided at both ends and bending points of a prospecting line without fail in order that the vicinities of such points will be blind spots in analysis. Furthermore, remote blasting points shall be provided as necessary to improve the accuracy of analysis.

12.4 Blasting Operations

The Contractor's engineer in charge of explosives shall witness any handling of explosives (hauling, charging of blast hole, blasting) at the jobsite without fail, and the date and time of blasting shall be notified the Engineer in advance.

After completion of blasting, it shall be confirmed whether there is any undetonated charge, and if found, it shall be removed. The site shall immediately be restored to its former state after blasting.

13. Analysis

Most appropriate calculation method such as Hagiwara's method shall be employed for analysis of measurement results, and in addition to discerning the thickness of overburden or the weathered zone, precise analyses of seismic wave velocities in rock bodies and parts of abnormal structure such as faults and sheared zones shall be performed.

13.1 Field Analyses

In the field, approximate analyses shall be made in succession from prospecting lines on which measurements have been completed, and the results shall be reported to the Engineer.

13.2 Precise Analyses

In performing analyses on measurement results, the most appropriate calculation method shall be used in accordance with the purpose, method, and condition of the travel-time curve. Other date (investigation results, existing geological data, etc.) shall be referred to in performing analyses, and they shall be reflected in the results of analysis as much as possible.

Table II.2.1 Work Quantity

Line No.	Length (m)	Remarks
S-1	250	
S-2	250	
S-3	200	
S-4	400	
S-5	200	
S-6	200	
TOTAL	1500	

