FINAL REPORT

FOR

THE FEASIBILITY STUDY ON MEDIUM SIZE DAMS

IN

MASVINGO PROVINCE IN THE REPUBLIC OF ZIMBABWE

ANNEX OF FEASIBILITY REPORT

MARCH 1988

JAPAN INTERNATIONAL COOPERATION AGENCY

FINAL REPORT

FOR

THE FEASIBILITY STUDY ON MEDIUM SIZE DAMS

IN

MASVINGO PROVINCE IN THE REPUBLIC OF ZIMBABWE

ANNEX OF FEASIBILITY REPORT

MARCH 1988

JAPAN INTERNATIONAL COOPERATION AGENCY

LIST OF ANNEXES

ANNEX A. TOPOGRAPHY AND GEOLOGY

Contents

A.1. Description of Dam Site Geology

1) Musaverema (I-2-1)

a) General Geology

The geology of the proposed dam area consists of gneiss, dolerite and river deposit.

Gneiss occupies most of the area. The outcrops are well observed in the left bank, but they are very few in the right bank where many tributaries flow into the main stream. The most widespread type of the gneiss is light grey, medium grained, massive and hard. Joints and crucks are very widely spaced.

Dolerite dykes are narrowly distributed in the area, and they are 10 m in width and less than 300 m in length.

River deposit is narrowly distributed along the main stream and consists of sand and clay with gravels. The deposit around the dam axis is about 250 m in width.

There is an extreme difference between the right and left bank; in the left bank massive and hard rocks are distributed, but in the right bank the highly weathered zone is very deep and thick and unconsolidated river deposits which have been transported by many tributaries are distributed. No faults nor folds were recognized in the field investigation.

b) Dam Axis Geology

Three(3) bore holes have been drilled reaching 51.2 m on the proposed dam axis. According to this result the geology of the dam axis consists of gneiss and river deposit.

Gneiss in the left bank is generally unweathered, hard, massive and classified into Ch - B class, but in the right bank gneiss is highly weathered up to 17 m below the surface (max. 11 m in the thickness) and cores are recovered as gravels and soils. The permeability coefficient ranges from 4.8×10^{-4} to 1.1×10^{-3} cm/sec. R.Q.D (Rock Quality Designation = Total length of cylindric cores longer than 10 cm) is zero per cent and the rocks are classified into cm class.

River deposit is distributed in the right bank with 250 m in width, and in BH-2 (Bore Hold No.2) the depth is confirmed up to 6 m. It consists of sand and clay with gravels. The permeability coefficient is $n \times 10^{-3}$ cm/sec. N-value of S.P.T (Standard Penetration Test) are more than 50 and then bearing capacity is sufficient for embankment load.

Stabilized water table was near 3 m below the surface in the river deposit and was near upper part of C1 class bedrock in gneiss.

2) Chinyamatumwa (II-1-6)

a) General Geoloty

The geology of the proposed dam area consists of granite and dolerite. Granite is divided into three main types; massive granite, pegmetite and granodiorite.

Granodiorite is distributed downstream of the dam axis. The most widespread type is pinkish white coloured, coarse grained, weathered skined, well jointed and soft rock. It contains masses of pegmatite.

Pegmatite is distributed around the dam axis, and light greyey coloured, very coarse grained and soft rock. Open joints and crucks are spaced from 10 to 50 cm. Pegmatite contains abundant large crystals of plagioclase and occasionally inclusions of amphibolite.

Massive granite is distributed in the upper stream of the dam axis, and greyey white coloured, medium to coarse grained and very hard rock. The rock is accompanied by abundant quartz veins, 10 to 50 cm in width.

A dolerite dyke, 20 to 40 m in width with N10 to 20E trend, is distributed across the dam axis. The rocks have been changed into boulders or soils by spheroidal weathering.

Foliation trend of the investigation area is NE, and many faults of the same direction with foliation are recognized. Pegmatite is also a dyke which intruded into same direction, and therefore the surrounding rocks, especially granodiorite, have been highly sheared. Dolerite has NS trend, and the surrounding rocks have been highly sheared as same as pegmatite.

b) Dam Axis Geology

Three(3) bore holes have been drilled reaching 40.78 m in the proposed dam axis. According to this result the geology of the dam axis consists of pegmatite, dolerite and terrace deposit.

Pegmatite is pinkish to greenish white colour when it is fresh, and it is characterized by large, often well formed crystals of plagioclase and small irregular masses of quartz set. The rock is completely weathered up to 4 m below surface, and cores are recovered as sand and clay. Permeability tests carried out at 3 m were n x 10^{-3} cm/sec. This zone is classified into D class. The zone between 4 and 10 m below surface is classified into Cl class and is highly weathered. Cores are recovered as gravels. Lugeon value is 40L in the left bank. The zone below Cl class is classified into Cm class. Core recovery in this zone is high, but open joints and crucks are closely spaced, and many small fractured zones by faults are recognized in the core observation. The Lugeon value in this zone ranges from 9 to 40L.

A dolerite dyke intrudes into granites across the dam axis. The dyke is 30 m in width and in parallel with the main stream. The rocks which are observed around the dam axis have been changed into boulders by spheroidal weathering. Permeability test carried out at 4.7 m below surface is 1.6 x 10^{-1} cm/sec. The bedrock of the dyke and the surrounding rocks are classified into D class.

Narrow terraces are distributed in the both banks. They almost consist of fine to medium grained sand and well compacted.

Dolerite intrudes into pegmatite which has NE foliation trend, and joints and crucks of surrounding bed rocks are closely spaced because of the shearing of the intruded dykes. There are no faults and folds in the field investigation, but several small fractures by faults are recognized in the core observation.

3) Mashoko (II-2-1)

a) General Geology

The geology of the proposed dam area consists of gneiss, metabasite and terrace deposit. In the field gneiss is divided into two types, banded gneiss and granulitic gneiss.

Banded gneiss is distributed in the left bank and forms well jointed dwallas. Generally it is fine to medium grained, greyey white coloured, banded, massive and fresh.

Granulitic gneiss is distributed in the wide area including the dam site. It is characterized by white colour, large crystals of quartz and plagioclase and weathered skins. Generally the rocks are highly weathered, and partly they have been changed into soils and very soft.

Metabasite is distributed widely in the upperstream of the dam site. It partly remains the structure of diabase. It is fine grained, greenish black coloured and well jointed rock with foliations trend ENE and characterized by reddish brown surface soil.

Terrace deposit is distributed along the main stream with maximum 150 m in width and 3 m in depth. It consists of sandy soil.

The geological structure is characterized by the distribution of metabasite of diabasic origin. The body is distributed in wide area with an irregilar shape, and the surrounding rocks are highly sheared. The foliation of the area trends ENE direction.

b) Dam Axis Geology

Three(3) bore holes have been drilled reaching 53.3 m in the proposed dam axis. According to this result the geology of the dam axis consists of granulitic gneiss, metabasite and terrace deposit and talus deposit.

Granulitic gneiss is pinkish white coloured, coarse grained and hard rock when it is fresh, and contains large crystals of quartz. In the left bank this hard rock which is classified into B class is recognized near 7 m below surface. In the right bank gneiss is highly weathered because metabasite intrudes into it, and cores are recovered as soils and gravels. This zone is classified into Cl class, and it ranges in Lugeon-Value from 7 to 18L.

Metabasite is pinkish white coloured, fine grained and hard rock when it is fresh, but the contact zone with gneiss is completely to highly weathered and softened. Cores recovery rate is very low and most cores are classified into D to Cl class.

Terrace deposit is mainly distributed in the right bank with 2 m in thick and with 150 m in width. Talus deposit is distributed at the foot of hills of the right bank. It consists of clayey soil with gravels and very loose.

The geology around the dam axis is complicated in structure because of the intrusion of metabasite. Gneiss and metabasite in the contact zone are altered, highly weathered and softened up to deep zone. It is characteristic in that unconsolidated deposits like terrace and talus are relatively well distributed.

4) Munjanganja (IV-4-10)

a) General Geology

The geology of the proposed dam area consists of granite and dolerite. In the field granite is divided into three types; massive granite, gneissic granite and porphyritic granite.

Massive granite is distributed in the upper stream of the dam axis and the right bank. Generally it is light greyey, massive, medium grained and hard rock, and joints and crucks are widely spaced.

Gneissic granite is distributed in the down stream of the dam axis and upper stream along the riverbed. It is light greyey coloured, massive, and hard rock which often shows a distinct banding due to concentration of biotite between wider bands of quartz and plagioclase. Joints are widely spaced.

Porphyritic granite is mainly distributed in the right bank. It is light greyey coloured, very coarse grained and highly weathered rock, and contains numerous large crystals of plagioclase and occasionally inclusion of amphibolite. Joints are closely spaced and widely opened.

A small dolerite dyke is distributed on the right bank of the down stream of the dam axis. The structure of granites is not confirmed, because granites grade laterally and vertically into each other. The foliation trend of the area is N60 - 70 W. Faults and folds are not recognized in the field.

b) Dam Axis Geology

Three(3) bore holes have been drilled reaching 52.6 m on the dam axis. According to this result the geology of the dam axis consists of massive granite, porphyritic granite and river deposit.

Massive granite is mainly distributed at the left bank. When it is fresh, it is light greyey coloured, medium to coarse grained, slightly weathered hard rock. Joints are widely spaced. At right bank the granite is completely weathered up to 4 m below surface and has been changed into loose reddish brown sandy soil. Below 6 m it is slightly weathered and classified into Ch - B class, but high permeability ranging from 32 to 45 Lugeons are recorded at 6.5 m in the right bank and 11.0 m in the river bed.

Pophyritic granite is mainly distributed in the left bank. When the granite is fresh, it is pinkish to greenish white coloured, very coarse grained soft rock, and contains fragments of amphibolite and large crystals of plagioclase. It is highly weathered up to deep zone in contrast to massive granite. Joints are closely spaced and Lugeon-value between 6 and 16 m is very high.

At the both banks stabilized water level is at or near the boundary between D and C1 class rock. In BH-2 it is at 0 m due to artesian water near 11.0 m below surface.

Massive granite structurally undelies porphyritic granite and dips to the right bank. The remarkable difference between the both granite is grain size and weathering condition, that is, massive granite is medium grained and poorly jointed, but porphyritic granite is very coarse grained and very well jointed. So that porphyritic granite is more pervious than massive granite. Several small fractured zones due to faults are recognized in core observation, and at the zones water return loss during drilling and high permeability are recorded.

5) Magudu (V-3-3)

a) General Geology

The geology of the proposed dam area consists of gneiss, dolerite and talus deposit.

Gneiss occupies most of the area. The widespread type of the gneiss is white to light grey coloured, medium grained, massive, hard and homegeneous rock. Joints are widely spaced, but partly the rocks are highly weathered and joints are closely spaced.

A dolerite dyke is distributed around the dam axis. The dyke forms a irregular shape and the presence of the dyke is confirmed by boulders of dolerite and reddish soil. It is dark greenish grey coloured, fine grained and hard rock, but it has been changed boulders and soils by spheroidal weathering.

Talus deposit is distributed at the foot of a hill, and it consists of sandy or clayey soil with gravels. The foliation of the area is NNE direction. Dolerite intrudes into gneiss and dips 20 to 40N. Faults and folds are not recognized in the field.

b) Dam Axis Geology

Three(3) bore holes have been drilled reaching 52.0 m on the proposed dam axis. According to this result the geology of the dam axis consists of gneiss, dolerite and talus deposit.

Gneiss is medium grained and white to light grey coloured rock, and contains numerous inclusions of pegmatite veins which are 1 to 50 cm in width. At the dam axis gneiss is highly weathered up to 14 m below surface, and cores are recovered as soils and gravels. In the right bank the zone between 0 and 8 m is classified into D class, and it ranges in permeability coefficient from 2.0 to 6.5 x 10^{-4} cm/sec, and in N-value from 30 to 40. The zone below 8 m is classified into C1 class, and cores are recovered as gravels, but Lugeon-value is less than 5L.

Dolerite is distributed at the right bank and 60 m in width. The rock has been changed into boulders by spheroidal weathering, and therefore cores are recovered as sands or gravels. Permeability is great, and the coefficient is n x 10^{-3} cm/sec near 8 m and n x 10^{-4} cm/sec near 16 m below surface.

Talus deposit is distributed at a foot of hills with maximum depth of 2 m and consists of sandy or clayey soil with gravels. Stabilized water level was 6 m at the right bank and 7.5 m at the river bed. In the dolerite dyke it was 1.5 m below surface. The geological structure at the dam axis is characterized in that dolerite intrudes into gneiss and dips 20 degrees to the right bank. The surrounding rocks of the dolerite are shared and highly weathered. General foliation of the area is NEN direction.

6) Mabvute (VII-1-12)

a) General Geology

The geology of the proposed dam area consists of gneiss, porphyritic granite and dolerite.

Gneiss is distributed in the southern part of the area. In the hill area gneiss is light grey coloured, medium grained, very hard rock, but along the main stream it is highly weathered and soft.

Porphyritic granite is widely distributed in the northern part and narrowly in southern part. The granite is light to dark grey or pinkish white coloured, coarse grained, massive and hard rock. In hill area it is hard, but along the main stream it is highly weathered and soft as same as gneiss.

Dolerite is distributed as two dykes in parallel with the main stream. The one of north part of the main stream is 30 m in width, and it acrosses the dam axis. The dolerite is dark greenish coloured and very hard rock, but it has been changed into boulders by spheroidal weathering.

The foliation of the area is generally dominant ENE trend and dips south. According to Short Report No.42 published by Zimbabwe Geological Survey, the foliation trend is due to large scale fold structure including the proposed area. The strike of the dolerite and joints is same with the axis of the fold. Porphyritic granite and dolerite intrude into gneiss, and therefore at the contact zone surrounding rocks are sheared and highly weathered.

b) Dam Axis Geology

Three(3) bore holes have been drilled reaching 51.8 m on the proposed dam axis. According to this result the geology of the dam axis consists of gneiss, porphyritic granite, dolerite and river deposit.

Gneiss ranges from massive and even-grained rock to banded and foliated rock. Partly porphyritic granite injects into gneiss and forms banded gneiss. In the both banks, gneiss at the contact zone with granite is highly weathered, and cores are recovered as sandy and clayey soil with gravels. In this zone N-value is low, and in BH-1 average N-value is 30.6 and in BH-3 26.5. Permeability coefficient in this zone is $n \times 10^{-4}$ cm/sec. In the river bed core recovery rate is high, and the granite is classified into Ch - Cm class. Lugeon-value of this zone is 8.5 to 11.5L.

Porphyritic granite is very coarse and massive. When it is fresh, the granite is light grey to pinkish white coloured and hard rock, and joints are widely spaced. At the contact zone with gneiss and dolerite the granite is completely to highly weathered. In the right bank permeability coefficient is $n \times 10^{-3}$ cm/sec.

Dolerite is distributed in the left bank as a dyke, and it is dark greenish grey coloured, very fine and hard, but has been changed into boulders. The dyke is 15 m width and the surrounding rock is highly sheared.

In the both banks, stabilized water level was near 6.0 to 7.5 m in D class bed rock. In the river bed, the level was at 1.5 m. The geological structure around the dam axis is characterized by the intrusion of porphyritic granite and dolerite and inclination to south. The contact zones of intrusive rocks are highly weathered and softened. It seems that the direction of the main stream is affected by the intrusive rocks.

Figure III-1-5 and Figure III-1-6

Table A-1 Rock Classification

Class	Characteristic
A	Unweathered rock. Component minerals and particles are unweathered and unaltered. Joints and fractures are very widely spaced (more than 1000 mm), closely separated (0 mm) and clean. Sound under firm blows with geological hammer is very clear. Core recovery is 100%.
B	Unweathered and very hard rock. Component minerals and particles are slightly weathered and altered. Joints and fractures widely spaced (300 - 1,000 mm) and very narrow separated (0 - 0.1 mm). Sound clearly under firm blows with hammer. Core recovery is not less than 90%.
Ch	Slightly weathered rock. Component minerals and particles except quartz are weathered and altered, however rock quality is relatively hard. Joints and fractures are medium spaced (100 - 300 mm), narrow separated (0.1 - 1.0 mm) and generally stained by limonite etc. Crumble along joints and fractures under strong blows with hammer, and sound slightly thickly. Core recovery is 75 - 90%.
Cm	Medium weathered and slightly soft rock. Component minerals and particles except quartz are slightly softened by weathering. Joints and crucks are closely spaced (30 - 100 mm), widely separated (1.0 - 5.0 mm) and stained. Crumble along joints and crucks under ordinary blows with hammer, and sound thickly. Core recovery is 50 - 75%.
Cl	Highly weathered and very soft rock. Component minerals and particles are softened by weathering. Joints and crucks are very closely spaced (10 - 30 mm), very widely separated (more than 5.0 mm) and stained and sometimes filled with clay. Joints and fractured spacing discoloured throughout. Crumble along joints and crucks under weak blows with hammer, and sound very thickly. Core recovery is 25 - 50%.
D	Completely weathered, very soft rock. Component minerals and particles are extremely softened and partly changed into soils. Joint and fracture spacing discoloured throughout. Crumble under very weak blows with hammer. Core recovery is 0 - 25%.

