Kalibiuk Formation is distributed downstream of the proposed dam axis for a stretch of approximately 200 m. (Refer to Fig. II.3.1)

Volcanic breccia originated from the eruption of Mt. Ungaran and Mt. Sundoro. This is composed of fine to coarse-grained tuffaceous sand matrix and various andesite gravels that consist of granule to boulder material with poor sorting. Joints in the volcanic breccia are not developed but a few loose and open joints still exist. On the other hand, tuffaceous sandstone has many sheet type joints parallel to the bedding. Based on the aerial photo analysis and field reconnaissance, large-scale fault and landslide detrimental to dam construction do not exist around the proposed dam site. (Refer to Fig. II.3.1)

(c) Engineering Geology

Detailed information regarding the fresh volcanic breccia is not presently available because foundation rock tests have not been carried out. Based on the results of field reconnaissance, the volcanic breccia is considered to possess sufficient soundness for the construction of a concrete gravity dam of less than 50 m in height.

The basement rock is not weathered from the riverbed up to EL. 170 m, slightly weathered from EL. 170 m to EL. 190 m and heavily weathered above EL. 190 m.

The maximum dam height shall be less than 50 m, which corresponds to EL. 190 m, considering rock soundness and the topographical condition in the left bank. Distribution and property of joints, especially sheet type joint, could not be identified by this field reconnaissance. Accordingly, watertightness which depends on the existence and property of joints has not been clarified.

(d) Construction Materials

There are no quarry sites near the proposed dam site, since riverbed deposits such as sand and gravel are not distributed along Blorong River. Also hard rocks such as andesite lava or intrusive rock do not exist near the proposed dam site. Hence, the intrusive rock of andesite at Mt. Mergi should be utilized as construction material. These have to be transported from the foot of Mt. Ungaran located far from the proposed dam site at a distance of about 20 km.

(2) Geology of Reservoir Area

Blorong River flows roughly south to west for 4 km from the vicinity of Temple Village at the upstream end of the reservoir to the vicinity of Sebubut Village with meanders. There are two tributaries and some creeks joining Blorong River. The bank slope is gentle at elevation above EL. 200 m.

Volcanic breccia is extensively distributed, but riverbed material, talus deposit and slope wash are scarcely distributed in the reservoir area. Accordingly, landslides do not exist and are not expected in the reservoir area even in the future. The slope in the reservoir area including the dam site is geologically stable.

3.2.2 Kudung Suren Dam (B-2) on Blorong River

(1) Topography and Geology of Dam Site

(a) Topography

Kudung Suren Dam is located downstream on Blorong River, near the confluence with the tributary, Glagan River, and near Kudung Suren Village (refer to Fig. II.1.1).

Blorong River in the vicinity of the proposed dam site heavily meanders on the alluvial plain. Around the dam axis the river forms an open valley. The riverbed elevation at the proposed dam axis is about EL. 35 m and the width is about 50 m. The slope gradient is 5 to 20 degrees along the left bank and 20 degrees along the right bank. The valley width is 800 m at the proposed elevation of the dam crest, which corresponds to EL. 76 m, and the ratio between height and valley width is approximately 1:20.

(b) Geology

The basement rock of the proposed dam site mainly consists of tuffaceous sandstone (Dts) intercalated with conglomerate belonging to Damar Formation which is marine in origin with local faults. These basement rocks are covered with topsoil on the gentle hill and flood plain deposit along the river (refer to Fig. II.3.2).

(c) Engineering Geology

Detailed information regarding the fresh basement rock is not presently available because foundation rock tests have not been carried out. Based on the results of field reconnaissance, the basement rock is considered to be stable for the construction of a fill dam of less than 40 m high because the soundness of tuffaceous sandstone at the dam site is not so high. The maximum dam height shall be less than 40 m, or lower than EL. 75 m from the geological point of view.

(d) Construction Materials

Riverbed deposit and flood plain deposits such as sand and gravel are distributed in the reservoir area and the downstream of the dam site, and they could be utilized as filter and random fill materials. Topsoil distributed on the hill could be utilized as borrow material, but hard rock such as andesite lava or intrusive rock do not exist near the proposed dam site. The particle size of riverbed materials is not sufficient for utilization as rockfill and riprap. Consequently, for rockfill and riprap material, the intrusive rock of andesite at Mt. Mergi should be utilized. This has to be transported from the foot of Mt. Ungaran located far from the proposed dam site at a distance of about 28 km.

(2) Geology of Reservoir Area

Blorong River flows roughly east to west with neanders at the reservoir area. River and flood plain deposits are widely distributed on the alluvial plains that are utilized as paddy fields. Damar Formation, composed of tuffaceous sandstone and conglomerate, is distributed in the hilly region. Talus deposit and slope wash are distributed in the reservoir area. Since rockfall and small landslides exist in the hilly region, some protection works should be planned.

3.2.3 Jatibarang Dam (K-3) on Kreo River

(1) Topography and Geology of Dam Site

(a) Topography

Jatibarang Dam is located downstream on the Kreo River, near the national park "Goa Kreo" and near Jatibarang and Gedawung villages (refer to Fig. II.1.1).

Kreo River in the vicinity of the proposed dam site has a roughly straight channel in the SW-NE direction for a stretch of approximately 500 m, while the upstream and downstream meander heavily. The river forms a gorge distributed with volcanic breccia around the dam axis. The riverbed elevation at the proposed dam axis is EL. 90 m and the width of the river is 10 to 15 m. The slope gradient is approximately 80 degrees from the riverbed to EL. 110 m along both banks. It is 40 to 50 degrees along the left bank and 35 degrees along the right bank above EL. 110 m. The gorge width is 155 m at the elevation of the proposed dam crest, EL. 162 m, and the ratio between height and valley width at EL. 162 m is approximately 1:2.2.

(b) Geology

The basement rock consists of alternating beds of volcanic breccia (VB), tuffaceous sandstone (VBs) and small lava flow (La). The greater part is made up of volcanic breccia. These rocks belong to Notopuro Formation formed in the Pliocene to Pleistocene.

Volcanic breccia is exposed above EL. 105 m and below EL. 85 m. These layers consist of tuffaceous sand matrix and various andesitic gravels composed of granule to boulder with bad sorting. Gravel content is 30 to 50% with sub-rounded to sub-angular configuration. The diameter of gravels is generally 5 to 20 cm and maximum gravel size is 60 cm.

Tuffaceous sandstone is exposed at the riverbed with a thickness of about 25 m and at EL. 120 m with thickness of about 10 m in the right bank. These units are divided into two facies as fine to medium tuffaceous sandstone and tuffaceous coarse sandstone with granule. These units locally include the thin layer of volcanic conglomerate. The concretion of tuffaceous sandstone is less stronger than volcanic breccia.

Volcanic conglomerate is exposed from Goa Kreo to the proposed dam axis with a thickness of 5 to 15 m. Volcanic conglomerate is composed of various rounded gravels with a diameter of 5 to 15 cm (maximum 25 cm) and sand matrix.

Lava flow is exposed locally near Goa Kreo and the proposed dam axis with a thickness of a few 10 cm to a few meters. This unit locally includes the facies of black auto-brecciated lava which is composed of dark grey andesitic gravels and similar andesitic matrix. Half of the gravels' ring is indistinct and the other half is distinct to the matrix.

Topsoil and/or talus deposits are thin with a thickness of a few 10 cm near the proposed dam axis. Riverbed deposits are distributed with a thickness of 1 to 2 m where the basement rock is exposed locally in the river.

Joints in the basement rock are not developed but a few loose and open joints still exist. These joints are sheeting joints parallel to the bedding. Large-scale fault and landslide detrimental for planning a dam do not exist around the proposed dam site, based on the field reconnaissance and the aerial photo analysis. (Refer to Fig. II.3.3)

(c) Engineering Geology

Detailed information regarding the fresh volcanic breccia is not presently available because foundation rock tests have not been carried out. However, based on the results of field reconnaissance, the basement rock is considered to possess sufficient soundness for the construction of a concrete gravity dam of less than 70 m in height. Tuffaceous sandstone distributed around the riverbed is less stronger than volcanic breccia and contains soft materials locally. The results of the previous rock investigation (triaxial compression test) for tuffaceous sandstone are as follows:

Internal Angle of Friction	:	over 35°
Cohesion	:	0 t/m^2
Permeability Coefficient	:	$2*10^{-3}$ to 10^{-5} cm/sec

The basement rock is fresh from the riverbed up to EL. 140 m, slightly weathered from EL. 140 m to EL. 160 m and heavily weathered above EL. 160 m.

The maximum dam crest elevation shall be lower than EL. 160 m from the geological and geographical points of view, with due consideration on rock soundness and topographical condition in the left bank which has a ridge width of less than 100 m above EL. 160 m. Distribution and property of joints, especially sheet type joint, could not be identified in this field reconnaissance.

Permeability of the basement rock depends on the distribution and property of joints, which were not clarified. However, the permeability of volcanic breccia is not high in general, although high in locations where sheet type joints exist.

(d) Construction Materials

Quarry sites do not exist near the proposed dam site, because riverbed and flood plain deposit comprise mainly soft rocks and flat gravel which are not widely distributed in Kreo River. Hard rock such as andesite lava or intrusive rock do not widely exist in the dam site; hence, the intrusive rocks of andesite at Mt. Mergi should be utilized as construction material. These have to be transported from the foot of Mt. Ungaran located far from the proposed dam site at a distance of about 16 km.

(2) Geology of Reservoir Area

Kreo River flows roughly south to north from the upper stretch to the vicinity of Jatibarang Village, then southwest to northeast from there to the downstream where the river forms a gorge while gently sloping at the elevation above EL. 170 m. On the other hand, Kreo River forms a basin and gentle topographical feature in the upstream from Goa Kreo. Their is one tributary, namely, Cabang River and some creeks joining the main stream that has meandered various river courses in the past, as analyzed from aerial photos.

The top of the ridge forms a gentle slope like a lava plateau at the elevation above EL. 170 m to EL. 200 m around the reservoir area. This gentle slope is utilized for residential areas and paddy fields. The basin is utilized for paddy fields and quarry site of aggregate.

There are some rockfalls and creep zones around the basin where claystone of Kalibiuk Formation is distributed below EL. 170 m. The geological strata is shown in Table II.4.1. Notopuro Formation, Damar Formation and Kalibiuk Formation are distributed around the reservoir area. Notopuro Formation is extensively distributed in the hilly land. On the other hand, Damar Formation and Kalibiuk Formation are distributed in the lowland that forms a basin. Alluvial deposits cover these basement rocks.

Notopuro Formation consists of volcanic breccia, tuffaceous sandstone, volcanic conglomerate and lava flow and originated from the eruption of Mt. Ungaran and Mt. Sundoro. These layers are distributed horizontally and cover unconformably the Damar Formation. Notopuro Formation is bound to the upstream by an east-west inferred fault.

Damar Formation, uncomformably overlying Kalibiuk Formation, consists of tuffaceous sandstone with granule to pebble. Kalibiuk Formation, uncomformably covered by Damar Formation, consists of bluish grey claystone, locally with sandstone. This claystone tends to cause landslide. Attention should be paid to the distribution of this layer in the planning of construction and the management of reservoir operation.

Riverbed and flood plain deposits cover these three formations, and talus deposit and slope wash are scarcely distributed in the reservoir area. Rockfall and small landslides are distributed in the lowland where Damar Formation and Kalibiuk Formation are distributed. The slope of volcanic breccia in the reservoir area including the dam site is stable because of the favorable geological condition.

3.2.4 Mundingan Dam (K-4) on Kreo River

(1) Topography and Geology of Dam Site

(a) Topography

Mundingan Dam is located upstream of the proposed Jatibarang Dam on Kreo River and near Mundingan and Kaligetas villages (refer to Fig. II.1.1).

Kreo River meanders in the vicinity of the proposed dam site and forms a gorge from the vicinity of the dam axis to the downstream. On the other hand, an alluvial plain widely expands upstream of the dam axis. The riverbed elevation at the proposed dam axis is EL. 185 m and the width of the river is 15 m. The slope gradient is approximately 10 to 15 degrees along the left bank and 20 to 25 degrees along the right bank. The valley width is 400 m at EL. 230 m, and the ratio between height and valley width at EL. 230 m is approximately 1:8.9. Fill dam is suitable for this topographical feature and geological condition.

(b) Geology

The basement rock in the vicinity of the proposed dam axis consists of alternating beds of volcanic breccia (VB) and tuffaceous sandstone (VBs) that belong to Notopuro Formation, with the greater part made up of volcanic breccia. Tuffaceous sandstone is horizontally distributed with thin layer at EL. 200 m. Notopuro Formation is bound to the upstream by an east-west inferred fault. Damar Formation and Kalibiuk Formation are distributed upstream of this fault. These basement rocks are covered with topsoil on the gentle slope above EL. 230 m and slope wash along the river.

Volcanic breccia originated from the eruption of Mt. Ungaran and Mt. Sundoro. This is composed of fine to coarse-grained tuffaceous sand matrix and various andesitic gravel of granule to boulder with poor sorting.

Joints in the volcanic breccia and tuffaceous sandstone are not developed, but a few loose and open joints still exist. These joints are sheet type joints parallel to the bedding. There are outstanding joints with spring near the dam axis in the left bank. Strike and dip is N45°E/90°. However, large-scale landslide detrimental to planning a dam do not exist around the proposed dam site, based on the aerial photo analysis and field reconnaissance. (Refer to Fig. II.3.4)

(c) Engineering Geology

Detailed information regarding the fresh volcanic breccia is not available, because foundation rock tests have not been carried out. However, based on the results of field reconnaissance, the basement rock is considered to possess sufficient soundness for the construction of a fill dam with a height of 50 m. Attention should be paid to the existence of inferred faults and joints with spring and the distribution and property of these should be explored.

The basement rock is fresh from the riverbed up to EL. 200 m, slightly weathered from EL. 200 m to EL. 220 m and heavily weathered above EL. 220 m. The maximum crest elevation is proposed at EL. 230 m from the geological and geographical points of view, with due consideration on rock soundness and topographical condition. Distribution and property of joints, especially sheet type joints, could not be identified in this field reconnaissance.

Watertightness depends on the distribution and property of joints, which were not clarified. However, the permeability of volcanic breccia is not high in general, although high in locations where sheet type joints exist.

(d) Construction Materials

Intrusive rock of andesite distributed at Mt. Mergi should be utilized as construction material. Quarry sites do not exist near the proposed dam site. Riverbed and flood plain deposits distributed at the basin consist of various gravels, but contain soft rocks and flat gravels of 30% and 40%. Besides, hard rocks such as lava flow and/or intrusive bodies do not exist extensively. Hence, the construction materials have to be transported from Mt. Mergi located at the foot of Mt. Ungaran far from the Jatibarang dam site at a distance of about 16 km.

The amount of andesite at Mt. Mergi has been estimated at over 5,900,000 m^3 and unconfined compression strength of trash andesite is about 800 to 1,200 kg/cm^2 as tested by P.T. Saptamitra Nusantara.

(2) Geology in Reservoir Area

Kreo River flow roughly south to north with meanders. Upstream of the proposed dam site are tributaries joining Kreo River forming a basin with a gentle geographical feature. Alluvial deposit composed of river deposit and flood plain deposit is distributed in this low land which is utilized as paddy field.

Volcanic breccia is extensively distributed in the hilly land. Damar Formation composed of tuffaceous sandstone and conglomerate and Kalibiuk Formation composed of claystone and sandstone are distributed in the lowland forming a basin. Riverbed and flood plain deposits cover these two formations, and talus deposit and slope wash are scarcely distributed in the reservoir area. Rockfall and small landslides are distributed in the lowland Damar Formation and Kalibiuk Formation. The slope where volcanic breccia exists is stable because of its favorable geological condition.

3.2.5 Kripik Dam (KR-1) on Kripik River

(1) Topography and Geology of Dam Site

(a) Topography

Kripik Dam is located downstream on Kripik River which is a tributary of Kreo River (refer to Fig. II.1.1).

Kripik River in the vicinity of the proposed dam site has a roughly straight channel in the SSW-NNE direction for a stretch of approximately 300 m, while the upstream and downstream are meandered. Around the dam site, a flood plain with gentle hilly feature has formed, where Damar Formation is distributed. The riverbed elevation at the proposed dam site is EL. 35 m and its width is 20 m. The slope gradient is approximately 10 to 15 degrees along the left bank and less than 10 degrees along the right bank. The valley width is 535 m at EL. 90 m, and the ratio between height and valley width at EL. 90 m is approximately 1:9.7. Fill dam is suitable for this geological feature.

(b) Geology

The basement rock in the vicinity of the proposed dam site consists of tuffaceous sandstone (Dts) and conglomerate (Dtg) of Damar Formation which are covered unconformably by volcanic breccia of Notopuro Formation. The greater part of this area is made up of tuffaceous sandstone. Conglomerate is interceded with sandstone and local faults. These basement rocks are covered with topsoil on the gentle hillside and flood plain deposit on the riverside. Damar Formation is marine in origin and complexity faulted here and there. (Refer to Fig. II.3.5)

(c) Engineering Geology

Detailed information regarding the fresh basement rock is not available, because foundation rock tests have not been carried out. However, based on the results of field reconnaissance, the basement rock is considered to be stable for the construction of a fill dam of less than 50 m in height. Many rockfalls and faults have developed and the soundness of sandstone is low at the proposed dam site.