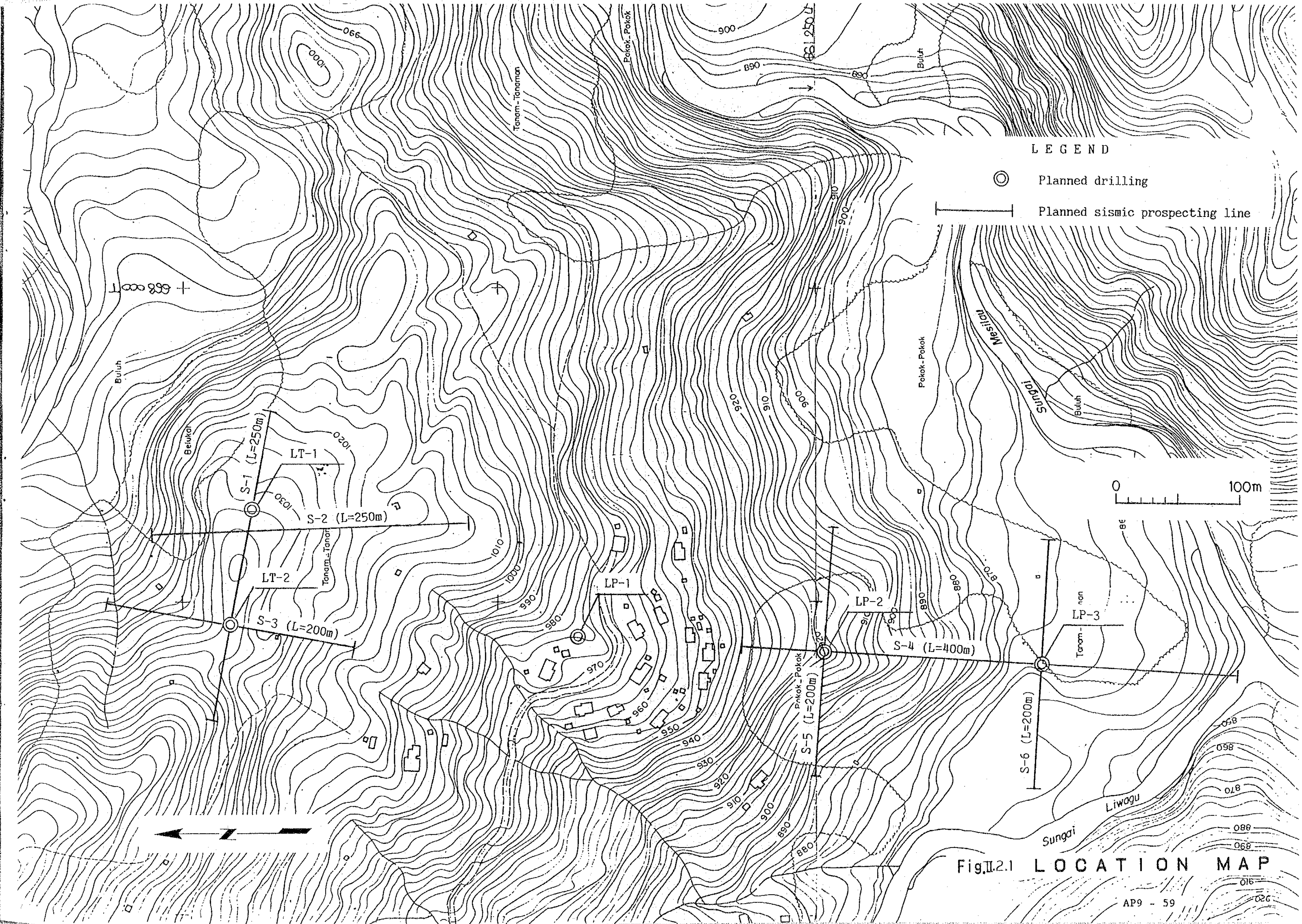


Fig.II.2.1 LOCATION MAP

II.3 GEOLOGIC MAPPING

1. General

The Specification shall be applicable to the Geological Mapping to be performed in order to obtain data necessary for the preliminary design of the Feasibility Study of the Small Scale Hydroelectric Power Development Project at Upper Liwagu River Basin in Sabah, Malaysia.

2. Objective

Objective of engineering geologic mapping of the project site and its surroundings is to clarify as follows:

(1) Distribution and feature of surface deposits and bedrocks
(2) Distribution and feature of faults and sheared zones
(3) Hydrogeologic condition of the site

3. Scope of Work

The specification describes the following works for the Geological Reconnaissance.

(1) Literature investigation
(2) Interpretation of aerial photograph
(3) Drawing of rout map and geologic map
(4) Reporting

4. Preparation of Geologic Mapping

4.1 Literature Investigation

(1) Collection and review of the existing data for topography and geology of the project area

(2) Interpretation of Topographical Map

The topography shows various landforms reflecting the difference of geological condition (e.g. hardness of the ground, the crustal movement). Topographical maps shall be interpreted in terms of talus, fan, terrace, karstic landforms, faults, landslide etc.

4.2 Interpretation of Aerial Photograph

The feature of an aerial photograph is that the shape of the land is exaggerated by stereoscopic view, and particular color tones and intensities can be emphasized. Consequently, it is easier to judge the topography by the aerial photograph than by topographical maps or observations on site.

The identification factors based on features of topography and combinations with color tones shall be as follows:

- drainage patterns (particularly their type and density)
- erosional features
- distribution of surface deposits (talus, terrace etc.) and outcrops
- color tones of surface deposits and outcrops
- vegetative cover
- lineament (straight stream courses, straight alignement of saddle etc.)
- tectonic landform (offset valleys, fault scraps, fault saddles etc.)
- gross geological structures (distribution of strata, direction of bedding, structural landform (homoclinal ridge, anticlinal valley) etc.)
- fault and joint systems
- distribution and form of landslide
- karst landform

These data shall be recorded on the drawings. These interpretation results shall be summarized on 1/50,000-scale and 1/5,000-scale maps.

5. Geologic Mapping

5.1 Topographic Map used for Geologic Mapping

Topographic map at the scale of 1/5,000 (for whole project area) and 1/500 (for the area near the structures) shall be used for geologic mapping.

5.2 Route Map

The important data observed in the field shall be described in route map.

These data must be organized to show the significant engineering geological features of the site. Important items for observations in geologic mapping may be listed as follows:

(1) Topographic feature

- enclosed depression, col, cliff, alluvial plain, alluvial fan, terrace, form of landslide, landform of fault etc.

(2) Property of surface deposits (talus deposit, gravel, residual soil etc.)