Figure. A-1 (1) Geological Map

I-2-1 Musaverema

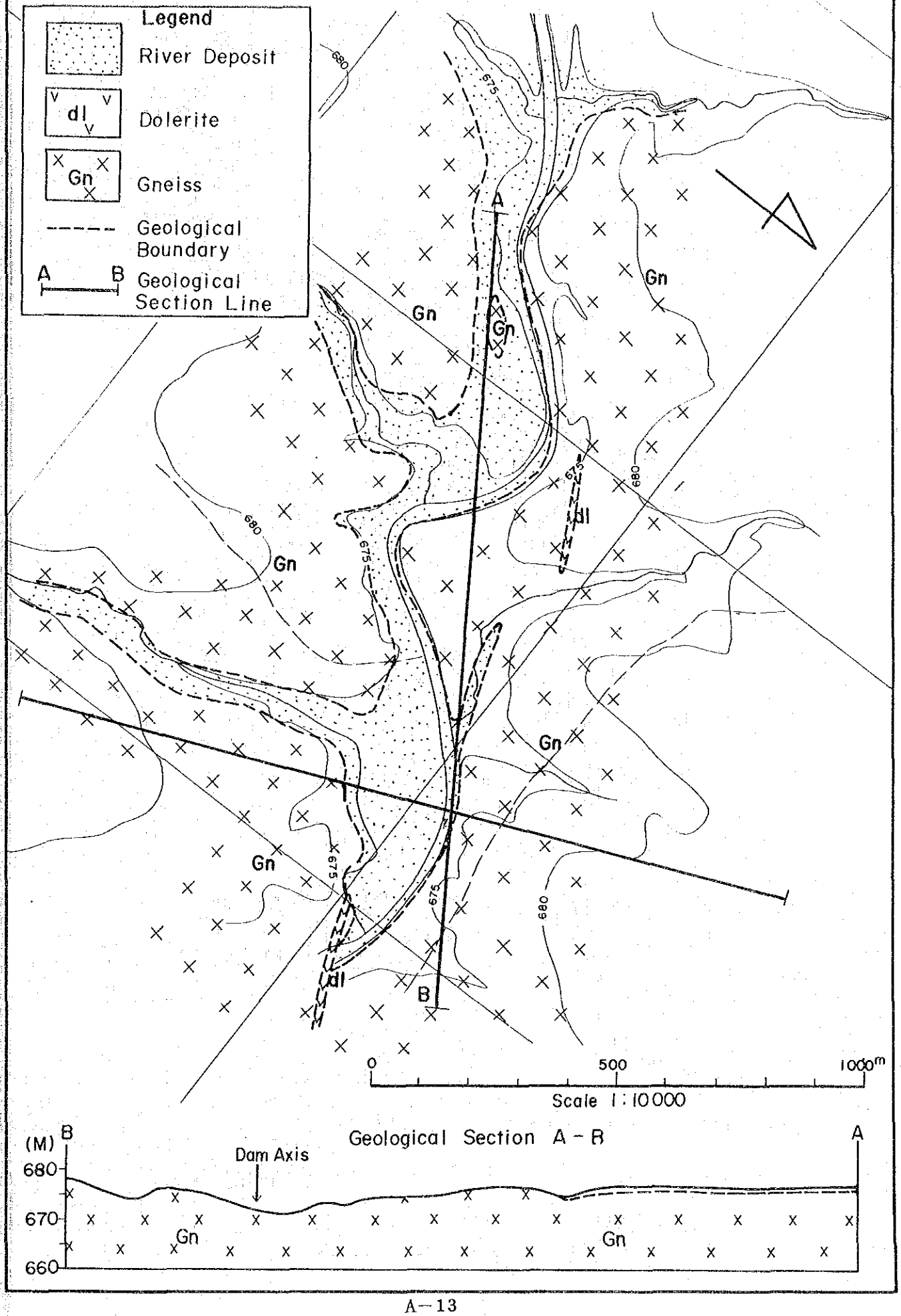


Figure. A - 1 (2) Geological Map

Ⅱ-1-6 Chinyamatumwi

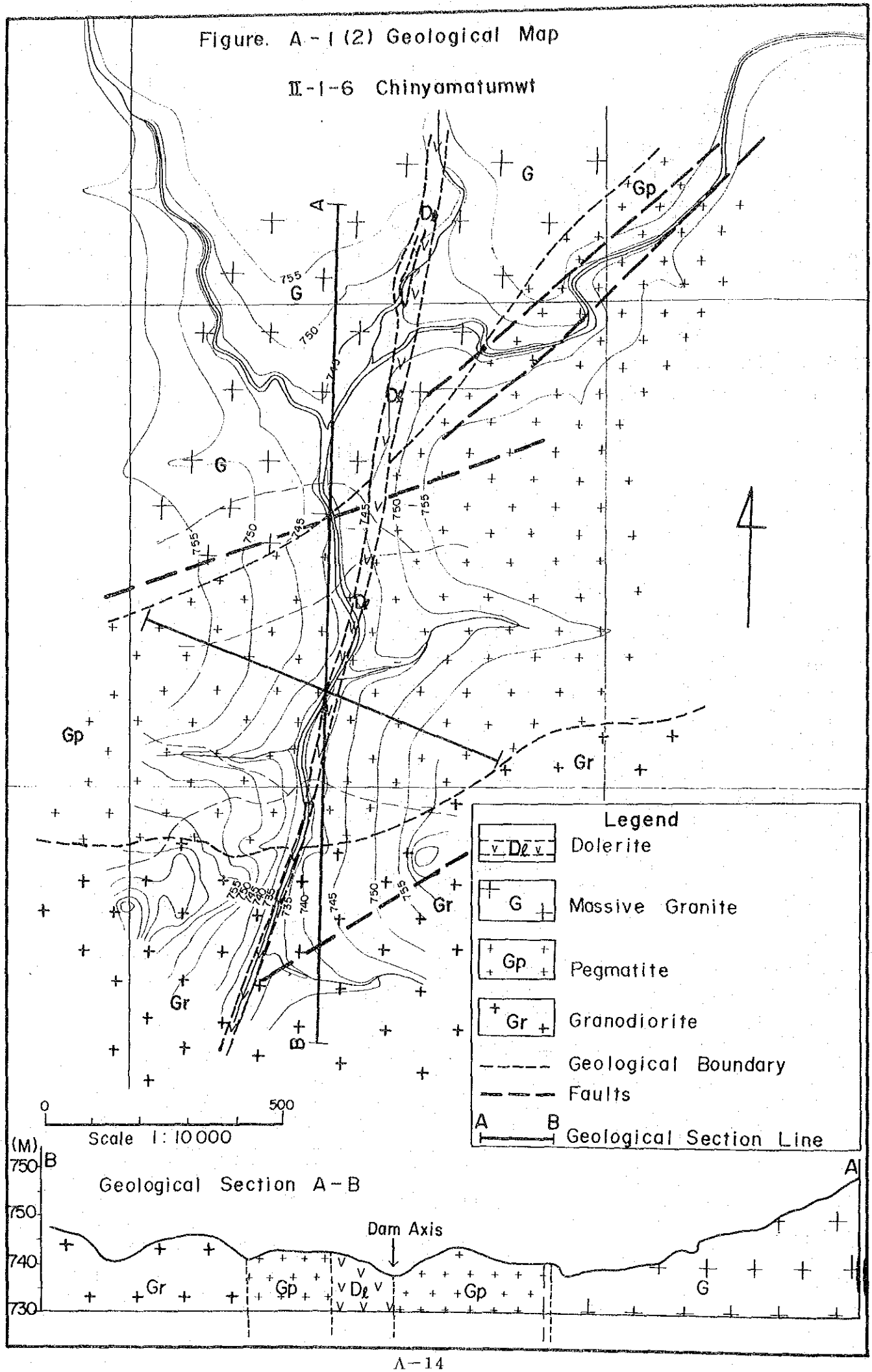
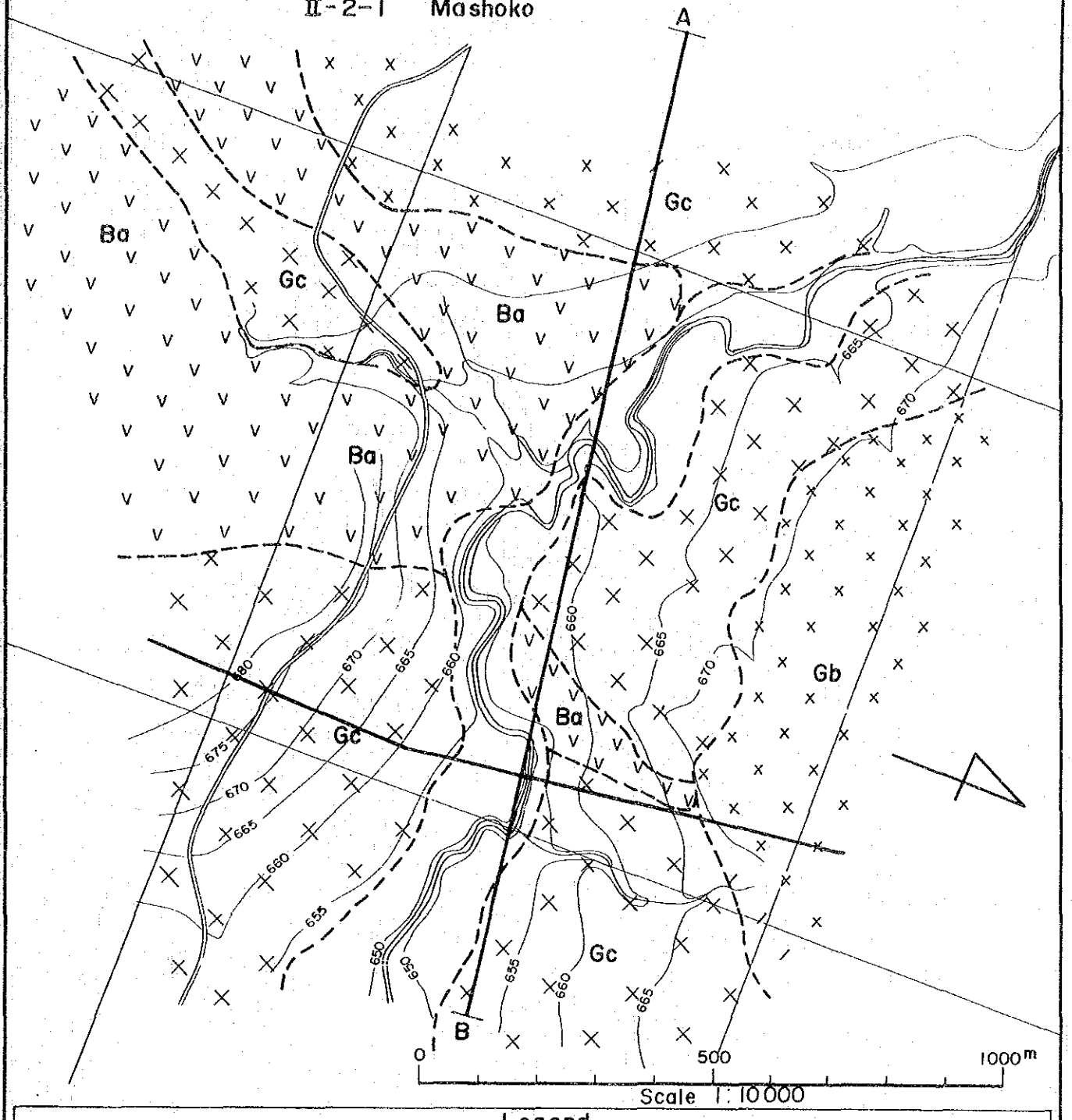


Figure. A-1 (3) Geological Map

II-2-1 Mashoko



Legend

- Terrace Deposits
- Gc — Porphyritic Gneiss
- Ba — Metabasite
- Gb — Banded Gneiss
- Geological Boundary
- A — B Geological Section Line

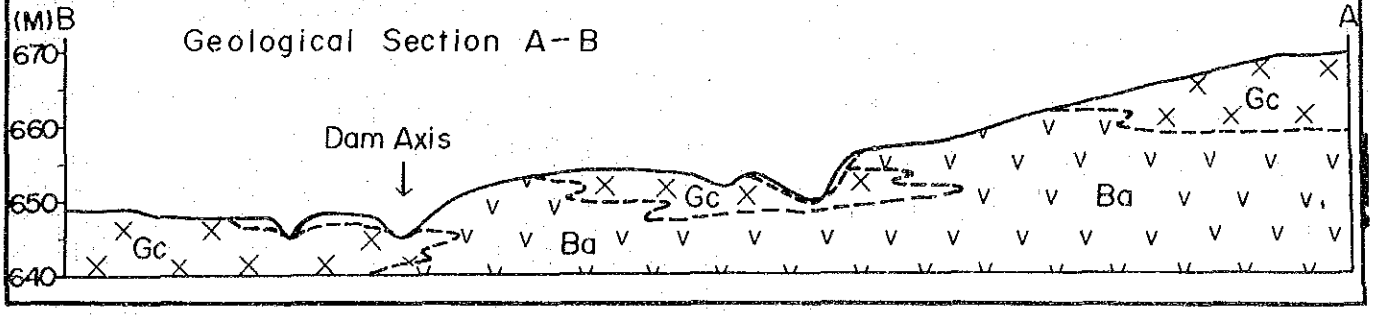


Figure. A-1(4) Geological Map

IV-4-10 Munjanganja

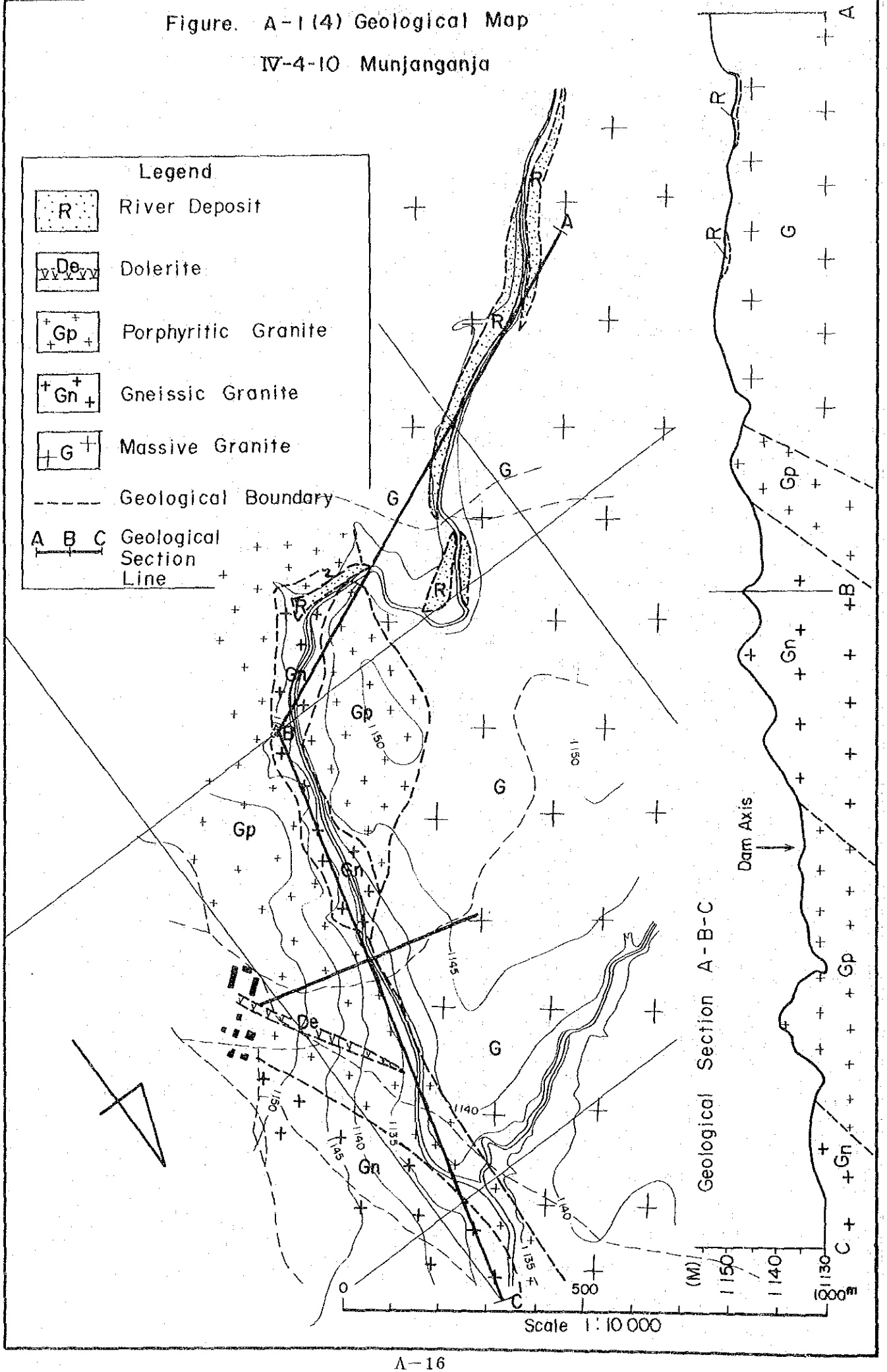
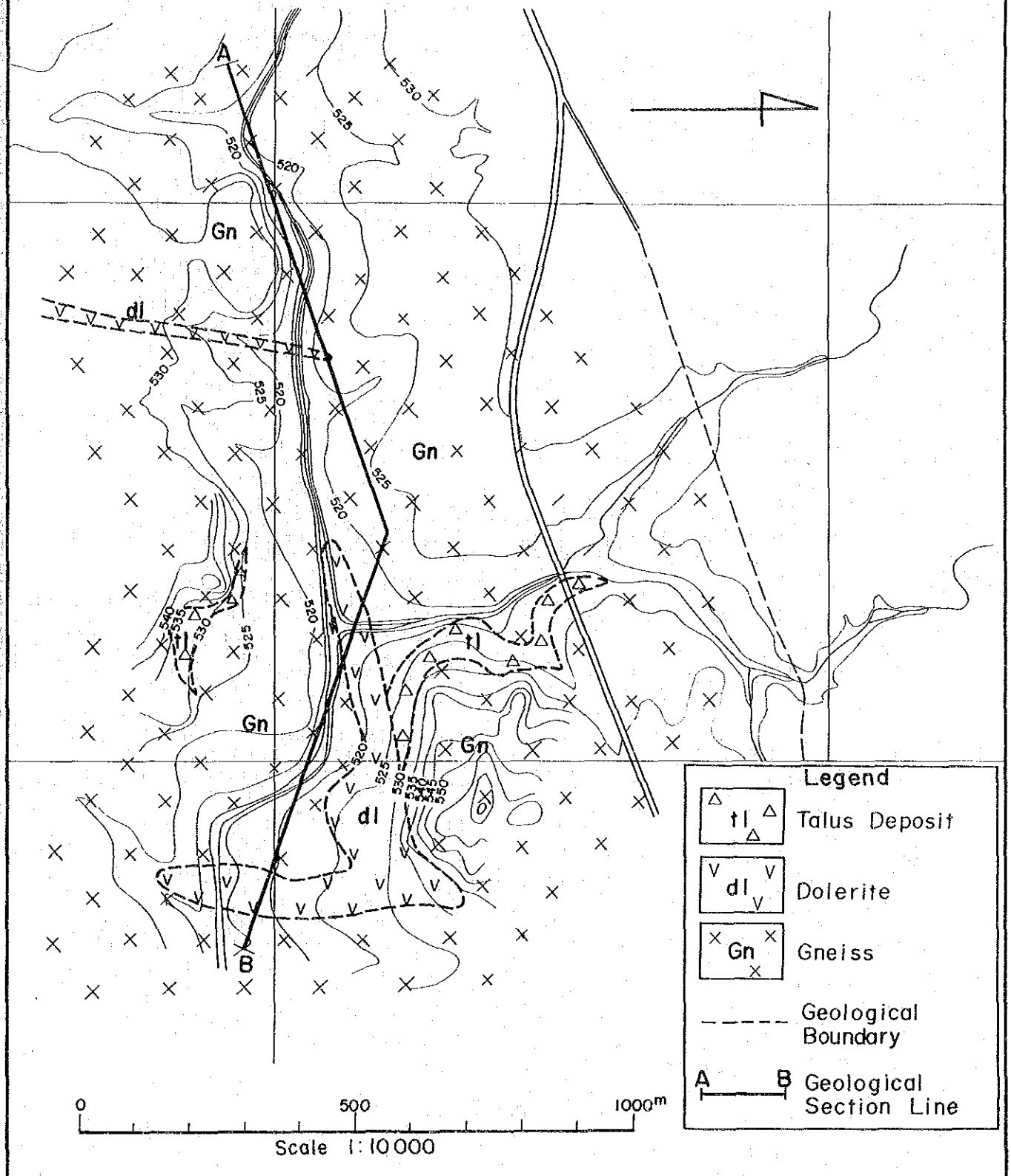


