Tertiary Period. This formation is white to gray or dark gray in color and is soft and compact but partly fractured with weathered open crack joint.

Tuffaceous Sandstone

The sandstone facies, fine to coarse grained, are main facies of the Genteng Formation which is gray to dark gray, and usually contain some pumice and lapilli occasionally together with conglomerate. The coarse grained sandstone shows a laminated structure of volcanic rock fragments and is poor cemented and stained with iron minerals.

Tuffaceous Claystone

The claystone facies is usually intercalation which is brown to brownish gray occasionally together with pumice. It is dense and compact but partly soft and fractured with slicken side.

Pumice Tuff

The pumice tuff facies is composed of whitish fine to coarse grained pumice together with volcanic sand with some lapilli. The pumice is usually weathered, soft and light in weight. Therefore pumice tuff is slightly weathered, porous, uncompacted, and easily broken by hammer hitting. This facies is distributed all over the project area.

Lapilli tuff

The lapilli tuff facies is widely distributed at the Cilawang dam site. The lapilli tuff is usually slightly weathered and well to moderately cemented, but clay seam joint is developed in some part. The fragments of lapilli tuff consist of hard basalt and andesite, of which color is dark gray to gray. The matrix of lapilli tuff consists of very fine grained tuff which is usually slightly weathered and soft.

Welded tuff

The welded tuff facies is genrally compact, massive, fairly dense, and well cemented, light to medium gray color. It is relatively lightweight with slightly weathered portion. The rock contains breccia, pumice and scattered lapilli.

(2) Quarternary Deposit

Quarternary deposit consists of terrace dposit and river deposit.

Terrace deposit

The terrace deposit consisting of stiff clay, sand and silt, stands at several meters above the riverbed, and widely spreads on the river terrace downstream of Gadeg village of the Cibeureum river and upstream of Karian village of the Ciberang river.

River deposit

The river deposit is composed of various sizes of sands and gravels, and overlies stream-dissected bedrock with a few meters in thickness at vicinity of Sajira village along the Ciberang river.

(3) Volcanic rock

Volcanic rock consisting of andesite, basalt and tuff-breccia is observed at southern part of the project area. These rocks belong to Miocene age.

Andesite

Andesite is exposed at G.Guradog which forms an intrusion dome, marked by a structure of columnar joints. This rock is gray in color and it is fragiable and rather soft. However, andesite in G.Sendi is rather hard and compact, proved by porfiritic texture, and overlain by the great thickness of weathered zone.

Basalt

Basalt rock is exposed at top of G. Alung and in the Ciapus riverbed. The basalt belongs to olivine basalt, of which color is black to dark gray with calcite veine. This rock is composed of columnar joint and it is fresh and very hard.

Tuff breccia

Tuff breccia is exposed at gravity slope of G. Alung and locally capped by basaltic lavas. These tuff breccia consist of basalt to andesite as fragments, of which its cement matrix is volcanic sand and ash. Fresh rock of tuff breccia are compacted and dense, of which color is dark gray.

2.2 Drilling Investigation

2.2.1 Equipment

The equipment listed below were used for the drilling works and the tests at the Karian dam site, Cilawang-Cicinta trans-basin tunnel, Guradog quarry site and Buyut diversion weir site, from the beginning of October to the middle of December 1984.

- Drilling rig : The rotary drilling machine with a capacity of drilling to the depth more than 50 meters with a drilling diameter not less than 73 mm diameter.
- Drilling pump: The reciprocating piston type with discharge capacity of 40-60 l/min and capable pressure of 10-20 kg/cm^2
- Packer : Pneumatically expanding type
- Penetration test equipment : 63.5 kg driver hammer and free fall from 75 cm of height.

2.2.2 Core Drilling

Diameter of the drill holes ranges from 73 to 76 mm. All core samples for every depth of drill hole were taken and kept in wooden cases which mark the depth of core recovery at every one meter interval and hole numbers. The bamboo tubes were placed at the positions of no core recovery.

During the drilling, the following matters were recorded;

- Hole No., date of operation, diameter of hole,
- Ground water table in the hole,
- Depth of drilling, progress of drilling and length of recovered core samples for each recovery core barrel, rock quantity designation, time for each progress of drilling, and
- Description of judgement on subsurface conditions, especially about boundary of each stratum.

2.2.3 Standard Penetration Test

The standard penetration tests were carried out in accordance with the Designation E-21 specified in Earth Manual.

2.2.4 Field Penetration Test

(1) Water Pressure Test

Water pressure test were performed in the drill holes for the rock formation by applying the single packer method (descending stage method) and double packer method.

The single packer method:

The first 3-5 m section is drilled and water pressure is tested and then next lower 3-5 m is drilled and water pressure is tested. Likewise, the drilling and water pressure test are conducted for every 3-5 m section to the bottom of the hole. A single packer is installed at each test section. Clean water is pumped into the test section under a constant pressure. After the injection rate becomes stable, the injected water quantity is measured for 10 minutes for each constant pressure. For each test section, the test pressure range is 0.5 kg/cm^2 to 3.5 kg/cm^2. This method was used mainly at the dam site and tunnel site.

The double packer method:

After drilling is completed, double packer is installed at the first test section and the test is conducted, and then next lower 3-5 m is tested, and so on. For each test section, the test pressure range is 0.3 kg/cm^2 to 2.0 km/cm^2. This method was used at the Buyut divertion work site.

(2) Constant-waterhead test

Field permeability tests under high water pressure are not applicable for unconsolidated or weathered layers of bore hole. In this case, constant waterhead test is performed in the drill holes.

A pipe casing is sunk to the designated depth and cleaned out to the bottom of the test section. After the hole is cleaned to the proper depth, the test is commenced by adding clean water through a metering system to maintain gravity flow at a constant head. Measurement of constant head, constant rate of flow into the hole, diameter of bore hole and length of test section are recorded.

(3) Calculation of permeability coefficient and Lugeon value

Permeability coefficient K is calculated as follows:

$$K = \frac{Q}{2\pi \times L \times H} \times \log \frac{L}{r} \quad (cm/sec)$$

where;

- Q : Constant rate of flow into the hole, (cm^3/s)
- L : Section length of the hole tested (cm)
- H : Total water head, and (cm)
- r : Radius of hole tested (cm)

Lugeon value is the amount of water leakage (ℓ/min) from 1 m testing section under 10 kg/cm^2 pressure.

Lugeon value (Lu) is calculated as follow :

$$Lu = \frac{10 \times Q}{P \times \ell}$$

where;

Q : Constant rate of injected water (ℓ/min)

ℓ : Section length of the hole tested (m)

P : Yielding pressure (kg/cm^2)

In case of bore hole diameter of 76 mm, 1 lugeon is approximately correspondent to 1.2 x 10^{-5} cm/sec. The test results are shown on Table C-3.

2.2.5 Borings

Out of twenty nine (29) numbers of bore holes, 7 were located in the Karian dam site, 5 were at the Cilawang-Cicinta trans-basin tunnel site, 2 were at the Guradog quarry site, and 15 were at Buyut diversion works site, respectively.

The locations of these are shown in each site geological map (Ref. Fig. C-2 - Fig. C-7). The list of borings is as shown in Table C-4 and also, drill logs are attached hereto as Annex.

2.3 Seismic Exploration

2.3.1 Equipment

The equipment listed below were used for the seismic exploration.

- Portable refraction systems : Geo Space Corporation, model GT-2B
- Recording medium : Polaraid type 47 (3000 ASA speed) photographic film, recording speeds 0.2, 0.3 or 0.4 of a second, 12 channels, Timing lines 10 ms timing, Input Impedance 520 ohms,
- Blaster : 90 volt capacitor type, self contained, including cap tester, System Frequency Response 10-300 Hz.
- Geophone : X-2S Geophone Model L-1, 14 Hz 300 ohm coil resistance.

2.3.2 Field Works

The survey lines were arranged so as to pass the boring point as much as possible to connect with the boring results.

In the area of dam site, the survey lines were arranged in grid type. In the trans-basin tunnel site, the survey lines were arranged on the tunnel route and two short lines intersect them diagonally. Number of survey lines is 3 at the Karian dam site, 4 at the Cilawang dam site, 3 at the Cilawang-Cicinta trans-basin tunnel and one line each at the quarry site and borrow area as listed in Table C-5. Their locations are shown on geological map of each site.

The field reconnaissance, survey line location, clearing, pegging and survey works were conducted from the end of August to the middle of September and prospecting was commenced from middle of September and finished by the end of October 1984 by Indonesian Contractor.

Geophone was set on the survey line at intervals of 5 m to receive the seismic wave, and blasting was performed at intervals of 55 m in the hole of about 1 m deep bored by hand auger. Measurement was carried out using a portable refraction system of 12 channels at 1 spread of 50 m - 60 m. Total consumption of the explosives was 250 kg of dynamite and 1000 pcs. of delay type electric detonators.

The seismic exploration works at both the old Karian dam site (From Line A to Line E) and Karian-Ciuyah tunnel site were carried out by PT.G.EPSILON in 1982 and in March 1984, respectively (Ref. 1 and 9).

2.4 Rock Test

Rock samples from boring holes at the Karian dam site, the Cilawang-Cicinta tunnel and the Guradog quarry site were collected and tested by D.P.M.A. Rock tests on the rock samples from the Cilawang dam site were already carried out by D.P.M.A. in 1983. The results of rock test are shown in Table C-6.

3. ENGINEERING GEOLOGY

3.1 The Karian Dam Site

New dam site is selected at narrow channel of the Ciberang river about 500 m downstream from the old dam site. The site is located at the tuffaceous sedimentary facies Tertiary rock. These rocks are overlain by top soil and thin residual soil and are exposed mostly along the river bank. The gorge is in an V-shaped valley. The right bank slope is around 40° up to elevation 60 m and then shows gentle slope in higher elevation. On the other hand, the left bank is ascending at angle of around 30° up to elevation 45 m and decreasing the slope angle gradually **in higher** elevation. General strike and dip at dam axis are N 30° E and 5° E, showing roughly horizontal. A defined fault have been confirmed along the river channel at the dam site (Ref. Fig. C-2).

Water pressure tests were carried out in the bore holes along the dam axis. The test results of KB17, KB18 and KB19 locating at left bank abutment show rather high values of $K=2.0 \times 10^{-4}$ cm/sec (16-36 m in depth), $K=1.1 \times 10^{-3}$ cm/sec (15-28 m in depth) and $K=7.0 \times 10^{-4}$ cm/sec (10-31 m in depth), respectively. The test result of KB20 locating at right river bank also shows a rather high value of $K=3.0 \times 10^{-4}$ cm/sec (3-32 m in depth).

From these results, the recommended depths of grout curtain for adequate water tightness under the dam are from 20 m to 40 m from the ground surface.

Seismic exploration at the dam site was carried out on and around the dam axis. From these results, the ground can be classified into 4 classes as follows judging from seismic wave velocity ranging from 0.3 to 2.5 km/sec (Ref. Fig. C-17).

Class	Velocity of Seismic Wave (km/sec)	Description
I	0.3	Top soil aluvium soft soil
II	0.6-0.7	Residual soil, hard soil decomposed rock, hard weathered rock
III	1.2-1.4	Slightly to moderately weathered soft rock with crack joint
IV	1.8-2.0 2.3-2.5	Soft rock, partly slightly weathered

Boring core from drilling hole at the Karian dam site is classified by quality of rock as CM, CL and D class. Quality classification of rock in dam foundation is shown on Table C-5. Almost all of the cored materials belong to CL class. These rocks consist of tuffaceous sandstone and pumice tuff with interbedded tuffaceous claystone. These tuffaceous rocks are generally moderately weathered, jointed and partly fractured. The rock of CM class is tuffaceous fine to medium grained sandstone. These sandstones are fairly hard, dense and compact. D class rock is composed of top soil, talus deposit and residual soil. Therefore, these classes are found always in top portion of drilling log and covering soft rock in 3 to 4 m thick. Based on these results, the recommended excavation line of dam foundation is shown on Fig. C-9.

According to the rock test of boring core, the degree of induration of these soft rocks are generally low as shown in Table C-6. As the compressive strengths of these rocks are in the order of 10 to 30 kg/cm^2, allowable height of fill type dam will be limited. Some rock samples showed low compressive strengths less than 10 kg/cm^2. It should be taken into consideration for the design of foundation treatment. And also slaking have to be taken into consideration, because saturated absorption of these rocks are generally very high (16-42%).

Geology of the reservoir area is roughly classified into the same geological formations of the dam site. Most part of the reservoir area consists of Tertiary tuffaceous sedimentary rocks. The weathered layer lies over those formations at the rims of the reservoir. There may be some fault lines cutting saddle portions on those rims. Some leakage of reservoir water can be considered through these fault. There are some outcrops of sandstone and few landslides along the Cibeureum river. It should be noted that the permeabilits tested in the similar sandstone of bore hole KB19 showed a rather high value of $K=5.7 \times 10^{-3}$ cm/sec.