- locality of distribution
- origin (weathering of bedrock, terrace, aeolian, landslide etc.)
- areal extent, continuity
- constituent material, particle size distribution
- homogeneity, bedding
- weathering, moisture content, compactness
- relation between surface deposit and bedrock

(3) Property of bedrock

- locality of outcrop
- kindness of rock (constituent material, particle size, fossils etc.)
- bedding (dip and strike, thickness of bed, feature of bedding plane)
- unconformity (shape and condition of surface)
- vein and intrusive rock (dip and strike, thickness, name of rock or mineral, hardness, parting, opening, corrosion)
- weathering (Table II.3.1), alteration
- hardness (Table II.3.1)
- property of crack spacing (Table II.3.1), orientation filling material (type, thickness), parting, opening, leaching

(4) Geological structure

1) Joint, fault, shear zone

- locality
- dip and strike
- continuity
- spacing
- filling material or fault breccia/gouge (type, thickness, compactness)
- parting, opening (leaching)
- roughness of joint/fault plane (slickenside, striation)
- displacement (relation of joint-fault set)
- conjugate joint/fault

2) Fold

- locality
- direction of axis and axial surface
- type (shear fold, slump fold etc.)

(5) Surface water and ground water (stream, creek, pond, spring)

- Locality of distribution
- Flow, temperature, water chemistry

(6) Vegetation (type, age, artificial/natural)

(7) Artificial Structures

5.3 Photos, Sketches and Samples

Important facts shall be recorded by photos, sketches and samples, its localities shall be recorded in rout map.

5.4 Geologic Mapping

Based on literature investigation, interpretation of aerial photograph and geologic reconnaissance, the following geologic maps shall be drawn in accordance with the form shown in appendix. The geological mapping shall be covered as shown in Fig. II.3.1.

- geologic plan of project area
- geologic profile of penstock, powerhouse and tailrace
- geologic sections of intake dam sites

6. Report

The report shall contain the information mentioned in chap. 4 and 5 and the following annexes.

(1) Drawings showing the results of interpretation of aerial photograph
(2) Rout map (1/5,000 and 1/500)
(3) Geologic maps (1/5,000 and 1/500)
(4) Photos and sketches
(5) Samples

Rock Classification and Evaluation for Geological Investigation Works by E.P.D.C.

Table II.3.1(a) Rock Classification for Adit and Outcrop

Weathering		Hardness		Crack Spacing	
1	Very fresh. No weathering of mineral component.	A	Very hard. Broken into Knifeedged pieces by strong hammer blow.	I	Over 100 cm
2	Fresh. Some minerals are weathered slightly. Usually no brown crack.	B	Hard. Broken into pieces by strong hammer blow.	II	40 - 100 cm
3	Fairly fresh. Some minerals are weathered. Cracks are stained and with weathered material.	C	Brittle. Broken into pieces by medium hammer blow.	III	20 - 40 cm
4	Weathered. Fresh portions still remain partially.	D	Very brittle. Easy broken into pieces by medium hammer blow.	IV	5 - 20 cm
5	Strongly weathered. Most minerals are weathered and altered to second minerals.	E	Soft. Able to dig with hammer.	V	Under 5 cm

Table II.3.1(b) Rock Classification for Drilled Core

Weathering		Hardness		Crack Spacing	
1	Very fresh. No weathering of mineral component.	1	Very hard. Broken into Knifeedged pieces by strong hammer blow.	1	Over 30 cm
2	Fresh. Some minerals are weathered slightly. Usually no brown crack.	2	Hard. Broken into pieces by strong hammer blow.	2	10 - 30 cm
3	Fairly fresh. Some minerals are weathered. Cracks are stained and with weathered material.	3	Brittle. Broken into pieces by medium hammer blow.	3	3 - 10 cm
4	Weathered. Fresh portions still remain partially.	4	Very brittle. Easy broken into pieces by medium hammer blow.	4	1 - 3 cm
5	Strongly weathered. Most are weathered and altered to second minerals.	5	Soft. Able to dig with hammer.	5	Under 1 cm