If a dam is to be planned, its proposed maximum height should be limited to EL. 220 m from the geological and geographical points of view. This is due to the rock soundness and topographical condition of both banks, which have less than 100 m of ridge width above EL. 90 m.

Watertightness depends on the distribution and property of joints, which were not clarified by the field reconnaissance. However, the permeability of tuffaceous sandstone and conglomerate is supposed to be high in general, because of the faults.

(d) Construction Material

Riverbed and flood plain deposits such as sand and gravel which are distributed in the reservoir and the downstream of the dam site, could be utilized as random fill and filter materials. Topsoil distributed on the hill could be utilized as borrow material, but hard rocks such as andesite lava or intrusive rock do not exist near the proposed dam site. The particle size of riverbed material is not sufficient for utilization as rockfill and riprap. Consequently, the intrusive rocks of andesite at Mt. Mergi should be utilized as fill and riprap material. These have to be transported from the foot of Mt. Ungaran located far from the proposed dam site at a distance of about 15 km.

(2) Geology in Reservoir Area

Kripik River flows roughly south to north with meanders. Upstream of the proposed dam site are tributaries joining Kripik River. Alluvial plain composed of river deposit and flood plain deposit is widely distributed along the river and utilized as paddy field.

Volcanic breccia is extensively distributed in the hilly land and covers unconformably Damar Formation and Kalibiuk Formation. Damar Formation composed of sandstone and conglomerate and Kalibiuk Formation composed of claystone and sandstone are distributed in the lowland. Riverbed and flood plain deposits cover these two formations, while talus deposit and slope wash are scarcely distributed in the reservoir area. Rockfall and small landslides exist in the lowland where Damar Formation and Kalibiuk Formation are distributed. The reservoir area has a favorable geological condition.

3.2.6 Garang Dam (G-3) on Garang River

(1) Topography and Geology of Dam Site

(a) Topography

Garang Dam is located on Garang River near Guwogede Village (refer to Fig. II.1.1).

Garang River in the vicinity of the proposed dam site has a roughly straight channel in the S-N direction for a stretch of approximately 250 m, while the upstream and downstream are heavily meandered. The river forms a gorge around the dam site where volcanic breccia is distributed. The riverbed elevation at the proposed dam axis is EL. 180 m and its width is 15 to 20 m. The slope gradient is approximately 40 degrees from the riverbed up to EL. 275 m and almost flat above EL. 275 m along the left bank, 45 to 50 degrees from the riverbed to EL. 250 m, and with gentle slope above EL. 250 m along the right bank. The gorge width is 180 m at EL. 250 m and the ratio between height and valley width at EL. 250 m is approximately 1:2.6.

(b) Geology

The basement rock in the vicinity of the proposed dam axis mainly consists of volcanic breccia (VB) and contains two intercalated sandstone beds (VBs) that belong to Notopuro Formation. Distribution of the intercalated sandstone is limited to around EL. 200 m. These basement rocks are covered with topsoil distributed on the gentle slope above EL. 275 m.

The volcanic breccia originated from the eruption of Mt. Ungaran and Mt. Sundoro and is composed of fine to coarse-grained sand matrix and various andesitic gravels that consist of granule to boulder material with poor sorting.

Joints in the volcanic breccia and sandstone are not developed but a few loose and open joints still exist. These joints are sheet type joints parallel to the bedding. Large-scale faults and landslides detrimental to the construction of a dam do not exist around the proposed dam site, based on the aerial photo analysis and field reconnaissance. (Refer to Fig. II.3.6)

(c) Engineering Geology

Detailed information regarding the fresh volcanic breccia is not presently available, because foundation rock tests have not been carried out. However, based on the results of field reconnaissance, the volcanic breccia is considered to possess sufficient soundness for the construction of a concrete gravity dam of less than 70 m in height.

The basement rock is fresh from the riverbed up to EL. 200 m, slightly weathered from EL. 200 m to EL. 250 m and heavily weathered above EL. 250 m. The maximum dam height shall be less than 70 m, which corresponds to EL. 250 m, with due consideration on rock soundness and topographical condition in the right bank which has a ridge width of less than 100 m above EL. 250 m.

Distribution and property of joints, especially sheet type joint, could not be identified in this field reconnaissance; however, there is a possibility of existence. Watertightness which depends on the distribution and property of joints is not clarified, but the permeability of volcanic breccia is not high in general, although high in locations where sheet type joints exist.

(d) Construction Material

There are no quarry sites near the proposed dam site, because riverbed deposits such as sand

and gravel are not widely distributed in Garang River and hard rock such as andesite lava or intrusive rock do not exist nearby. Hence, the intrusive rock of andesite at Mt. Mergi should be utilized for construction materials. This has to be transported from the foot of Mt. Ungaran located far from the proposed dam site at a distance of about 9 km.

(2) Geology in Reservoir Area

Garang River flows roughly south to north with meanders. It forms a gorge from the vicinity of the dam site to the downstream with both banks sloping gently in the reservoir area. This gentle slope in the reservoir area exists on the high land, approximately 50 to 100 m above the riverbed.

Volcanic breccia and talus deposit are extensively distributed in the reservoir area, but slope wash is scarcely distributed. Accordingly, landslides do not exist in the reservoir area and not expected even in the future. The slope in the reservoir area and the dam site is stable because of the favorable geological condition.

3.2.7 Babon Dam (Ba-2) on Babon River

Alluvial plains extend widely from the middle reaches to the downstream and a hilly region that looks like a "monadnock" remains in the middle reaches of the river. The upstream of Babon River is in the mountainous region where a dam is not effective for flood control because of the small catchment area. Consequently, the dam site is located at the hilly region in the middle reaches (refer to Fig. II.1.1).

The two alternative sites for dam are located upstream from the confluence of Babon River and East Floodway; one near Krakalan Village and the other near Kebontaman. At the proposed dam site, claystone and limestone of Kalibiuk Formation covered with river deposit and flood plain deposit are distributed. The site has sufficient height of hill, but basement rock has a watertightness problem because of limestone distribution. Besides, the width of the valley is very large; 1,280 m at EL. 75 m (dam height is 35 m). Also, this site is located in the residential areas of Kebutaman and Taruloyo villages. (Refer to Fig. II.3.7)

3.3 Recommendations

Blorong Dam, Kudung Suren Dam, Jatibarang Dam, Mundingan Dam, Garang Dam and Babon Dam are recommendable as dam sites based on geological and topographical points of view. Kripik Dam does not have favorable geological and topographical conditions for dam construction.

Blorong and Garang dam sites have good geological conditions. Rock soundness is sufficient in proportion to the dam scale and permeability is not high in general. The rivers form a gorge with a narrow valley. Large faults are not developed and the slope is stable in both the dam sites and the reservoirs areas. Moreover, the catchment areas (77 km^2 for Blorong and 71 km^2 for Garang) are larger, although the reservoir capacity is smaller than those of the other dam sites.

Jatibarang dam site is very similar to the Blorong and Garang dam sites with respect to geology and topography. The reservoir capacity is larger, but the catchment area of 53 km^2 is smaller than the aforesaid two dam sites. Also, there are important compensation realty of transmission line and paddy fields in the reservoir area. Moreover, the national park Goa Kreo is located near the dam site in the reservoir area.

Mundingan dam site is suitable for a rockfill dam due to its geographical feature of wide valley and gentle slope. Rock soundness is sufficient in proportion to the dam scale, but there are paddy fields and a transmission line in the reservoir area.

CHAPTER 4 GEOLOGICAL INVESTIGATION AT JATIBARANG DAM SITE

4.1 Outline of the Investigation

Geological investigation in the feasibility study stage has been carried out at the site of Jatibarang Dam which is selected as a priority project in the master plan study. The purpose of this investigation is to clarify the topographical and geological conditions and the rock soundness and permeability of the basement rock at the Jatibarang dam site and the reservoir area. The investigation consisted of field reconnaissance, field works, laboratory tests and geological analysis that are summarized below. Data are compiled in the Data Book which is attached hereto, and geological analysis was conducted in the home office in Japan based on these available data.

(1) Field Reconnaissance

Dam Site	:	about 0.5 km^2
Reservoir Area	:	about 5.5 km^2 (refer to Fig. II.4.1)

(2) Field Works

Drilling	:	3 sites (B-1, B-2, B-3), total depth of 210 m. (refer to Fig. II.4.2)
Lugeon Test	:	27 times

The details of field works are as follows:

No.	Location	Depth (m)	Elevation EL.(m)	Water Level GL(-m)	Lugeon Test (times)	Sample (pcs.)
B-1	Left Bank	70.0	158.408	40.50	11	2
B-2	Riverbed	70.0	90.141	0.30	7	2
B-3	Right Bank	70.0	171.782	51.65	9	2
Total	3 holes	210.0	-	-	27	6

(3) Laboratory Tests

Specific Gravity and Absorption Test : 6 samples

Unit Weight Test : 6 samples

Compression Test : 6 samples

4.2 Geology

The general geological features are described in 3.2.3. The detailed geology which were clarified by boring tests are described below.

Volcanic breccia is exposed above EL. 105 m and below EL. 85 m. These layers consist of tuffaceous sand matrix and various andesitic gravels composed of granule to boulder with bad sorting. Gravel content is 30 to 50% with sub-rounded to sub-angular configuration. The diameter of gravel is generally 5 to 20 cm and maximum gravel size is 60 cm.

Tuffaceous sandstone is exposed at the riverbed with a thickness of about 25 m and at EL. 120 m with thickness of about 10 m in the right bank. These units are divided into two facies as fine to medium tuffaceous sandstone and tuffaceous coarse sandstone with granule, and they locally include the thin layer of volcanic conglomerate. The concretion of tuffaceous sandstone is less stronger than volcanic breccia.

Volcanic conglomerate, composed of various rounded gravels with a diameter of 5 to 15 cm (maximum 25 cm) and sand matrix, is exposed from Goa Kreo to the proposed dam axis with a thickness of 5 to 15 m.

Lava flow is exposed locally near Goa Kreo and the proposed dam axis with a thickness of a few 10 cm to a few meters. This unit locally include facies of black auto-brecciated lava which is composed of dark grey andesitic gravels and similar andesitic matrix. Half of the gravels' ring are indistinct and the other half are distinct to the matrix.

Topsoil and/or talus deposits are thin with a thickness of a few 10 cm near the proposed dam axis. Riverbed deposit is distributed with a thickness of 1 to 2 m where basement rock is exposed locally in the river. Joints in the basement rock are not developed but a few loose and open joints still exist. These joints are sheet type joints parallel to the bedding. Large-scale fault and landslide detrimental for the construction of a dam do not exist around the proposed dam axis, based on the field reconnaissance and the aerial photo analysis. (Refer to Table II.4.1)

4.3 Engineering Geology

4.3.1 Rock Soundness

Basement rock is fresh from the riverbed, EL. 90 m, up to EL. 115 m, slightly weathered from EL. 115 m to EL. 130 m and heavily weathered above EL. 130 m in the left bank. On the other hand, in the right bank, the basement rock is fresh from the riverbed up to EL. 130 m, slightly weathered from there to EL. 145 m and heavily weathered above EL. 145 m.

Distribution of sheeting joint can be determined from the results of lugeon test and observation of core samples. Sheeting joints are distributed below the riverbed at about EL. 65 m to EL. 95 m. The sheer strength of fresh volcanic breccia is expected to be about 80 to 90 t/m^2, but tuffaceous sandstone will be 60 to 70 t/m^2.

The maximum dam height shall be less than 74 m, which correspond to EL. 164 m, with due consideration on weathering, rock soundness and topographic condition in the left bank which has a ridge width of less than 100 meters above EL. 160 m.

4.3.2 Permeability

Joints and cracks of the fresh basement rock are scarcely developed around the dam site. Accordingly, the permeability is low without distribution of sheeting joints near the ground surface and around EL. 65 m to EL. 75 m in the riverbed. Since joints and cracks are developed in the weathered zone, the permeability of weathered rock is high above the water table (refer to Fig. II.4.3) at both banks.

The permeability of lava flow is slightly high (Lugeon value: 4-6) as compared with other basement rocks (Lugeon value: below 4).

Spring occurred at two depths in Drillhole B-2. The amount of spring was 64 l/min at the maximum pressure of 2.0 kg/cm^2 at the depth of 42 meters, and 66 l/min at 1.8 kg/cm^2 at the depth of 62 meters. Lithology could not be clarified, because the drilling bit could not be made stable due to the spring pressure and it was difficult to take core samples.

4.3.3 Results of Laboratory Test

The results of laboratory tests are summarized in Table II.4.2. Unconfined compression strength of volcanic breccia ranges from about 71 to 120 kg/cm^2, and tuffaceous sandstone ranges from about 35 to 82 kg/cm^2.

4.4 Recommendations

Special attention should be paid to the following points:

(1) The existence of rockfalls and creep zones where Damar Formation and Kalibiuk Formation are distributed in the left bank of the reservoir area: Careful management of the reservoir operation is required.

(2) The existence of paddy fields, electric transmission line and a national park named Goa Kreo in the reservoir area.

(3) The existence of sheeting joints: The distribution and property of the sheeting joints should be investigated by field reconnaissance and Lugeon tests in the next project stage.

(4) The existence of lava flows: The permeability of lava flow is high in general. The distribution and property of the lava flow should be investigated in the next project stage.

(5) The existence of springs at Drillhole B-2: Grouting should be conducted under careful management.

(6) The property of andesite at Mt. Mergi: The andesite at Mt. Mergi can be utilized as aggregate of construction materials; however, the andesite pieces tend to be flat.

CHAPTER 5 SUBSOIL INVESTIGATION ALONG WEST FLOODWAY/ GARANG RIVER

This CHAPTER deals with the subsoil investigation conducted by the JICA Study Team along West Floodway/Garang River for the stretch of 9.6 km from the river mouth. The data of the investigation are compiled in the Data Book. The results of subsoil investigation conducted by the Ministry of Public Works (DPU) also have been examined by the Team.

5.1 Outline of the Investigation

The investigation conducted in the feasibility study stage aimed to provide basic information on subsoil mechanics for the improvement works of West Floodway/Garang River. Items and quantities of investigation and tests are summarized in Table II.5.1.

5.2 Geology along West Floodway/Garang River

Locations of machine boring sites are shown in Fig. II.5.1. The histograms of N-value are summarized in Fig. II.5.2 by soil layers. Based on the results obtained by the investigation and tests, subsoil profiles were prepared as shown in Fig. II.5.3.

5.2.1 Topography

The study area is located downstream of Garang River where the alluvial plain extends to the Jawa Sea. In the upper stretch of Garang River, a valley having a width of 500 m to 1,000 m at EL. 4 - 15 m exists and alluvial deposit is observed along the valley.

5.2.2 Geology

Two major Quaternary formations are observed at the study area. Damar Formation of the Pleistocene and the Upper Pliocene is exposed at the hilly region along the upper stream of Garang River. Alluvial deposits of the Holocene are extensively exposed at the plain area downstream.

Damar Formation at the hilly region is composed mainly of tuffaceous sandstone and conglomerate. Alluvial deposit is composed mainly of clay, silt and sand with gravel or shell fragments in both the plain area downstream and the hilly region upstream. However, in the hilly region, much gravel is confirmed in each layer. On the other hand, shell fragments are observed in the plain area instead of gravel. It is, therefore, expected that alluvial deposit in the hilly region is categorized as fluvial deposit and that in the plain area is categorized as shallow marine deposit from the sedimentary environmental point of view.

5.2.3 Stratigraphy

Basement rock in the study area is Damar Formation (Dtg) composed of tuffaceous sandstone and conglomerate. Claystone of Kalibiuk Formation of the Lower Pleistocene also is locally exposed south of the study area near boring site B-10. (Refer to Table II.5.2)

Alluvial deposit consists of fluvial deposit in the upper stream and shallow marine deposit in the lower stream. The layers of each deposit are summarized as follows:

(1) Fluvial Deposits

Layer	Symbol
Upper Sand Layer	As1'
Gravel Layer	Ag
Upper Clay Layer	Ac1'
Lower Sand Layer	As2'
Lower Clay Layer	Ac2'
Basal Sand Layer	As3'

(2) Shallow Marine Deposits

Layer	Symbol
Upper Sand Layer	As1
Upper Clay Layer	Ac1
Middle Sand Layer	As2
Lower Clay Layer	Ac2

Contemporaneous heterotopic facies of these two deposits are observed in the stations between P100 and P131 of the subsoil profile (refer to Fig. II.5.3). In the layer of shallow marine deposit (As1, Ac1, As2 and Ac2) and fluvial deposit (As1', Ac1', As2' and Ac2'), different facies represented by gravel and shell fragments are confirmed in spite of the simultaneous formation of both deposits at the same geological age.

5.3 Field Investigation

5.3.1 Machine Boring

Machine boring, 198 meters in total, was carried out at 11 sites as shown in Table II.5.1 and Fig. II.5.3.