Figure. A-1(5) Geological Map

V-3-3 Magudu



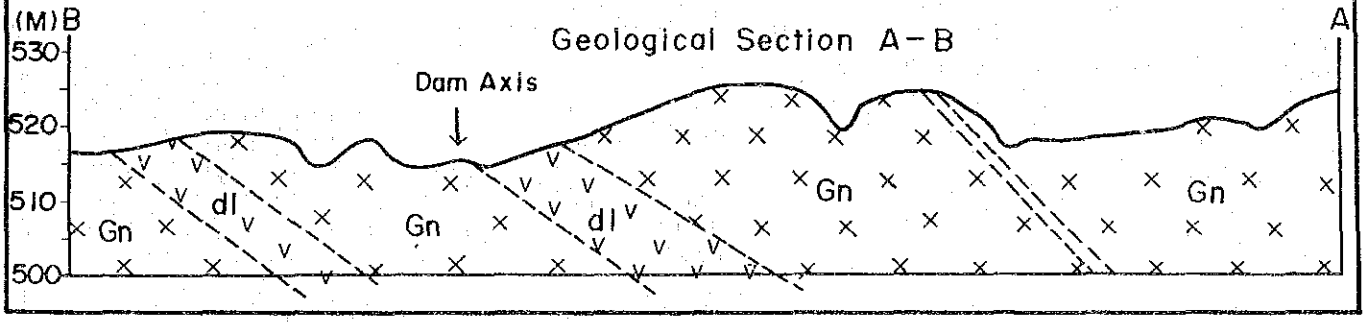
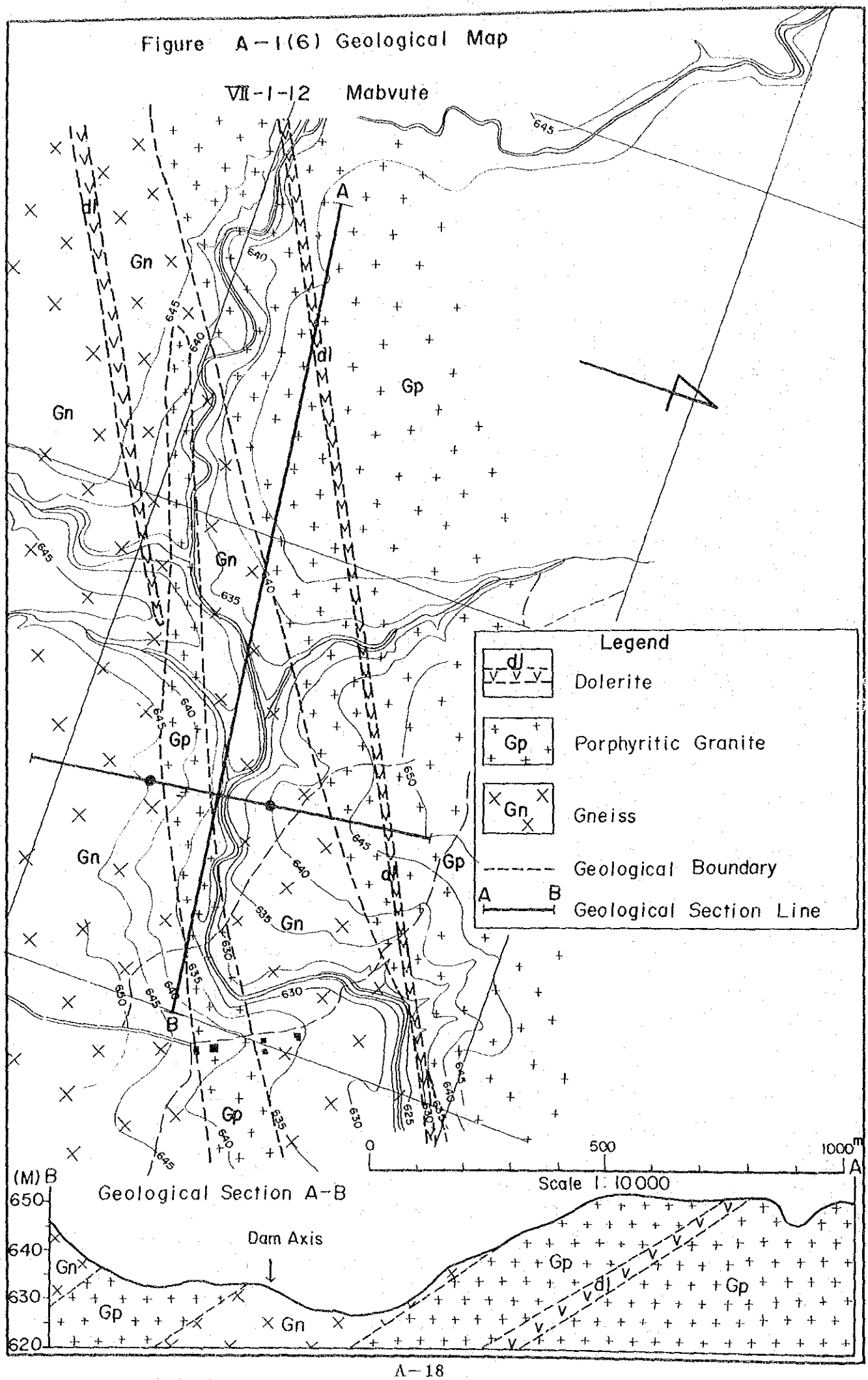


Figure A-1(6) Geological Map



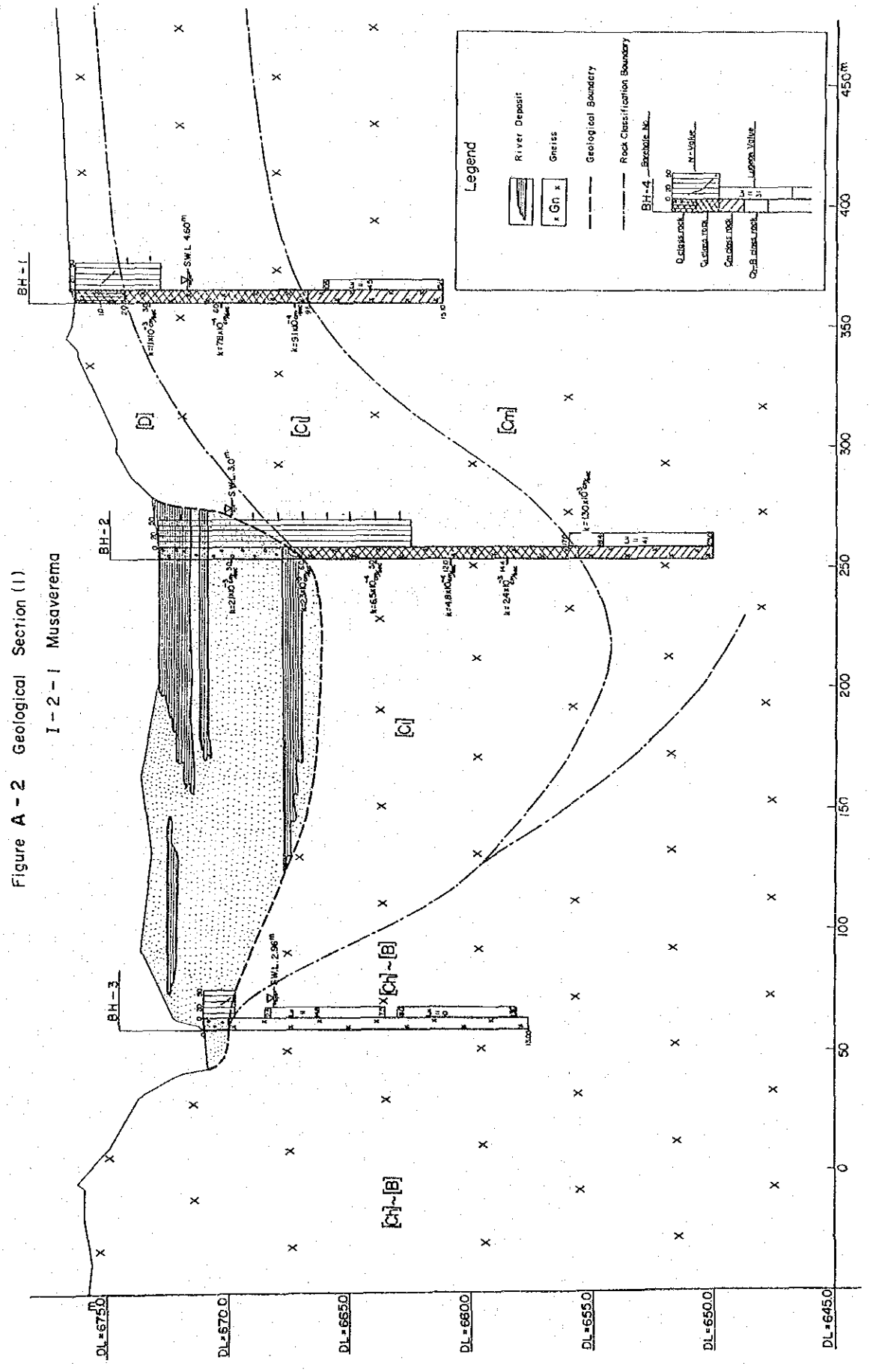


Figure A - 2 Geological Section (1)

I - 2 - 1 Musaverema

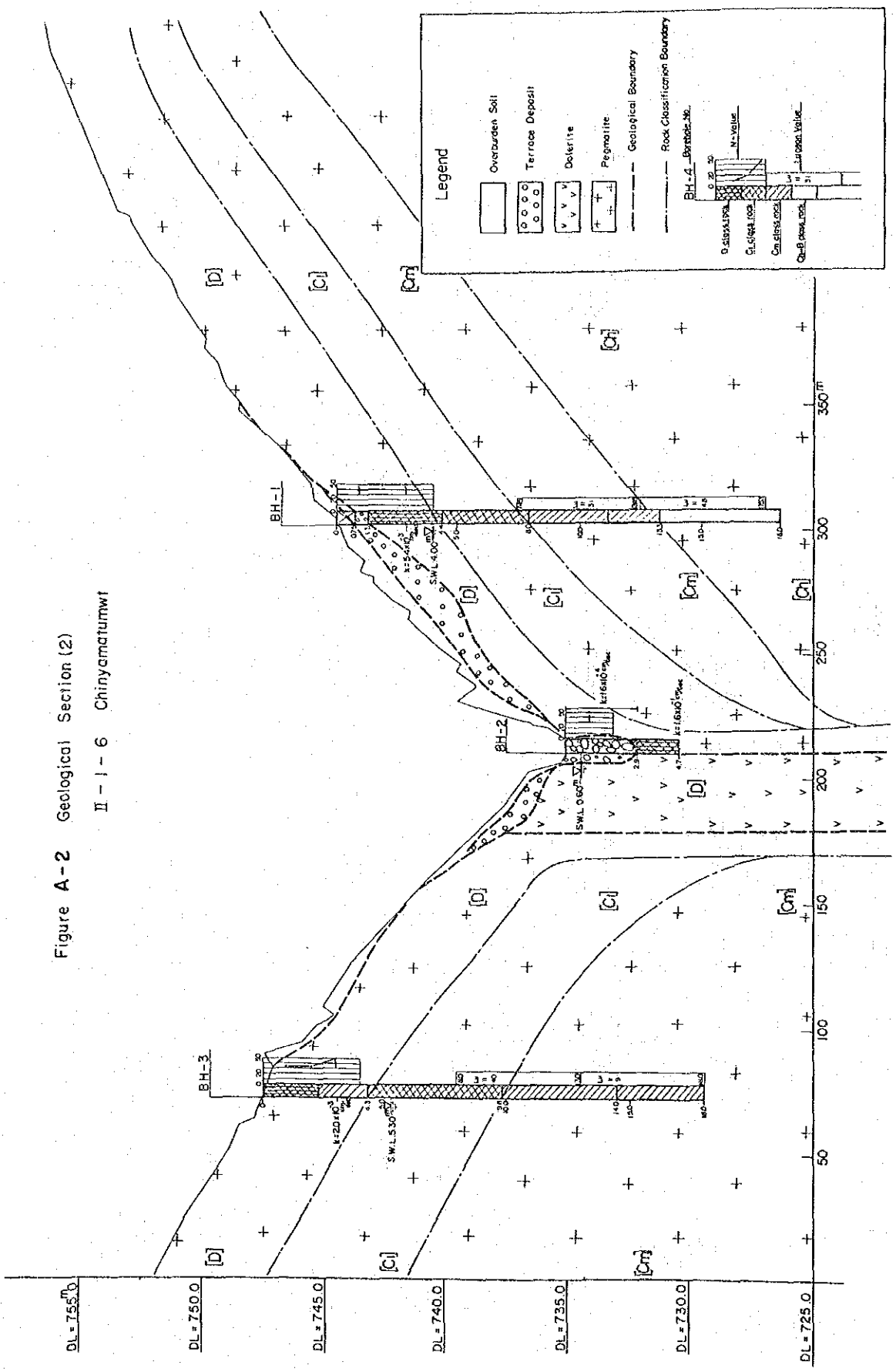


Figure A-2 Geological Section (2)

II - 1 - 6 Chinyamatumwi

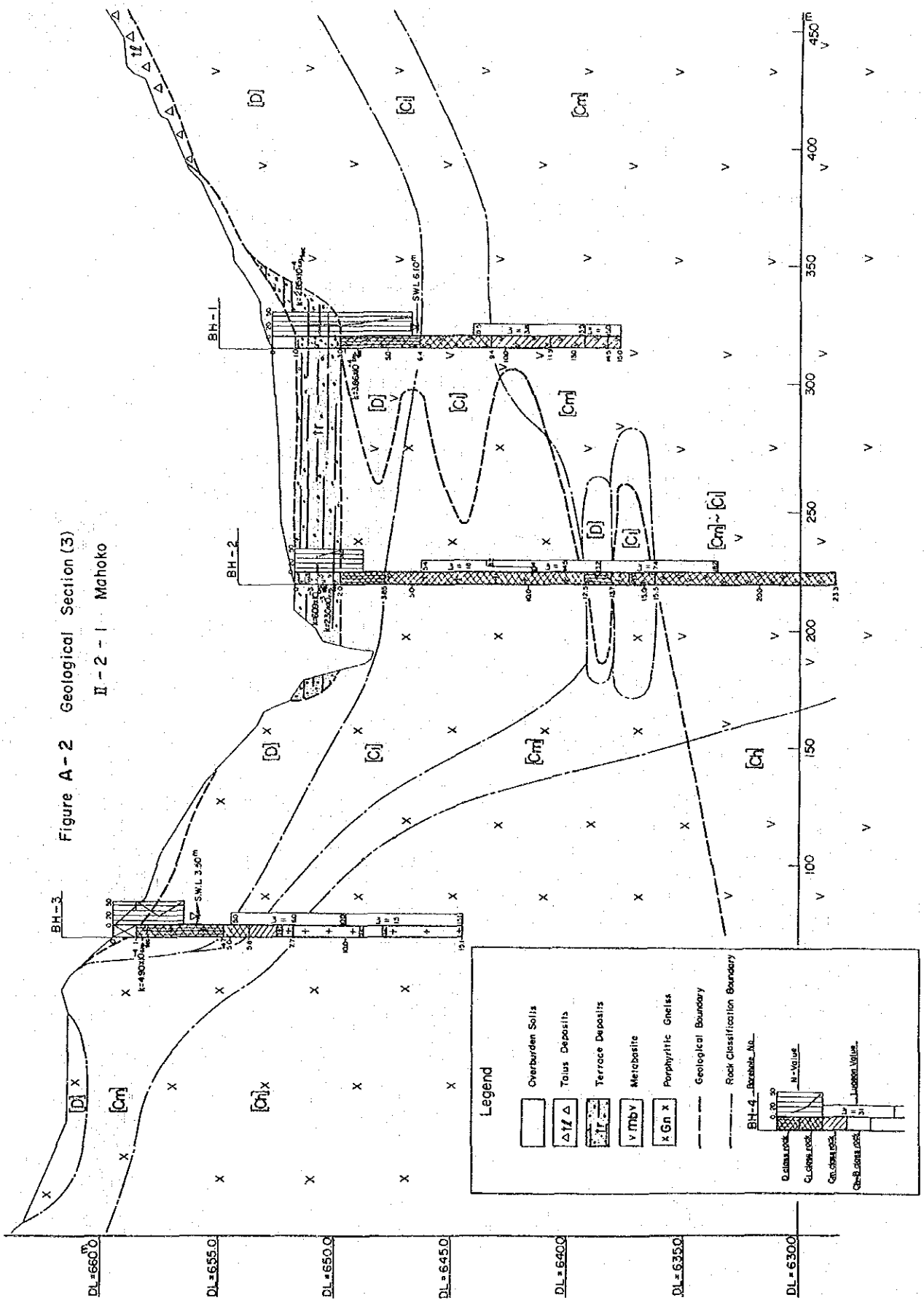


Figure A-2 Geological Section (3)