3.2 The Cilawang Dam Site

The site is located at the tuffaceous sedimentary facies of Tertiary period, about 1500 m downstream from Cilawang village. These rocks are overlain by top soil and thin residual soil. The main geological formation consists of lapilli tuff of the Genteng Formation Pleiocene. Conglomerate (2 to 3 m thick) of round gravel of andesite appears at the riverbed. Strike and dip of the dam site is N 25° W, 10° E with gentle dip to right bank side. No fault has been found so far but there is high possibility that a tectonic fractured line extends northward (trend of N 30° E) running across the dam axis diagonally (Ref. Fig. C-3).

Quality classification of rock in drilling hole is fairly better than that of the Karian dam site, because of the slightly high ratio of CM class rock.

Fig. C-11 shows a recommended excavation line of dam foundation which corresponds to that of the base of D class rock (top soil, talus deposit and residual soil). Depending upon the induration, rock compressive strength of core samples on this site vary from 4.0 kg/cm^2 to 75 kg/cm^2. The distribution of weak rock zone especially less than 10 kg/cm^2 in compressive strength should further be studied in detail. Therefore, fill type dam is recommendable for this site.

Water pressure test were carried out in October and November 1983 by DPMA. The permeability of most of the tuffaceous sedimentary rocks in the Cilawang dam site is less than that of the highly porous layer in the Karian dam site, but it has also high permeability layer found at CB-4 ($K= 2.02 \times 10^{-3}$ cm/sec) at 10-20 meter in depth (Ref. Fig.C-12).

Seismic exploration at the dam site was carried out on and around the dam axis in 4 exploration lines totalling 1240 m in length, and ground was classified into 4 classes depending on the velocity of elastic wave propagation (Ref. Fig. C-11). The characteristics of each zone are described below.

Class	Velocity of Seismic Wave (km/sec)	Description
I	0.3-0.4	Top soil, aluvium soft soil
II	0.6-0.7	Residual soil, hard soil decomposed rock, hard weathered rock
III	1.2-1.4	Slightly to moderately weathered soft rock with crack joint
IV	2.0-2.3 2.3-2.5 2.6-3.0	Soft rock, (fine to coarse grained tuff, lapilli tuff conglomerate tuff) partly slightly weathered.

Geological condition of reservoir area is mostly similar to that of Karian dam reservoir area.

3.3 The Karian-Ciuyah Trans-basin Tunnel

The trans-basin tunnel (1000 m in length) to connect the Karian reservoir and the Cibeureum river is located near Ciuyah village.

Topography of around the tunnel site shows gently sloped hill. General geology in the vicinity of the tunnel site is similar to that of the Karian dam site (Ref. Fig. C-4).

According to the boring data, subsurface geology of tunnel site is mainly composed tuffaceous fine to medium grained sandstone with intercalation of pumice tuff and claystone. The RQD value shows rather small percentage. And also many slicken side it found at each bore hole. It may be an indication of fractured zone.

Water permeability test of the drilling holes in the soft rock zone shows the values in the order of 10^{-4} cm/sec to 10^{-6} cm/sec.

Seismic exploration at the trans-basin tunnel site was carried out along the tunnel route by the local contractor (PT. G. EPSILON) in March 1983 (Ref. 9). Based on the results of exploration at 7 lines totalling 2,971 m in length, ground can be classified into 4 classes depending on the velocity of elastic wave propagation (Ref. Fig. C-13). The characteristics of each zone are described below.

Class	Velocity of Seimic Wave (km/sec)	Description
I	0.25-0.3	Top soil, aluvium, soft soil
II	0.6-0.7	Residual soil, hard soil, talus hard weathered rock
III	1.0-1.3 1.1-1.3	Slightly to moderately weathered soft rock with crack joint
	1.8-2.0 2.0-2.2 2.3-2.4	Soft rock partly slightly weathered

3.4 Cilawang-Cicinta Trans-basin Tunnel

The trans-basin tunnel (2,000 m long) to connect the Cilawang reservoir and the tributary of the Cicinta river is located near Pasir Gedung.

The most part of the tunnel will pass through the tuffaceous sandstone and claystone. General geology in the vicinity of the tunnel site is similar to that of the Karian dam site (Ref. Fig. C-5).

According to the boring results, rocks of tunnel site are generally soft and partly fractured with slicken side. The RQD category shows from very poor to poor. It may be some indications of fractured weak zone.

Seismic exploration at the diversion tunnel site was carried out along the tunnel route by local contractor (PT. G. EPSILON) in October 1984. Based on the exploration results for 3 lines totalling 3,000 m in length, ground can be classified into 4 classes depending on the velocity of elastic wave propagation (Ref. Fig. C-14). The characteristics of each zone are described below.

Class	Velocity of Seimic Wave (km/sec)	Description
I	0.3	Top soil, aluvium, soft soil
II	0.6-0.7	Residual soil, hard soil hard weathered rock
III	1.0-1.2	Slightly to moderately weathered soft rock
IV	2.0-2.2	Soft rock partly slightly weathered.

3.5 Gadeg Diversion Works

The site of Gadeg diversion works is located at near Gadeg village. Geological condition of the site is almost similar to that of the Karian dam site. The geological map of the area is shown in Fig. C-6.

The Cibeureum river turns to northward direction from upstream of the weir site. Large scale of river terraces are widely distributed along both river banks.

Basement of the weir site is composed of tuffaceous soft sedimentary rocks, having general strike NS and dip 12° W. They are composed of fine to coarse grained tuffaceous sandstone intercalating tuffaceous claystone with pumice tuff. River terrace deposits mainly consist of silty clay.

Superficial weathered zone of the soft rock can be assumed to be 2-3 m thick on the hilly area. These superficial layers correspond to that of D class in rock quality classification. Succeeding layers consisting of tuffaceous soft sedimentary rock correspond to CM and CL classes (Ref. Fig. C-15).

Water permeability test of the drilling holes in the soft rocks show the K-values in the order of 10^{-3} cm/sec to 10^{-4} cm/sec.

3.6 Buyut Diversion Works

The site of Buyut diversion works is located at 700 m upstream of Buyut village. Topography of the diversion site shows hilly area and narrow V-shaped meandering river valley. General geology of the site is similar to that of the Karian dam site. The geological map of the area is shown in Fig. C-6.

According to the boring data, subsurface geology at the sites of diversion works and headreach canal is mainly composed tuffaceous fine to coarse grained sandstone with intercalation of pumice tuff and lapilli tuff. The bed trends north-northwest and dips eastward.

Superficial weathered zone of the soft rock can be assumed to be 3-5 m thick on the hilly area. These superficial layers including top soil and talus deposits become thicker to the downstream reaches. Top soil and superficial layer corresponds to that of D class in rock quality classification. Succeeding layers consisting of tuffaceous soft sedimentary rock correspond to CM and CL classes (Ref. Fig. C-16).

3.7 Guradog Quarry Site

The Guradog quarry site is located at near Guradog village, Kecamatan Maja, about 15 km south of the Karian dam site. Gunung Guradog (EL. 226 m) and Gunung Alung (EL. 245) form small domes beside the Ciapus river. The relative height of Gunung Guradog and Gunung Alung is about 100 m each from the riverbed.

Geology of Gunung Guradog consists of andesite which is marked by a structure of columnar joints, and also is formed by the surface intrusion. The exposed rock is fragile. It seems such andesite is not suitable for the embankment materials of fill-type dam.

While, geology of Gunung Alung consists of olivine basalt marked by the columnar joint, compressive strength of which shows heigher valves of more than 900 kg/cm^2 (Ref. Table C-6). The fresh basaltic lava is also exposed in the Ciapus riverbed. However, fresh tuff breccia is confirmed by boring at 32 m in depth at bore hole BG-5. The slightly weathered tuff breccia is exposed in the north side steep slope of Gunung Alung. So that, basalt rocks are restricted in distribution. The geophysical profile is shown in Fig. C-21. The rock test data for tuff breccia and basalt is shown in Table C-6.

It is estimated the available quantity of basalt is about 380 x $10^3 m^3$. This will be used for the outer side of rock fill portion of dams. Tuff breccia, the quantity of which is abundant, will be used for inner side of rock fill portion of dams.

Seismic exploration at the quarry site was carried out on the Gunung Alung with 1 exploration line of 445 m in length, and ground is classified into 3 classes depending on the velocity of elastic wave propagation. The characteristics of each zone are described below.

Class	Velocity of Seismic Wave (km/sec)		Description
I	0.3,	0.3-0.5	Top soil
II	1.0-1.2,	1.1-1.3	Slightly weathered blocky rock with open joint
III	4.5,	4.5-5.0	Fresh very hard rock with calcited vein

3.8 Sajira Borrow Area

The Sajira borrow area is located at near Karian village along Ciberang river, about 7 km south from the Karian dam site. In the vicinity of the Sajira borrow area, the Ciberang river flows at El. 55 m with 50 m in width. There are well developed river terraces. The borrow area is selected on the large river terrace (500 m x 500 m) on the right bank. The terrace is about 5 to 8 m higher than the riverbed, and silty clay of 3 to 5 m in thickness covers its surface. Sand and gravel materials are available in riverbed and terrace deposits. Sand and gravel layer of 4 to 6 m in thickness is covered by the silty clay (Ref. Fig. C-8).

Seismic exploration at the borrow area was carried out on the right bank river terrace with 1 exploration line of 440 m in length, and ground is classified into 4 classes depending on the velocity of elastic wave propagation (Ref. Fig. C-22). The characteristics of each zone are described below.

Class	Velocity of Seismic Wave (km/cm)	Description
I	0.3	Top soil aluvium silty clay
II	0.6-0.7	Terrace deposit (sandy silt with gravel)
III	1.1-1.3	Terrace deposit (gravel with sand)
IV	1.8-2.2	Soft rock

3.9 Seismicity

Earthquake data in Indonesia are available in "Earthquakes in Indonesia" prepared by Meteorological and Geophysical Institute, Jakarta, which records 7,118 events during the period from 1948 to 1979.

From the above record, the peak ground acceleration of the proposed dam sites has been calculated as follows :

Long NC = A - BxIJ (Frequency-Intensity Relation by the Kawasumi's method)

where;

NC : Accumulated frequency

IJ : The earth intensity in Japanese Meteorological Agency scale at the project site

A, B : Constant

Relation of acceleration ($\overline{a}$) and Ij was calculated by the following formula (Kawasumi, 1951).

$$\overline{a} = 0.45 \times 10^{0.5\ Ij} \text{ (in gal)}$$

(1) Karian Dam Site

Epicentral of influential earthquabes of the dam site is plotted and shown in Fig. C-24.

Earthquake Intensity and Frequency

Intensity (IJ)	Frequency in 32 years	Frequency in 100 years	Cumulative Number for 100 years
0 (0. - 0.5)	51	159.38	350.02
1 (0.6 - 1.5)	43	134.38	190.64
2 (1.6 - 2.5)	13	40.63	56.26
3 (2.6 - 3.5)	4	12.50	15.63
4 (3.6 - 4.5)	1	3.13	3.13
5 (4.6 - 5.5)	0	0.	0.
6 (5.6 - 6.5)	0	0.	0.
7 (6.6 - 7.5)	0	0.	0.

Non-Linear Regression Analysis by Least Square Method

Log(Y) = 2.689 - 0.518*X

Coefficient of Correlation

RR = 0.989

Expected Maximum Intensity for 100 years

= 5.19

Maximum Acceleration in a Return Period of 100 years

= 177. gal

= 0.18 g

(2) Cilawang Dam Site

Epicentral of influential earthquakes of the dam site is plotted and shown in Fig. C-25.

Earthquake Intensity and Frequency

Intensity (IJ)	Frequency in 32 years	Frequency in 100 years	Cummulative No. for 100 years
0 (0. 0.5)	48	150.00	331.26
1 (0.6 - 1.5)	41	128.13	181.26
2 (1.6 - 2.5)	12	37.50	53.13
3 (2.6 - 3.5)	4	12.50	15.63
4 (3.6 - 4.5)	1	3.13	3.13
5 (4.6 - 5.5)	0	0.	0.
6 (5.6 - 6.5)	0	0.	0.
7 (6.6 - 7.5)	0	0.	0.

Non-Linear Regression Analysis by Least Square Method

$$\mathrm{Log}(Y) = 2.661 - 0.511*X$$

Coefficient of Correlation

RR = 0.989

Expected Maximum Intensity for 100 years

= 5.21

Maximum Acceleration in a Return Period of 100 years

= 181 gal

= 0.18 g

4. SUMMARY AND RECOMMENDATION

The geologic map shows the geology of the dam sites to be formed of tuffaceous sedimentary rocks of the Genteng Formation in Tertiary age. These rocks are composed of Pliocene fine to coarse grained tuffaceous sandstone. Pumice tuff, lapilli tuff, basal conglomerate, welded tuff, and tuffaceous claystone facies. These tuffaceous rocks are classified as soft rock especially weakness in pumiceous facies. Numerous field permeability coefficient of $K = 3.0 \times 10^{-4}$ cm/sec to $K = 3.0 \times 10^{-3}$ cm/sec even in the deeper part of the foundation and abutment.