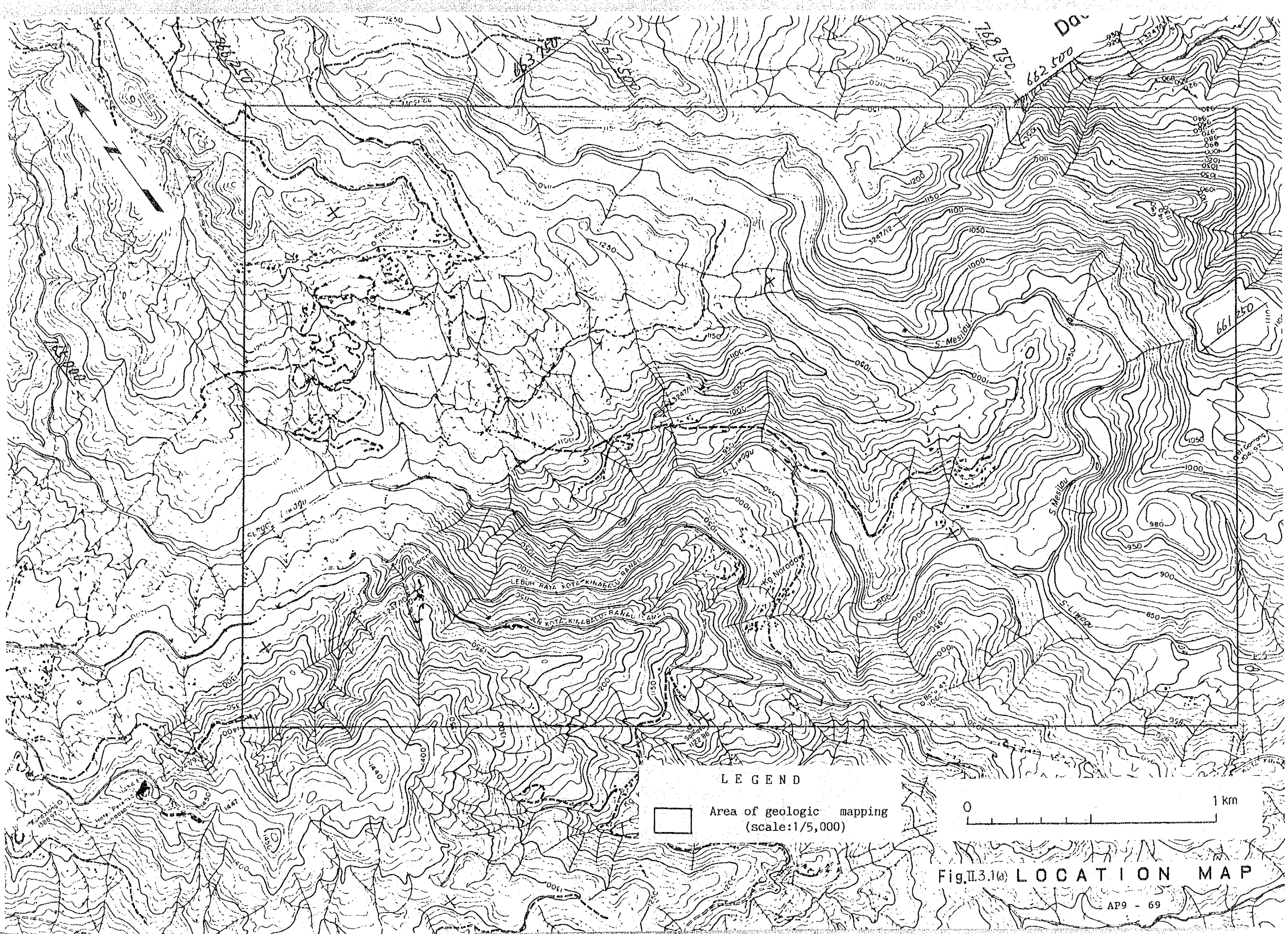


Fig.II.3.1(d) LOCATION MAP

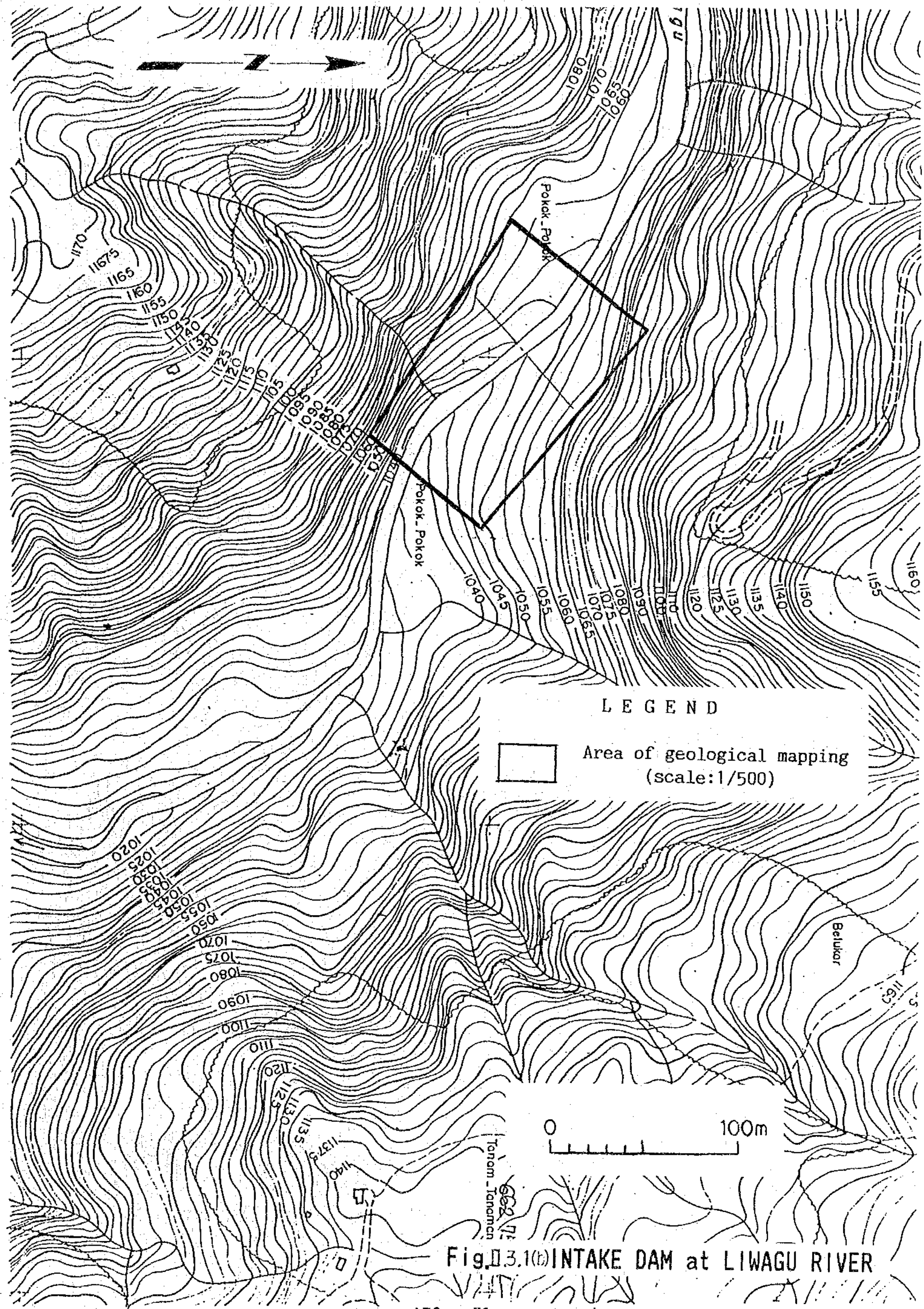