II-2-1 Mahoko

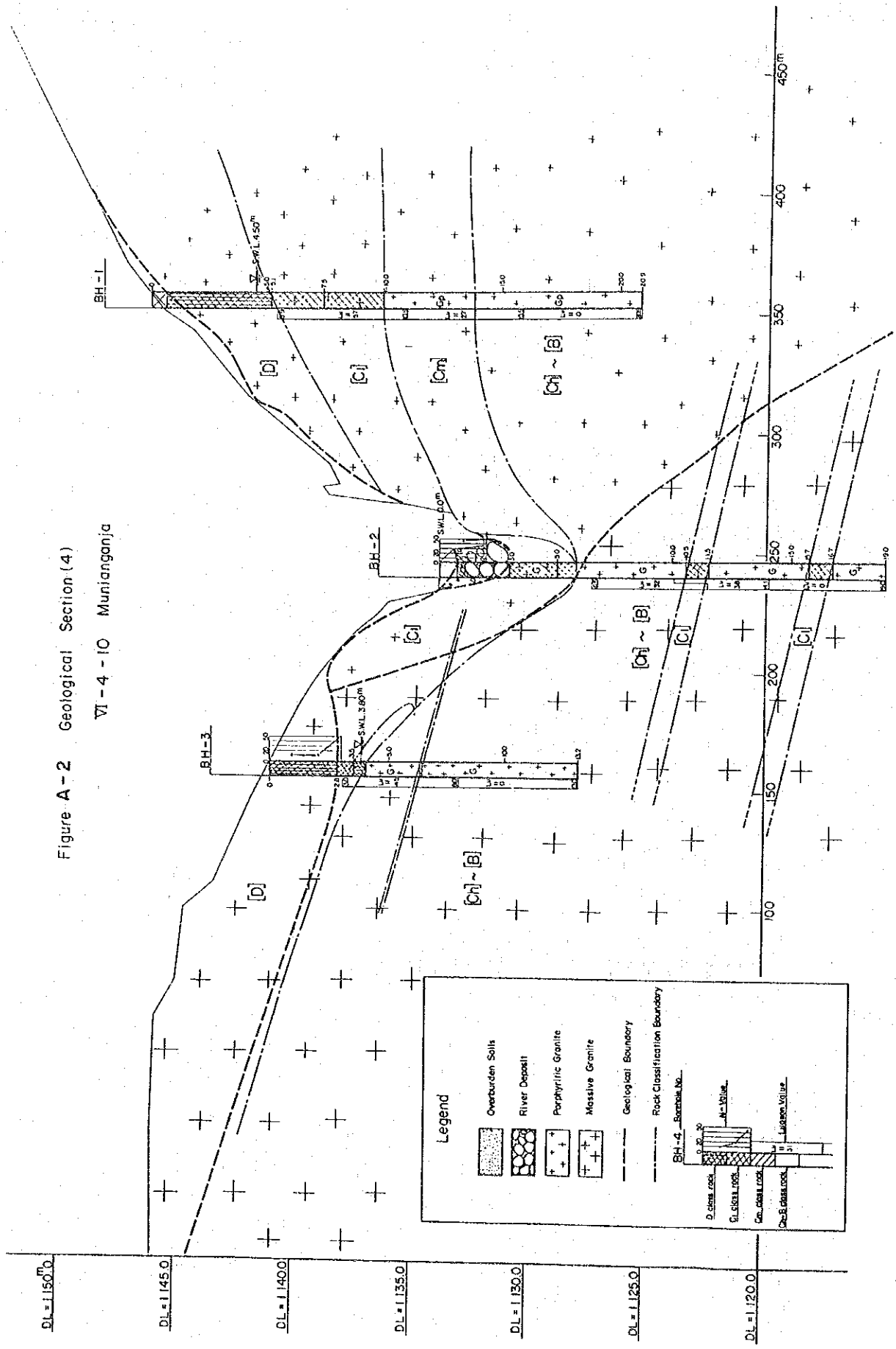
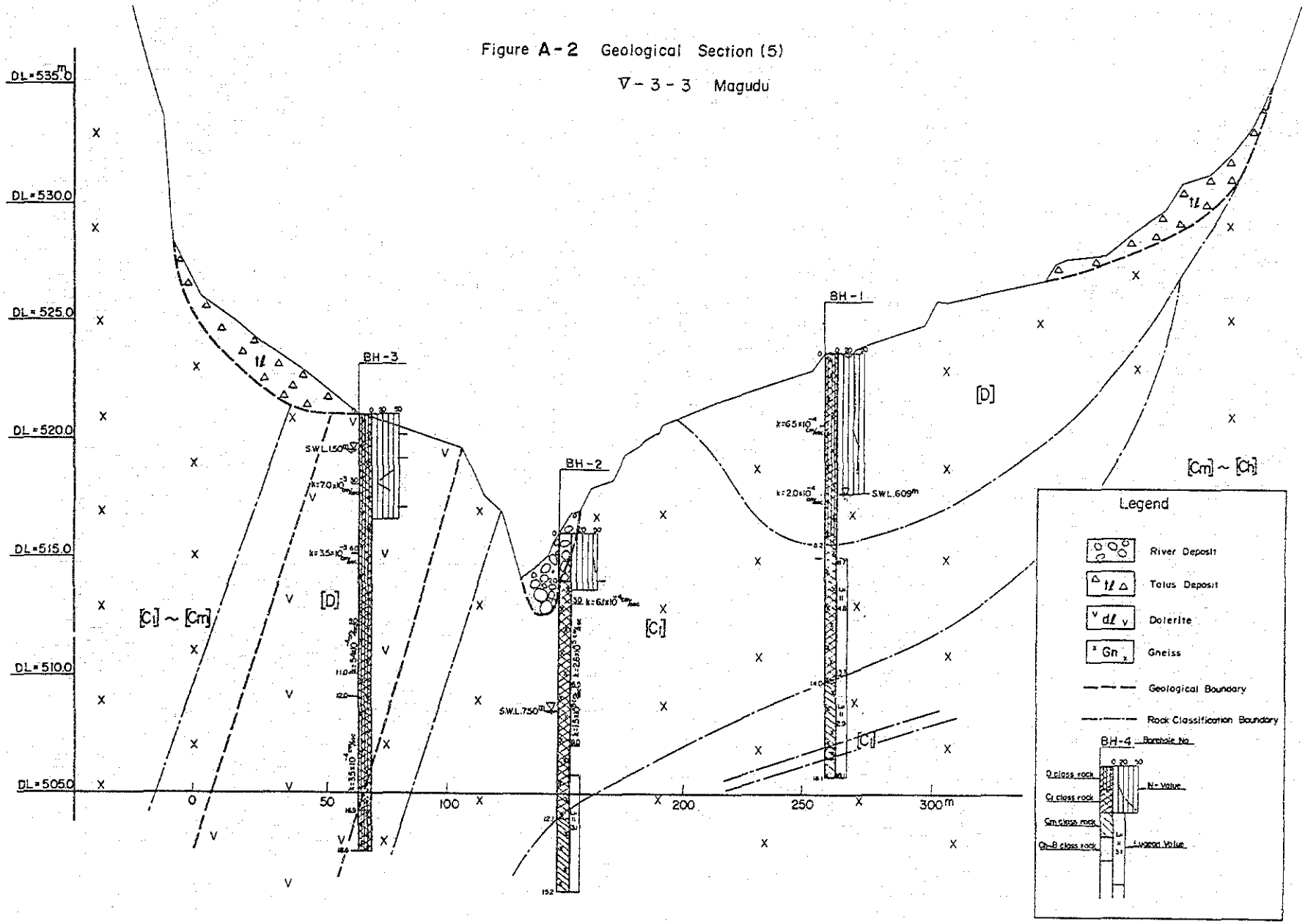


Figure A-2 Geological Section (4)

VI-4-10 Muniganja

Figure A-2 Geological Section (5)

∇-3-3 Magudu



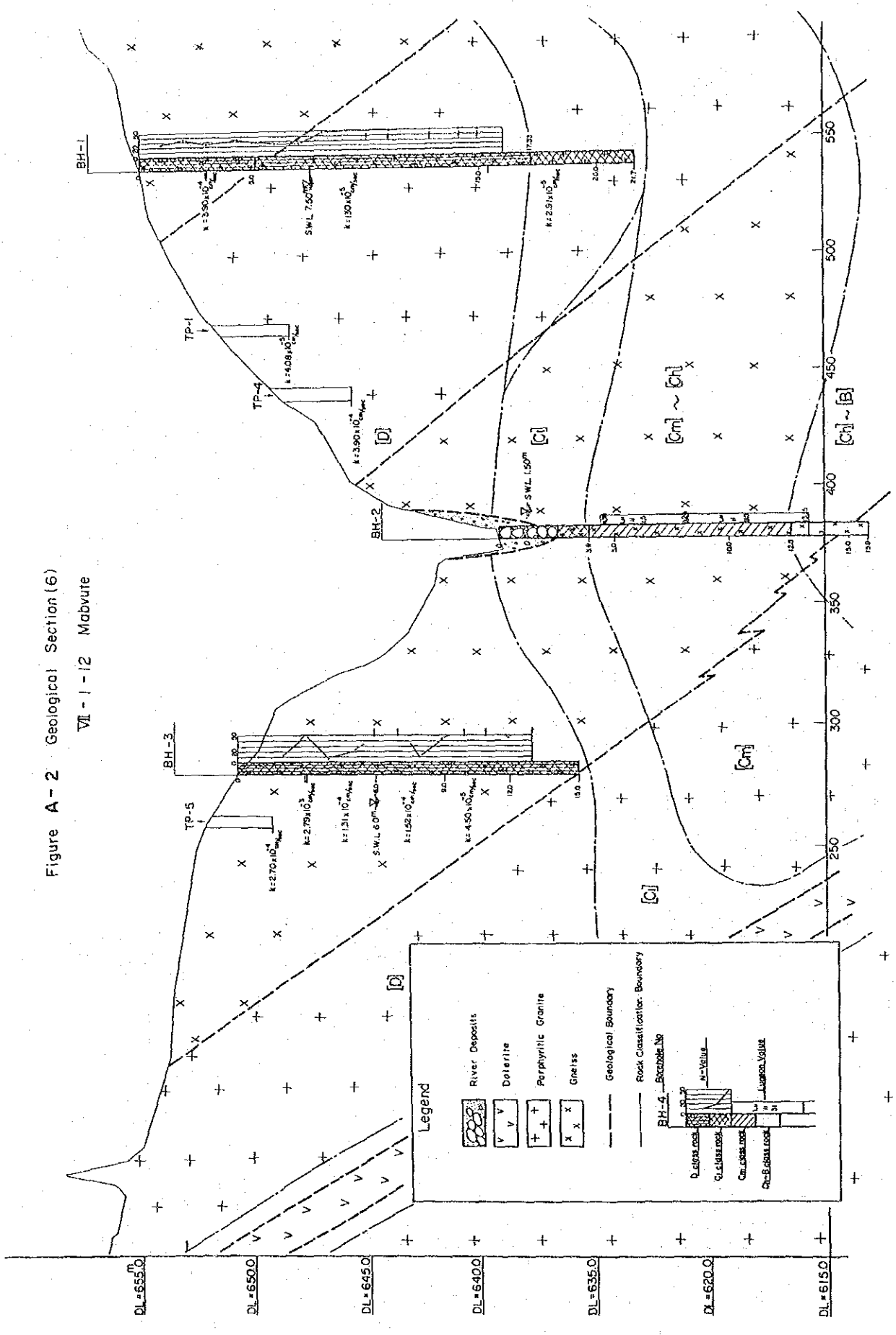


Figure A-2 Geological Section (6)

VI-1-12 Mabvute

Figure A-3 (1)

DRILL LOG

HOLE NO. 1 SHEET NO. 1 OF 1

PROJECT	MEDIUM SIZE DAMS IN MASVINGO PROVINCE			DEPTH	15.10m	ELEVATION	
SITE	I-2-1 MUSAVEREMA	COORDINATE	: :	INCLINATION	90°	DRILL RIG	
AVERAGE CORE RECOVERY		DATE	FROM 24-08 TO 25-08	DRILLED		LOGGED	

DATE	DEPTH	ELEVATION	ROCK TYPE OR FORMATION	COLUMN SECTION	DESCRIPTION	S.P.T. DEPTH	S.P.T. BLOWS (mm)	CORE RECOVERY %	CORE RECOVERY cm	R.Q.D	WATER PRESSURE TEST LUGEON VALUE	DEPTH
24-08	2.05		Gneiss		reddish brown-brown, completely weathered recovered as sand with gravels,	D	1.0 9/300		0			
					light brown-grey, highly weathered, medium to coarse grained, joints are very closely spaced, opened and stained, very soft and broken by fingers, partly changed into soils		2.0 10 20 30 40 50 / 65 130 180 215 250		23		K = 1.1 × 10⁻³ cm/sec	
							3.0 10 20 30 40 50 / 50 100 200 300 350		76			
							S.W.L 4.60m		21		K = 7.6 × 10⁻⁴ cm/sec	
						Cl			100			
25-08	9.60				grey, medium weathered, joints are closely to widely spaced, opened and stained, soft and easily broken by hammering,				145			
						Cm			145			
									132			
	15.10								34			

HOLE NO.

※R.Q.D is Rock Quality Designation, R.Q.D=(Total length of cylindric cores longer than 10 cm)/(Total core length) × 100%
※LUGEON VALUE is l/min/m under injection water pressure of 10kg/cm²
※DEPTH and ELEVATION are in meter

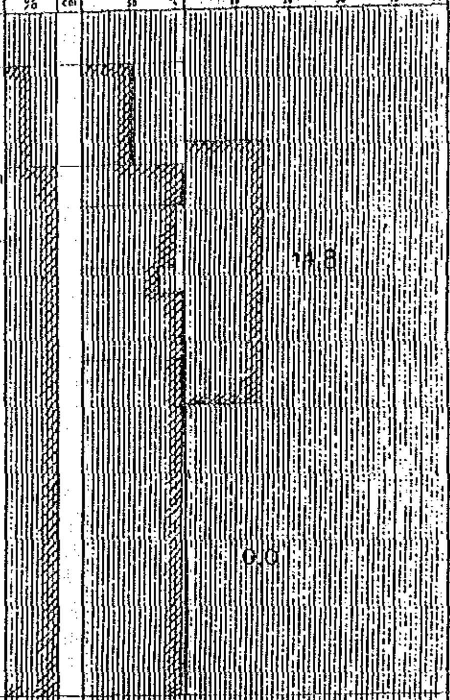
Figure A-3 (2)

DRILL LOG

HOLE NO. 3 SHEET NO. 1 OF 1

PROJECT	MEDIUM SIZE DAMS IN MASVINGO PROVINCE			DEPTH	13.05 m	ELEVATION	
SITE	I-2-1 MUSAVEREMA	COORDINATE	: :	INCLINATION	90°	DRILL RIG	
AVERAGE CORE RECOVERY		DATE	FROM 22-08 TO 23-08	DRILLED		LOGGED	

DATE	DEPTH	ELEVATION	ROCK TYPE OR FORMATION	COLUMN SECTION	DESCRIPTION	S.P.T. BLOWS	CORE RECOVERY	R.Q.D	WATER PRESSURE TEST LUGEON VALUE
	1.00		River Deposit		dark brown Sand, medium, loose				
22-08 / 23-08	13.05		Gneiss	× ×	grey, slightly weathered to fresh medium to coarse grained, joints are widely spaced, opened to closed and stained, broken along joints by strong hammering, hard to very hard. 4.86m~5.00m fractured (Ch ∫ B)	S.W.L 2.96m			14.8 / 0.0



HOLE NO.

*R.Q.D is Rock Quality Designation, R.Q.D=(Total length of cylindric cores longer than 10 cm)/(Total core length) × 100%
*LUGEON VALUE is l/min/m under injection water pressure of 10kg/cm²
*DEPTH and ELEVATION are in meter

Figure A-3 (3)

DRILL LOG Figure A - 2

HOLE NO. 2 SHEET NO. 1 OF 1

PROJECT	MEDIUM SIZE DAMS IN MASVINGO PROVINCE			DEPTH	21.00m	ELEVATION	
SITE	I-2-1 MUSAVEREMA	COORDINATE	: :	INCLINATION	90°	DRILL RIG	
AVERAGE CORE RECOVERY		DATE	FROM 21-08 TO 25-08	DRILLED		LOGGED	

DATE	DEPTH	ELEVATION	ROCK TYPE OR FORMATION	COLUMN SECTION	DESCRIPTION	S.P.T. BLOWS mm	CORE RECOVERY % cm	R.Q.D	WATER PRESSURE TEST LUGEON VALUE	DEPTH
21-08	1.30		River Deposits		brownish black, Clay with gravels, loose,	1.0 10/15 20/30 30/120 40/165 50/235				
	1.70				Sand, medium, loose					
	2.00				Clay with gravels dark brown,	2.0 10/25 20/55 30/90 40/115 50/140				
					Sand with gravels medium grained loose,	3.0 10/25 20/45 30/45 40/45 50/45	2.00			
						4.0 10/25 20/50 30/55 40/60 50/60				
	5.12					6.0 50/				
	6.00				clay and boulders,	6.0 10/10 20/15 30/25 40/30 50/35				
22-08				× ×	dark grey ~ grey, highly weathered, medium grained, joints are very closely spaced, and cores almost are recovered as gravels very soft,	7.0 10/10 20/20 30/45 40/65 50/80				
						8.0 10/30 20/85 30/125 40/150 50/180				
						9.0 10/25 20/45 30/68 40/75 50/45				
						10.0 50/				
							10			
			Gneiss				40			
23-08							15			
							20			
	17.40						135			
24-08					light grey, medium weathered, medium grained, joints closely to widely spaced, opened and stained,					
25	21.00			× ×	18.50m ~ 18.70m fractured:					

HOLE NO.

※R.Q.D is Rock Quality Designation, R.Q.D=(Total length of cylindric cores longer than 10 cm)/(Total core length) × 100%
※LUGEON VALUE is l/min/m under injection water pressure of 10kg/cm²
※DEPTH and ELEVATION are in meter

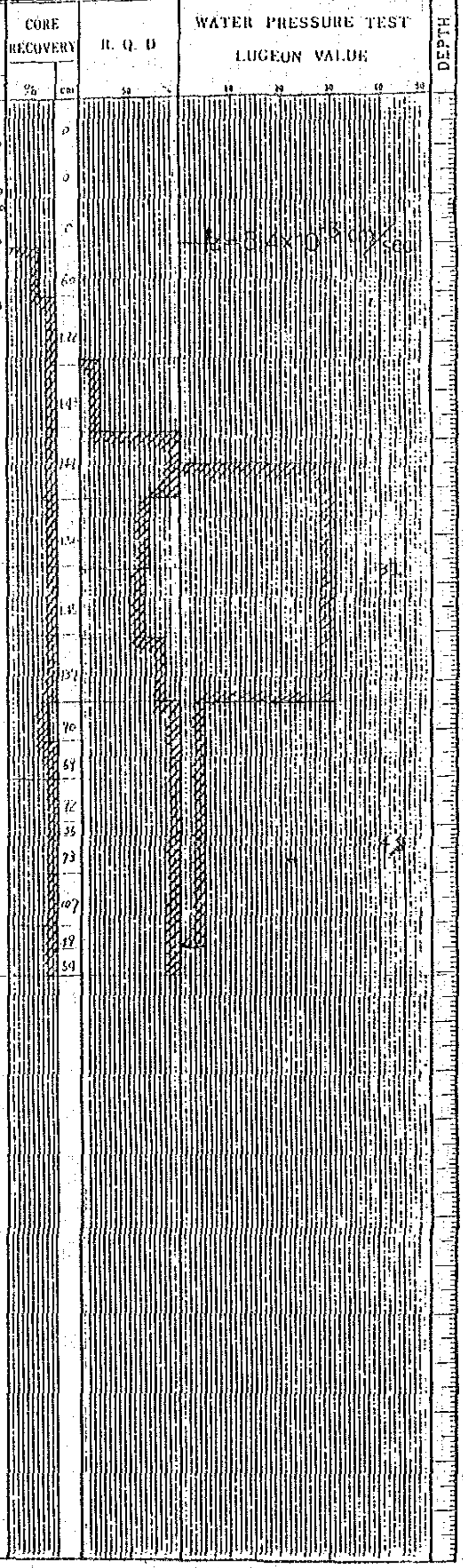
Figure A-3 (4)

DRILL LOG

HOLE NO. 1 SHEET NO. 1 OF 1

PROJECT	MEDIUM SIZE DAMS IN MASVINGO PROVINCE			DEPTH	18.07^{m}	ELEVATION	
SITE	H-1-6 Chinyamatumwt	COORDINATE	: :	INCLINATION	90°	DRILL RIG	
AVERAGE CORE RECOVERY		DATE	FROM 26-07 TO 29-07	DRILLED		LOGGED	

DATE	DEPTH	ELEVATION	ROCK TYPE OR FORMATION	COLUMN SECTION	DESCRIPTION		DEPTH	S.P.T. BLOWS
26-07	0.70		Overburden		Silt, light grey,			
	1.30		Terrace Deposit		Sand with gravels		1.0	10/10, 20/5, 30/5, 40/10, 50/20
	4.40		Pegmatite	+	pinkish white, completely weathered, very coarse grained, recovered as fragmentary rocks.	D	2.0	10/125, 20/155, 30/280, 40/270, 50/300
							3.0	10/10, 20/35, 30/50, 40/55, 50/65
								SWL 4.00^{m}
	7.00			+	pinkish white, highly weathered, very coarse grained, joints are very closed and stained, partly contain clay, very soft,	CI		
27-07	13.30			+	pinkish white, medium weathered, joints are widely spaced, open and stained 9.85~10.05 / 10.88~11.08 fractured	CM		
28-07	18.07			+	pinkish white, slightly coarse ~ very coarse grained, joints are widely spaced, opened and hard, stained,	CH ~ B		



HOLE NO.

*R.Q.D is Rock Quality Designation, R.Q.D=(Total length of cylindric cores longer than 10 cm)/(Total core length) x 100%
*LUGEON VALUE is l/min/m under injection water pressure of 10kg/cm²
*DEPTH and ELEVATION are in meter

Figure A-3 (5)

DRILL LOG

HOLE NO. 2 SHEET NO. 1 OF 1

PROJECT	MEDIUM SIZE DAMS IN MASVINGO PROVINCE			DEPTH	4.70^m	ELEVATION	
SITE	II-1-6 Chinyamatumwt	COORDINATE	: :	INCLINATION	90°	DRILL RIG	
AVERAGE CORE RECOVERY		DATE	FROM 30-07 TO 31-07	DRILLED		LOGGED	

DATE	DEPTH	ELEVATION	ROCK TYPE OR FORMATION	COLUMN SECTION	DESCRIPTION	S.P.T. DEPTH	S.P.T. BLOWS (mm)	CORE RECOVERY %	CORE RECOVERY cm	R.Q.D	WATER PRESSURE TEST LUGEON VALUE	DEPTH
30-07	3.00		River Deposit		Sands and gravels very loose	1.0 2.0 3.0	SWL 0.60m 10/45, 20/90, 30/130, 40/140, 50/150 50 50		0		K=1.8×10[illegible] cm/sec	
31-07	4.70		Pegmatite		light brown, completely weathered, recovered as **gravels.**				10		K=1.8×10[illegible] cm/sec	

HOLE NO.