The soft rock lies below 2 to 10 meters from the surface in the abutments of on the both dam sites and has moderately to rather low bearing strength for a high fill dam. Generally, rock bearing strength of drilling core at the both dam sites shows low compressive strength of $C = 10$ to 30 kg/cm^2. In some case, very low compressive strength of $C = 4$ to 9 kg/cm^2 was observed.

On the basis of the above results, it will be essential to carry out more intensive investigations in the future detail design stage. These should include geological, geohydrological and geotechnical studies supported by a programme of core boring, lugion test, standard penetration test (SPT), rock test, grout test, in-situ direct shear test, pumping test, lateral load test (LTT), and etc. This would permit an assessment of the permeability coefficient of dam foundation and would indicate the distribution of weak rock. These are helpful for the assessment of bearing capacity of the foundation for dams and its related structures.

Judging from the field investigation results, it is assumed the available quantity of rock materials (tuff breccia and basalt) are sufficient for the construction of both the Karian and Cilawang dams. However, it is recommended that some additional core boring would be done in the future detailed design stage to grasp the quality and quantity of such rocks more in detail. G. Sendi is recommendable as an alternative quarry site, if necessary.

<u>R E F E R E N C E</u>

1. BINA PROGRAM/DJP/DPU, PENYELIDIKAN GEOLOGI, PENYELIDIKAN GEOFISIK DAN PEMBORAN GEOLOGI INTI BERIKUT PERMEABILITY TEST & SPT UNTUK KEDALAMAN 400 METER, Main Report, Gamma Epsilon P.T., Dec. 1982 (in English) and Supporting Report (in English).

2. BINA PROGRAM/DJP/DPU, PENYELIDIKAN GEOLOGI DAN PEMBORAN INTI RENCANA WADUK KARIAN (2000 HA, 300 M) LAPORAN UTAMA, Gamma Epsilon P.T., Feb. 1983 (in English), Executive Summary (in English), and LAPPORAN PENUNJANG (in Indonesian)

3. DPMA/DJP/DPU, PENYELIDIKAN (GEOTEKNIK 167 METER DI RENCANA RESERVOIR DAN DAM KARIAN (LANJUTAN), Mar. 1984 (in Indonesian) and ALBUM FOTO (in Indonesian)

4. DPMA/DJP/DPU, PENYELIDIKAN GEOTEKNIK 300 METER DI RENCANA TEROWONGAN, BENDUNG DAN RESERVOIR CILAWANG, Mar. 1984 (In Indonesian) and ALBUM FOTO (in Indonesian)

5. OPMA/DJP/DPU, PENYELIDIKAN GEOLOGI DAN MEKANIKA TANAH DI LOKASI BENDUNG GADEG SERTA PEMBUATAN MODEL TEST DI BENDUNG GADEG, (BAGIAN GEOLOGI TEKNIK), Mar. 1983.

6. BINA PROGRAM/DJP/DPU, PENYELIDIKAN GEOLOGI, MEKANIKA TANAH DAN PEMBORAN INTI 300 M PADA BORROW AREA/QUARRY DI SAJIRA, LAPORAN PENUNJANG, Gamma Epsilon P.T. Mar. 1984 (in Indonesian) and Executive Summary (in English).

7. BINA PROGRAM/DJP/DPU, PENGUKURAN, PENYELIDIKAN PEMBUATAN DESIGN BENDUNG DAN SALURAN IRIGASI, GADEG-JAWA BARAT BUKU-II, P.T. Kertahayu, Mar. 1983 (in Indonesian).

8. BGR/LAPORAN GEOLOGI LEMBAR SERANG, JAWA SEKALA 1:100,000, E.Rusmana etc, 1982(in Indonesian) BGR (Bidang Geologi Regional)

9. BINA PROGRAM/DJP/DPU, PENYELIDIKAN GEOLOGI TEKNIK PADA RENCANA TEROWONGAN CIUYAH 3000 M, Gamma Epsilon P.T., Mar. 1984 (in Indonesian).

10. JAPANESE NATIONAL COMMITTEE OF THE INTERNATIONAL COMMISSION ON LARGE DAMS, "Standards for Geological Investigation of Dam Foundation", 1978 (in English).

Table C-1 SUMMARY OF PREVIOUS INVESTIGATIONS

SUMMARY OF EXISTING CORE BORINGS

Location	Number of holes	Depth Min.	Depth Max.	Meter	Purpose
Karian dam site	16	15	60	620	Foundation Conditions permeabilities, and water table locations
Ciuyah tunnel	7	25	60	260	Foundation Conditions
Cilawang dam site	7	20	40	170	Foundation Conditions and Permeabilities
Cicinta tunnel	4	25	50	130	Foundation Conditions
Quarry site (Guradog & Alung)	4	35	40	150	Rock quality Conditions
Quarry site (Sediri)	4	30	40	150	Rock quality Conditions
Gadeg Weir Site	15	13	30	370	Foundation Conditions and permeabilities
TOTAL:	57			1850	

SUMMARY OF EXISTING SEISMIC SURVEYS

Location	Number of lines	Length Min.	Length Max.	Total Meter	Purpose
Karian dam site	8	86	570	1817	Foundation Conditions
Ciuyah tunnel	7	189	1531	2971	Foundation and Rock quality Condition
TOTAL:	15			4788	

Table C-2 STRATIGRAPHY OF NORTH BANTEN AREA

		Stratigraphy	Composition	Thickness
QUARTERNARY	Holocene	Alluvial deposits Holocene volcanoes		
	Pleistocene			
	Upper	Terrace deposits		
	Middle	Volcanoes formed after block-faulting and collapse of the Danau comples		
	Lower	Bojong Formation (upper part of the Banten tuffs)	Clauconite, tuffaceous, more or less Sandy marls, with Limestone lenses. Pumice tuffs, Basal conglomerates	200
TERTIARY	Pliocene			
	Upper	Cilegon Formation (Pumice tuff with marine intercalla-tions) and part of the Cikeusik Formation	Pumice tuffs	50
			Pumice tuffs, rich in hornblende	60
			Pumice tuffs	40
			Pumice tuffs, rich in biotite	50
	Middle	Cipacar Formation	Upper part; tuffaceous glauconitic marls, clay, sandstones, andesitic breccia. Lower part; pumice tuffs	400
	Lower	Genteng Formation	Pumice tuffs, rich in plant remains and silicified wood	730
	Miocene			
	Upper		Instruction of hornblende andesite	
	Upper part of the Middle Miocene	Bojongmanik Formation	Marls and clays with browncoal, tuff snadstone andesitic gravels. IN the upper part also pumice tuffs.	
	Lower to Middle Miocene	Badui Formation and Lower Bojongmanik Formation	Limestone, marls, clay-shales, Basal andesitic conglomerates and sand stones	
	Lower	Sareweh Formation Cimadag Formation Citarate Formation		

Table C-3 QUANTITY OF CORE BORINGS

Location	Boring No.	Drilling Depth in meter	Water Pressure Test	Remarks
Karian dam site	KB-17	40	0*1	by D.P.M.A.
	KB-18	40	0	"
	KB-19	40	0	"
	KB-20	40	0	"
	KB-21	40	0	"
	KB-22	20	0	"
	KB-23	20	0	"
Sub-total:	7	240		
Cilawang-Cicinta tunnel	CCB-1	20	0	"
	CCB-2	20	0	"
	CCB-3	20	0	"
	CCB-4	15	0	"
	CCB-5	15	0	"
Sub-total:	5	90		
Guradog quarry site	BG-5	40	X*2	"
	BG-6	40	X	
Buyut diversion works	DH-1	15	*3	by K.HEXAGON
	-2	10		"
	-3	15		"
	-4	30		"
	-5	35		"
	-6	35		"
	-7	15		"
	-8	15		"
	-9	15		"
	-10	10		"
	-11	10		"
	-12	15		"
	-13	10		"
	-14	35		"
	-15	35		"
Sub-total:	15	300		
TOTAL :	29	710		

*1 Partially no test
*2 No test
*3 Randam test

Table C-4 QUANTITY OF SEISMIC EXPLORATION

Location	Exploration line	Length in meter	Total in meter
Karian dam site	A	600	
	B	200	
	C	200	1000
Cilawang dam site	A	500	
	B	300	
	C	220	
	D	220	1240
Cilawang - Cicinta Tunnel	A	2250	
	B	400	
	C	350	3000
Guradog quarry site	A	445	445
Sajira borrow area	A	440	440
TOTAL :	12 lines		6125

Table C-5 QUALITY CLASSIFICATION ROCK IN DAM FOUNDATION

Rock Class	
A	Rock-forming minerals/1 are fresh and not weathered or altered. Joints and cracks are closed tightly, no weatherings on their planes. Clear sound is emitted when hammered.
B	Rock-forming minerals are weathered slightly or partially altered and the rock is hard. Joints and cracks are closed tightly. Clear sound is emitted when hammered.
C_H	Rock-forming minerals are weathered and the rock is fairly hard. Tightness of joints and cracks is slightly reduced and each block is apt to be exfoliated along joints and cracks sometimes contain clay and other material which may be coloured by limonite. A slightly dull sound is emitted when hammered.
C_M	Rock-forming minerals are weathered and the rock is slightly soft. Exfoliation of the rock occurs along joints and cracks by normal hammering. Joints and cracks sometimes contain clay and other materials. A somewhat dull sound is emitted when hammered.
C_L	Rock-forming minerals are weathered, and the rock is soft. Exfoliation of the rock occurs along joints and cracks by light hammering. Joints and cracks contain clay. A dull sound is emitted when hammered.
D	Rock-forming minerals are weathered, and the rock is very soft. There is virtually no bond between rock blocks, and collapse occurs at the slightest hammering. Joints and cracks contain clay. A very dull sound is emitted when hammered.

/1 : Except quartz

Source : Ref. 10

Table C-6 RESULTS OF ROCK TEST (1/3)

SAMPLE BORE HOLE NO.	NO. DEPTH (m)	COMPRE-SSIVE STRENG-TH σc (Kg/cm²)	LONG WAVE VELO-SITY Vp (m/sec)	SHEAR WAVE VELO-SITY Vs (m/sec)	DENSITY ρ (g/cm³)	YOUNG'S MODULUS OF ELA-STICITY E (Kg/cm²)	POISSON'S RATIO μ (-)	MODULUS OF RIGIDITY G (Kg/cm²)	AIR DRIED DENSITY γn (g/cm³)	AIR DRIED WATER CONTENT Wp (%)	SATU-RATED DENSITY γs (g/cm³)	SATURATED WATER CONTENT/ ABSORP-TICN Ws %	DRY DENSITY γd (g/cm³)	DEGREE OF SATURA-TION S (%)	POROSI-TY n (%)	APPA-RENT SPECI-FIC GRAVITY GaP (-)	TRUE SPECIFIC GRAVITY Gtr (-)	VOID RATIO e (-)
KB-17	4.75-5.00	39.79	1579.69	972.12	1.73	3.98×10^4	0.19	1.67×10^4	1.73	14.51	1.79	18.68	1.51	77.70	28.19	1.51	2.10	0.39
	5.15-5.37	23.45	1753.83	1060.47	1.69	4.68×10^4	0.21	1.94×10^4	1.69	20.33	1.80	28.30	1.40	71.85	39.62	1.40	2.32	0.66
	7.00-7.24	20.07	1598.53	970.54	1.35	3.13×10^4	0.21	1.30×10^4	1.35	7.23	1.79	41.96	1.26	17.22	52.85	1.26	2.67	1.12
	7.24-7.50	11.77	1565.63	910.91	1.67	3.51×10^4	0.24	1.41×10^4	1.67	24.19	1.39	24.19	1.39	82.01	33.61	1.39	2.09	0.51
	7.75-8.00	9.72	1333.33	750.00	1.68	2.44×10^4	0.26	9.64×10^4	1.68	27.57	1.73	31.51	1.32	87.50	41.50	1.32	2.25	0.71
KB-18	3.45-3.80	32.79	1807.14	1100.00	1.43	4.26×10^4	0.21	1.76×10^4	1.43	9.89	1.63	24.91	1.30	39.71	32.46	1.30	1.93	0.48
	7.13-7.28	24.66	1958.33	1175.00	1.74	5.97×10^4	0.22	2.45×10^4	1.74	20.15	1.79	23.45	1.45	85.92	33.91	1.45	1.19	0.51
	8.15-8.30	39.58	1726.79	1028.72	1.48	3.93×10^4	0.23	1.60×10^4	1.48	5.83	1.62	15.91	1.40	36.67	22.29	1.40	1.80	0.29
KB-19	4.60-4.70	12.37	1056.67	679.29	1.93	2.09×10^4	0.15	9.08×10^3	1.93	28.89	1.78	18.30	1.50	157.86	27.45	1.50	2.07	0.38
	6.63-6.78	33.67	1497.06	925.45	1.85	3.86×10^4	0.19	1.62×10^4	1.85	14.54	1.89	16.95	1.62	85.94	27.31	1.62	2.22	0.38
	7.45-7.55	96.99	2115.91	1410.61	1.36	6.11×10^4	0.11	2.76×10^4	1.36	9.68	1.65	33.87	1.23	28.57	41.72	1.23	2.11	0.72
	8.10-8.25	42.23	1760.71	1126.45	1.37	4.09×10^4	0.17	1.75×10^4	1.37	9.29	1.72	37.43	1.25	24.82	46.92	1.25	2.36	0.88
KB-20	5.05-5.20	13.48	940.00	648.28	1.65	1.47×10^4	0.04	7.07×10^3										
	5.65-5.80	12.03	880.83	604.00	1.58	1.24×10^4	0.06	5.88×10^3	1.58	13.55	1.66	19.42	1.39	69.79	27.04	1.39	1.91	0.37
	8.00-8.15	11.06	920.91	519.49	1.60	1.11×10^4	0.26	4.40×10^3										
	9.50-9.65	4.07	607.69	395.00	1.25	4.53×10^3	0.14	1.99×10^3	1.25	15.44	1.41	29.96	1.08	51.55	32.45	1.08	1.60	0.48
KB-21	9.30-9.45	10.63	1090.53	740.00	1.49	1.79×10^4	0.07	8.32×10^3	1.49	3.85	1.69	17.63	1.44	21.82	25.33	1.44	1.92	0.34
KB-23	4.20-4.40	21.53	1854.17	1085.37	1.71	5.10×10^4	0.24	2.05×10^4	1.71	31.53	1.76	34.69	1.30	90.88	45.21	1.30	2.38	0.83
	5.28-5.62	48.40	2492.50	1384.72	1.72	8.58×10^4	0.28	3.36×10^4	1.72	6.56	1.82	12.51	1.61	52.46	20.19	1.61	2.02	0.25
	7.10-7.25	20.44	1066.32	653.55	1.75	1.82×10^4	0.19	7.61×10^3	1.75	33.56	1.79	37.29	1.31	90.00	48.74	1.31	2.55	0.95
	8.16-8.39	39.40	1423.53	864.29	1.85	3.40×10^4	0.21	1.41×10^4	1.85	31.45	1.93	36.81	1.41	85.44	51.79	1.41	2.92	1.07