Fig.Ⅱ3.1(b) INTAKE DAM at LIWAGU RIVER

Oleh Jabatan Tanah dan Ukur, Sabah, Feb., 1988

766 250 T

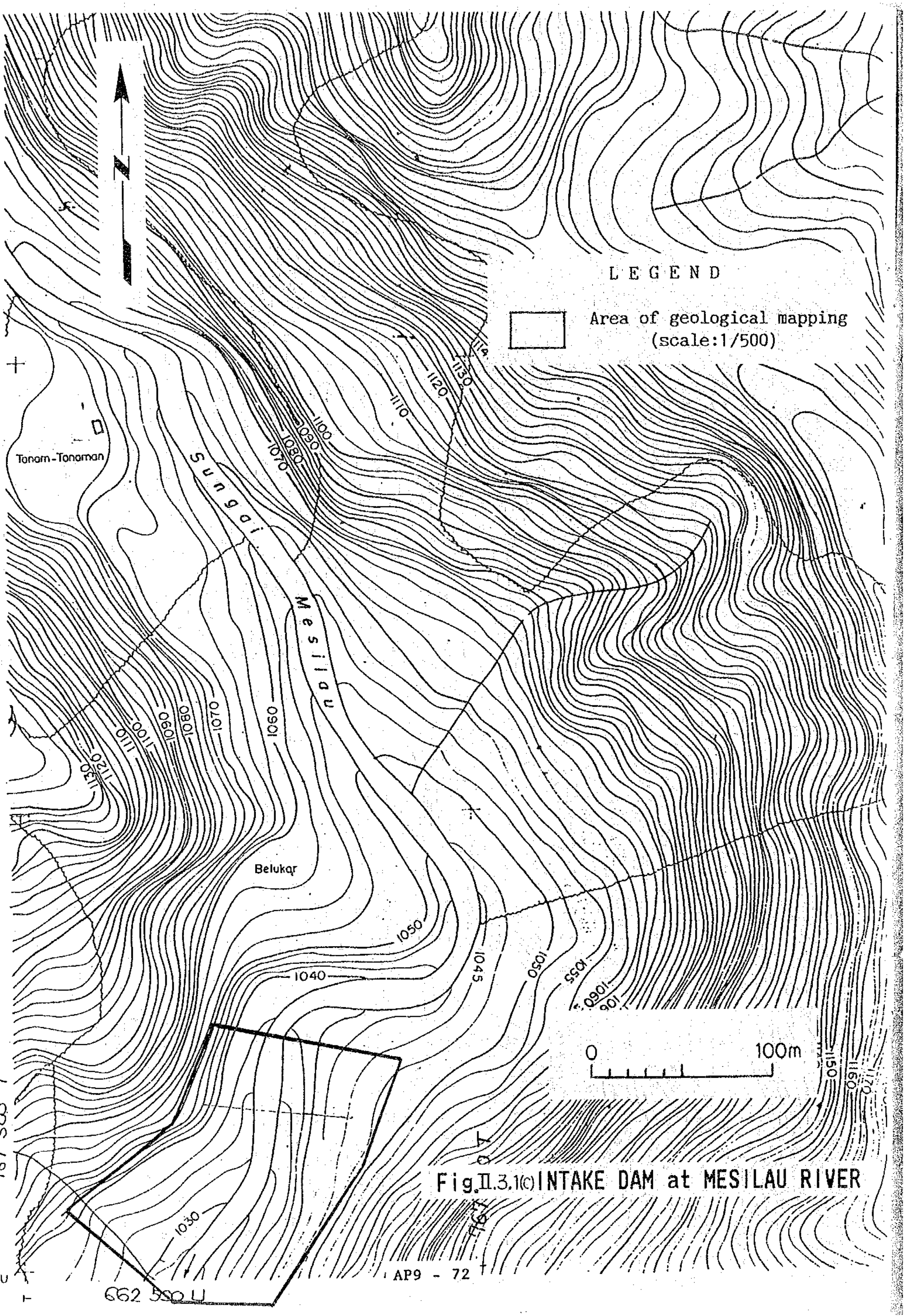