* R.Q.D is Rock Quality Designation, R.Q.D=(Total length of cylindric cores longer than 10 cm)/(Total core length) x 100%
* LUGEON VALUE is l/min/m under injection water pressure of 10kg/cm²
* DEPTH and ELEVATION are in meter

Figure A-3 (6)

DRILL LOG

HOLE NO. 3 SHEET NO. 1 OF 1

PROJECT	MEDIUM SIZE DAMS IN MASVINGO PROVINCE			DEPTH	18.01 m	ELEVATION	
SITE	II-1-6 Chinyamatumwt	COORDINATE	: :	INCLINATION	90°	DRILL RIG	
AVERAGE CORE RECOVERY		DATE	FROM 23-07 TO 28-07	DRILLED		LOGGED	

DATE	DEPTH	ELEVATION	ROCK TYPE OR FORMATION	COLUMN SECTION	DESCRIPTION	S.P.T. DEPTH	S.P.T. BLOWS mm	CORE RECOVERY %	CORE RECOVERY cm	R.Q.D	WATER PRESSURE TEST LUGEON VALUE	DEPTH
23-07	2.21				light brown, completely weathered, recovered as soil with gravels, very loose,	D	1.0 10 20 30 35 / 20 20 20 30		0			
					greenish white, recovered as sand and gravells, very soft,	D	2.0 10 20 30 37 / 18 23 27 35		0			
24-07	4.30					D	5.0 10 20 30 40 50 / 20 45 60 70 70		74			
							1.0 50		0			
			Pegmatite		pinkish white, highly weathered, coarse~very coarse grained, joints are closely to medium spaced opened and stained, vertical joints many, soft, easily separated along joints, partly recovered as rounded gravels	Cl	▽ S.W.L 5.30m		149			
	9.80											
25-07					pinkish white, medium weathered, very coarse, joints are medium to widely spaced, opened and stained,	Cm			202			
26									75			
27-07									75			
									152			
									74			
28-07									38			
									112			
	18.01											

HOLE NO.

*R.Q.D is Rock Quality Designation, R.Q.D=(Total length of cylindric cores longer than 10 cm)/(Total core length) × 100%
*LUGEON VALUE is l/min/m under injection water pressure of 10kg/cm²
*DEPTH and ELEVATION are in meter

Figure A-3 (7)

DRILL LOG

HOLE NO. 1 SHEET NO. 1 OF 1

PROJECT	MEDIUM SIZE DAMS IN MASVINGO PROVINCE		DEPTH	15.06m	ELEVATION	
SITE	II-2-1 MASHOKO	COORDINATE : :	INCLINATION	90°	DRILL RIG	
AVERAGE CORE RECOVERY		DATE FROM 6-08 TO 8-08	DRILLED		LOGGED	

DATE	DEPTH	ELEVATION	ROCK TYPE OR FORMATION	COLUMN SECTION	DESCRIPTION		S.P.T. DEPTH	S.P.T. BLOWS mm	CORE RECOVERY % cm	R.Q.D	WATER PRESSURE TEST LUGEON VALUE	DEPTH
6-08	1.00		Over-burden		light grey, Silt,		1.0	10 20 / 35 30cm	100			
			Terrace Deposits		Silty Sand, light brown-light grey, compact,		2.1	10 20 30 / 150 270 350	100			
	3.00			V V	bluish grey, completely weathered,		3.1	10 20 30 / 110 270 380	100			
				V	recovered as soils	D	4.1	10 20 30 / 130 320 340	100			
				V V	with gravels,		5.1	20 20 20 35 / 120 235 290 300	100			
				V	▽ S.W. 6.10m		6.0	10 20 30 36 / 70 170 255 300	40			
	6.40		Meta-basite	V V	grey-dark grey, highly weathered, medium-fine grained,				48			
				V	joints are very closely spaced,	CI			20			
				V V	opened and stained,				51			
	9.40			V	very soft,				39			
7-08				V V	grey-dark grey, medium weathered, joints are closely spaced,	Cm			57			
				V	10.50-11.00 fractured,				49			
	11.90			V V					87			
				V	pinkish grey, slightly weathered, joints are closely				73			
				V V	to widely spaced, partly	Cm						
8-08				V	changed into gravels,				155			
	15.06			V V								

HOLE NO.

※R.Q.D is Rock Quality Designation, R.Q.D=(Total length of cylindric cores longer than 10 cm)/(Total core length) × 100%
※LUGEON VALUE is l/min/m under injection water pressure of 10kg/cm²
※DEPTH and ELEVATION are in meter

Figure A-3 (8)

DRILL LOG

HOLE NO. 2 SHEET NO. 1 OF 1

PROJECT	MEDIUM SIZE DAMS IN MASVINGO PROVINCE		DEPTH	23.03 m	ELEVATION
SITE	II-2-1 MASHOKO	COORDINATE : :	INCLINATION	90°	DRILL RIG
AVERAGE CORE RECOVERY		DATE FROM 1-08 TO 4-08	DRILLED		LOGGED

DEPTH	ROCK TYPE OR FORMATION	COLUMN SECTION	DESCRIPTION		S.P.T. DEPTH	S.P.T. BLOWS (mm)	WATER PRESSURE TEST LUGEON VALUE
1.78	Terrace Deposits		light grey, silty sand,		1.07	10/100, 20/190, 30/275, 34/300	[illegible]
3.85		× ×	reddish brown, completely weathered recovered as very loose sandy silt,	D	2.12	10/40, 20/80, 30/110, 40/135, 50/155	[illegible]
					3.00	10/85, 20/155, 30/210, 40/260, 50/275	
12.50	Gneiss	× ×	light brown-pinkish white, highly weathered, coarse grained, joints are very closely spaced, opened and stained, partly recovered as soil, very soft.	CI		S.W.L 7.50 m	1.8; 14.6
13.65	Meta-basite	v v	greenish brown, very soft, broken by finger.	D			
15.59	Gneiss	× ×	pinkish grey, highly weathered, very soft,	CI			
23.03	Meta-basite	v v	dark grey to black, medium weathered, fine grained, joints are widely spaced, closed and stained, soft, easily broken by hammering, contains many inclusions of veins of quartzite,	CM ~ CI			7.4; 6.5

*R.Q.D is Rock Quality Designation, R.Q.D = (Total length of cylindric cores longer than 10 cm)/(Total core length) x 100%

*LUGEON VALUE is l/min/m under injection water pressure of 10 kg/cm²

*DEPTH and ELEVATION are in meter

HOLE NO.

Figure A-3 (9)

DRILL LOG

HOLE NO. 3 SHEET NO. 1 OF 1

PROJECT	MEDIUM SIZE DAMS IN MASVINGO PROVINCE		DEPTH	15.13m	ELEVATION
SITE	II-2-1 MASHOKO	COORDINATE : :	INCLINATION	90°	DRILL RIG
AVERAGE CORE RECOVERY		DATE FROM 4-08 TO 7-08	DRILLED		LOGGED

DATE	DEPTH	ELEVATION	ROCK TYPE OR FORMATION	COLUMN SECTION	DESCRIPTION		DEPTH	S.P.T. BLOWS mm	CORE RECOVERY %	R.Q.D	WATER PRESSURE TEST LUGEON VALUE	DEPTH
20-4-08	1.00		Over-burden		light grey, Silt, very loose.		1.0	10/0 20/0 30/0 40/0 50/0				
				× ×	reddish brown-light grey,		2.0	10/2cm 20/3cm				
				×	completely weathered,	D	3.0	50/				
				× ×	recovered as sand and gravels,			▽ S.W.L 3.05m				
				×	very soft,							
	4.71			× ×	highly weathered,							
				×	very soft,	Cl						
	5.79			× ×	light grey, medium weathered, coarse grained, joints							
5-6-08			Gneiss	×	are closely spaced,	Cm						
	7.70			× ×	grey-pinkish white,							
				×	slightly weathered,							
					very coarse grained,							
				× ×	joints are widely spaced, opened and							
				×	stained,	Ch						
7-8-08				× ×	10.60m~10.75m 11.60~11.75 14.90~15.10 } fractured,	B						
				× ×								
				×								
	15.13											

※R.Q.D is Rock Quality Designation, R.Q.D=(Total length of cylindric cores longer than 10 cm)/(Total core length) x 100%
※LUGEON VALUE is l/min/m under injection water pressure of 10kg/cm²
※DEPTH and ELEVATION are in meter

HOLE NO.

Figure A-3 (10)

DRILL LOG

HOLE NO. 1 SHEET NO. 1 OF 1

PROJECT	MEDIUM SIZE DAMS IN MASVINGO PROVINCE			DEPTH	20.91 m	ELEVATION	
SITE	IV-4-10 MUNJANGANJA	COORDINATE	: :	INCLINATION	90°	DRILL RIG	
AVERAGE CORE RECOVERY		DATE	FROM 16-07 TO 20-07	DRILLED		LOGGED	

DATE	DEPTH	ELEVATION	ROCK TYPE OR FORMATION	COLUMN SECTION	DESCRIPTION	DEPTH	S.P.T. BLOWS / mm	CORE RECOVERY % / cm	R.Q.D	WATER PRESSURE TEST LUGEON VALUE	DEPTH
16-07	0.70		Overburden soil		Silt, light grey, yellowish brown, completely weathered coarse to medium grained, recovered as sand with rock pieces,	D					
							▽ S.W.L 4.50 m	36 / 22			
17-07	5.12		Porphyritic Granite		pink-greyish white, highly weathered, very coarse grained, joints are closely spaced and stained, very soft,	Cl		65 / 47 / 55 / 173			
17-07	9.85				pink-greenish white, medium weathered, very coarse grained, joints are widely spaced and stained, soft,	Cm		103 / 197			
19-07	13.70				greyish white, slightly weathered to fresh, joints are very widely spaced, closed and clean, contain many inclusions of fragments of amphibolite,	Ch / B		165 / 91 / 70 / 102 / 100 / 100 / 100 / 100			
20-07	20.91										

HOLE NO.

※R.Q.D is Rock Quality Designation, R.Q.D=(Total length of cylindric cores longer than 10 cm)/(Total core length) × 100%
※LUGEON VALUE is l/min/m under injection water pressure of 10kg/cm²
※DEPTH and ELEVATION are in meter

Figure A-3 (11)

DRILL LOG

HOLE NO. 2 SHEET NO. 1 OF 1

PROJECT	MEDIUM SIZE DAMS IN MASVINGO PROVINCE			DEPTH	19.06 m	ELEVATION	
SITE	IV-4-10 MUNJANGANJA	COORDINATE	: :	INCLINATION	90°	DRILL RIG	
AVERAGE CORE RECOVERY		DATE	FROM 21-07 TO 24-07	DRILLED		LOGGED	

DATE	DEPTH	ELEVATION	ROCK TYPE OR FORMATION	COLUMN SECTION	DESCRIPTION	S.P.T. DEPTH	S.P.T. BLOWS	CORE RECOVERY %	CORE RECOVERY cm	R.Q.D	WATER PRESSURE TEST LUGEON VALUE	DEPTH
21-07	0.70		Overburden soil		Silt, light grey, loose,		▽ min SWL 0.00m					
			River Deposits		Sand and gravels, gravels are very hard and consisting of granites,	1.0	10 20 30 40 49 / 80 145 200 260 303					
	3.00					2.0	10 20 30 40 50 / 50 78 120 125 125					
			Porphyritic Granite		pinkish white, highly weathered, coarse grained, joints are closely spaced and stained, very soft,	Cl		136				
	5.75							85				
22-07			Massive Granite		pink-grey, slightly weathered, very coarse grained, joints are widely spaced and stained, almost hard,	Ch		83				
								59				
								118				
								45				
								81				
								63				
	10.52							78				
	11.52				10.52-11.52, fractured fragmentary, water coming up,	Cl		98				
23-07						Ch						
						S						
						B						
	15.67											
24-07					slightly weathered, coarse grained, joints are widely spaced, fresh and hard, 15.7-16.7 fractured,	Cl		53				
						Ch		70				
								48				
								40				
	19.06							27				
					*static water level 10.0	10						

HOLE NO.

*R.Q.D is Rock Quality Designation, R.Q.D = (Total length of cylindric cores longer than 10 cm)/(Total core length) × 100%
*LUGEON VALUE is l/min/m under injection water pressure of 10kg/cm²
*DEPTH and ELEVATION are in meter

Figure A-3 (12)

DRILL LOG

HOLE NO. 3 SHEET NO. 1 OF 1

PROJECT	MEDIUM SIZE DAMS IN MASVINGO PROVINCE			DEPTH	13.02 m	ELEVATION	
SITE	IV-4-10 MUNJANGANJA	COORDINATE	: :	INCLINATION	90°	DRILL RIG	
AVERAGE CORE RECOVERY		DATE	FROM 16-07 TO 20-07	DRILLED		LOGGED	

DATE	DEPTH	ELEVATION	ROCK TYPE OR FORMATION	COLUMN SECTION	DESCRIPTION		S.P.T. DEPTH	S.P.T. BLOWS (mm)	CORE RECOVERY %	CORE RECOVERY cm	R.Q.D	WATER PRESSURE TEST LUGEON VALUE	DEPTH
16-07					reddish brown, completely weathered, recovered as very loose sand	D	1.0	10/20 14/32					
							2.0	10/20 13/30					
	2.80				highly weathered fragmentary	CI	3.0	10/10 20/85 30/110 40/125 50/130					
	3.50				Fractured, no cores	D		S.W.L. 3.80m					
	4.02		Massive Granite		greyish white, fresh, hard, coarse-medium grained, joints are widely spaced and clean, including many biotite bands,	Ch J B			28	57			
17-07									44	34			
									69	69			
									59	39			
18-07					5.50 - 6.60 fractured, no cores,				50	138			
									96				
19-07									139				
									127				
20-07	13.02												

HOLE NO.

*R.Q.D is Rock Quality Designation, R.Q.D = (Total length of cylindric cores longer than 10 cm)/(Total core length) x 100%

*LUGEON VALUE is l/min/m under injection water pressure of 10kg/cm²

*DEPTH and ELEVATION are in meter

Figure A-3 (13)

DRILL LOG

HOLE NO. 1 SHEET NO. 1 OF 1

PROJECT	MEDIUM SCALE DAMS IN MASVINGO PROVINCE			DEPTH	18.14m	ELEVATION	
SITE	V-3-3 MAGUDU	COORDINATE	: :	INCLINATION	90°	DRILL RIG	
AVERAGE CORE RECOVERY		DATE	FROM 18-08 TO 20-08	DRILLED		LOGGED	

DATE	DEPTH	ELEVATION	ROCK TYPE OR FORMATION	COLUMN SECTION	DESCRIPTION		S.P.T. DEPTH	S.P.T. BLOWS mm	CORE RECOVERY %	CORE RECOVERY cm	R.Q.D	WATER PRESSURE TEST LUGEON VALUE	DEPTH
18-08					dark grey-brown, Silt, sandy, completely weathered, partly including angulor very coarse grained gravels, loose to compact,	D	1.00	10/20/30/33 (15/15/20/30)					
							2.20	10/20/30/34 (20/20/20/30)					
							3.41	10/20/30 (40/22/30)					
							4.00	10/20/30/60 (20/15/17/30)					
							5.12	10/20/30/37 (15/18/27/30)					
								S.W.L 6.09m					
	8.18		Gneiss		pinkish white-light grey, highly weathered, recovery as gravels, joints are stained, coarse grained, very soft.	Cl				56			
19-08										54			
										26			
										130			
										42			
										38			
	14.05				light grey, medium weathered, joints are closely spaced and stained, soft,	Cm				146			
20-08	16.78												
	17.30				fractured, very soft	Cl							
	18.14				medium weathered,	Cm							

HOLE NO.

※R.Q.D is Rock Quality Designation, R.Q.D= (Total length of cylindric cores longer than 10 cm)/(Total core length) x 100%
※LUGEON VALUE is l/min/m under injection water pressure of 10kg/cm²
※DEPTH and ELEVATION are in meter

Figure A-3 (14)

DRILL LOG

HOLE NO. 2 SHEET NO. 1 OF 1

PROJECT	MEDIUM SCALE DAMS IN MASVINGO PROVINCE		DEPTH	15.27m	ELEVATION
SITE	V-3-3 MAGUDU	COORDINATE : :	INCLINATION	90°	DRILL RIG
AVERAGE CORE RECOVERY		DATE FROM 14-08 TO 17-08	DRILLED		LOGGED

DATE	DEPTH	ELEVATION	ROCK TYPE OR FORMATION	COLUMN SECTION	DESCRIPTION		S.P.T. BLOWS (DEPTH / mm)	CORE RECOVERY (% / cm)	R.Q.D	WATER PRESSURE TEST LUGEON VALUE
	2.00		River Deposits		Sand and gravels,		1.0: 10/135, 20/200, 30/255, 40/275, 42/300; 2.0: 10/30, 20/45, 30/65, 40/75, 50/90			
14-08, 15, 16-08	12.17		Gneiss	× ×	brown to grey, highly weathered, medium to coarse grained, joints are closely spaced, opened and stained, very soft and partly changed to gravels, partly including large quartz crystals	Cl	S.W.L 7.50m	96, 42, 24, 60, 65, 41, 56, 133, 61, 107		k = [illegible] cm/sec; k = 2.6×10[illegible] cm/sec; k = 1.6×10[illegible] cm/sec
17	15.27			× ×	medium weathered, soft, easily broken by hammering, partly including large quartz crystals	Cm		115, 77, 85		

HOLE NO.

*R.Q.D is Rock Quality Designation, R.Q.D=(Total length of cylindric cores longer than 10 cm)/(Total core length) x 100%
*LUGEON VALUE is l/min/m under injection water pressure of 10kg/cm²
*DEPTH and ELEVATION are in meter

Figure A-3 (15)

DRILL LOG

HOLE NO. 3 SHEET NO. 1 OF 1

PROJECT	MEDIUM SIZE DAMS IN MASVINGO PROVINCE			DEPTH	18.61 m	ELEVATION	
SITE	V-3-3 MAGUDU	COORDINATE	: :	INCLINATION	90°	DRILL RIG	
AVERAGE CORE RECOVERY		DATE	FROM 16-08 TO 19-08	DRILLED		LOGGED	

DATE	DEPTH	ELEVATION	ROCK TYPE OR FORMATION	COLUMN SECTION	DESCRIPTION	S.P.T. BLOWS	CORE RECOVERY	R.Q.D	WATER PRESSURE TEST LUGEON VALUE
16-08			Dolerite	v v	dark brown-greenish black, completely weathered, recovered as soil and gravels, partly mixed gneiss gravels, soils generally fine to medium, D	10/15 20/55 30/100 40/125 50/185; 10/60 20/75 30/110 40/135 50/165; 10/300; 10/65 20/60 30/105 40/145 50/185	0		$k = 7.0 \times 10^{-3}$ cm/sec; $k = 5.5 \times 10^{-3}$ cm/sec; $k = 6.4 \times 10^{-4}$ cm/sec
19-08	13.00			v v	greenish black completely weathered, recovered as gravels, very soft D		27		$k = 5.5 \times 10^{-4}$ cm/sec
	16.94		Gneiss	× ×	greenish grey, highly weathered, very soft, D		48		
	18.61						60		

HOLE NO.