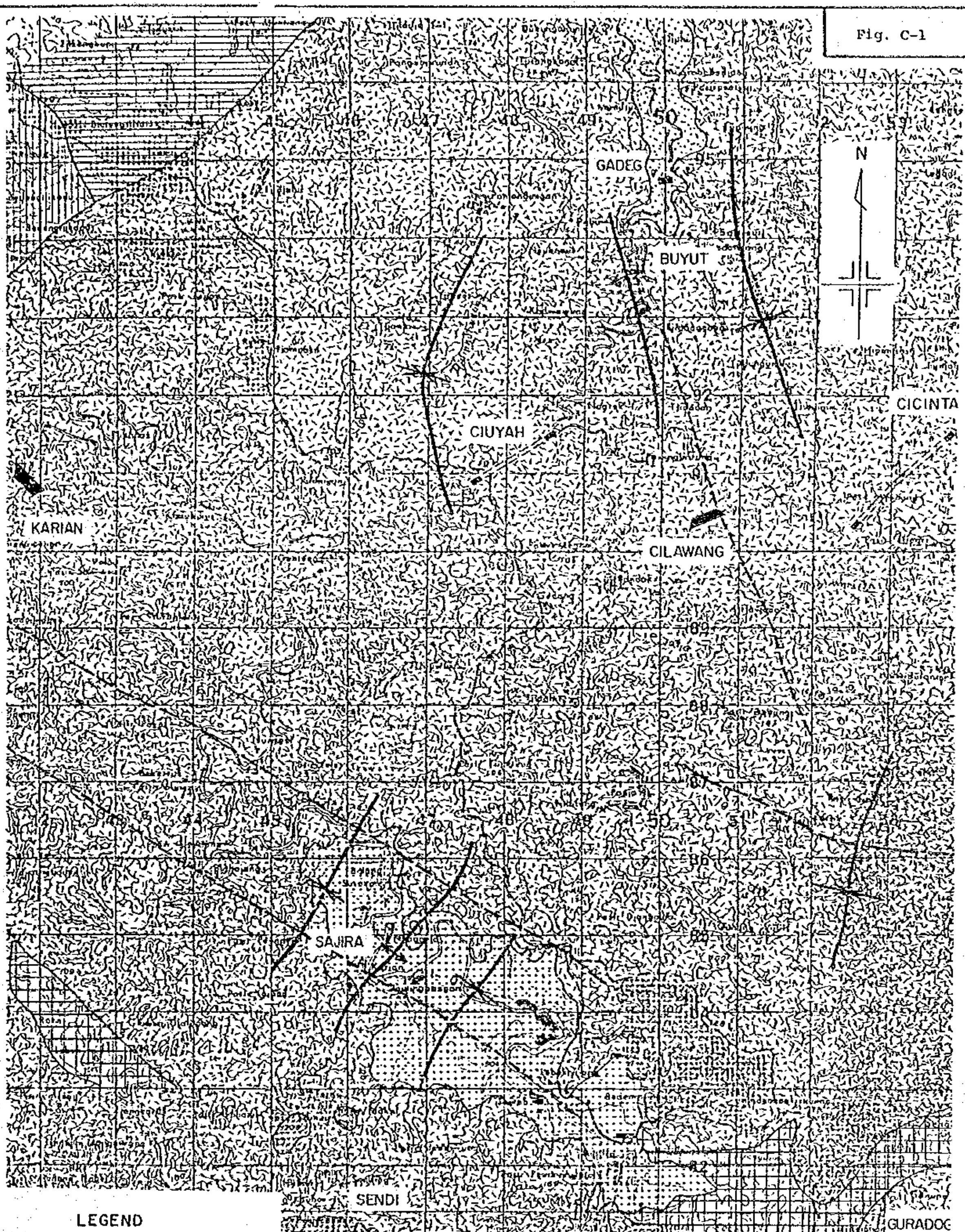
Table C-6 RESULTS OF ROCK TEST (2/3)

SAMPLE NO. BORE HOLE NO.	DEPTH (m)	COMPRESSIVE STRENGTH σc (Kg/cm²)	LONG WAVE VELOSITY Vp (m/sec)	SHEAR WAVE VELOSITY Vs (m/sec)	DENSITY ρ (g/cm³)	YOUNG'S MODULUS OF ELASTICITY E (Kg/cm²)	POISSON'S RATIO μ (-)	MODULUS OF RIGIDITY G (Kg/cm²)	AIR DRIED DENSITY γ_n (g/cm³)	AIR DRIED WATER CONTENT Wp (%)	SATURATED DENSITY γ_s (g/cm³)	SATURATED WATER Ws (%)	DRY DENSITY γ_d (g/cm³)	DEGREE OF SATURATION S (%)	POROSITY n (%)	APPARENT SPECIFIC GRAVITY GaP (-)	TRUE SPECIFIC GRAVITY Gtr (-)	VOID RATIO e (-)
CB-1	3.55-3.75	44.85	2114.63	1256.52	1.49	5.90×10^4	0.23	2.40×10^4	1.49	4.15	1.75	31.54	1.43	18.88	31.54	1.43	2.09	0.46
	5.60-5.85	23.95	776.67	506.52	1.57	9.22×10^3	0.12	4.11×10^3										
	7.35-7.70	9.84	852.00	551.81	1.65	1.17×10^4	0.14	5.12×10^3										
	8.30-8.50	19.52	1221.18	752.17	1.57	2.16×10^4	0.19	9.06×10^3										
	9.76-10.00	13.10	1064.71	707.03	1.45	1.64×10^4	0.11	7.39×10^3										
CB-2	8.40-8.60	55.22	1741.27	1205.49	1.56	4.80×10^4	0.04	2.31×10^4	1.56	18.25	1.82	38.61	1.32	47.27	50.83	1.32	2.68	1.03
	9.25-9.58	12.46	1144.00	560.78	1.67	1.44×10^4	0.34	5.36×10^3										
	12.55-12.78	18.17	1080	530.64	1.68	1.26×10^4	0.34	4.68×10^3										
	14.07-14.25	27.47	1077.65	688.72	1.60	1.78×10^4	0.15	7.74×10^3										
CB-3	2.00-2.20	22.77	2011.11	1239.73	1.37	5.13×10^4	0.19	2.15×10^4	1.37	4.04	1.91	45.16	1.31	8.95	59.31	1.31	3.23	1.46
	2.20-2.35	23.89	2002.13	1289.04	1.82	7.11×10^4	0.15	3.08×10^4	1.82	4.22	1.92	10.02	1.75	42.08	21.24	1.75	2.12	0.27
	2.35-2.55	17.20	2023.40	941.58	1.87	4.59×10^4	0.36	1.69×10^4										
	3.65-3.82	14.07	1888.89	867.35	1.68	3.52×10^4	0.37	1.29×10^4										
	5.20-5.45	19.75	895.45	604.29	1.68	1.34×10^4	0.07	6.26×10^3										
	9.50-9.95	4.10	640.61	434.98	1.40	5.80×10^3	0.07	2.70×10^3										
CB-4	1.50-1.80	75.92							1.36	5.07	0.06	32.60	1.29	15.55	42.10	1.29	2.23	0.73
	2.00-2.80	30.75							1.60	4.48	1.81	18.95	1.53	23.67	28.97	1.53	2.15	0.40
	2.27-2.45	15.91	1818.18	1234.57	1.44	4.81×10^4	0.07	2.24×10^4										
	4.00-4.25	7.97																
	6.60-6.80	19.01																
	10.45-10.65	19.50																
CB-5	2.12-2.30	8.42																
	2.30-2.55	43.49							1.55	1.88	1.77	16.53	1.52	11.38	25.11	1.52	2.03	0.34
	3.25-3.45	18.62							1.52	1.73	0.15	15.49	1.49	11.18	23.08	1.49	1.94	0.30

Table C-6 RESULTS OF ROCK TEST (3/3)

SAMPLE NO. BORE HOLE NO.	DEPTH (m)	COMPRESSIVE STRENGTH σ_c (Kg/cm^2)	LONG WAVE VELOSITY Vp (m/sec)	SHEAR WAVE VELOSITY Vs (m/sec)	DENSITY ρ (g/cm^3)	YOUNG'S MODULUS OF ELASTICITY E (Kg/cm^2)	POISSON'S RATIO μ (-)	MODULUS OF RIGIDITY G (Kg/cm^2)	AIR DRIED DENSITY γ_n (g/cm^3)	AIR DRIED WATER CONTENT Wp (%)	SATURATED DENSITY γ_s (g/cm^3)	SATURATED WATER Ws (%)	DRY DENSITY γ_d (g/cm^3)	DEGREE OF SATURATION S (%)	POROSITY n (%)	APPARENT SPECIFIC GRAVITY GaP (-)	TRUE SPECIFIC GRAVITY Gtr (-)	VOID RATIO e (-)
CCB-1	4.65-4.75	13.65	1463.24	956.73	1.41	2.96×10^4	0.12	1.32×10^4	1.41	18.01	1.59	33.26	1.20	54.17	39.78	1.20	1.99	0.66
	4.75-4.90	61.80	2265.91	1347.30	1.70	7.75×10^4	0.23	3.15×10^4	1.70	10.27	1.82	17.86	1.55	57.50	27.59	1.55	2.13	0.38
	5.75-5.92	21.91	1652.17	974.36	1.31	3.12×10^4	0.23	1.27×10^4	1.31	5.96	1.71	38.83	1.23	15.35	47.93	1.23	2.37	0.92
CCB-2	10.20-10.42	30.82	1646.88	1054.00	1.36	3.55×10^4	0.15	1.54×10^4	1.36	7.21	1.64	29.78	1.27	24.21	37.70	1.27	2.03	0.61
	13.80-14.00	20.47	1375.00	887.10	1.50	2.74×10^4	0.14	1.20×10^4	1.50	17.46	1.70	33.33	1.27	52.38	42.42	1.27	2.21	0.74
CCB-3	4.48-4.65	4.32	877.00	531.51	1.37	9.52×10^3	0.21	3.95×10^3	1.37	27.10	1.48	37.86	1.08	71.58	40.70	1.08	1.81	0.69
	7.86-8.00	11.97	840.00	486.96	1.56	9.37×10^3	0.24	3.77×10^3										
	8.43-8.55	12.06	1033.33	563.64	1.57	1.31×10^4	0.29	5.09×10^3										
CCB-4	7.58-7.70	16.54	1111.11	689.66	1.72	1.97×10^4	0.18	8.34×10^3	1.72	12.65	1.89	23.44	1.53	53.97	35.88	1.53	2.39	0.56
CCB-5	4.37-4.40								1.54	23.72	1.56	25.21	1.25	94.07	31.47	1.25	1.82	0.46
	4.37-4.48		1633.33	1000.00	1.54	3.79×10^4	0.21	1.57×10^4										
BG-5	34.50-34.95 (Tuff Breccia)								2.07	11.06	2.12	14.02	1.86	78.89	26.09	1.86	2.52	0.35
		160.66	2515.91	1495.95	2.07	1.16×10^5	0.23	4.72×10^4										
		159.54	2892.11	1717.19	2.07	1.53×10^5	0.23	6.22×10^4										
		161.06	3020.00	1461.29	2.07	1.22×10^5	0.35	4.51×10^4										
	36.00-36.50 (Tuff Breccia)								2.28	7.08	2.30	7.76	2.13	91.23	16.55	2.13	2.56	0.20
		125.74	2712.50	1466.22	2.28	1.30×10^5	0.30	5.00×10^4										
		161.98	2593.33	1341.38	2.28	1.10×10^5	0.32	4.18×10^4										
		116.04	3137.50	1673.33	2.28	1.70×10^5	0.31	6.51×10^4										
BG-5	(Basalt)	1864.33	5790	3618.75	2.76	8.70×10^5	0.18	3.69×10^5										
		892.10	5666.67	3187.50	2.76	7.23×10^5	0.26	2.86×10^5										
									2.76	0.91	2.77	1.17	2.73	77.78	3.20	2.75	2.82	0.03