5.3.2 Standard Penetration Test

Standard penetration test (SPT) was carried out 196 times, at every 1 meter of all boreholes. Histogram of N-value for each layer is shown in Fig. II.5.2. The results of SPT are given in Table II.5.3

5.4 Laboratory Test

The following laboratory tests were conducted applying ASTM standards for each 30 disturbed samples obtained from boring cores:

Specific Gravity Test	:	30 samples
Water Content Test	:	30 samples
Particle Size Analysis	:	30 samples

Samples were collected mainly from surface layers such as rd, Ac1, As1' and Ac1' which are expected to be part of the excavation work. The results of laboratory tests, together with sampling depths, are summarized in Table II.5.4.

5.5 Consideration on Construction Works

5.5.1 Excavation

(1) Station P1 to P10

River deposit (rd) and basement rock (Dtg) are exposed in this section. The N-value of river deposit is 1 to 24 with the average of about 5. River deposits can be excavated by a backhoe with small capacity of 0.6 m^3. Basement rock can be excavated by a backhoe having a big capacity of over 1.2 m^3, or a 32-ton bulldozer with ripper.

(2) Station P10 to P33

River deposit (rd) and lower clay layer (Ac2') of fluvial deposit are exposed in this section. River deposits can be excavated by a backhoe with small capacity, but the Ac2' layer has the N-value of 28 to over 50 and should be excavated by a backhoe with big capacity of over 1.0 m^3.

(3) Station P33 to P41

River deposit (rd), upper sand layer (As1') and upper clay layer (Ac1') of fluvial deposit are exposed in this section. River deposit and Ac1' layer can be excavated by a backhoe with small capacity, but the As1' layer has the N-value of 7 to over 50 with the average of 30 and should be excavated by a backhoe with big capacity of over 1.0 m^3, or a 32-ton bulldozer.

(4) Station P41 to P105

River deposit (rd), upper sand layer (As1') and gravel layer (Ag) of fluvial deposit are exposed in this section. River deposit can be excavated by a backhoe with small capacity. The As1' layer has the N-value of 7 to over 50 with the average of 30 and the gravel layer has the N-value of 22 to over 50 with the average of over 46; hence, these two layers should be excavated by a backhoe with big capacity of over 1.0 m^3, or a 32-ton bulldozer.

(5) Station P105 to P206

River deposit (rd), upper sand layer (As1) and upper clay layer (Ac1) of shallow marine deposit are exposed in this section. N-values of these layers are less than 10 so they can be excavated by a backhoe with small capacity.

5.5.2 Trafficability

In the construction site, trafficability of excavation and transportation equipment depends on the mechanical soil property affected by the water content. "Cone Index" (qc) is used to examine trafficability and is estimated by N-value as follows:

Cone Index qc = 2N : in case of cohesive soil
Cone Index qc = 4N : in case of sand

Based on the above experimental conversion formula, the cone index of each soil is estimated as shown in Table II.5.5.

5.6 Recommendations

Additional field investigations should be planned in the construction stage. The investigation in this study stage was conducted to collect general subsoil conditions for the urgent project study and the number of borings and laboratory tests is not enough to grasp the detailed soil distribution and soil soundness for the proposed structures and their construction works. Consequently, 8 to 10 borings especially at the final locations of bridges and other important facilities are recommended in addition to the existing borings.

TABLES

TABLE II-2-1 GEOLOGICAL STRATA OF STUDY AREA

EPOCH	SYMBOL	FORMATION	NAME	LITHOLOGY
HOLOCENE	ts	–	Top Soil Talus dt	Clay, gravel (angular)
	rd	–	River Bed dt.	Sand, gravel inter - bedded silt and clay
	fd	–	Flood Plain dt	Sand, gravel, silt and clay
PLEISTOCENE	VB VBs	NOTOPURO	Volcanic Breccia	VB ; Volcanic Breccia VBs; Tuffaceous sandstone
	La		Lava Flow	Andesite lava Exposed locally
	Dts Dtg	DAMAR	Tuffaceous Sandstone	Dts ; Tuffaceous sandstone Dtg; Conglomerate
PLIOCENE	Kc Kcl	KALIBIUK	Blue Claystone	Kc ; Blue Claystone, marl, Sandstone Kcl ; Limestone

Table II-3-1 POSSIBLE DAM SITES

River	Site Name	Catchment *1 Area	Width *2 of Valley	Hight *3 of Dam	Geological Feature	Reservoir Capacity	Compensation Realty	Judgment *4
Blorong	B-1	Large	Middle	Low	Weathered	Large	Existing Weir/Paddy Field	X
	B-2	Large	Wide	Middle	Weathered	Large	Residence, Paddy field	Δ
	B-3	Middle	Narrow	High	Good	Middle	-	O
	B-4	Middle	Narrow	High	Limestone, leakage	Large	Paddy Field	X
Kreo	K-1	Middle	Middle	High	Eidge is narrow	Small	-	X
	K-2	Middle	Narrow	High	Good	Small	-	X
	K-3	Middle	Narrow	High	Good, Natural Park (goa Kreo)	Large	Transmission line/Paddy Field	O
	K-4	Middle	Wide	Middle	Good	Large	Transmission line/Paddy Field	O
Kripik	KR-1	Small	Wide	High	Rich in fault/rock fall	Large	Paddy Field	Δ
	KR-1	Very Small	Narrow	High	Good	Small	-	X
Garang	G-1	Middle	Narrow	High	Good	Small	-	X
	G-2	Middle	Narrow	High	Good	Small	-	X
	G-3	Middle	Narrow	High	Good	Middle	-	O
Babon	Ba-1	Middle	Wide	Low	Widely distributed Alluvial dt.	Large	Paddy Field	X
	Ba-2	Middle	Wide	Low	Limestone, leakage	Large	Village/Paddy Field	Δ

*1 Small : <30km2
Middle : 30~100km2
Large : >100km2

*2 Narrow : <200m
Middle : 200~500m
Wide : >500m

*3 Low : <20m
Middle : 20~50m
High : >50m

*4 O Good
Δ Some problems
x Bad

Table II.3.2 TOPOGRAPHICAL AND GEOLOGICAL FEATURES OF THE PROPOSED DAM SITES

Name of Dam	Basement Rock			Geology	Maximum Dam Hight H(m)	River-bed EL(m)	Width at H W(m)	H : W	Proposed Dam Type *1	Construction Material	Catchment Area (Km2)	Reservoir Capacity	Compensation Realty
	Epoch	Formation	Lithology										
Blorong (B-3)	Pleistocene ~ Pliocene	Notopuro	-Volcanic Breccia (VB) -Tuffacious Sand stone (VBs)	-V.B. is sufficient to support such scale dam -Weathered above EL 190 meter	50 (EL=190m)	140	118	1:2.4	G	Intrusive Rock	51	Middle	-
Kudung Suren (B-2)	"	Damar	Dts, Dtg	-Alluvial deposit is widely distributed	41 (EL=76m)	35	800	1:20	F	"	147	Large	Residential area Paddy field
Jatiburang (K-3)	"	"	VB VBs	-VB is sufficient to support such scaled dam -Width of ridge is less than 100m above EL 160m	72 (EL=162m)	90	155	1:2.2	G	"	53	Large	Transmission line Paddy field
Mundingan (K-4)	"	"	VB VBs	-Weathered above EL 220 meter -Sheeting joint are developed	45 (EL=230m)	185	400	1:8.9	F	River bed; Sand/gravel	46	Large	Transmission line Paddy field
Kripik (KR-1)	"	Damar	-Taffaceous Sand stone (Dts) -Conglomerater (Dtg)	-Fault and rock fall are abundant at the dam site -Width of ridge is less than 100m above EL 90m	55 (EL=90m)	35	535	1:9.7	F	"	<30	Large	Paddy field
Garang (G-3)	"	Notopuro	VB VBs	-Good condition in geology -Width of ridge is less than 100m above EL 250m	70 (EL=250m)	180	180	1:2.6	G	Intrusive Rock	71	Middle	-
Babon Ba-2	Pliocene	Kalibiuk	Claystone Limestone	-Leakage	35 (EL=75m)	40	1,280	1:32	F	River-bed	52	Large	Residential area Paddy field

Note *1 G: Concrete Gravity Dam
F: Rockfil Dam

Table II.4.1 GEOLOGICAL STRATA AT JATIBARANG DAM SITE

Age	Symbol	Formation	Name	Lithology
Quaternary Holocene	ts		Top soil Talus deposit	clay, sand and gravel
	rd		River bed deposit	Sand, rounded gravel (granule to boulder) with clay
	fd		Flood plain deposit	Sand, rounded gravel (granule to cobble) and clay
Tertiary ~ Quaternary Pliocene ~ Pleistocene	VB	Notopuro	Volcanic breccia	Volcanic flow Matrix ; tuffaceous sand Gravel ; content 30~50%,φ =5~40cm φ max 60cm, bad sorting, rounded to sub angular
	VBs		Tuffaceous sandstone	Fine to medium sand Coarse sand with granule, well sorting
	VBC		Volcanic conglomerate	Matrix, medium to coarse Gravel ; content 40~60%, φ 5~15cmφ max25cm, well sorting rounded
	La		Lava (andesite)	Lava flow, (a few 10cm to a few meters) and discontinuously locally with auto brecciated
	Dts	Damar	Tuffaceous sandstone	Sandstone with granule to pebble,
Pliocene	Kc	Kalibiuk	Claystone	Bluish grey claystone, locally with sandstone/limestone

Table II·4·2 SUMMARY OF LABORATORY TEST AT JATIBARANG DAM SITE

Drillhole NO.	Sampling Depth (m)	Lithology	Specific Gravity Gs	Void Ratio e	Natural Water Content Wn(%)	Unit Weight (g/cm^3)	Unconfined Compression Strength σc (kg/cm^2)
B–1	48.60~48.90	Volcanic breccia	2.762	0.192	4.674	2.425	119.09
	51.25~51.45	Tuffaceous sandstone	2.767	0.605	9.470	1.888	81.97
B–2	3.10~ 3.50	Volcanic breccia	2.739	0.576	12.861	1.957	34.86
	18.40~18.65	Tuffaceous sandstone	2.803	0.405	9.714	2.189	35.61
B–3	35.15~35.40	Volcanic breccia	2.714	0.394	5.070	2.044	70.87
	46.50~46.90	Tuffaceous sandstone	2.767	0.192	4.674	2.425	47.82

Table II-5-1 QUANTITIES OF SUB-SOIL INVESTIGATION

Field Investigation					Laboratory Test			Remarks
Borehole No.	Elevation (m)	Depth (m)	SPT*1 (times)	Sampling *2 (pcs)	Specific Gravity	Water Content	Particle Size	
B - 1	1.999	20	20	3	3	3	3	
2	1.868	20	20	3	3	3	3	
3	2.416	20	20	3	3	3	3	
4	2.425	20	20	3	3	3	3	Railway Bridge
5	2.785	20	19	3	3	3	3	Road Bridge
6	7.541	20	19	3	3	3	3	Simongan Weir
7	7.881	20	20	3	3	3	3	Simongan Weir
8	9.769	10	10	2	2	2	2	
9	7.795	10	10	2	2	2	2	
10	12.584	10	10	2	2	2	2	
11	4.302	28	28	3	3	3	3	Simongan Bridge
Total	-	198	196	30	30	30	30	

*1 Standard Penetration Test
*2 Disturbed Soil Sampling

Table II.5.2 GEOLOGICAL STRATA OF WEST FLOODWAY/GARANG RIVER

Symbol		Description	N-Value (Average)	Thickness (m)
rd		River bed deposit, consists of clay, silt and gravel with roots of plant.	1 ~ 15 (5.6)	1 ~ 5 locally 10m
As1		Sand, silty ~ clayey sand with organic materials (coral, shell), colored grey to dark grey	4 ~ 15 (8.0)	2 ~ 3
	As1'	Sand and silty sand interbedded with gravel, colored grey, dark grey to brownish grey.	7 ~ 50< (30.0)	2 ~ 4
	Ag	Sand and gravel to boulder that is very hard, grain size ; 0.3mm ~ 40cm	23 ~ 50< (46.8)	1 ~ 9
Ac1		Clay and silt intercalated fine sand, contain organic materials (shell), colored dark grey	1 ~ 4 (1.5)	8 ~ 18
	Ac1'	Mainly consists of silt, locally clay with sand and gravel, colored dark grey	5 ~ 27 (13.6)	2 ~ 9
As2	As2'	Sand interbedded with clay, silt and gravel, colored grey to dark grey	12 ~ 21 (15.9)	2 ~ 3
Ac2		Clay and silt intercalated with sand and gravel, colored dark grey	1 ~ 25 (16.2)	5<
	Ac2'	Silt with gravel and sand, well-compacted, colored dark grey to brownish dark grey	28 ~ 50< (47.8)	5 ~ 10
	As3'	Sand with gravel, well-compacted, colored dark grey to brownish grey	31 ~ 50< (48.1)	3 ~ 10
	↑ Fluvial Deposits		—	—
↑ Shallow Marine Deposits				
Dtg		Basement rock (Damar Formation) Tuffaceous sandstone, Conglomerate, Volcanic breccia	50<	7<

Table II.5.3 N-VALUE OF EACH LAYER

Deposits	Soil layer	Test number	Average	Minimum	Maximum
River	rd	31	4.9	1	24
Sallow Marine	As1	3	8.0	4	15
"	Ac1	64	1.6	1	4
"	As2	8	15.9	12	21
"	Ac2	17	16.2	1	25
Fluvial	As1'	10	30.0	7	>50
"	Ag	17	>46.4	22	>50
"	Ac1'	13	13.6	5	27
"	As2'	8	15.9	12	21
"	Ac2'	13	>47.8	28	>50
"	As3'	10	>48.1	31	>50
Basement rock	Dtg	10	>50	>50	>50