*R.Q.D is Rock Quality Designation, R.Q.D=(Total length of cylindric cores longer than 10 cm)/(Total core length) x 100%
*LUGEON VALUE is l/min/m under injection water pressure of 10kg/cm²
*DEPTH and ELEVATION are in meter

Figure A-3 (16)

DRILL LOG

HOLE NO. 1 SHEET NO. 1 OF 1

PROJECT	MEDIUM SIZE DAMS IN MASVINGO PROVINCE			DEPTH 21.71 m	ELEVATION
SITE	VII-1-12 MABVUTE	COORDINATE	: :	INCLINATION 90°	DRILL RIG
AVERAGE CORE RECOVERY		DATE	FROM 10-08 TO 12-08	DRILLED	LOGGED

DATE	DEPTH	ELEVATION	ROCK TYPE OR FORMATION	COLUMN SECTION	DESCRIPTION		S.P.T. DEPTH	S.P.T. BLOWS mm	CORE RECOVERY %	CORE RECOVERY cm	R.Q.D	WATER PRESSURE TEST LUGEON VALUE	DEPTH
11-08	5.07		Gneiss	× ×	reddish brown, sandy silt, completely weathered, recovered as soil with gneiss gravels, loose to slightly compact,	D	1.0 2.0 3.0 4.45 5.07	10 20 26 10 20 30 31 10 20 27 10 20 30 31 10 20 30					
11-08	17.33		Granite	+	light grey to white, completely weathered, silty sand, recovered as soil with granite gravels, loose to compact, fine to coarse grained,	D	6.07 7.07 8.00 9.00 10.0 11.0	10 20 23 10 20 26 10 20 30 40 48 10 20 30 40 50 10 20 30 40 50 10 20 30 40 50	87 80	58 6 88			
12-08	21.71			+	pinkish white, highly weathered, medium to coarse grained, joints are very closely spaced, opened and stained very soft.	CI	13.28 14.96 15.43	10 20 30 40 50 10 20 30 40 50 50					

HOLE NO. ( )

※R.Q.D is Rock Quality Designation, R.Q.D=(Total length of cylindric cores longer than 10 cm)/(Total core length) × 100%
※LUGEON VALUE is l/min/m under injection water pressure of 10kg/cm²
※DEPTH and ELEVATION are in meter

Figure A-3 (17)

DRILL LOG

HOLE NO. 2 SHEET NO. 1 OF 1

PROJECT	MEDIUM SIZE DAMS IN MASVINGO PROVINCE			DEPTH	15.90m	ELEVATION	
SITE	VII-1-12 MABVUTE	COORDINATE	: :	INCLINATION	90°	DRILL RIG	
AVERAGE CORE RECOVERY		DATE	FROM 9-08 TO 13-08	DRILLED		LOGGED	

DATE	DEPTH	ELEVATION	ROCK TYPE OR FORMATION	COLUMN SECTION	DESCRIPTION	DEPTH	S.P.T. BLOWS mm	CORE RECOVERY % cm	R.Q.D	WATER PRESSURE TEST LUGEON VALUE	DEPTH
9-08			River Deposite		gravels, (granite and dolerite),		S.W.L 1.50m				
	1.78				greenish black, highly weathered, joints are very closed, opend, dirty,	Cl		25 34			
	3.85		Gneiss		greenish black, medium weathered, medium grained, joints are closely to widely spaced, opened and dirty, sometimes filled with green clay,	Cl		81 92 75 87 95			
11-08					5.85m – 6.00m, 9.84 – 10.14, 11.90 – 12.10 fractured by faults,			132 134 110			
13-08	12.50				greenish black, slightly weathered, almost fresh, joints are widely spaced, opened and clean. partly changing to granitic features.	Ch		85			
	15.90										

HOLE NO.

※R.Q.D is Rock Quality Designation, R.Q.D=(Total length of cylindric cores longer than 10 cm)/(Total core length) x 100%
※LUGEON VALUE is l/min/m under injection water pressure of 10kg/cm².
※DEPTH and ELEVATION are in meter

Figure A-3 (18)

DRILL LOG

HOLE NO. 3 SHEET NO. 1 OF 1

PROJECT	MEDIUM SIZE DAMS IN MASVINGO PROVINCE			DEPTH	15.00m
SITE	VII-1-12 MABVUTE	COORDINATE	: :	INCLINATION	90°
AVERAGE CORE RECOVERY		DATE	FROM 13-08 TO 14-08	DRILLED	
				ELEVATION	
				DRILL RIG	
				LOGGED	

DATE	DEPTH	ELEVATION	ROCK TYPE OR FORMATION	COLUMN SECTION	DESCRIPTION	S.P.T. BLOWS (DEPTH / mm)	CORE RECOVERY %	R.Q.D %	WATER PRESSURE TEST LUGEON VALUE	DEPTH
13-08					reddish brown-yellowish white-grey, completely weathered recovered as soil in split barrel, fine to medium grained, loose, sometimes including pieces of gneiss,	1.0 10/12 2.0 10/300 3.0 10/60 20/85 30/110 40/135 50/165 4.0 10/300 5.0 10/75 20/300 6.0 10/95 20/155 30/205 40/260 50/275 7.0 10/75 20/150 30/225 40/275 50/345 8.0 10/300 9.0 30/120 40/180 43/215 50/255 50/300 10.0 10/95 20/135 30/165 40/165 50/165 11.0 10/95 20/135 30/155 40/180 50/205 12.0 10/150 20/160 30/210 40/250 50/340 13.0 50/				
14-08	15.00		Gneiss				6.00			

※R.Q.D is Rock Quality Designation, R.Q.D=(Total length of cylindric cores longer than 10 cm)/(Total core length) x 100%
※LUGEON VALUE is l/min/m under injection water pressure of 10kg/cm²
※DEPTH and ELEVATION are in meter

HOLE NO.

Table A-2 (1) Summary of Permeability Test (I-2-1 Musaverema)

B.H. No	Type	Depth of Test m	A(cm)	Depth to W.L. H(cm)	Borehole Radius r(cm)	Casing Length (m)	Water Intake $Q(cm^3/sec)$	Coefficient of Permeability K(cm/sec)	Lugeon Value Lu, Lu'
BH-1	C	3.0	(0)	299	4.1	3.0	14.37	1.1×10^{-3}	
	C	6.0	(0)	409	4.1	6.0	16.42	7.8×10^{-4}	
	C	9.0	(0)	299	4.1	9.0	14.37	9.1×10^{-4}	
	P	10.1-15.1	(500)	456	3.8	9.0	96.7	1.3×10^{-4}	Lu' 4.5
BH-2	C	3.0	(0)	150	4.1	3.0	16.42	2.1×10^{-3}	
	C	6.0	(0)	420	4.1	6.0	49.26	2.3×10^{-3}	
	C	9.0	(0)	420	4.1	9.0	14.07	6.5×10^{-4}	
	C	12.0	(0)	420	4.1	12.0	10.39	4.8×10^{-4}	
	C	14.0	(0)	420	4.1	14.0	51.31	2.4×10^{-3}	
	C	17.0-18.4	(140)	554	3.8	17.0	366.67	1.3×10^{-3}	Lu' 129.0
	P	18.0-23.0	(500)	554	3.8	17.0	56.7/2.0kg	6.3×10^{-5}	Lu 4.1
BH-3	P	2.5-7.5	(500)	195	3.8	2.0	178.3/2.5kg	5.6×10^{-4}	Lu' 14.8
	P	8.0-13.0	(500)	296	3.8	2.0	—	—	Lu 0.0

P: Packer Test

C: Constant Head Test

$$K = \frac{Q}{\pi H(4r+A)} (cm/sec)$$

Table A-2 (2) Summary of Permeability Test (Ⅱ-1-6 Chinyamatumwt)

B.H. No	Type	Depth of Test m A(cm)	Depth to W.L. H(cm)	Borehole Radius r(cm)	Casing Length (m)	Water Intake Q(cm^3/sec)	Coefficient of Permeability K(cm/sec)	Lugeon Value Lu, Lu'
BH	C	3.0 (0)	300	4.1	3.0	83.5	5.4×10^{-3}	
|	P	7.5 - 12.5 (500)	428	3.8	6.0	284.3/3.5kg	4.1×10^{-4}	Lu' 31.0
1	P	12.5 - 17.5 (500)	194	3.8	9.0	17.0/2.5kg	5.4×10^{-5}	Lu 4.8
BH	C	0 - 3.0 (300)	59	4.1	0	9.3	1.6×10^{-4}	Lu' 12.0
|								
2	C	4.0 - 4.7 (70)	59	4.1	1.0	256.2	1.6×10^{-2}	Lu' 500.0
BH	C	3.0 (0)	300	4.1	3.0	30.9	2.0×10^{-3}	
|	P	8.0 - 13.0 (500)	452	3.8	6.0	744.5/2.0kg	1.0×10^{-3}	Lu' 40.0
3	P	13.0 - 18.0 (500)	548	3.8	9.0	67.5/2.5kg	7.6×10^{-5}	Lu 9.0

P: Packer Test

C: Constant Head Test

$$K = \frac{Q}{\pi H(4r+A)} \text{ (cm/sec)}$$

Table A-2 (3) Summary of Permeability Test (Ⅱ-2-1 Mashoko)

B.H. No	Type	Depth of Test m	A(cm)	Depth to W.L. H(cm)	Borehole Radius r(cm)	Casing Length (m)	Water Intake Q(cm^3/sec)	Coefficient of Permeability K(cm/sec)	Lugeon Value Lu, Lu'
BH 1 1	C※	1.0	(23.0)	23.0	7.3	0	0.87	2.30×10^{-4}	
	C※	3.0	(27.5)	27.5	9.0	0	2.11	3.86×10^{-4}	
	P	8.5 - 13.5	(500)	662.0	3.8	6.0	123.3/2.0kg	1.15×10^{-4}	Lu' 31.0
	P	10.0 - 15.0	(500)	483.0	3.8	9.0	106.7/2.0kg	1.36×10^{-4}	Lu' 15.0
BH 1 2	C※	1.0	(19.0)	19.0	7.5	0	17.81	6.09×10^{-3}	
	C※	1.4	(19.0)	19.0	7.5	0	6.79	2.32×10^{-3}	
	P	5.4 - 10.4	(500)	415.0	3.8	3.0	122.3/2.0kg	1.82×10^{-4}	Lu' 18.0
	P	8.2 - 13.2	(500)	578.0	3.8	6.0	40.8/2.0kg	4.36×10^{-5}	Lu' 14.5
	P	13.2 - 18.2	(500)	594.0	3.8	9.0	262.8/2.5kg	2.73×10^{-4}	Lu 7.4
	P	18.0 - 23.0	(500)	750.0	3.8	15.0	213.3/2.5kg	1.76×10^{-4}	Lu 6.5
BH 1 3	C※	1.0	(31.0)	31.0	9.0	0	3.19	4.90×10^{-4}	
	P	5.0 - 10.0	(500)	160.0	3.8	3.0	143.3/2.5kg	5.53×10^{-4}	Lu' 6.0
	P	10.1 - 15.1	(500)	305.0	3.8	6.0	7.67	1.55×10^{-5}	Lu' 1.5

P: Packer Test

C: Constant Head Test

$$K = \frac{Q}{\pi H(4r+A)} \text{ (cm/sec)}$$

※ test on the bottom of sampling pit

Table A-2 (4) Summary of Permeability Test (IV-4-10 Munjanganja)

B.H. No	Type	Depth of Test m	A(cm)	Depth to W.L. H(cm)	Borehole Radius r(cm)	Casing Length (m)	Water Intake Q(cm^3/sec)	Coefficient of Permeability K(cm/sec)	Lugeon Value Lu, Lu'
BH 1	C	1.1	(0)	316	4.1	0	28.39	6.5×10^{-4}	
	C	3.0	(0)	316	4.1	3.0	3.25	2.0×10^{-4}	
1	P	5.9 - 10.9	(500)	820	3.8	6.0	557.7/2kg	4.2×10^{-4}	Lu' 57.0
	P	10.9 - 15.9	(500)	805	3.8	6.0	474.3/2kg	3.6×10^{-4}	Lu' 27.0
BH 1	P	6.5 - 11.5	(500)	90	3.8	3.0	760.0/2.5kg	5.2×10^{-3}	Lu' 32.0
	P	10.1 - 14.0	(390)	-56	3.8	6.0	773.3/2.5kg	6.1×10^{-1}	Lu' 58.0
2	P	14.0 - 19.0	(500)	- 3	3.8	9.0	14.7/2.5kg	9.1×10^{-3}	Lu 0.7
BH 1	P	3.0 - 8.0	(500)	800	3.8	3.0	651.8/1.5kg	5.0×10^{-4}	Lu' 45.0
3	P	8.1 - 13.1	(500)	137	3.8	6.0	2.8/2.0kg	1.3×10^{-5}	Lu' 0.0

P: Packer Test

C: Constant Head Test

$$K = \frac{Q}{\pi H(4r+A)} \text{ (cm/sec)}$$

Table A-2 (5) Summary of Permeability Test (V-3-3 Magudu)

B.H. No	Type	Depth of Test m A(cm)	Depth to W.L. H(cm)	Borehole Radius r(cm)	Casing Length (m)	Water Intake Q(cm^3/sec)	Coefficient of Permeability K(cm/sec)	Lugeon Value Lu, Lu'
BH 1 1	C	3.0 (0)	371	4.1	3.0	12.4	6.5×10^{-4}	
	C	6.0 (0)	371	4.1	6.0	3.8	2.0×10^{-4}	
	P	8.7 - 13.7 (500)	415	3.8	6.0	80.0/2.0kg	1.2×10^{-4}	Lu' 4.6
	P	13.1 - 18.1 (500)	609	3.8	9.0	115.0/5.0kg	1.2×10^{-4}	Lu 2.9
BH 1 2	C	3.0 (0)	175	4.1	3.0	5.50	6.1×10^{-4}	
	C	3.0 - 6.5 (350)	528	3.8	3.0	15.41	2.6×10^{-5}	Lu' 4.3
	C	6.0 - 9.0 (300)	692	3.8	6.0	10.27	1.5×10^{-5}	Lu' 8.9
	P	10.2 - 15.2 (500)	750	3.8	9.0	145.0/5.0kg	1.2×10^{-4}	Lu 3.1
BH 1 3	C	3.0 (0)	120	4.1	3.0	43.1	7.0×10^{-3}	
	C	6.0 (0)	120	4.1	6.0	21.6	3.5×10^{-3}	
	C	9.0 - 11.0 (200)	112	3.8	9.0	41.1	5.4×10^{-4}	Lu' 113.5
	C	12.0 - 18.6 (660)	150	3.8	12.0	113.0	3.5×10^{-4}	Lu' 67.0

P: Packer Test

C: Constant Head Test

$$K = \frac{Q}{\pi H(4r+A)} \text{ (cm/sec)}$$

Table A-2 (6) Summary of Permeability Test (VII-1-12 Mabvute)

B.H. No	Type	Depth of Test m A(cm)	Depth to W.L. H(cm)	Borehole Radius r(cm)	Casing Length (m)	Water Intake $Q(cm^3/sec)$	Coefficient of Permeability K(cm/sec)	Lugeon Value Lu, Lu'
BH-1	C※	3.0 (29.0)	22.8	7.25	0	1.62	3.90×10^{-4}	
	C	3.0-15.0 (1200)	720.0	3.8	3.0	36.9	1.30×10^{-5}	Lu' 2.0
	C	15.0-21.7 (670)	720.0	3.8	15.0	37.0	2.91×10^{-5}	Lu' 2.0
BH-2	P	4.4 - 8.2 (386)	105.0	3.8	3.0	115.0/2.5kg	8.69×10^{-4}	Lu' 11.5
	P	8.4 -13.4 (500)	125.0	3.8	6.0	171.7/3.5kg	8.49×10^{-4}	Lu' 8.5
BH-3	C	3.0 (0)	200.0	4.1	3.0	28.7	2.79×10^{-3}	
	C	3.0 - 6.0 (300)	300.0	3.8	3.0	39.0	1.31×10^{-4}	Lu' 17.0
	C	6.0 - 9.0 (300)	300.0	3.8	6.0	45.2	1.52×10^{-4}	Lu' 12.0
	C	8.0 -12.0 (400)	700.0	3.8	8.0	41.1	3.05×10^{-5}	Lu' 6.0
	C	8.0 -15.0 (700)	600.0	3.8	8.0	39.0	2.89×10^{-5}	Lu' 3.0

P: Packer Test

C: Constant Head Test

$$K = \frac{Q}{\pi H(4r+A)} \text{ (cm/sec)}$$

※ test on the bottom of sampling pit

ANNEX B. METEOROLOGY AND HYDROLOGY

Contents

Table B-1 Mean Monthly Meteorology from 1976 to 1985

Records (unit) and Station	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Mean
1. Rainfall (mm)													
Masvingo	6	4	17	40	75	97	151	120	88	18	14	2	53
Zaka	12	8	17	40	107	147	140	160	100	16	27	5	65
B. Range	4	8	23	44	89	92	130	141	95	27	20	3	56
2. Max. Temp. (°c)													
Masvingo	21	24	27	28	29	29	29	28	27	26	24	22	26
Zaka	23	26	28	30	30	30	30	29	29	28	26	23	28
B. Range	25	28	30	31	32	32	33	31	31	30	28	25	30
3. Min. Temp. (°C)													
Masvingo	6	8	12	15	17	17	17	17	16	12	9	6	13
Zaka	9	10	14	17	18	19	19	19	18	15	12	9	15
B. Range	9	11	15	17	19	20	21	20	18	16	12	9	16
4. R. Humidity (%)													
Masvingo	66	57	56	60	65	71	71	77	75	71	68	67	67
Zaka	62	54	53	56	61	67	69	76	74	68	63	63	64
B. Range	60	55	56	57	61	66	67	74	64	66	66	63	63
5. Wind Speed (Knot)													
Masvingo	5.3	6.4	6.9	7.4	6.9	6.4	5.6	6.4	6.0	5.5	5.0	4.9	6.1
Zaka	2.6	3.0	3.3	3.5	3.3	3.0	2.8	2.6	2.2	2.4	2.5	2.3	2.8
B. Range	2.8	3.2	4.6	5.2	4.1	3.5	3.1	3.3	2.9	2.3	1.8	2.4	3.3
6. Sunshine (Hour)													
Masvingo	8.3	9.4	8.8	8.3	7.6	7.3	8.1	7.1	7.4	8.4	8.5	8.3	8.1
Zaka	- No data -												
B. Range	8.0	8.5	8.0	7.9	7.7	8.1	8.4	7.4	7.5	8.4	8.2	8.0	8.0

Note: 1. Rainfall 2. Maximum Temperature 3. Minimum Temperature
4. Relative Humidity 5. Wind Speed 6. Sunshine Hour

Table B-2 Mean Monthly Rainfall

(unit:mm)