Fig. C-1



LEGEND

- Quaternary Sediment
- Bojong Formation
- Banten Tuff
- Genteng Formation
- Bojong Manik Formation
- Andesite & Basalt
- Assumed Fault
- Anticline
- Syncline
- Damsite (Proposed)
- Tunnel (Proposed)

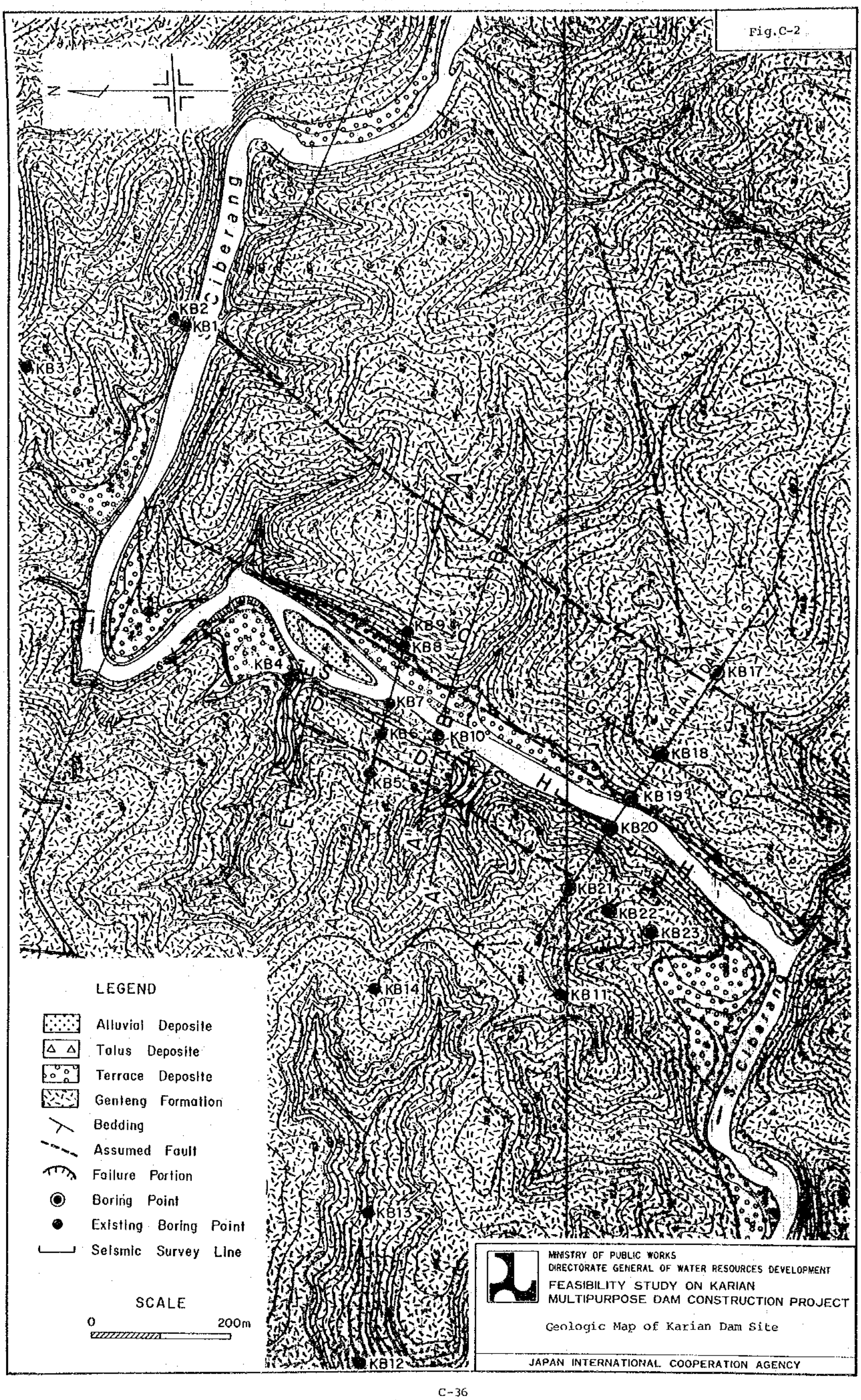
SCALE

0 — 2 km

MINISTRY OF PUBLIC WORKS
DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT
FEASIBILITY STUDY ON KARIAN
MULTIPURPOSE DAM CONSTRUCTION PROJECT

General Geologic Map

JAPAN INTERNATIONAL COOPERATION AGENCY



Geologic Map of Karian Dam Site

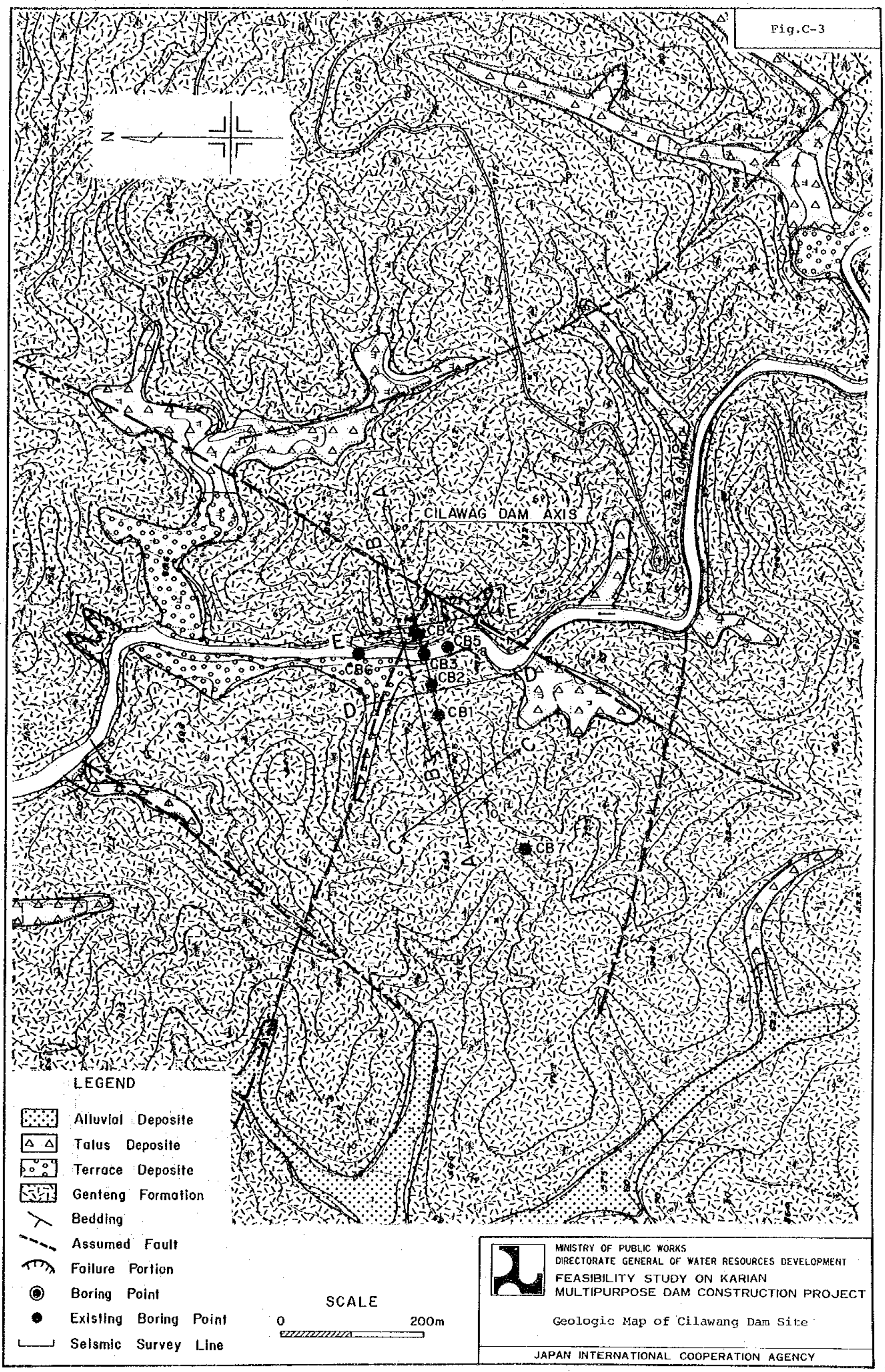


Fig.C-3
N
CILAWAG DAM AXIS
A
B
C
D
E
CB1
CB2
CB3
CB4
CB5
CB6
CB7
LEGEND
Alluvial Deposite
Talus Deposite
Terrace Deposite
Genteng Formation
Bedding
Assumed Fault
Failure Portion
Boring Point
Existing Boring Point
Seismic Survey Line
SCALE
0
200m
MINISTRY OF PUBLIC WORKS
DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT
FEASIBILITY STUDY ON KARIAN
MULTIPURPOSE DAM CONSTRUCTION PROJECT
Geologic Map of Cilawang Dam Site
JAPAN INTERNATIONAL COOPERATION AGENCY

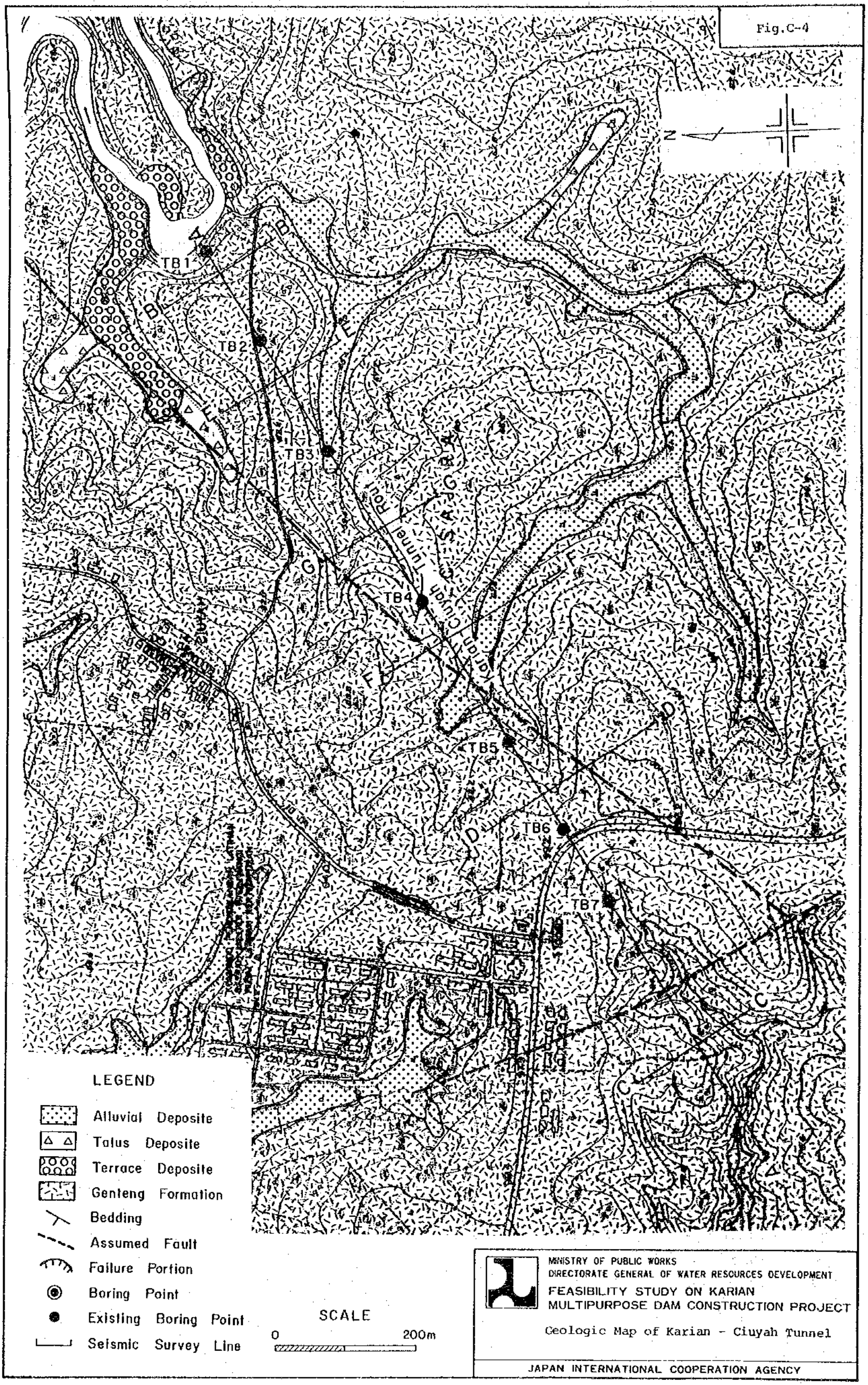


Fig.C-4
N
TB1
TB2
TB3
TB4
TB5
TB6
TB7
Tunnel Route
Ciuyah
LEGEND
Alluvial Deposite
Talus Deposite
Terrace Deposite
Genteng Formation
Bedding
Assumed Fault
Failure Portion
Boring Point
Existing Boring Point
Seismic Survey Line
SCALE
0
200m
MINISTRY OF PUBLIC WORKS
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FEASIBILITY STUDY ON KARIAN
MULTIPURPOSE DAM CONSTRUCTION PROJECT
Geologic Map of Karian - Ciuyah Tunnel
JAPAN INTERNATIONAL COOPERATION AGENCY