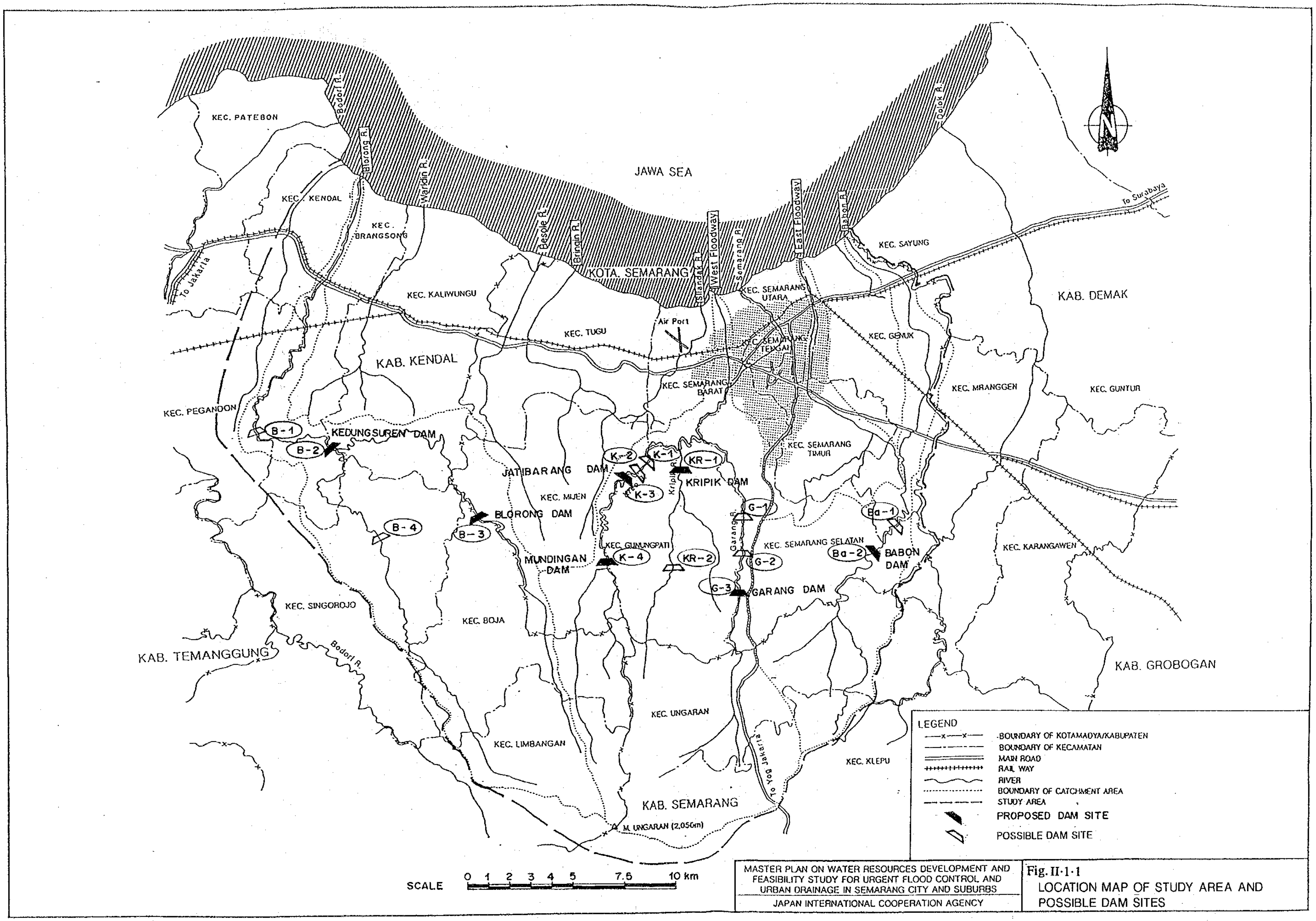
Table II.5.4 SUMMARY OF LABORATORY TEST
ALONG WEST FLOODWAY/GARANG RIVER

Sample		Soil	N-	Specific	Water	Particle Size		
Boring No.	Depth (m)	Layer	Value	Gravity ; G	Content ; Wn (%)	Clay (%)	Sand (%)	Gravel (%)
B-1	5.40 ~ 5.70	Ac1	2	2.848	36.258	64.3	35.7	0
	10.40 ~ 10.70	Ac1	1	2.647	74.227	98.9	1.1	0
	15.30 ~ 15.70	Ac1	1	2.699	69.198	85.5	14.5	0
B-2	5.35 ~ 5.70	Ac1	2	2.597	62.819	80.0	20.0	0
	10.40 ~ 10.70	Ac1	1	2.549	92.456	97.7	2.3	0
	15.40 ~ 15.70	Ac1	1	2.543	70.987	97.4	2.6	0
B-3	5.30 ~ 5.60	Ac1	2	2.584	44.597	98.4	1.6	0
	10.35 ~ 10.70	Ac1	1	2.746	46.251	97.1	2.9	0
	15.20 ~ 15.70	Ac1	2	2.792	50.217	99.0	1.0	0
B-4	5.00 ~ 5.30	Ac1	1	2.698	54.473	72.7	27.3	0
	10.00 ~ 10.30	Ac1	3	2.683	68.941	91.3	8.7	0
	16.15 ~ 16.50	Ac2	24	2.640	27.496	72.4	27.6	0
B-5	4.70 ~ 5.00	As1	15	2.876	17.010	37.4	57.1	5.5
	9.60 ~ 10.00	Ac1	3	2.728	49.374	83.2	13.8	3.0
	11.50 ~ 12.00	Ac1	4	2.681	50.948	86.5	13.5	0
B-6	4.60 ~ 5.00	As1'	7	2.747	51.187	73.5	26.1	0.4
	5.30 ~ 5.60	As1'	32	2.847	15.425	43.7	47.2	9.1
	9.60 ~ 10.00	Ac1'	7	2.848	39.275	59.5	40.5	0
	14.60 ~ 15.00	Ac1'	27	2.751	45.191	95.4	4.6	0
B-7	2.00 ~ 2.30	rd	5	2.715	53.644	89.6	10.4	0
	9.30 ~ 9.70	Ac1'	8	2.842	36.259	40.8	59.2	0
	10.20 ~ 10.35	Ac1'	10	2.751	28.879	65.6	34.4	0
B-8	2.35 ~ 2.70	rd	5	2.795	49.661	76.0	24.0	0
	7.20 ~ 7.40	Ag	>50	2.843	16.368	29.4	42.6	28.0
B-9	2.30 ~ 2.50	As1'	37	2.830	13.578	49.9	31.1	19.0
	5.15 ~ 5.40	Ac1'	17	2.732	64.128	92.8	7.2	0
B-10	1.30 ~ 1.70	rd	12	2.694	30.142	80.8	19.2	0
	6.00 ~ 6.35	VB	>50	2.744	20.410	59.6	22.4	18.0
B-11	3.40 ~ 3.70	rd	12	2.623	43.241	54.6	45.4	0
	9.20 ~ 9.40	Ag	>50	2.751	38.800	34.7	55.3	10.0
	17.00 ~ 17.20	Ac2'	>50	2.541	19.380	37.4	62.6	0

Table II.5.5 ESTIMATED CONE-INDEX

N - value			Estimated Qc (average)	
Layer	(average)	Soil Classification	Unit Kg/cm2	
rd	1 to 15 (5)	cohesive soil	2 to 30	(10)
As1	4 to 15 (8)	sand	16 to 60	(32)
Ac1	1 to 4 (1.6)	cohesive soil	2 to 8	(3.2)
As2	12 to 21 (16)	sand	48 to 84	(64)
Ac2	1 to 25 (16)	cohesive soil	2 to 50	(32)
As1'	7 to 21 (30)	sand	28 to 84	(120)
Ac1'	5 to 27 (14)	cohesive soil	10 to 54	(28)
Ac2'	28 to <50 (14)	cohesive soil	56 to <100	(100)

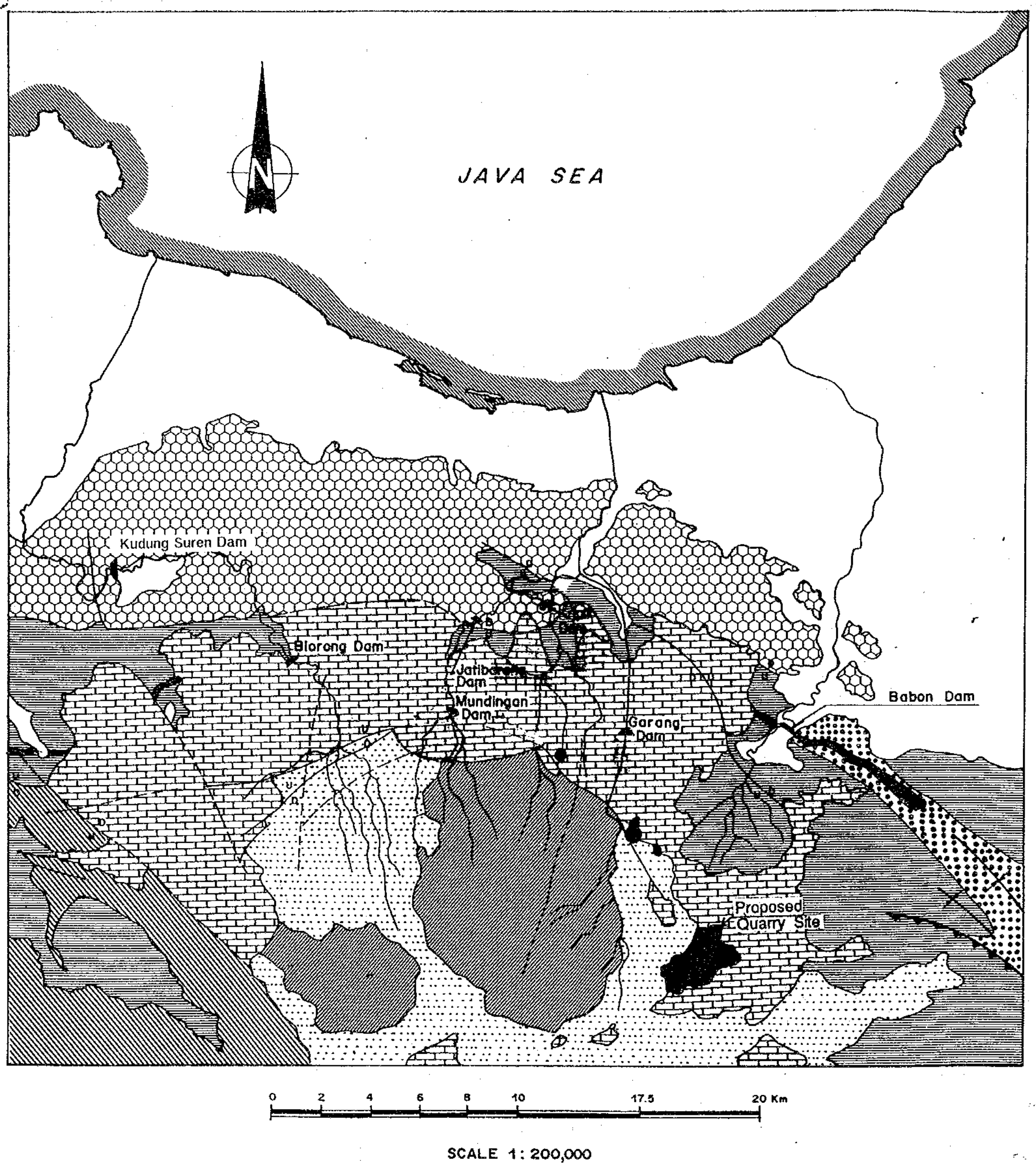
FIGURES



MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. II-1-1
LOCATION MAP OF STUDY AREA AND POSSIBLE DAM SITES



LEGEND :

- ALLUVIUM : Coastal plain; clay and sand , stream deposits; sand , silt, gravel and boulder
- MIDDLE G. UNGARAN LAHAR AND VOLCANIC ROCK : Augite – olivine basalt flows
- LAVA FLOW OF G. UNGARAN : Augite – hornblende andesite
- NOTOPURO FORMATION : Volcanic breccia, lava flows, tuff, tuffaceous sandstone and claystone
- DAMAR FORMATION : Tuffaceous sandstone , conglomerate , volcanic breccia and tuff
- KALIBIUK FORMATION : Claystone, marl, sandstone , conglomerate , volcanic breccia and tuff
- BANYAK MEMBER : Alternation of tuffaceous sandstone , calcareous siltstone , sandstone and pebbly sand stone
- PENYATAN FORMATION : Sandstone , breccia , tuff, claystone and lava flow .
- LIMESTONE
- INTRUSIVE ROCKS : Augite – hornblende andesite and augite – olivine andesite
- NORMAL FAULT : U = up D = down
- REVERSE FAULT
- FOLD AXIS
- INFERRED FAULT

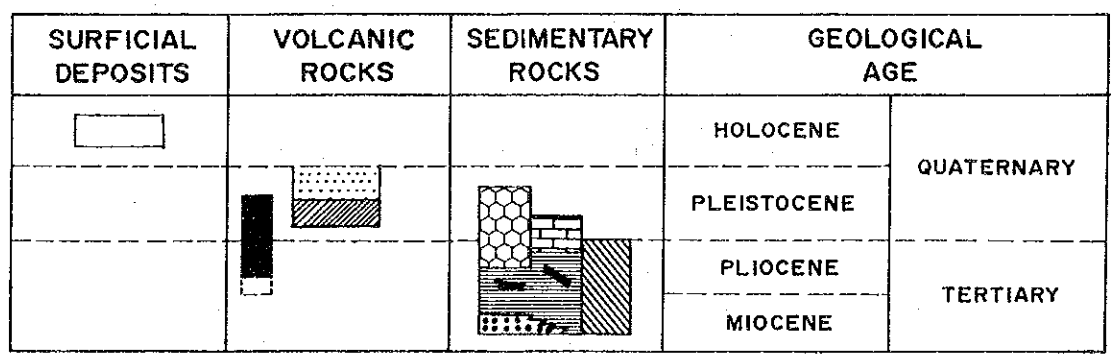


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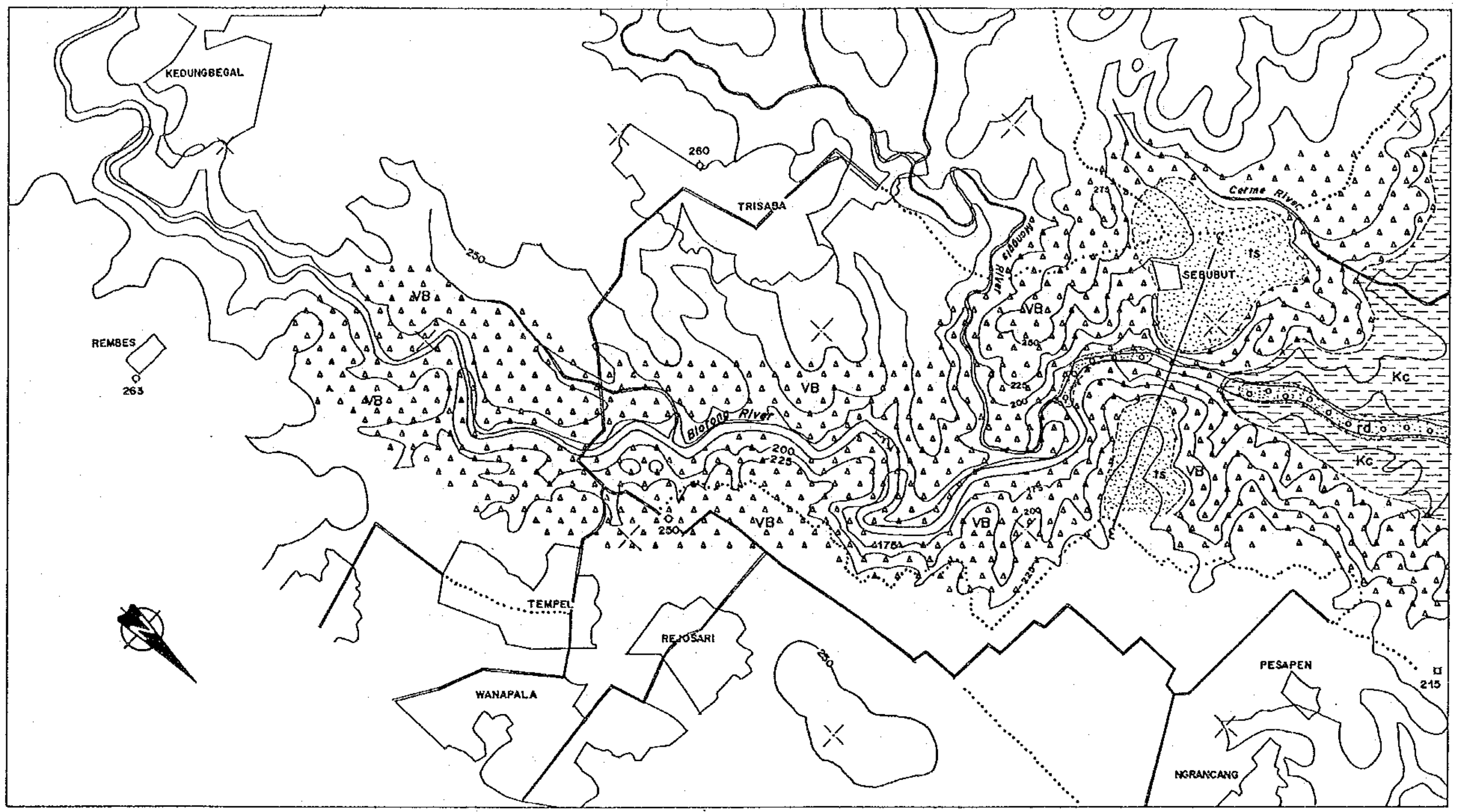
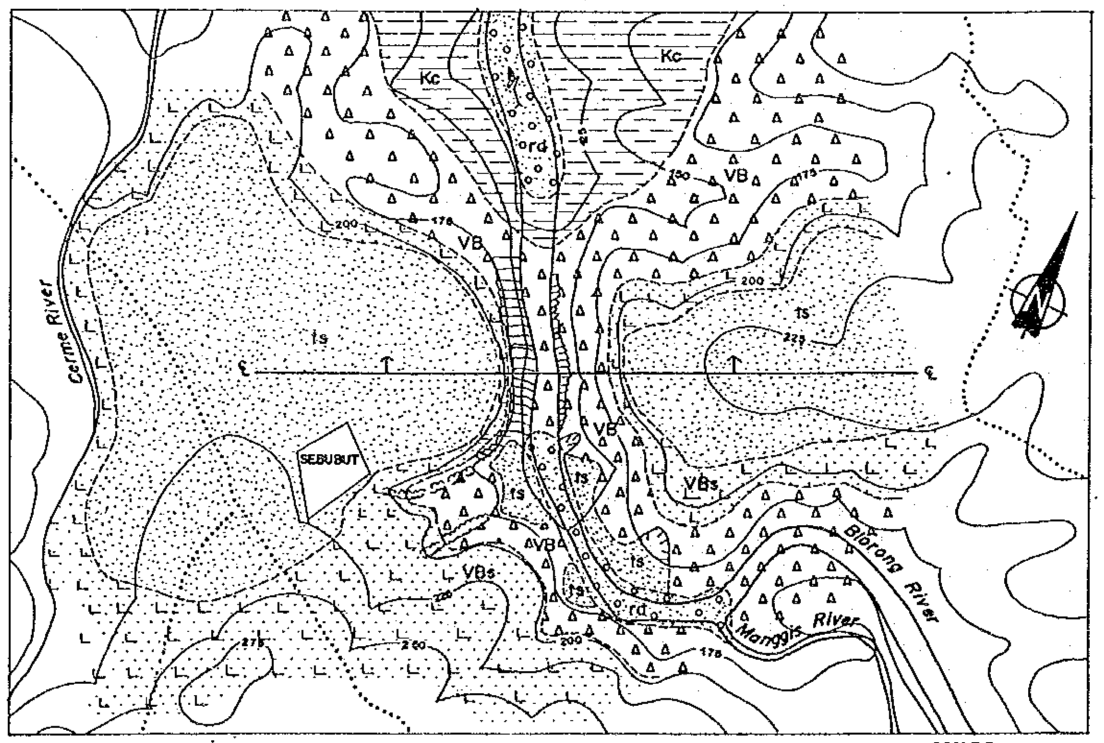
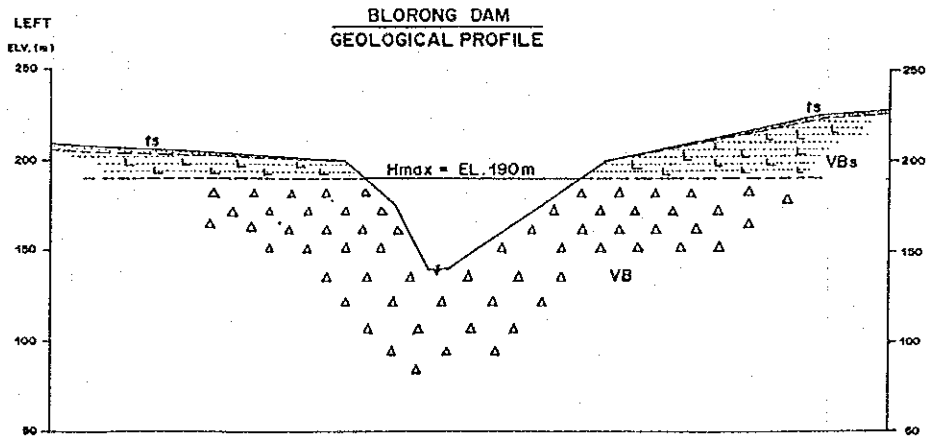
Fig. II·2·1 REGIONAL GEOLOGICAL MAP AROUND THE STUDY AREA