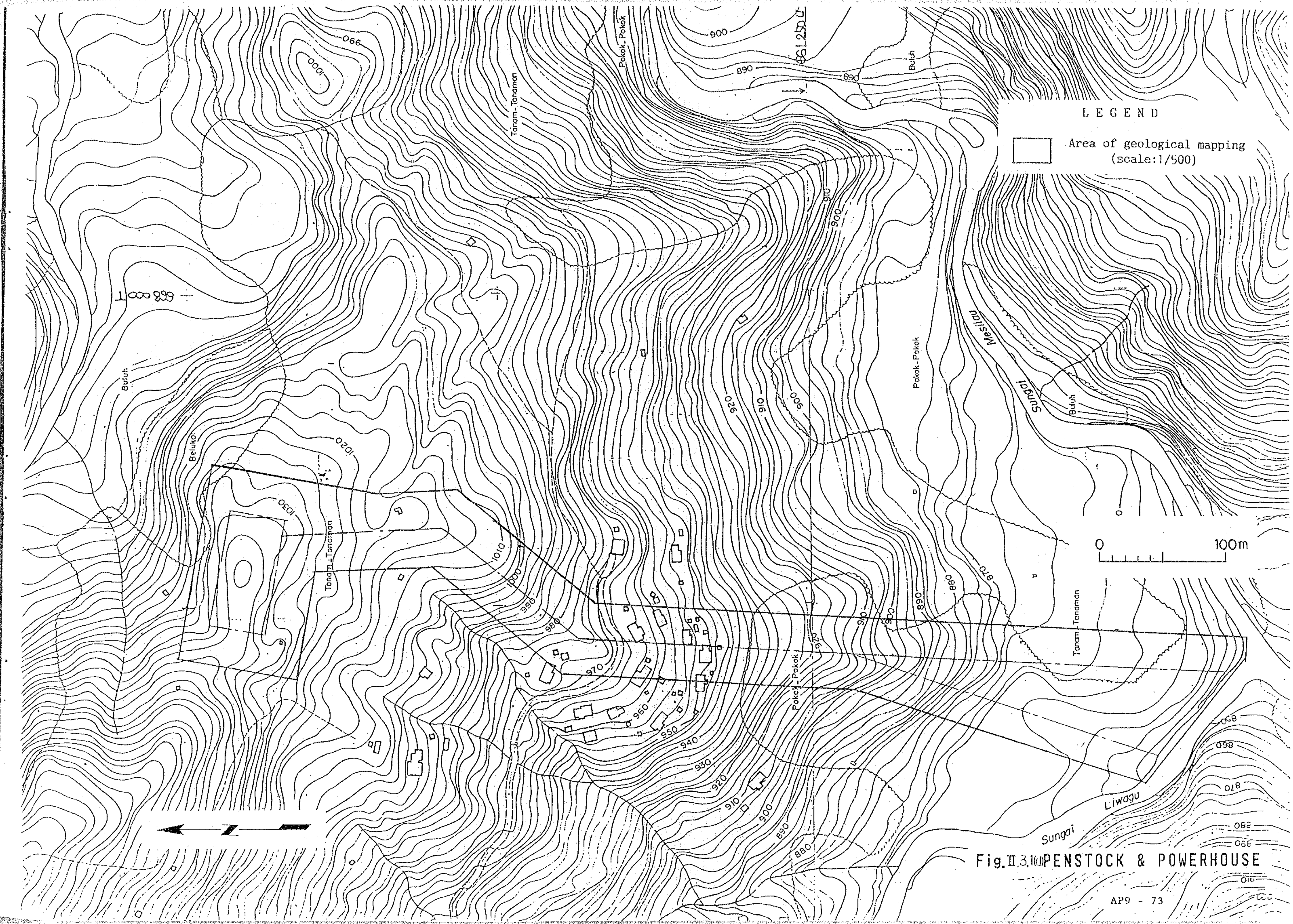


Fig.II.3.1(c) INTAKE DAM at MESILAU RIVER


LEGEND
Area of geological mapping
(scale:1/500)
0
100m
Pokok-Pokok
Tanam-Tanaman
Buluh
Belukar
Sungai Mesilau
Sungai Liwagu
1000
1020
1030
1010
990
980
970
960
950
940
930
920
910
900
890
880
870