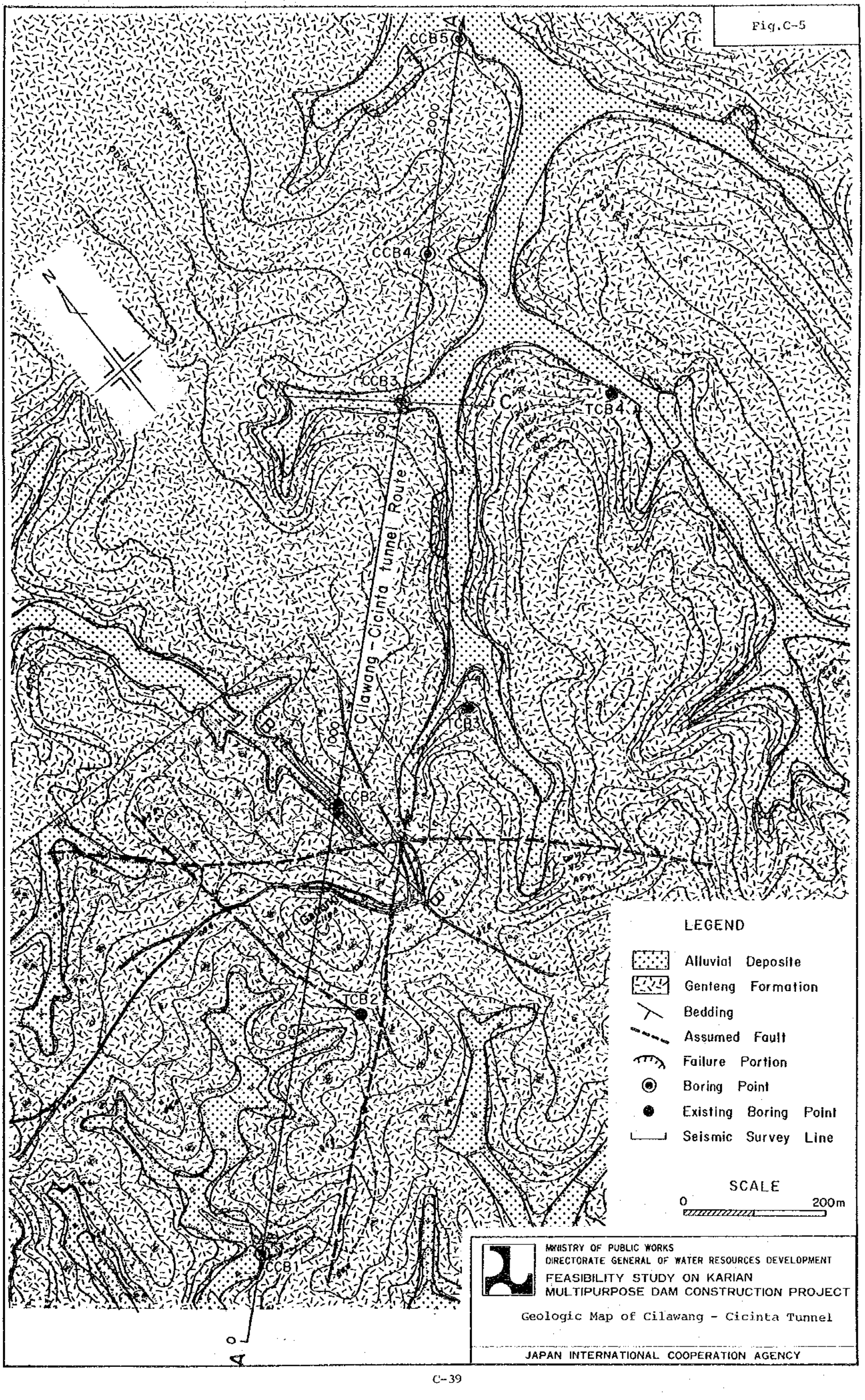
Fig.C-5
CCB5
CCB4
CCB3
CCB2
CCB1
TCB4
TCB3
TCB2
2000
1500
1000
500
0
Cilawang - Cicinta tunnel Route
LEGEND
Alluvial Deposite
Genteng Formation
Bedding
Assumed Fault
Failure Portion
Boring Point
Existing Boring Point
Seismic Survey Line
SCALE
0
200m
MINISTRY OF PUBLIC WORKS
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FEASIBILITY STUDY ON KARIAN
MULTIPURPOSE DAM CONSTRUCTION PROJECT
Geologic Map of Cilawang - Cicinta Tunnel
JAPAN INTERNATIONAL COOPERATION AGENCY

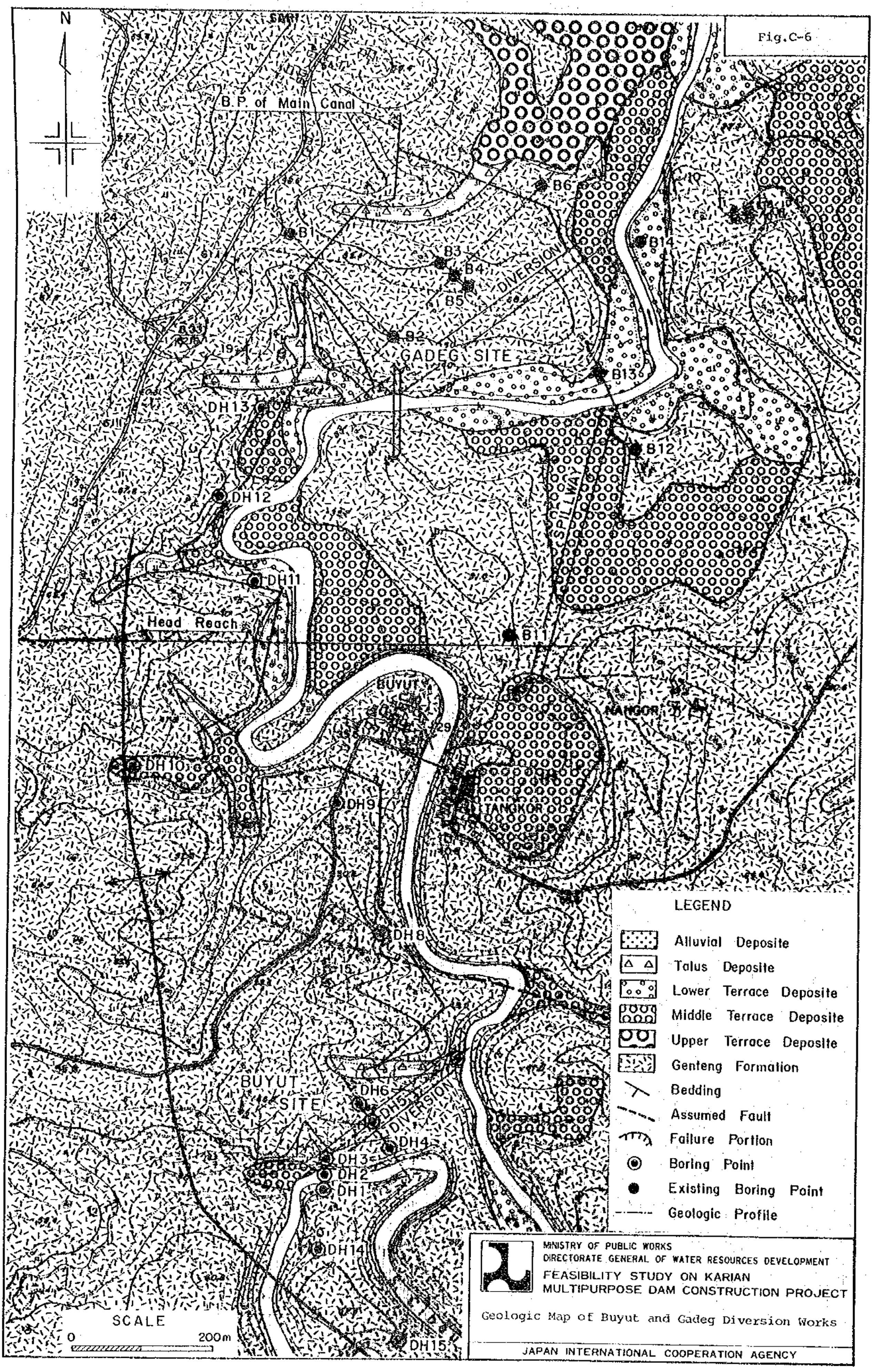
Fig.C-6
N
B.P. of Main Canal
B1
B2
B3
B4
B5
B6
B11
B12
B13
B14
DIVERSION
GADEG SITE
SPILLWAY
DH1
DH2
DH3
DH4
DH5
DH6
DH8
DH9
DH10
DH11
DH12
DH13
DH14
DH15
Head Reach
BUYUT
TANGKOR
BUYUT SITE
DIVERSION
SCALE
0
200m
LEGEND
Alluvial Deposite
Talus Deposite
Lower Terrace Deposite
Middle Terrace Deposite
Upper Terrace Deposite
Genteng Formation
Bedding
Assumed Fault
Failure Portion
Boring Point
Existing Boring Point
Geologic Profile
MINISTRY OF PUBLIC WORKS
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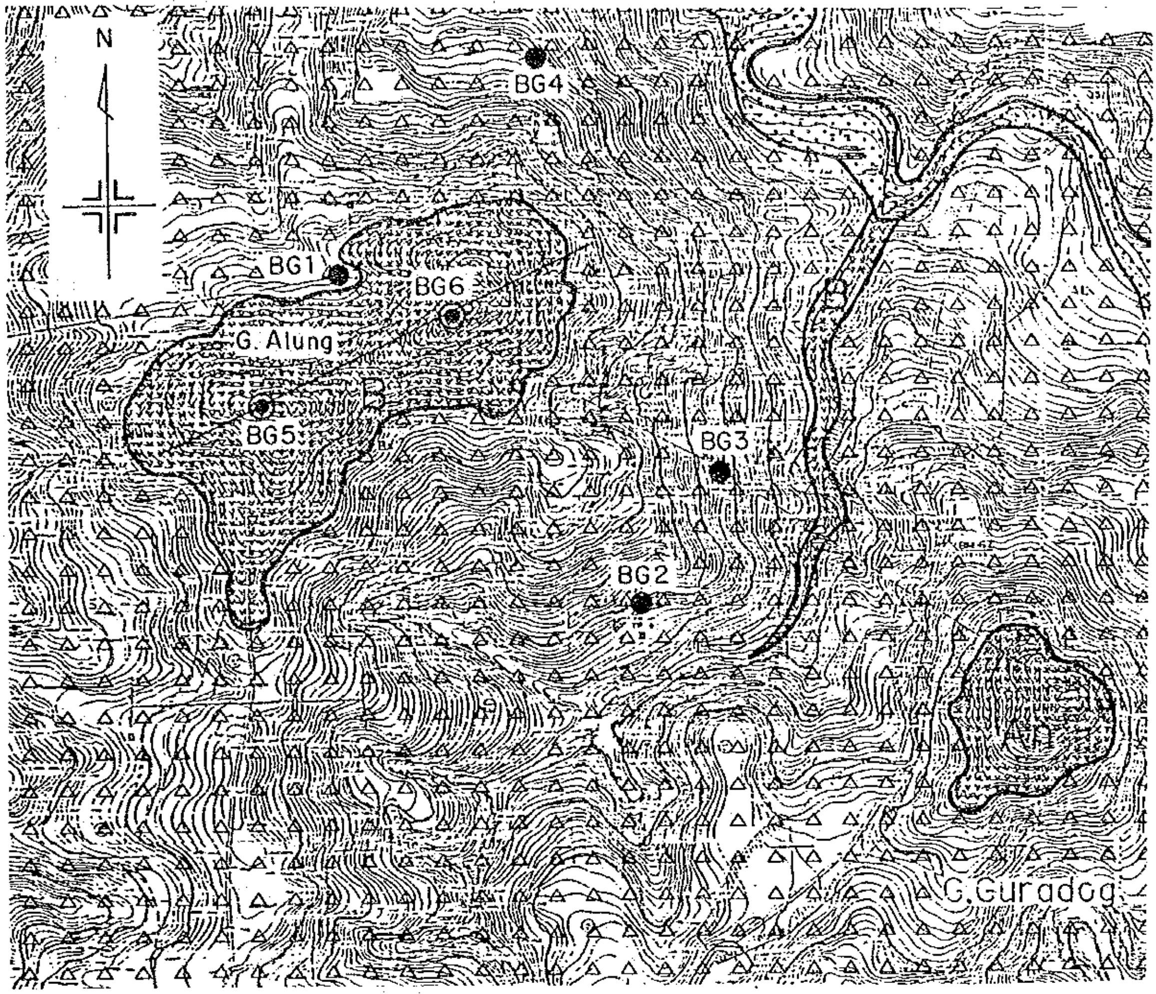
FEASIBILITY STUDY ON KARIAN
MULTIPURPOSE DAM CONSTRUCTION PROJECT
Geologic Map of Buyut and Gadeg Diversion Works
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig.C-7