BLORONG RESERVOIR PLAN



BLORONG DAMSITE PLAN





LEGEND

EPOCH	SYMBOL	FORMATION	NAME	LITHOLOGY
HOLOCENE	ts	-	Top Soil Talus dt	Clay, gravel (angular)
	rd	-	River Bed dt.	Sand, gravel inter - bedded silt and clay
	fd	-	Flood Plain dt	Sand, gravel, silt and clay
PLEISTOCENE	VB	NOTOPURO	Volcanic Breccia	VB ; Volcanic Breccia
	VBs			VBs; Tuffaceous sandstone
	La		Lava Flow	Andesite lava Exposed locally
	Dts	DAMAR	Tuffaceous Sandstone	Dts; Tuffaceous sandstone
	Dtg			Dtg; Conglomerate
PLIOCENE	Kc	KALIBIUK	Blue Claystone	Kc ; Blue Claystone, marl, Sandstone
	Kcl			Kcl; Limestone

- Lithologic boundary
- cr= 3m — Fault cr= 3m ; Width of crushed zone
- Inferred fault
- 40 — Strike and dip of bedding
- 50 — Strike and dip of joint
- 60 — Strike and dip of fault
- Rock fall and landslide
- Spring
- Outcrop (Cliff)
- Outcrop

SCALE A. 0 100 200 300 400 500 750 1000 m

SCALE B. 0 50 100 150 200 250 375 500 m

SCALE C. 0 20 40 60 80 100 150 200 m

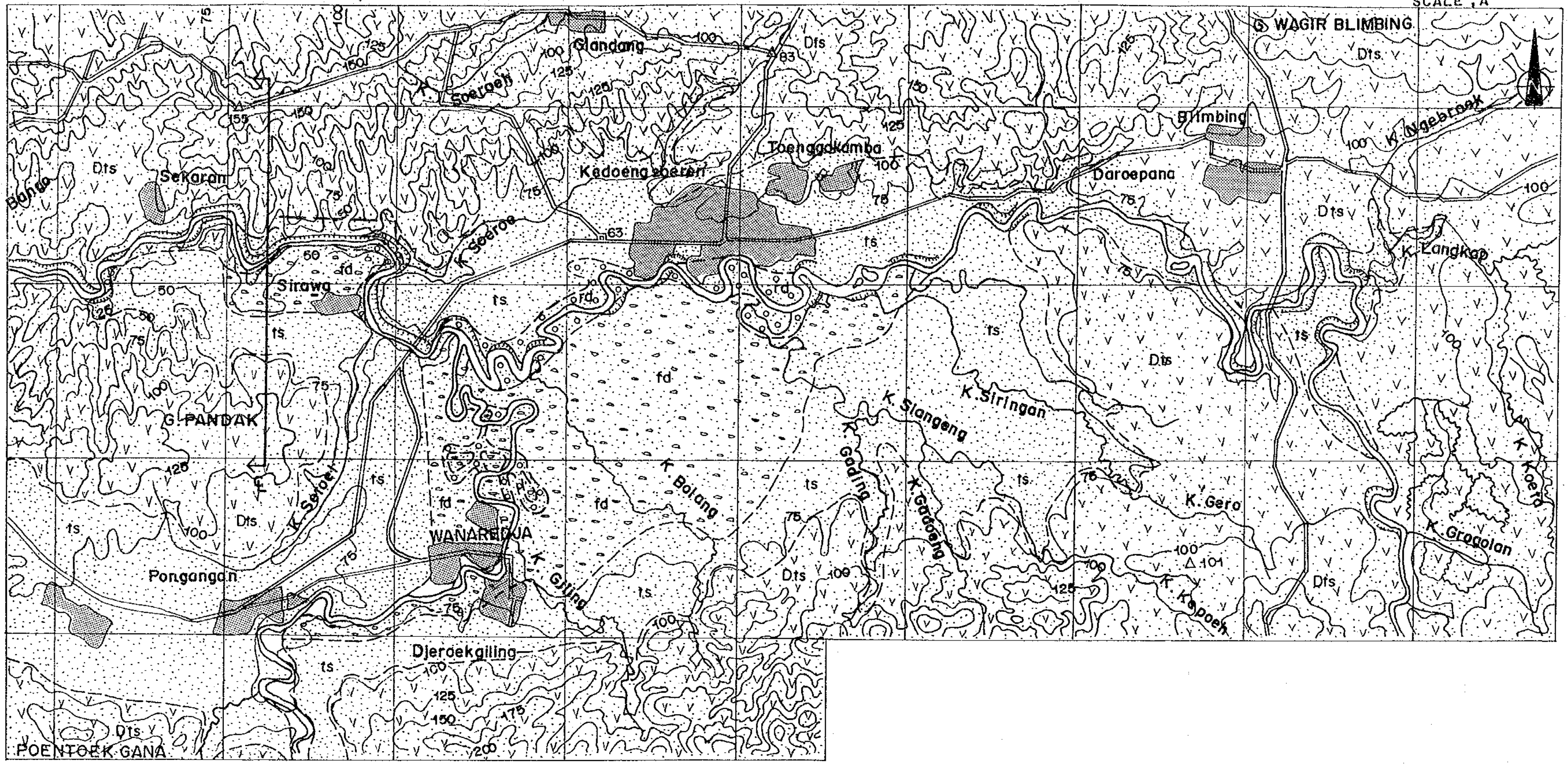
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS

JAPAN INTERNATIONAL COOPERATION AGENCY

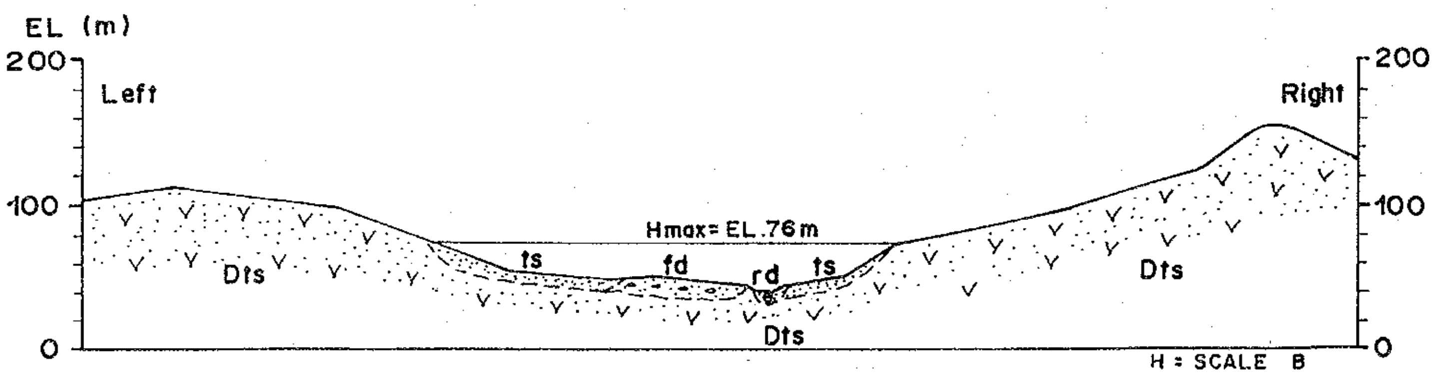
Fig.II.3.1

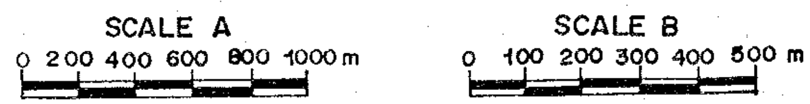
GEOLOGICAL MAP OF BLORONG DAM

PLAN

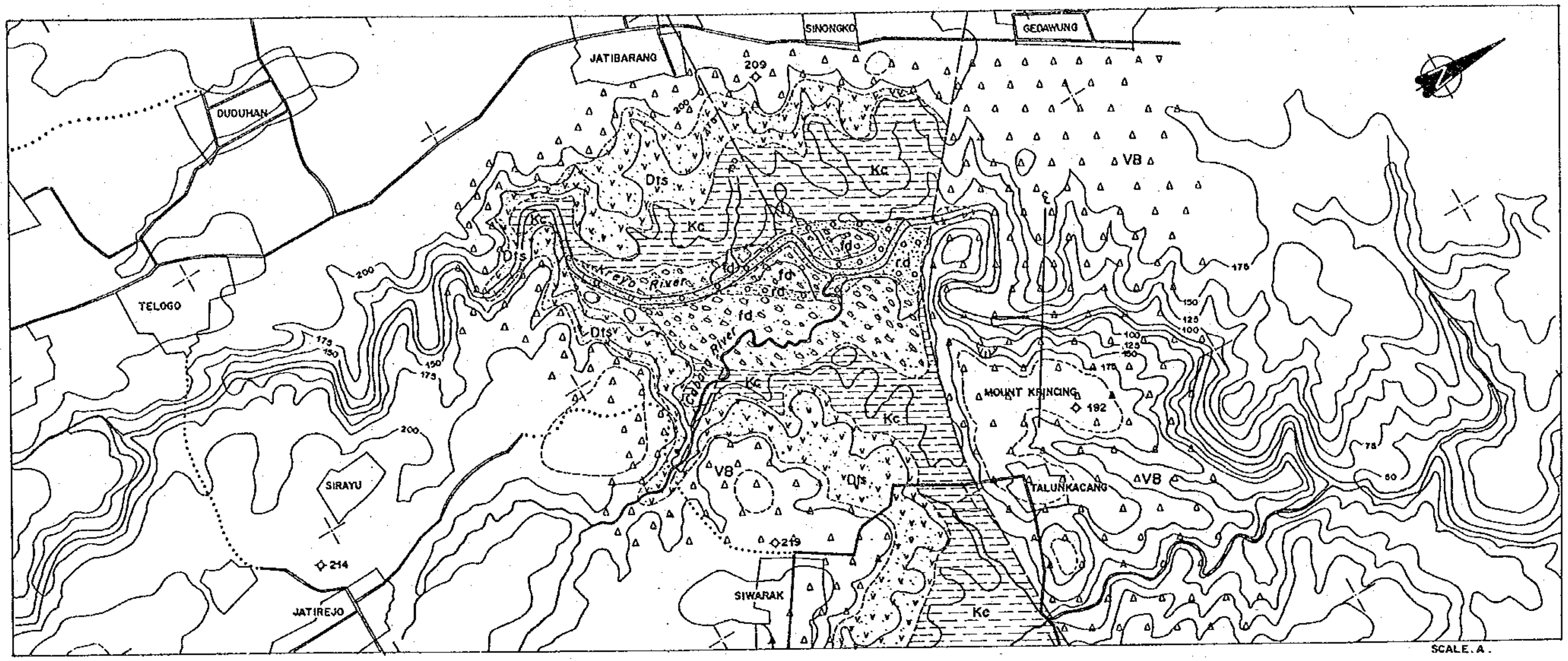


GEOLOGICAL PROFILE

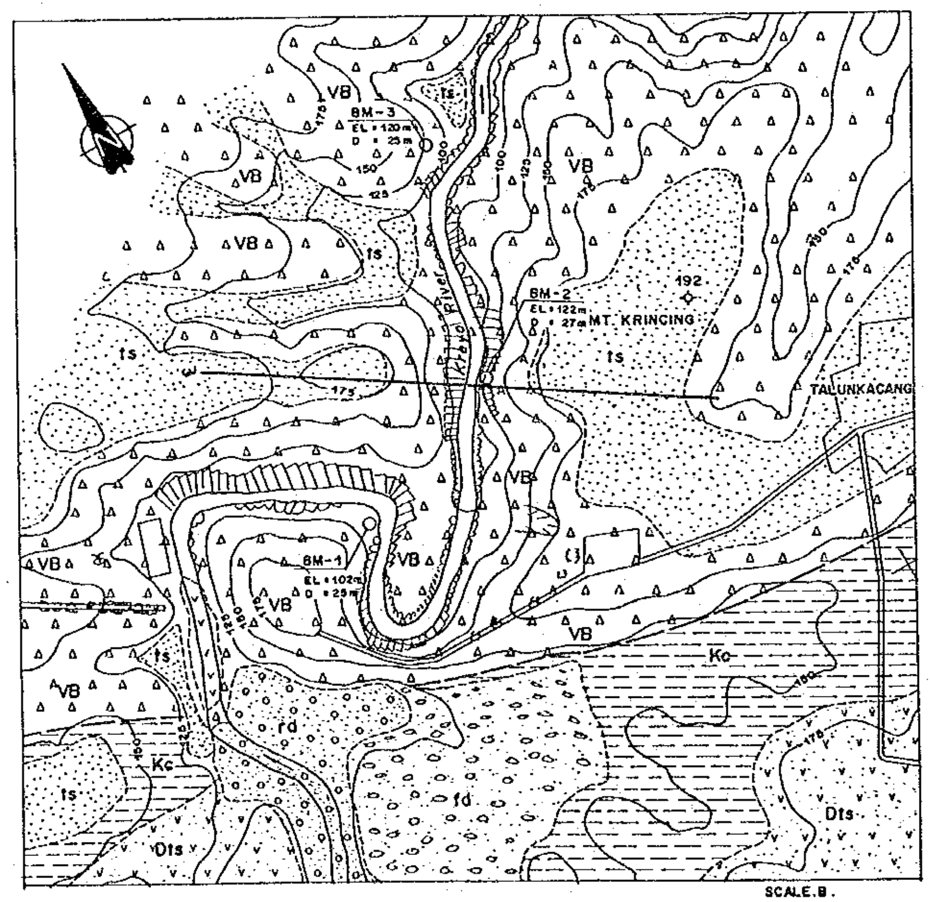




MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. II.3.2 GEOLOGICAL MAP OF KUDUNG SUREN DAM

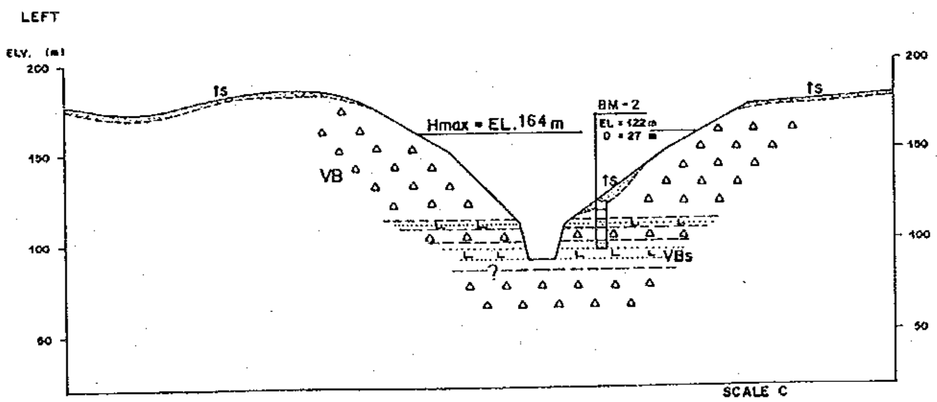


JATIBARANG RESERVOIR PLAN



JATIBARANG DAMSITE PLAN

JATIBARANG DAM
GEOLOGICAL PROFILE



LEGEND

EPOCH	SYMBOL	FORMATION	NAME	LITHOLOGY
HOLOCENE	ts	–	Top Soil Talus dt.	Clay, gravel (angular)
	rd	–	River Bed dt.	Sand, gravel inter-bedded silt and clay
	fd	–	Flood Plain dt.	Sand, gravel, silt and clay
PLEISTOCENE	VB	NOTOPURO	Volcanic Breccia	VB ; Volcanic Breccia
	VBs			VBs; Tuffaceous sandstone
	La		Lava Flow	Andesite lava Exposed locally
	Dts	DAMAR	Tuffaceous Sandstone	Dts; Tuffaceous sandstone
	Dtg			Dtg; Conglomerate
PLIOCENE	Kc	KALIBIUK	Blue Claystone	Kc ; Blue Claystone, marl, Sandstone
	Kcl			Kcl; Limestone