No.	Name of Station	Data Period	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Tatal
	(No. of Project Area)														
	(I-2-1)														
460	Chendebvu Dam	1961-85	4	5	12	23	75	109	132	111	68	34	15	6	594
411	Stera	do	3	4	13	26	72	113	121	120	84	34	17	5	612
	(II-1-6)														
667	Mushandure	1951-85	10	12	18	42	112	208	180	190	112	44	25	16	969
680	Makore	do	5	6	11	25	91	160	133	139	67	30	15	11	693
	(II-2-1)														
676	Mashoko	1951-85	8	12	15	36	95	172	176	175	85	42	25	17	858
682	Chiremwaremwa	1953-85	4	6	9	25	81	140	119	130	65	27	15	10	631
	(IV-4-10)														
644	Fungidza Hill	1951-85	3	3	10	29	84	161	139	125	61	29	11	5	660
642	Mukaro	do	2	2	12	35	104	186	157	137	62	28	11	6	742
	(V-3-3)														
627	Faversham	1951-85	4	11	16	35	104	157	158	162	87	42	15	13	804
615	Bangala	1961-85	9	14	20	47	120	150	162	176	94	49	28	12	881
	(VII-1-12)														
623	Zingwena	1956-85	8	12	15	32	84	128	147	159	79	39	25	11	739
632	Svuura	do	5	6	13	29	97	160	143	139	76	27	10	11	716

Note : No. of Rainfall Station ---- Station Network listed by Meteorological Services

Figure. B-1 Mean Monthly Rainfall

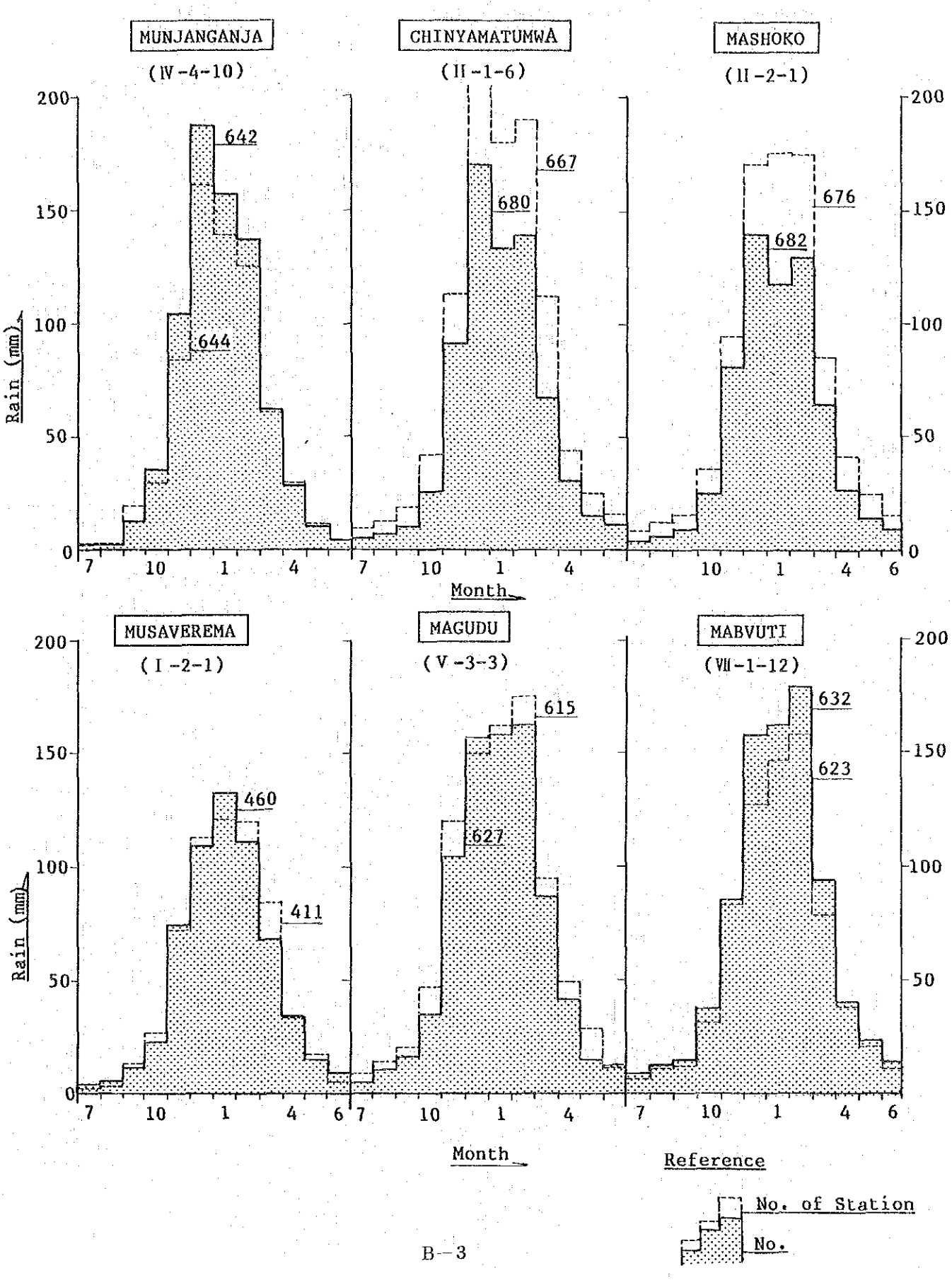


Table B-3 Mean Monthly Evaporation (observed)

(Unit:mm)

No.	Name of Station	Data Period	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
EE/15	Makoholi	1965-85	112	154	197	210	190	176	184	144	155	134	119	100	1875
/21	Manjirenji Dam	1975-85	104	147	167	181	189	195	194	151	150	134	118	96	1826
/14	Bangala Dam	1975-85	89	126	152	172	168	169	181	147	148	124	105	82	1663
/13	Esquilingwe Weir	1965-85	115	156	194	230	228	215	226	179	171	146	127	107	2094

Figure B-2 Mean Monthly Evaporation (Observed)

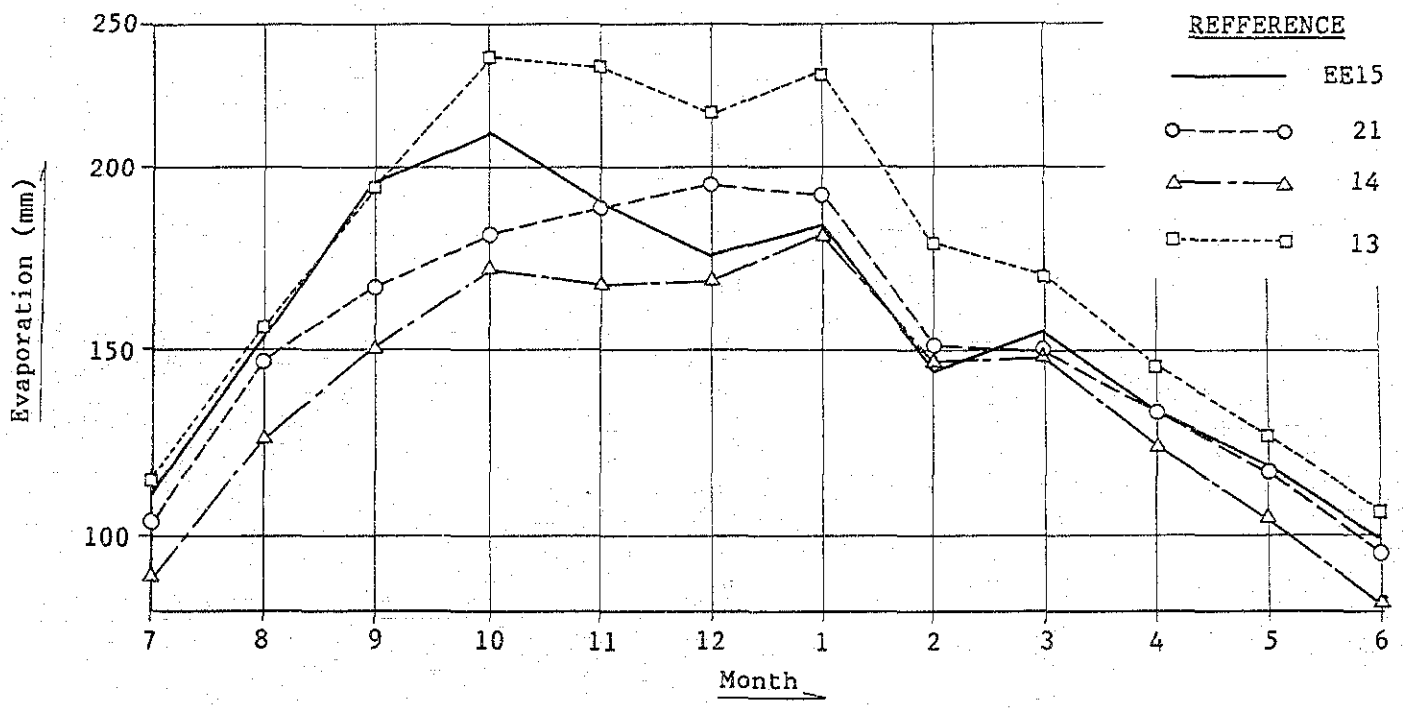


Table B-4 Stage Capacity of Reservoirs

Musaverema(I-2-1)

EL	A	C
671	0	0
672	66750	33
674	282250	382
676	700500	1365
677	970500	2201
678	1565250	3469
679	2022250	5262
680	2504500	7526

Chinyamatumwa(II-1-6)

EL	A	C
735	0	0
737	6000	7
739	16500	29
741	43250	89
743	97000	229
745	166500	493
747	254000	913
749	350250	1517
751	470500	2338

Mashoko(II-2-1)

EL	A	C
648	0	0
650	1725	2
652	8250	12
654	20250	40
656	65000	125
658	104000	294
660	150800	549
662	245250	945
664	355750	1546
666	490250	2392
668	679000	3562

Munjanganja(IV-4-10)

EL	A	C
1132	0	0
1133	500	1
1135	4500	5
1137	11500	21
1139	20750	54
1141	48500	123
1143	86500	258
1145	178500	523
1147	374000	1075
1148	498000	1511
1149	643500	2082

Magudu(V-3-3)

EL	A	C
514	0	0
516	27250	27
518	63250	118
520	128500	310
522	263750	702
524	461000	1427
526	720500	2608
528	1071000	4400
530	1475000	6946

Mabvute(VII-1-12)

EL	A	C
628	0	0
630	8625	9
632	38625	56
634	83000	178
636	132500	393
638	208000	734
640	304250	1246
642	488375	2038
644	711250	3238
646	972000	4921

Note

EL : Elevation(m), A : Area(sq.m), C : Capacity(×1000cu.m)

Figure B-3(1) Stage Capacity Curve (I-2-1)

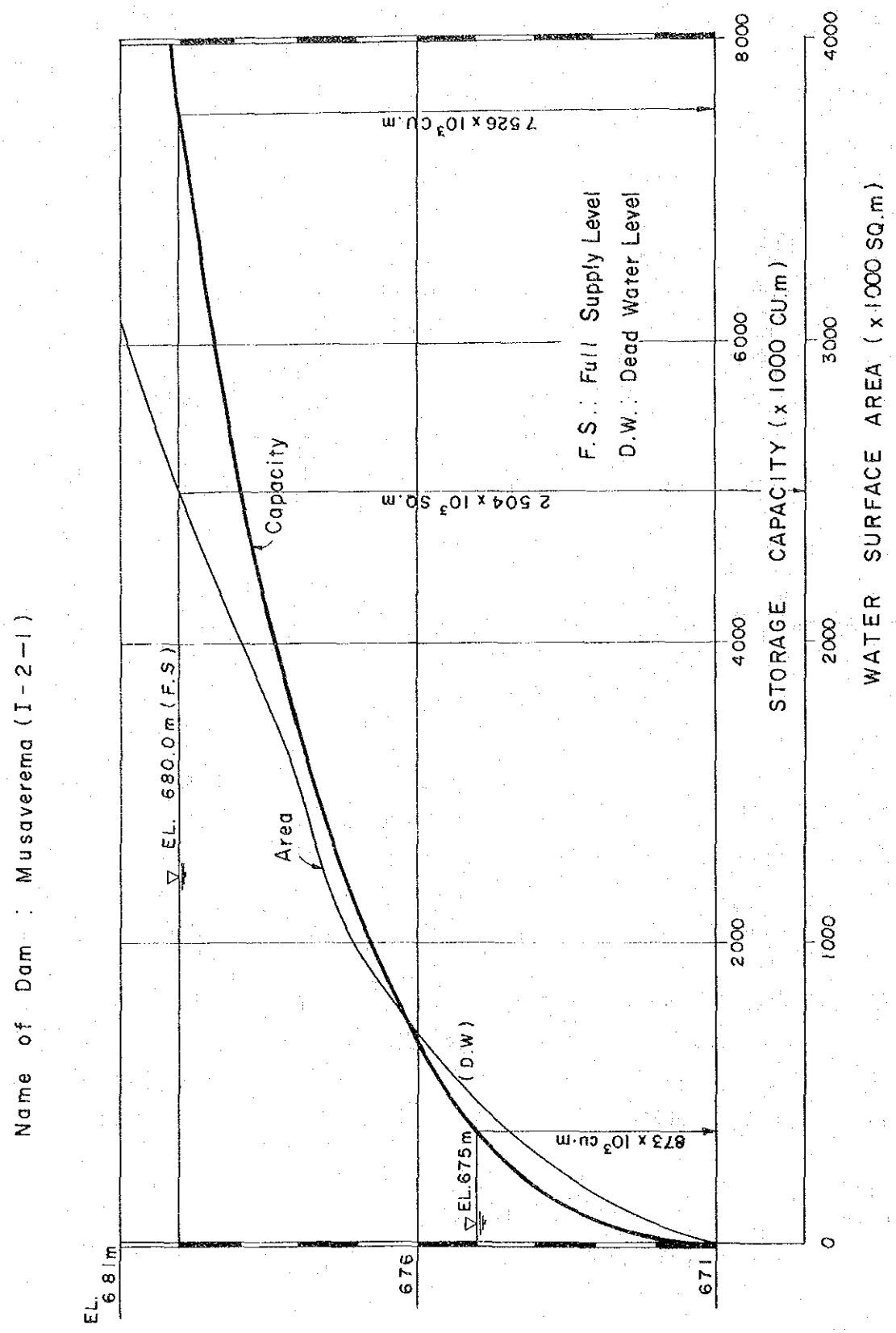


Figure B-3(2) Stage Capacity Curve (II-1-6)

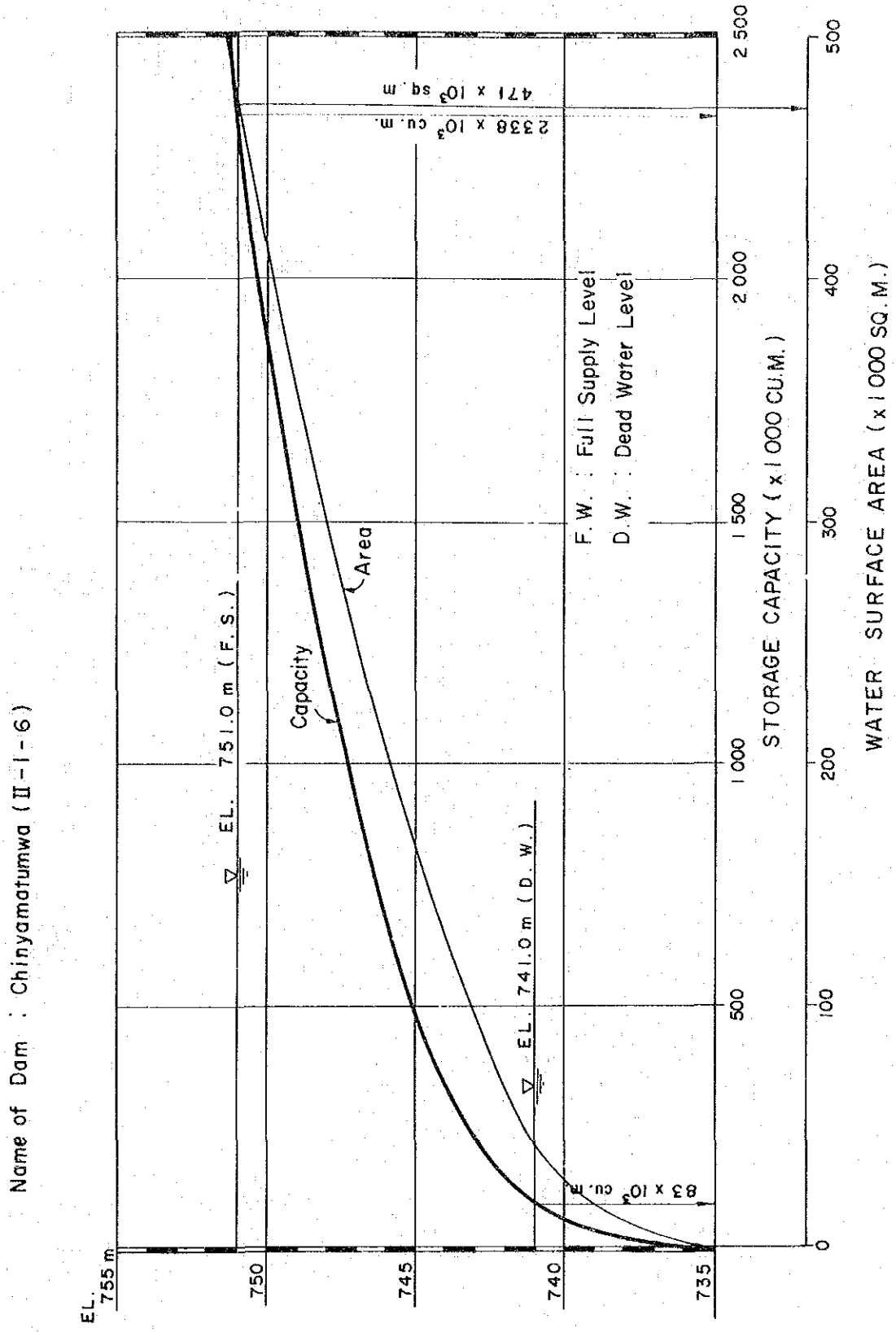


Figure B-3 (3) Stage Capacity Curve (II-2-1)