LEGEND

- Alluvial Deposite
- Basalt
- Andesite
- Tuff Breccia
- Assumed Fault
- Failure Portion
- Boring Point
- Existing Boring Point
- Seismic Survey Line

SCALE

0 200m

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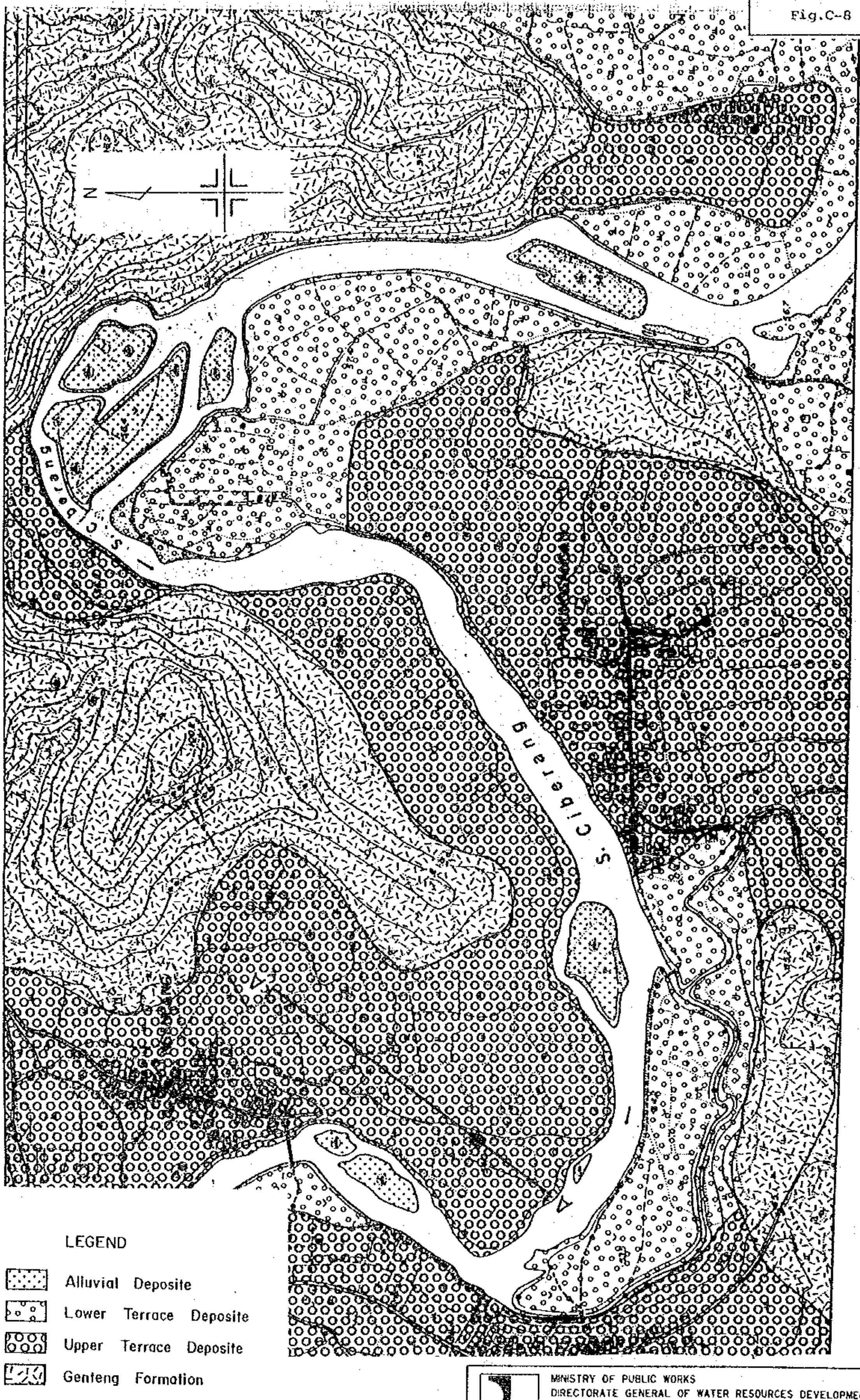
DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT
FEASIBILITY STUDY ON KARIAN
MULTIPURPOSE DAM CONSTRUCTION PROJECT

Geologic Map of Guradog Quarry Site

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig.C-8



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FEASIBILITY STUDY ON KARIAN MULTIPURPOSE DAM CONSTRUCTION PROJECT

Geologic Map of Sajira Borrow Area

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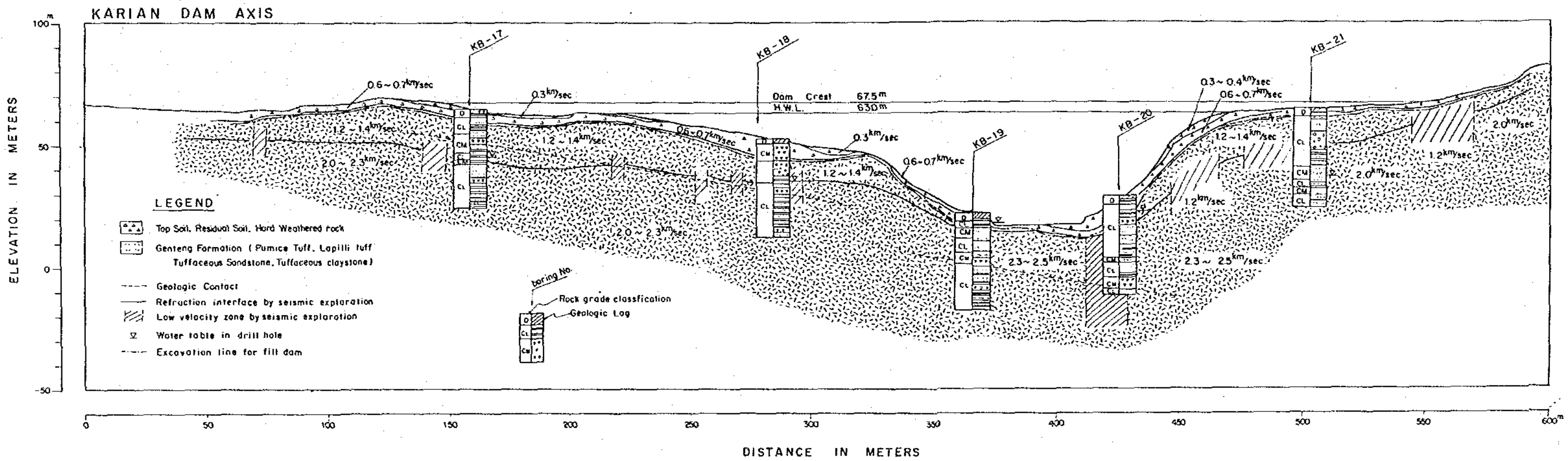
Fig.C-9



MINISTRY OF PUBLIC WORKS
DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT
FEASIBILITY STUDY ON KARIAN MULTIPURPOSE DAM CONSTRUCTION PROJECT

Geologic Profile of Karian Dam Site (Dam Axis)

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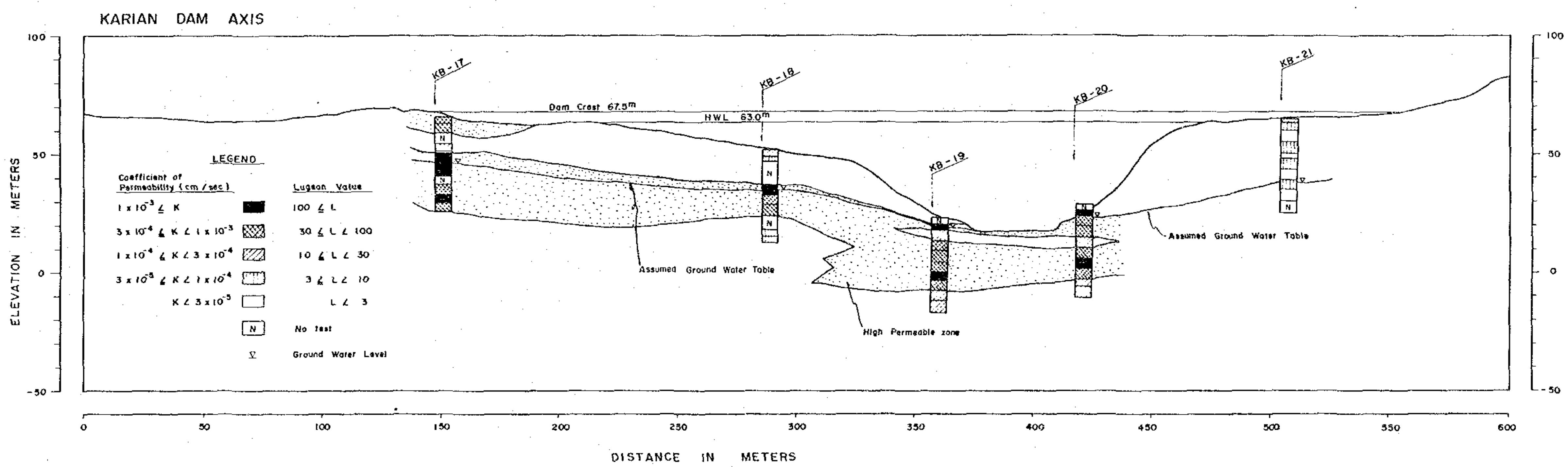
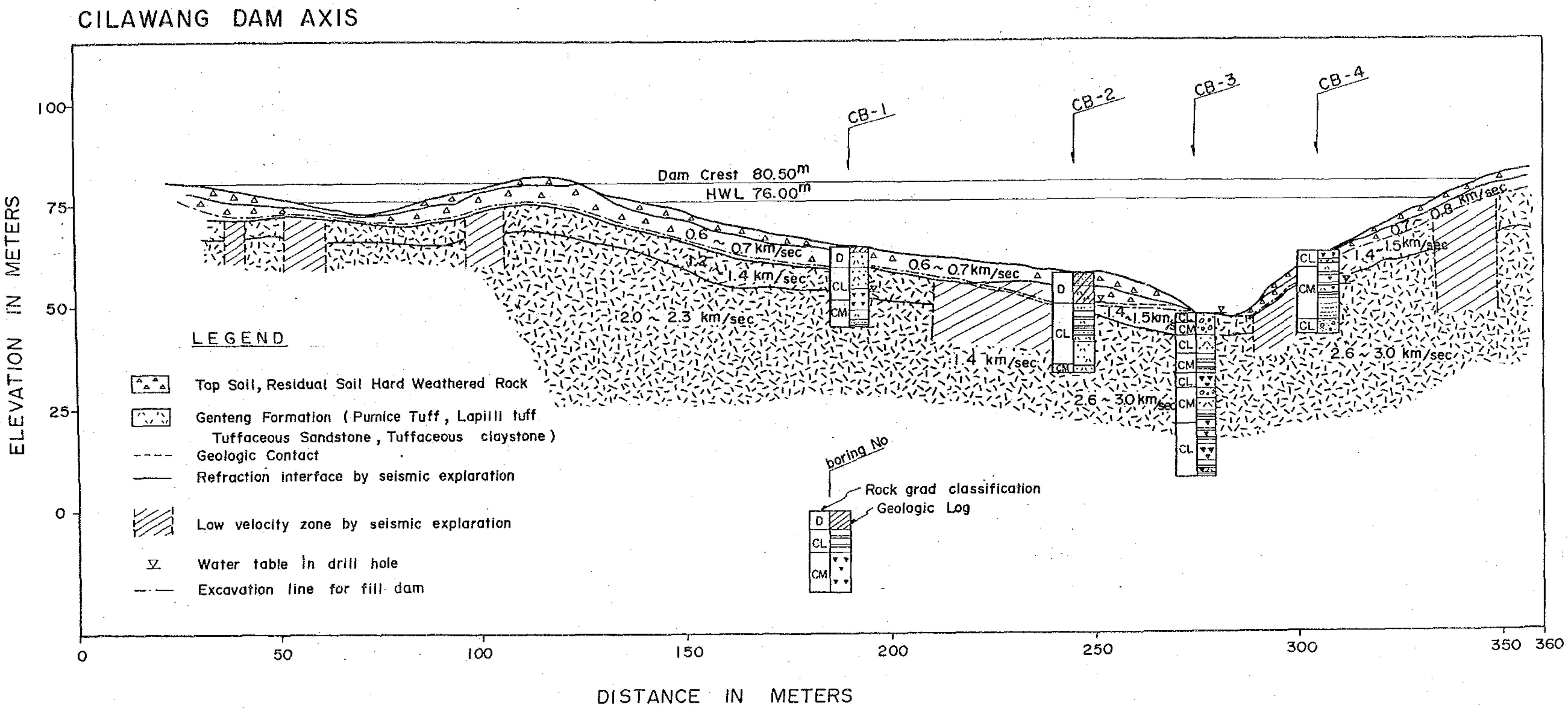