- Lithologic boundary
- Fault cr = 3m ; Width of crushed zone
- Inferred fault
- Strike and dip of bedding
- Strike and dip of joint
- Strike and dip of fault
- Rock fall and landslide
- Spring
- BM-1 Existing drillholes
- Outcrop (Cliff)
- Outcrop

SCALE. A. 0 100 200 300 400 500 750 1000 m

SCALE. B. 0 50 100 150 200 250 375 500 m

SCALE. C. 0 20 40 60 80 100 150 200

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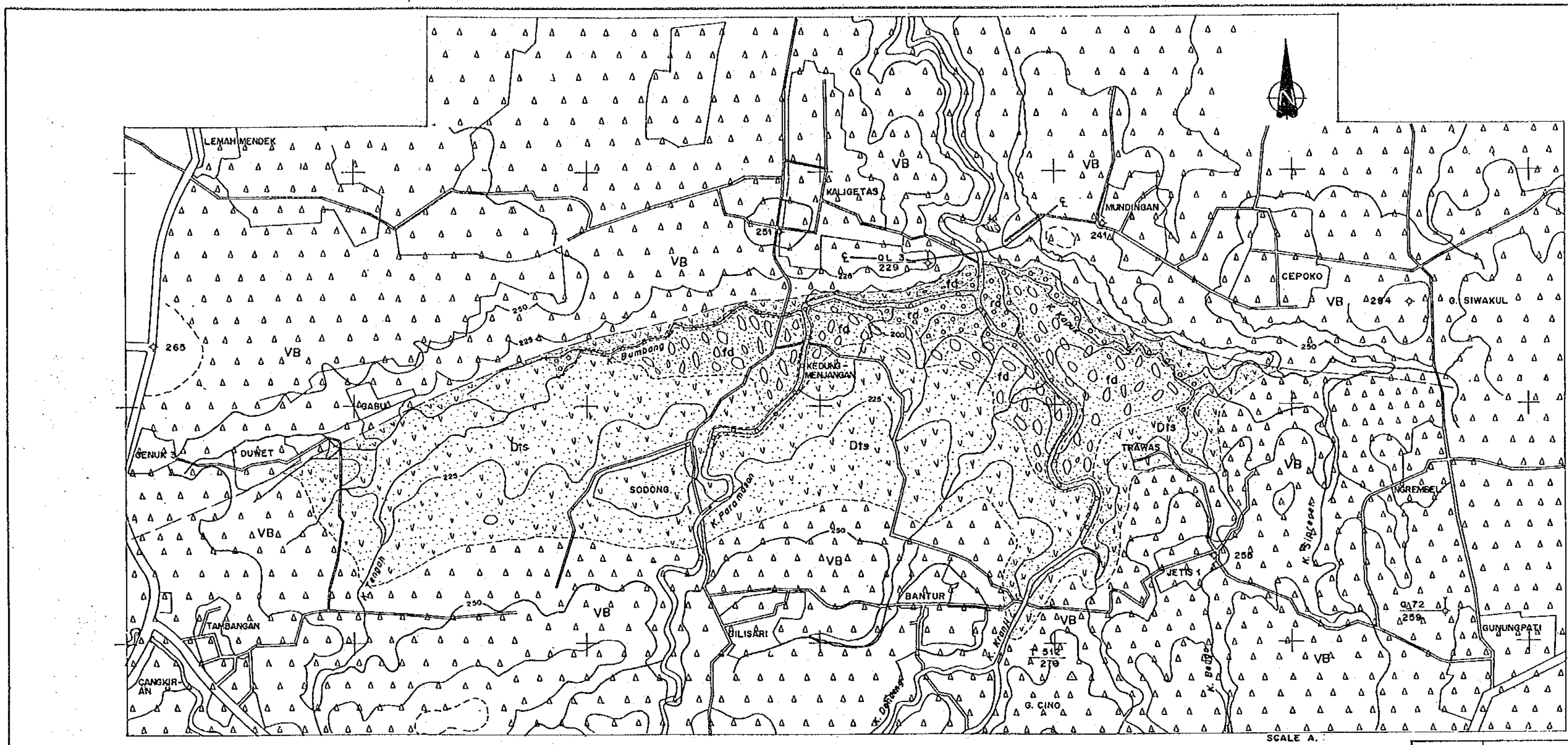
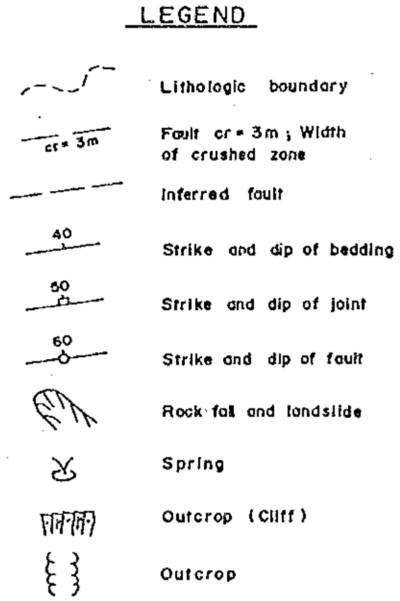
FIG.II-3-3

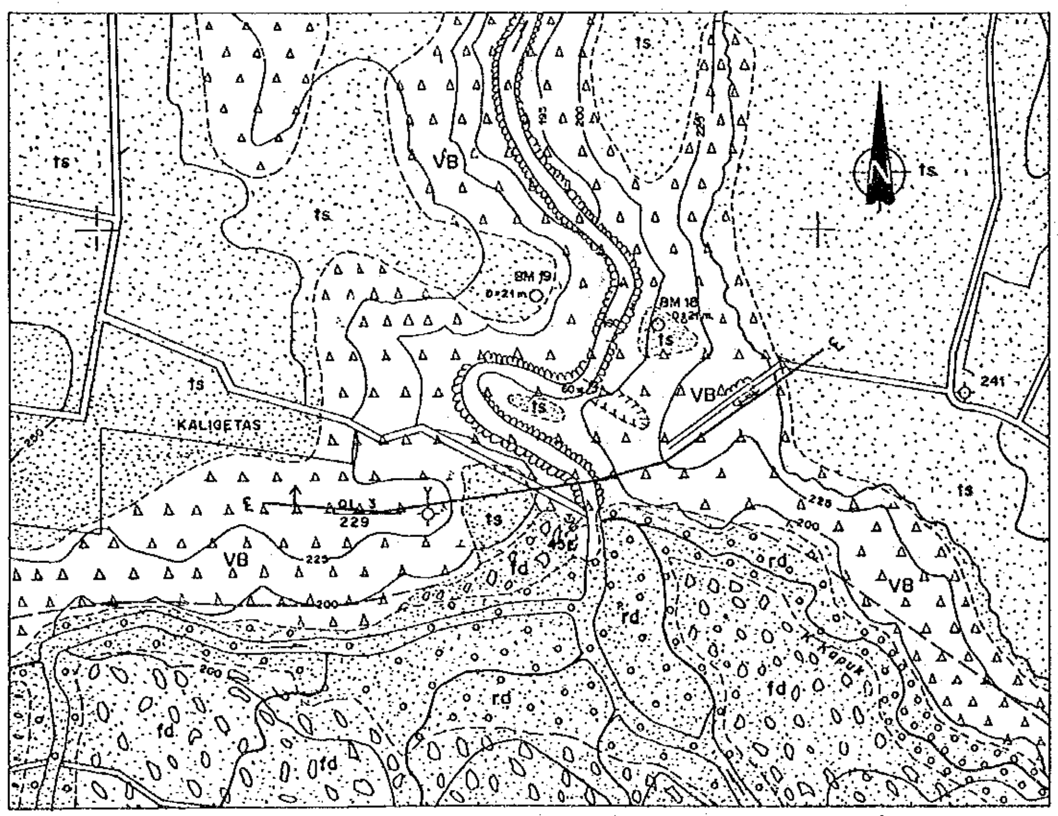
GEOLOGICAL MAP OF JATIBARANG DAM



MUNDINGAN RESERVOIR PLAN

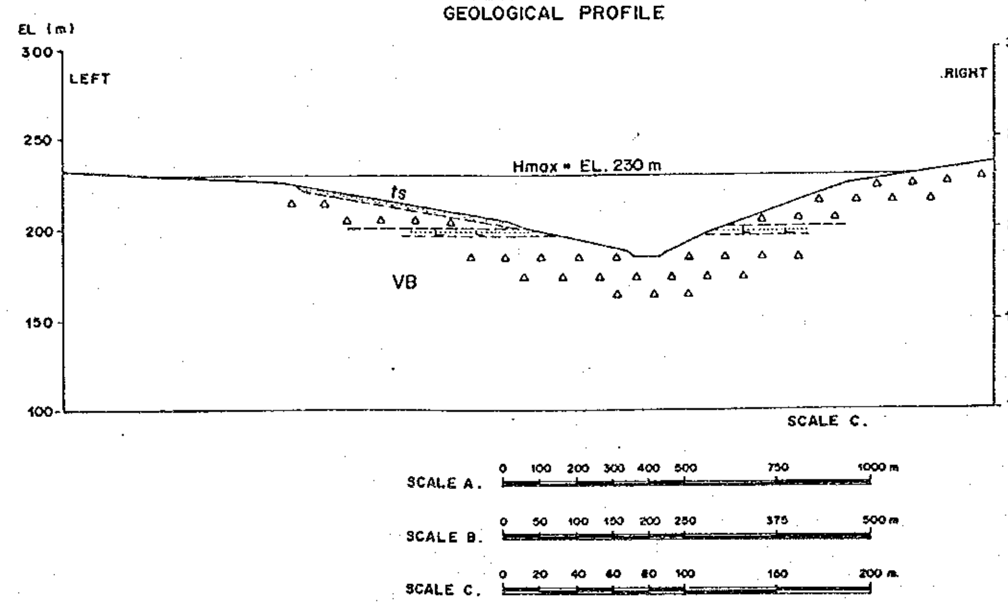


EPOCH	SYMBOL	FORMATION	NAME	LITHOLOGY
HOLOCENE	ts	–	Top Soil Talus dt.	Clay, gravel (angular)
	rd	–	River Bed dt	Sand, gravel inter-bedded. silt and clay
	fd	–	Flood Plain dt.	Sand, gravel, silt and clay
PLEISTOCENE	VB VBs	NOTOPURO	Volcanic Breccia	VB ; Volcanic Breccia VBs ; Tuffaceous sandstone
	La		Lava Flow	Andesite lava Exposed locally
	Dts Dtg	DAMAR	Tuffaceous Sandstone	Dts ; Tuffaceous sandstone Dtg; Conglomerate
PLIOCENE	Kc Kcl	KALIBIUK	Blue Claystone	Kc ; Blue Claystone, marl, Sandstone Kcl; Limestone



MUNDINGAN DAMSITE PLAN

MUNDINGAN DAM
GEOLOGICAL PROFILE



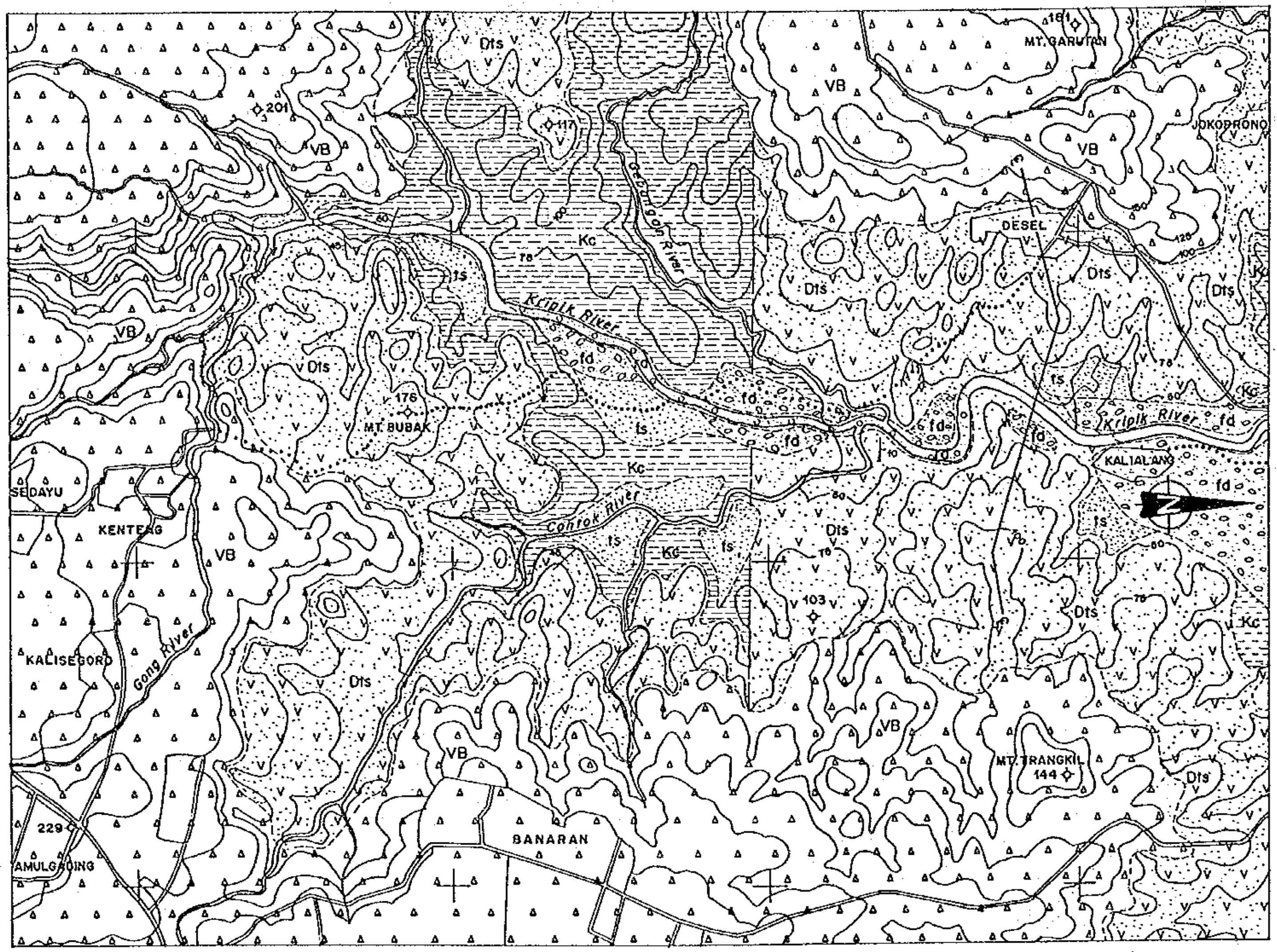
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS