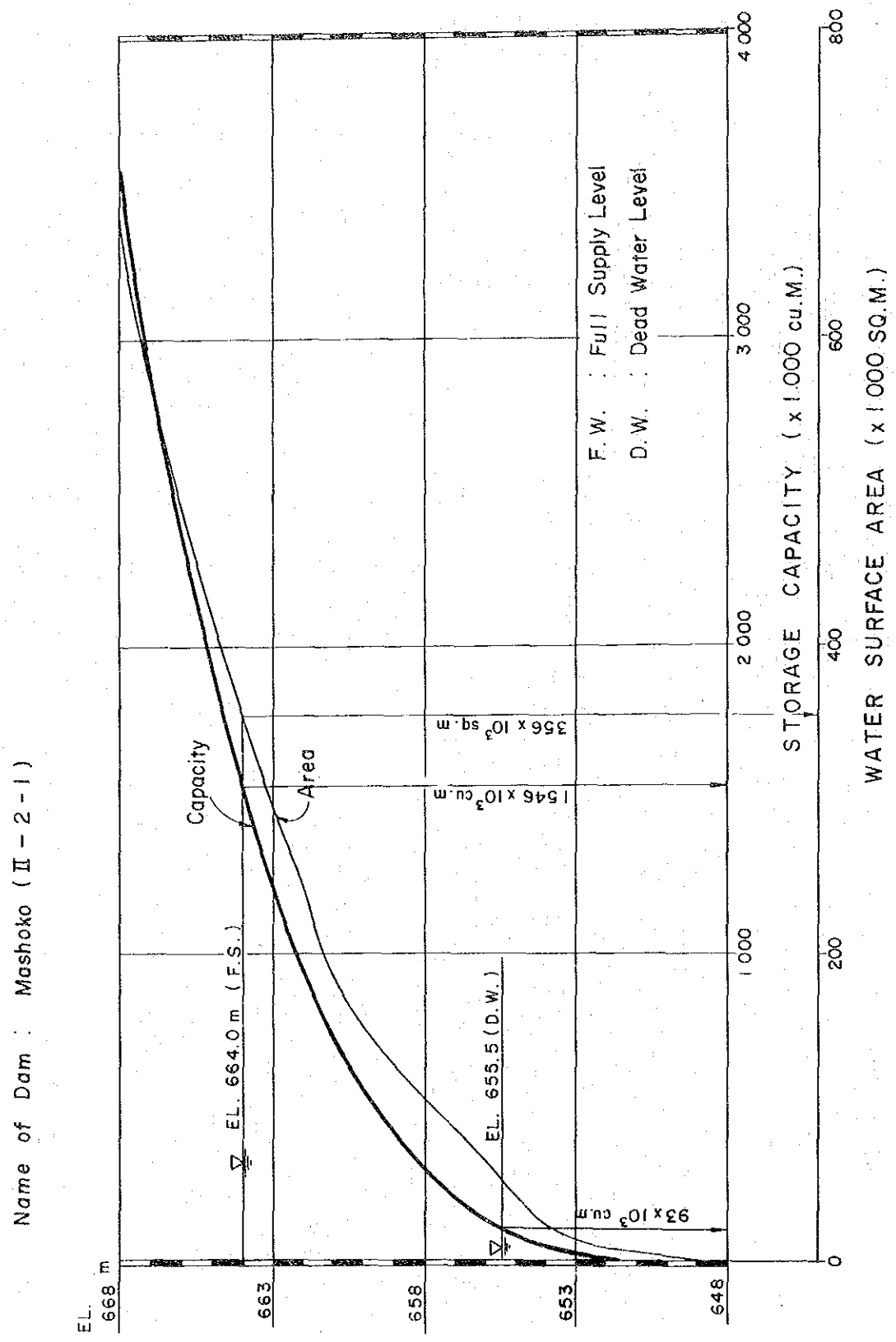


Figure B-3(4) Stage Capacity Curve (Ⅳ-4-10)

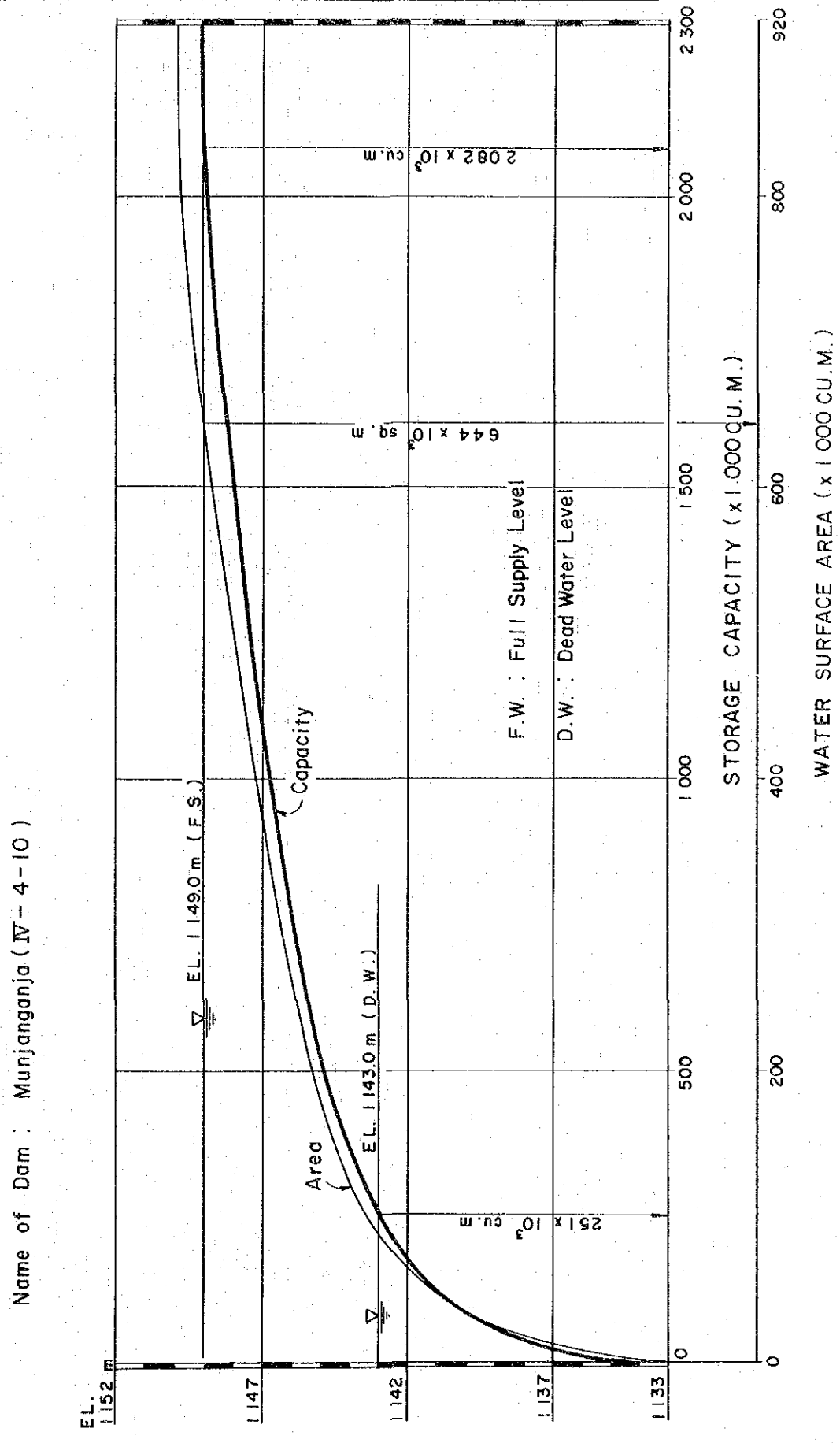


Figure B-3(5) Storage Capacity Curve (∇-3-3)

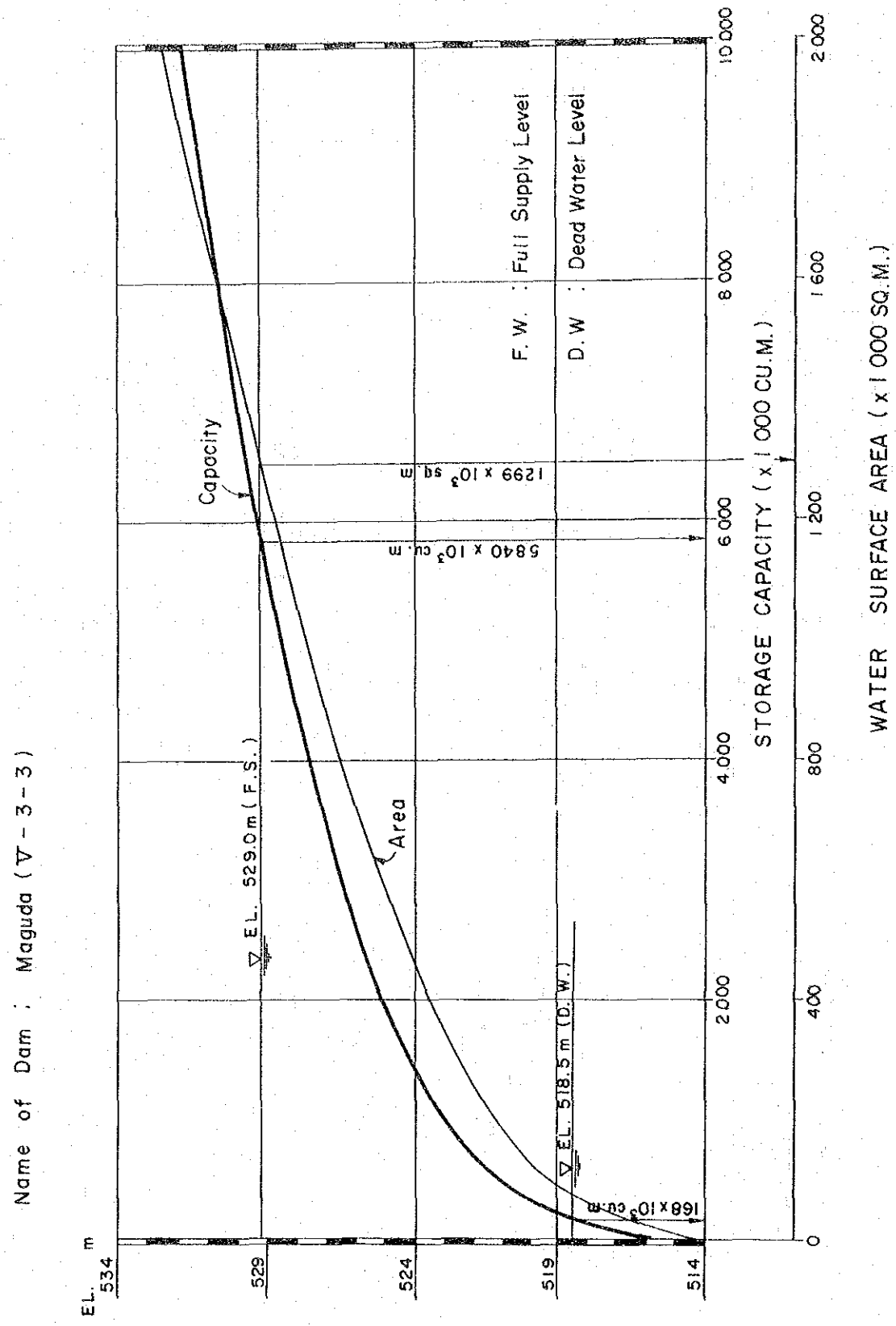


Figure B-3(6) Stage Capacity Curve (VII-1-12)

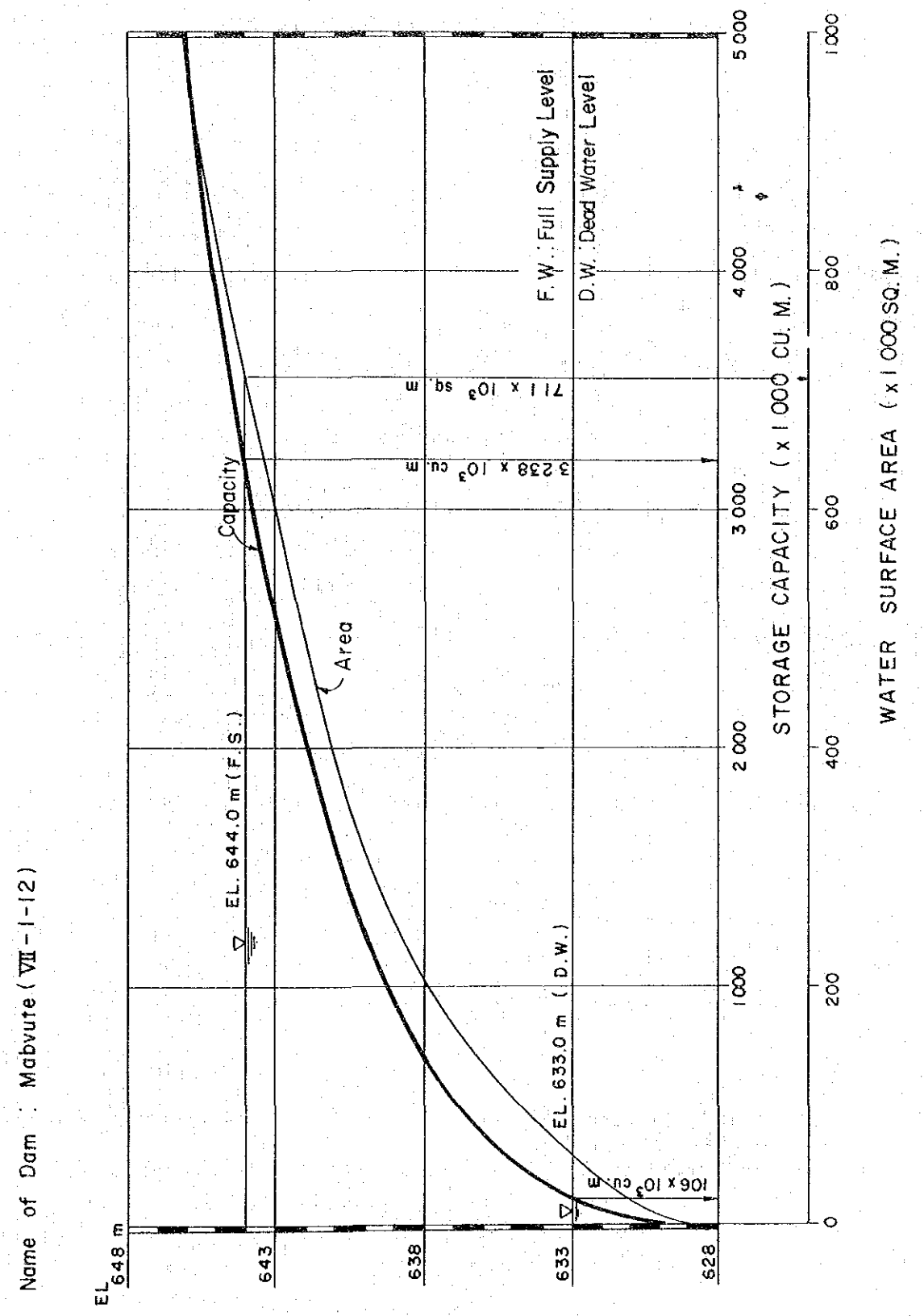


Table B-5 Interpolaion of Q/MAR to CV

Name of Dam		MAR-EF $\times 10^3$	C.V.	Storage Ratio	Q/MAR 4% Risk	Q/MAR 10% Risk	Q/MAR 40% Risk
Musaverema	(I-2-1)	2300	120	1.5	*	0.17	*
Chinyamatumwa	(II-1-6)	13000	100	1.3	0.29	0.38	0.63
Mashoko	(II-2-1)	10000	140	1.1	0.16	0.24	0.48
Magudu	(V-3-3)	9300	120	2.0	*	0.35	*
Mabvute	(VII-1-12)	23000	85	0.9	*	0.39	*

Name of Dam		Risk Level	Q/MAR 80% CV	Q/MAR 100% CV	Q/MAR 140% CV
Musaverema	(I-2-1)	4%	0.13	0.10	0.02
		10	0.30	0.21	0.15
		40	0.49	0.43	0.32
Magudu	(V-3-3)	4%	0.38	0.30	0.20
		10	0.50	0.40	0.28
		40	0.77	0.70	0.58
Mabvute	(VII-1-12)	4%	0.29	0.23	0.16
		10	0.40	0.30	0.22
		40	0.63	0.53	0.43

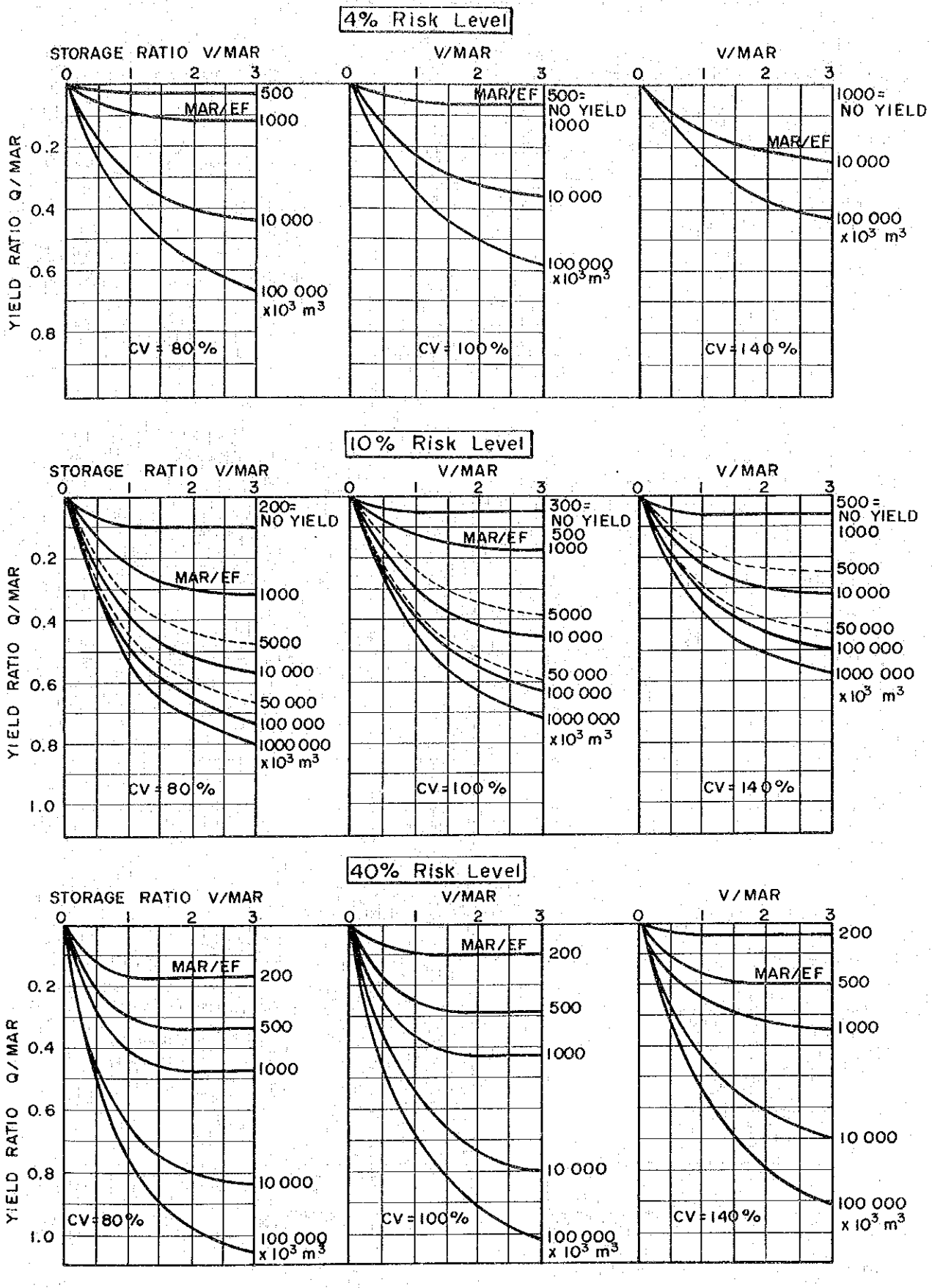
NOTE: *··· to be interpolated by using yield curves of CV = 80, 100 and 140%

Yield curves at 4, 10 and 40 percent levels are derived from the report of "Soil and Water Conservation", appendix 31.

Q···· Reservoir Yield, MAR··· Mean Annual Runoff

CV··· Co-efficient of Variation

Figure B-4 Yield Curves at 4, 10 and 40% Risk Levels*



NOTE * Copied From the Report of "Soil and Water Conservation", Figure A31.1-3