JAPAN INTERNATIONAL COOPERATION AGENCY

FIG.II-3-4

GEOLOGICAL MAP OF MUNDINGAN DAM

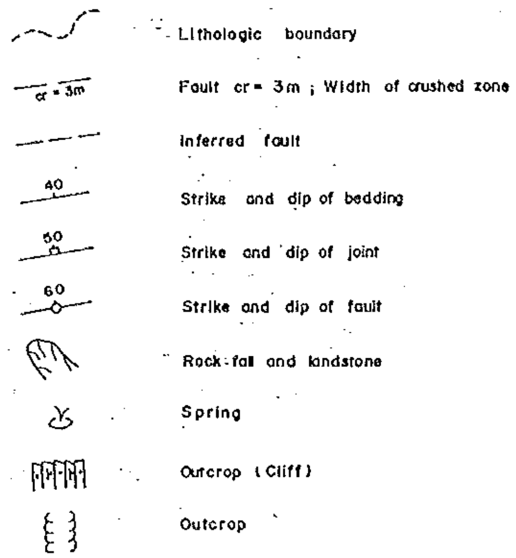
KRIPIK RESERVOIR PLAN



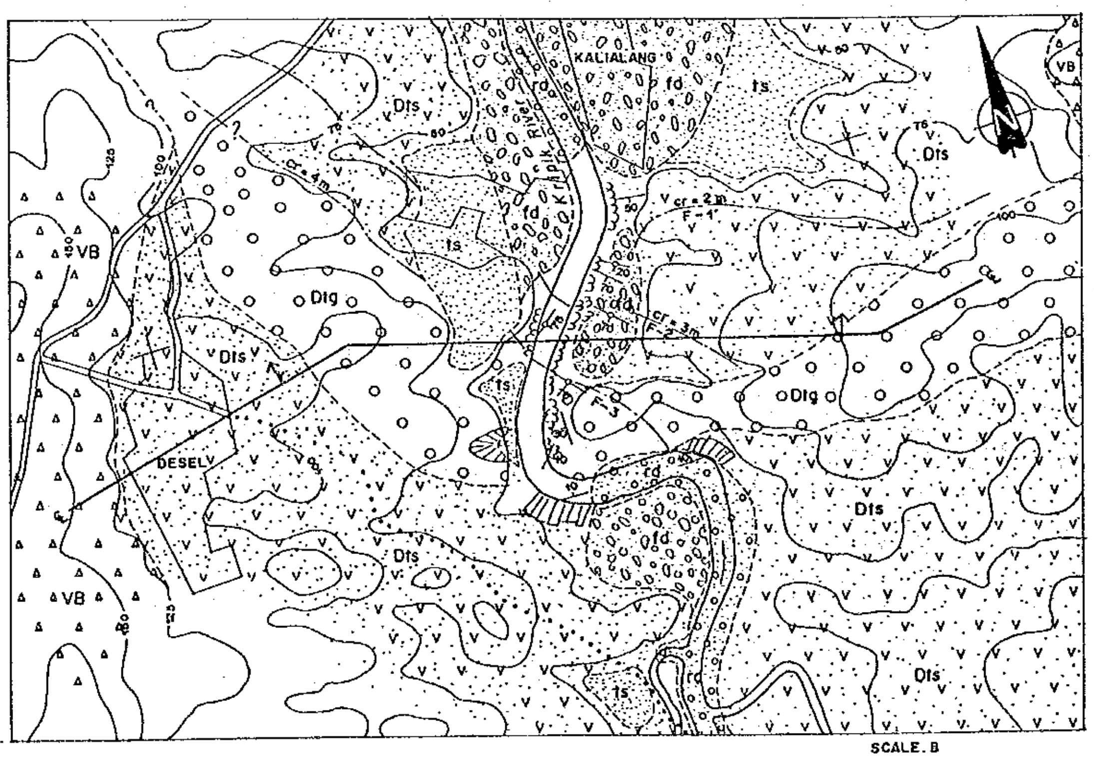
SCALE. A

LEGEND

EPOCH	SYMBOL	FORMATION	NAME	LITHOLOGY
HOLOCENE	ts	–	Top Soil Talus dt	Clay, gravel (angular)
	rd	–	River Bed dt.	Sand gravel inter-bedded silt and clay
	fd	–	Flood Plain dt	Sand, gravel, silt and clay
PLEISTOCENE	VB, VBs	NOTOPURO	Volcanic Breccia	VB; Volcanic Breccia; VBs; Tuffaceous sandstone
	La		Lava Flow	Andesite lava Exposed locally
	Dts, Dtg	DAMAR	Tuffaceous Sandstone	Dts; Tuffaceous sandstone; Dtg; Conglomerate
PLIOCENE	Kc, Kcl	KALIBIUK	Blue Claystone	Kc; Blue Claystone, marl, Sandstone; Kcl; Limestone

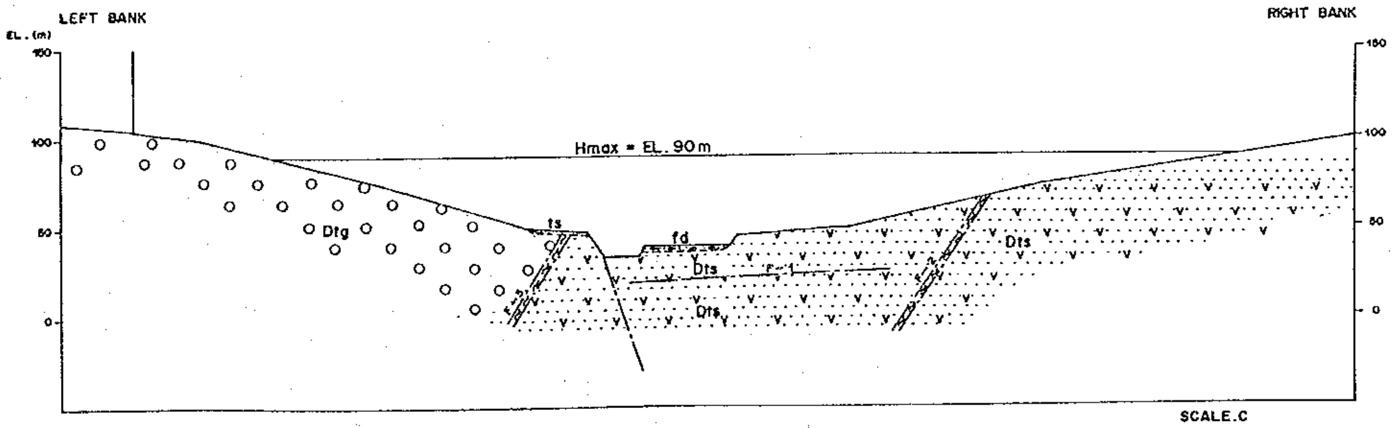


KRIPIK DAMSITE PLAN

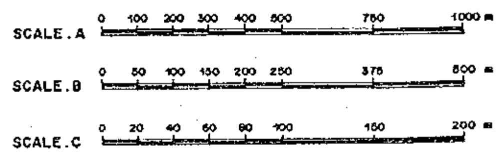


SCALE. B

KRIPIK DAM GEOLOGICAL PROFILE



SCALE. C



MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS

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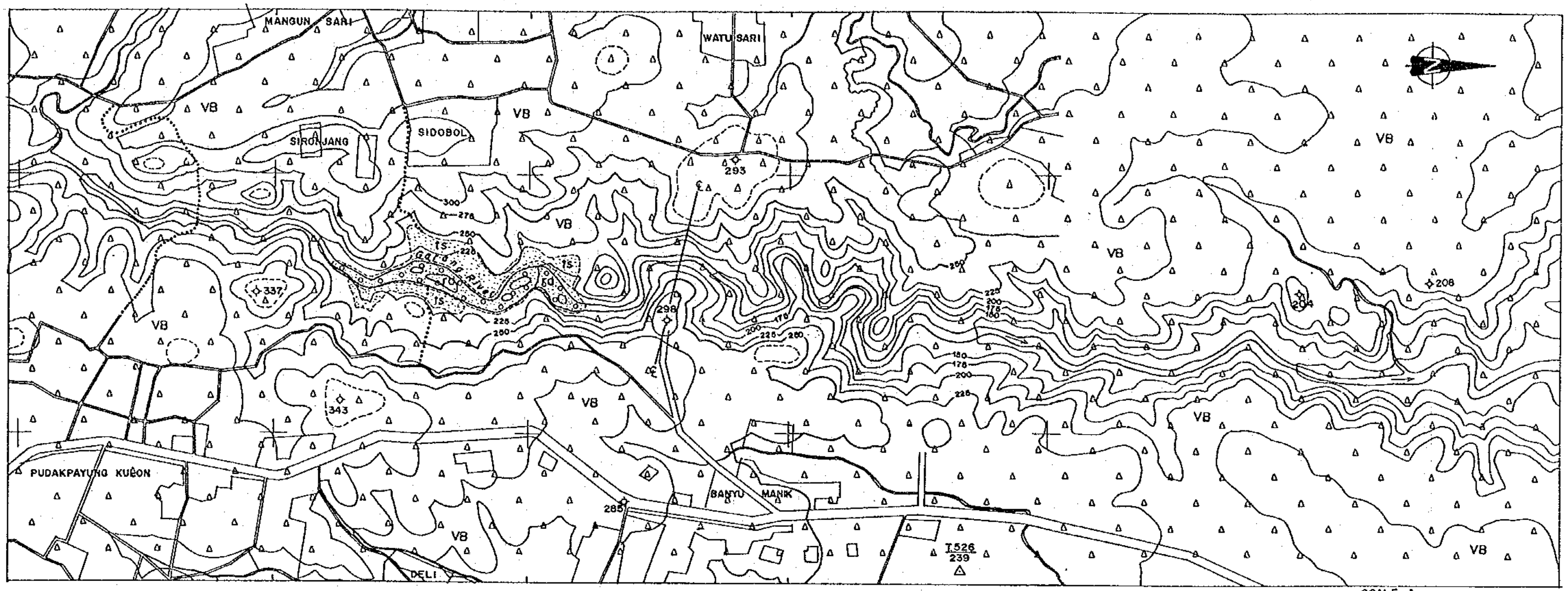
FIG.II-3-5

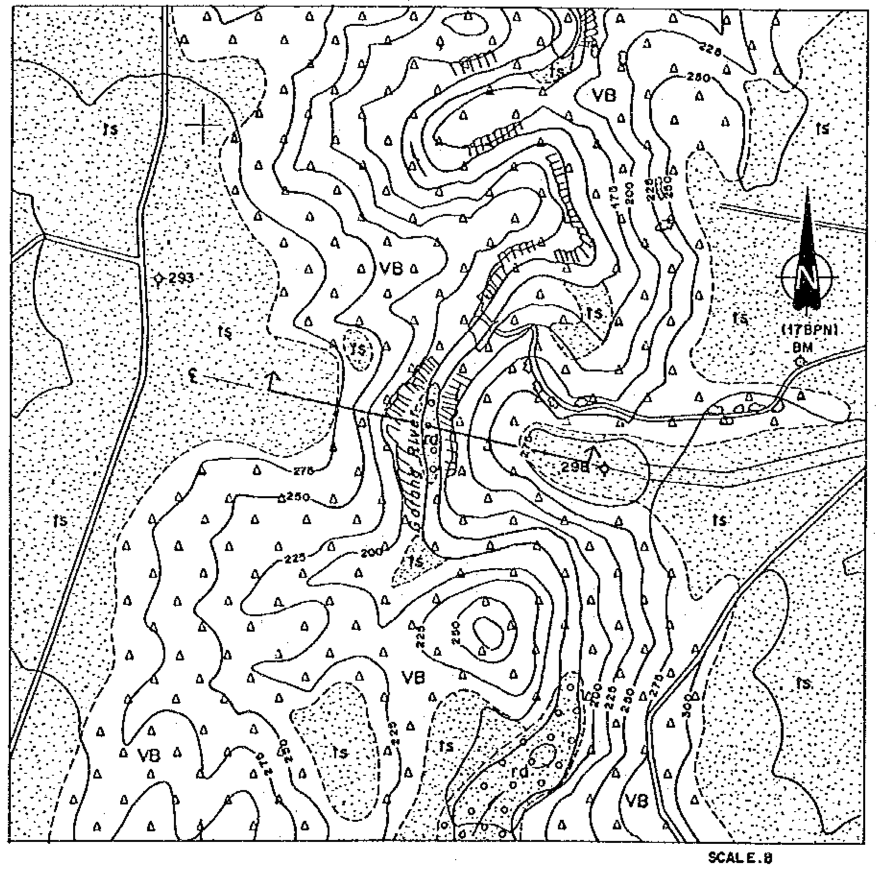
GEOLOGICAL MAP OF KRIPIK DAM



GARANG RESERVOIR PLAN

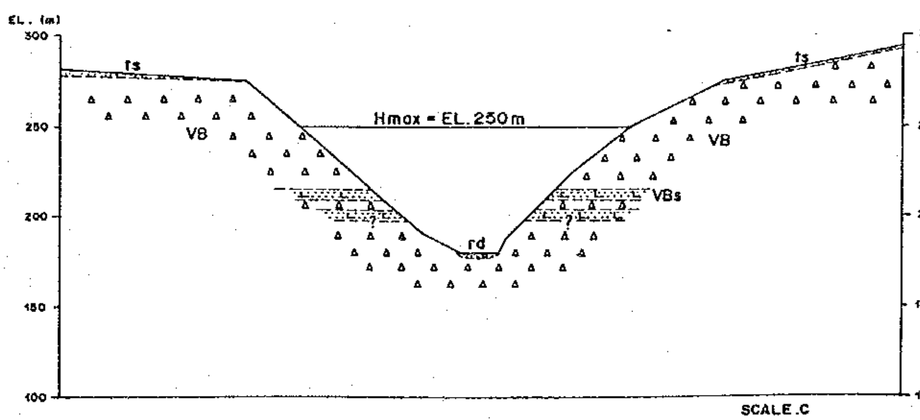
LEGEND

- Lithologic boundary
- cr= 3m — Fault cr= 3m ; Width of crushed zone
- Inferred fault
- 40 — Strike and dip of bedding
- 50 — Strike and dip of joint
- 60 — Strike and dip of fault
- Rock fall and landslide
- Spring
- O BM-1 — Existing drillholes
- Outcrop (Cliff)
- Outcrop



GARANG DAMSITE PLAN

GARANG DAM
GEOLOGICAL PROFILE



EPOCH	SYMBOL	FORMATION	NAME	LITHOLOGY
HOLOCENE	ts	–	Top Soil Talus dt	Clay, gravel (angular)
	rd	–	River Bed dt	Sand, gravel inter-bedded silt and clay
	fd	–	Flood Plain dt	Sand, gravel, silt and clay
PLEISTOCENE	VB VBs	NOTOPURO	Volcanic Breccia	VB ; Volcanic Breccia VBs; Tuffaceous sandstone
	La		Lava Flow	Andesite lava Exposed locally
	Dts Dtg	DAMAR	Tuffaceous Sandstone	Dts; Tuffaceous sandstone Dtg; Conglomerate
PLIOCENE	Kc Kcl	KALIBIUK	Blue Claystone	Kc ; Blue Claystone, marl, Sandstone Kcl; Limestone

SCALE. A 0 100 200 300 400 500 750 1000 m
SCALE. B 0 50 100 150 200 250 375 500 m
SCALE. C 0 20 40 60 80 100 150 200 m

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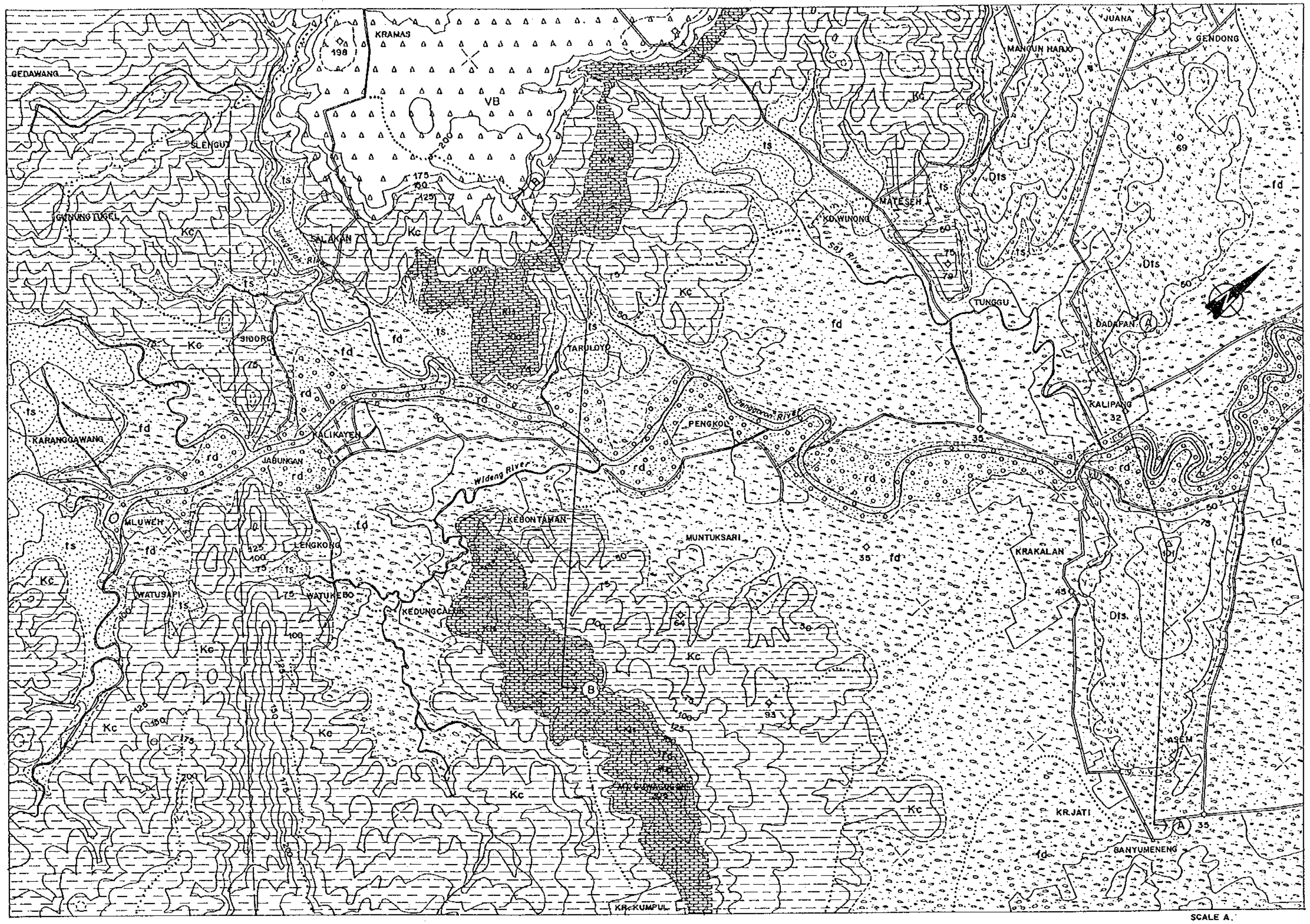
FIG.II-3-6

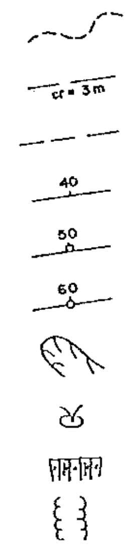
GEOLOGICAL MAP OF GARANG DAM



BABON RESERVOIR PLAN

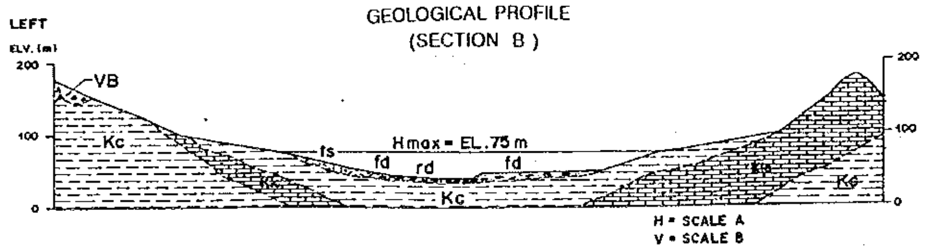
LEGEND

EPOCH	SYMBOL	FORMATION	NAME	LITHOLOGY
HOLOCENE	ts	–	Top Soil Talus dt.	Clay, gravel (angular)
	rd	–	River Bed dt	Sand, gravel inter-bedded silt and clay
	fd	–	Flood Plain dt.	Sand, gravel, silt and clay
PLEISTOCENE	VB	NOTOPURO	Volcanic Breccia	VB; Volcanic Breccia
	VBs			VBs; Tuffaceous sandstone
	La		Lava Flow	Andesite lava Exposed locally
	Dts	DAMAR	Tuffaceous Sandstone	Dts; Tuffaceous sandstone
	Dtg			Dtg; Conglomerate
PLIOCENE	Kc	KALIBIUK	Blue Claystone	Kc; Blue Claystone, marl, Sandstone
	Kcl			Kcl; Limestone



Lithologic boundary
Fault cr = 3 m ; Width of crushed zone
inferred fault
Strike and dip of bedding
Strike and dip of joint
Strike and dip of fault
Rock fall and landslide
Spring
Outcrop (Cliff)
Outcrop

BABON DAM
GEOLOGICAL PROFILE
(SECTION B)



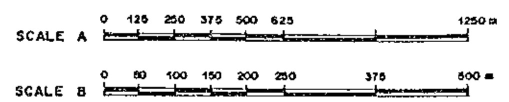


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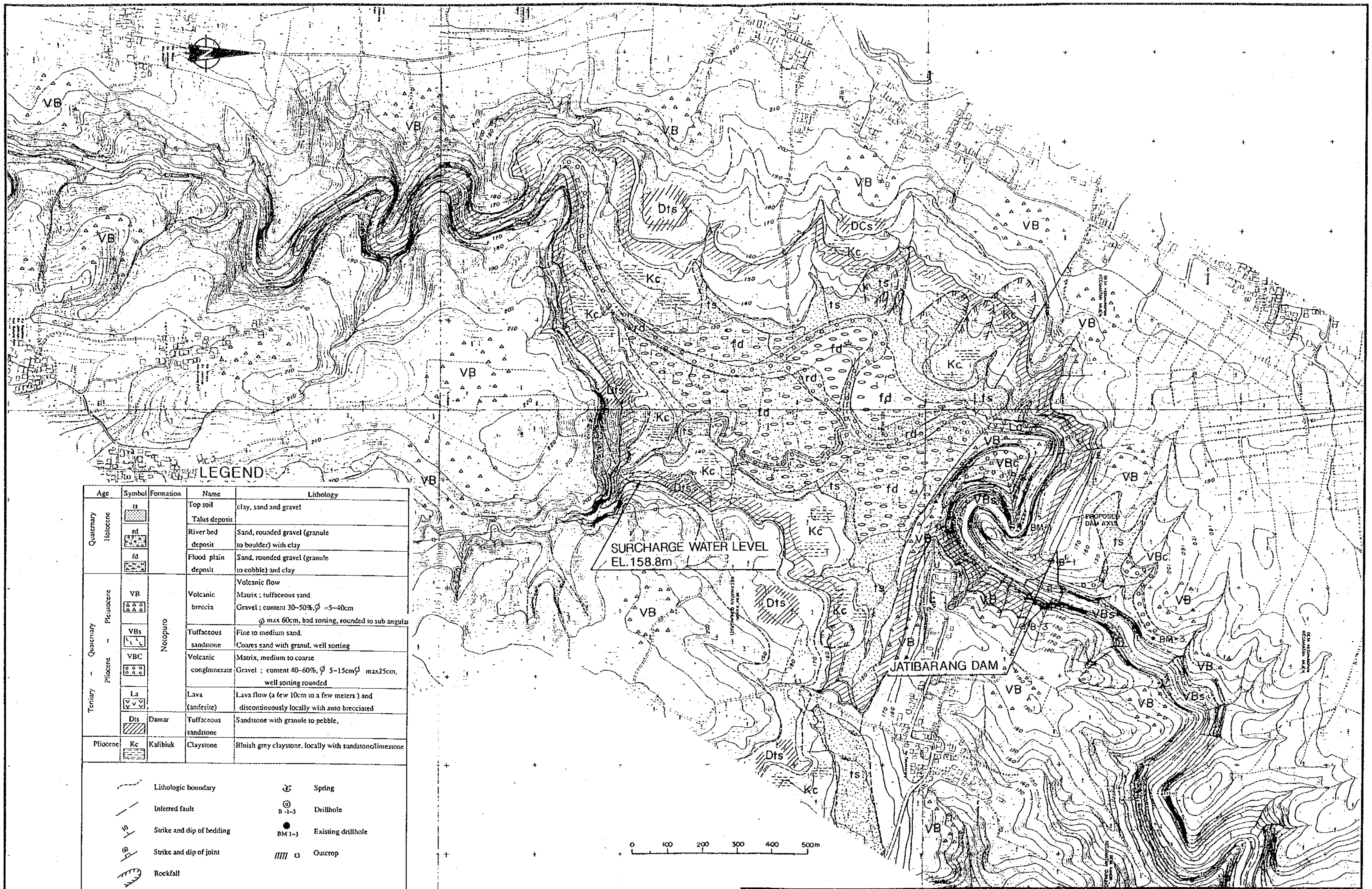
FIG.II-3-7

GEOLOGICAL MAP OF BABON DAM



Age	Symbol	Formation	Name	Lithology
Quaternary Holocene	ts		Top soil Talus deposit	clay, sand and gravel
	rd		River bed deposit	Sand, rounded gravel (granule to boulder) with clay
	fd		Flood plain deposit	Sand, rounded gravel (granule to cobble) and clay
Tertiary - Quaternary Pliocene - Pleistocene	VB	Notopuro	Volcanic breccia	Volcanic flow Matrix ; tuffaceous sand Gravel ; content 30~50%,φ =5~40cm φ max 60cm, bad sorting, rounded to sub angular
	VBs		Tuffaceous sandstone	Fine to medium sand. Coares sand with granul, well sorting
	VBC		Volcanic conglomerate	Matrix, medium to coarse Gravel ; content 40~60%, φ 5~15cmφ max25cm, well sorting rounded
	La		Lava (andesite)	Lava flow (a few 10cm to a few meters) and discontinuously locally with auto brecciated
	Dts	Damar	Tuffaceous sandstone	Sandstone with granule to pebble,
Pliocene	Kc	Kalibiuk	Claystone	Bluish grey claystone, locally with sandstone/limestone

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Fig.II.4.1 GEOLOGICAL MAP OF JATIBARANG RESERVOIR AREA

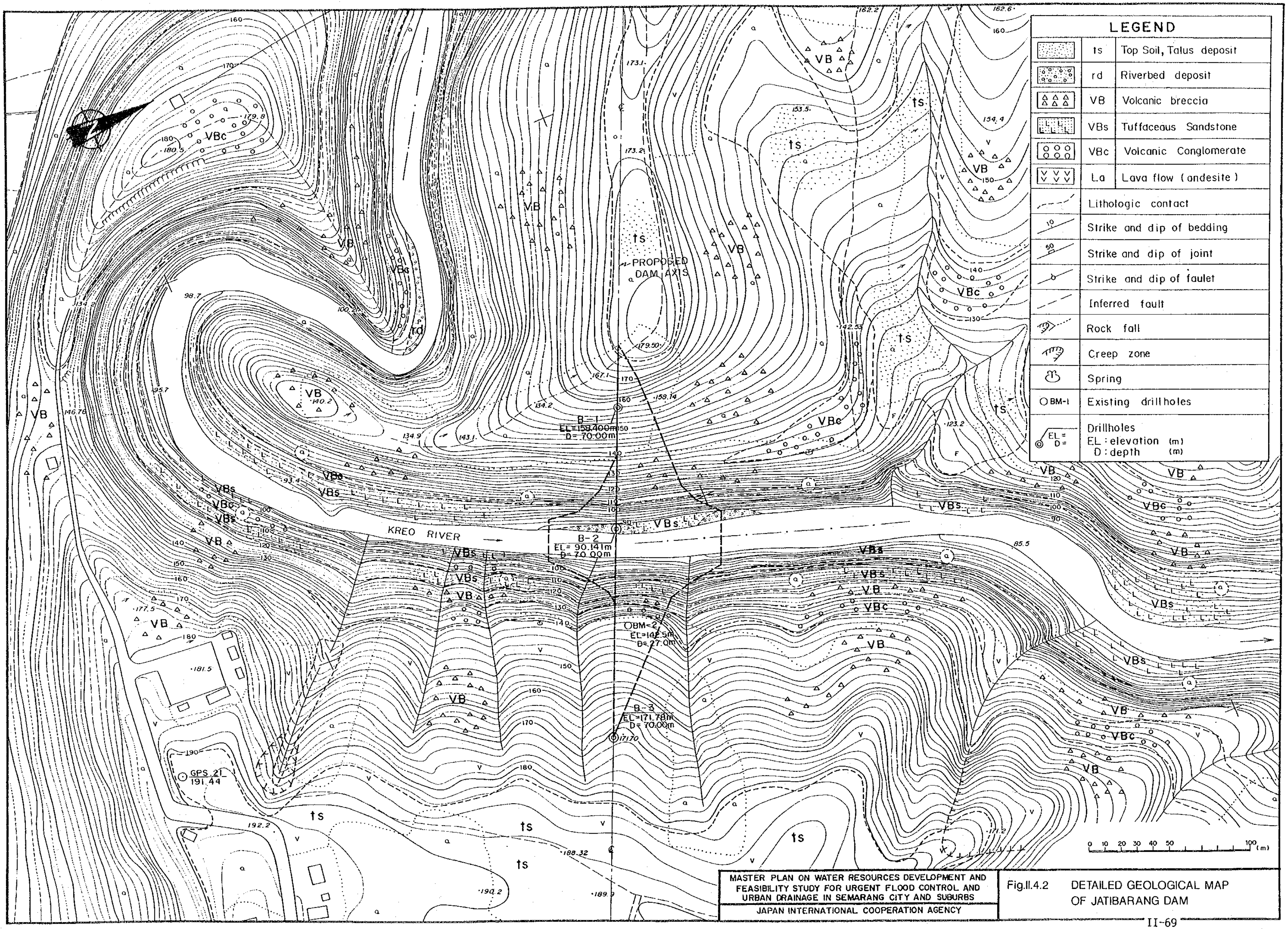
LEGEND
ts Top Soil, Talus deposit
rd Riverbed deposit
VB Volcanic breccia
VBs Tuffaceaus Sandstone
VBc Volcanic Conglomerate
La Lava flow (andesite)
Lithologic contact
Strike and dip of bedding
Strike and dip of joint
Strike and dip of faulet
Inferred fault
Rock fall
Creep zone
Spring
BM-1 Existing drillholes
Drillholes
EL : elevation (m)
D : depth (m)
KREO RIVER
PROPOSED DAM AXIS
B-1
EL=158.400m
D=70.00m
B-2
EL=90.141m
D=70.00m
BM-2
EL=142.5m
D=27.0m
B-3
EL=171.78m
D=70.00m
GPS 21
191.44
0 10 20 30 40 50 100 (m)
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS
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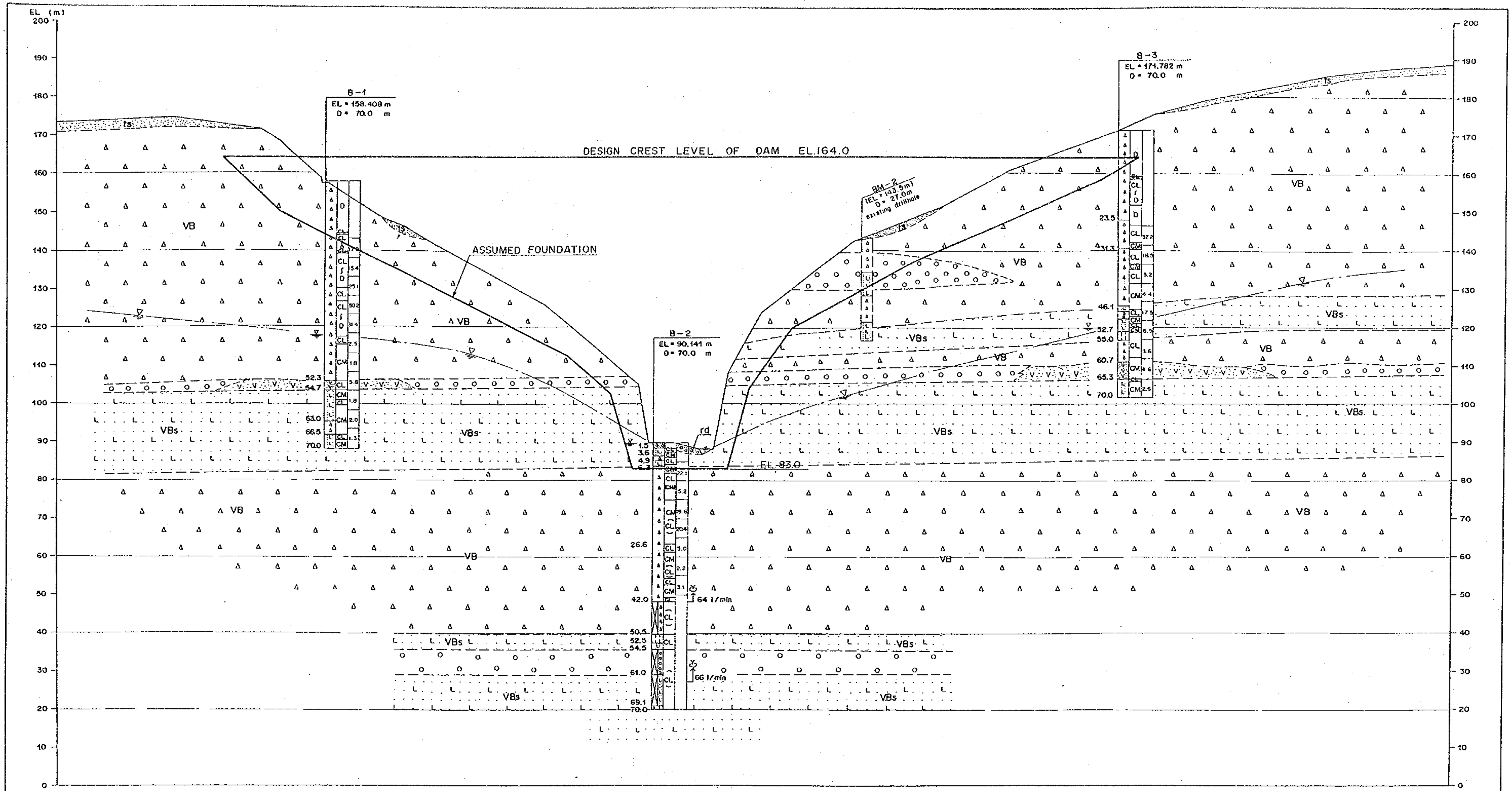
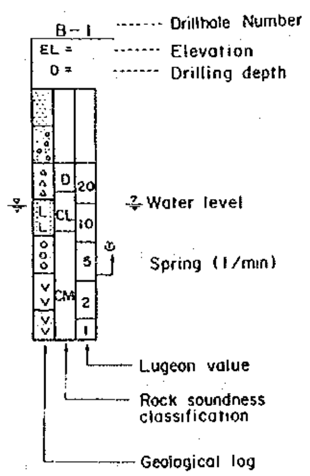
Fig.II.4.2 DETAILED GEOLOGICAL MAP OF JATIBARANG DAM



		LEGEND
	ts	Top Soil, Talus deposit
	rd	Riverbed deposit
	VB	Volacanic breccia
	VBs	Tuffaceous Sandstone
	Vc	Volacanic Conglomerate
	La	Lava flow (andesite)
		Auto brecciated lava
		Lithologic boundary
		Water table
		Spring



MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS

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Fig.II.4.3 GEOLOGICAL PROFILE OF JATIBARANG DAM AXIS