MINISTRY OF PUBLIC WORKS
DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT
FEASIBILITY STUDY ON KARIAN MULTIPURPOSE DAM CONSTRUCTION PROJECT

Permeability Profile of Karian Dam Site (Dam Axis)

JAPAN INTERNATIONAL COOPERATION AGENCY



MINISTRY OF PUBLIC WORKS
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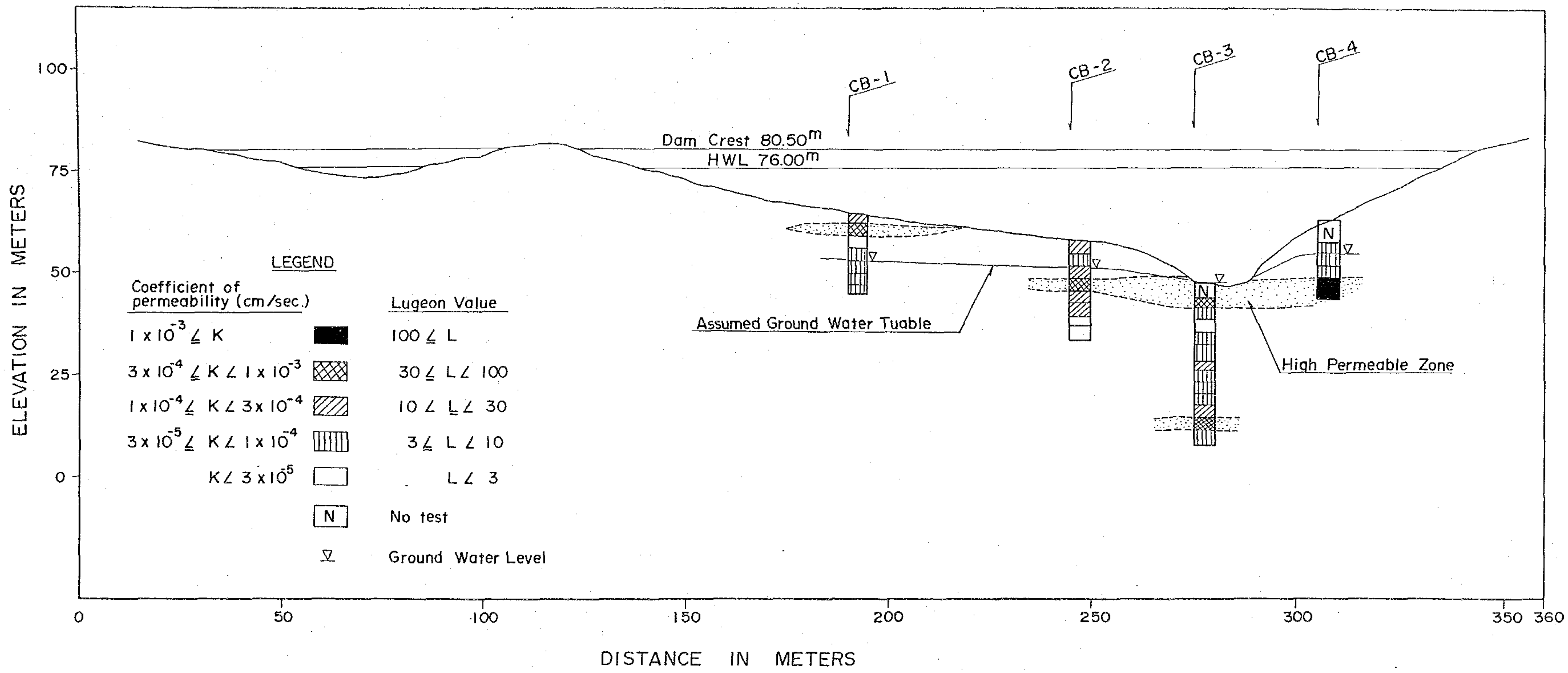
FEASIBILITY STUDY ON KARIAN
MULTIPURPOSE DAM CONSTRUCTION PROJECT
Geologic Profile of Cilawang Dam Site

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig.C-12

CILAWANG DAM AXIS

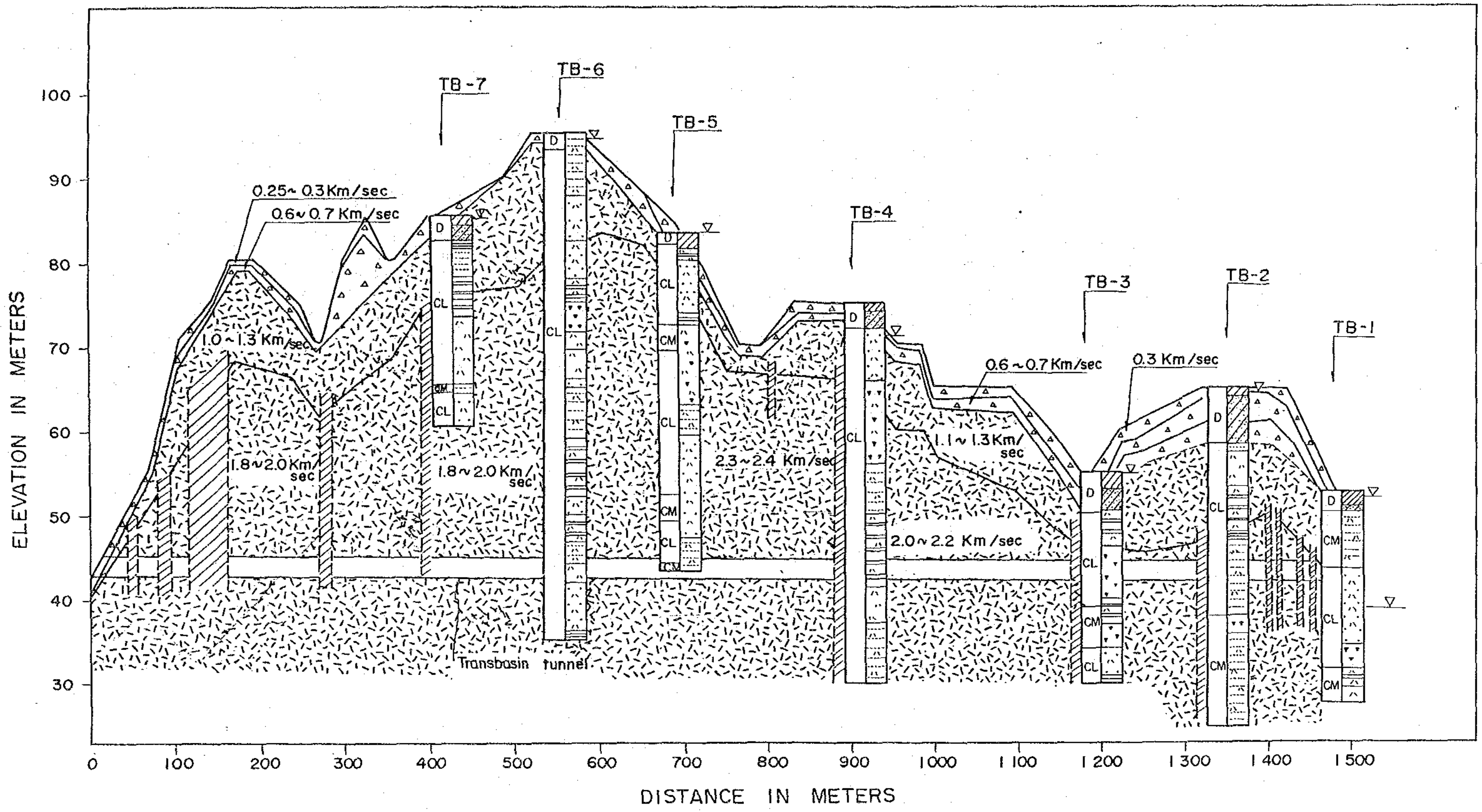


MINISTRY OF PUBLIC WORKS
DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT
FEASIBILITY STUDY ON KARIAN MULTIPURPOSE DAM CONSTRUCTION PROJECT

Permeability Profile of Cilawang Dam Site (DAm Axis)

JAPAN INTERNATIONAL COOPERATION AGENCY

KARIAN - CIUYAH TUNNEL



LEGEND

- Top Soil, Residual Soil, Hard Weathered Rock
- Genteng Formation (Pumice Tuff, Lapilli tuff Tuffaceous Sandstone, Tuffaceous claystone)
- Geologic Contact
- Refraction interface by seismic explaration
- Low velocity zone by seismic explaration
- Water table in drill hole

boring No.
Rock grade classification
Geologic Log

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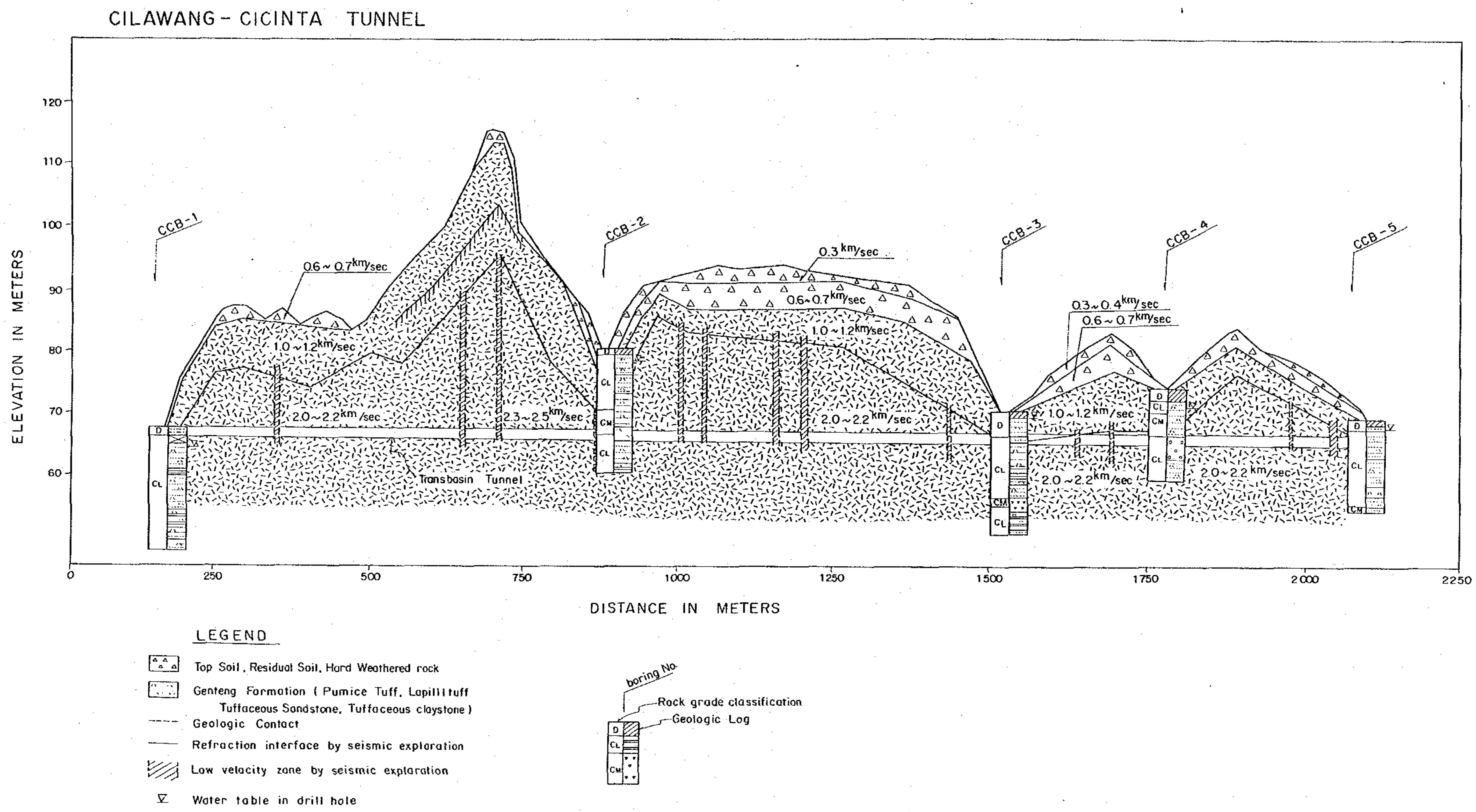
FEASIBILITY STUDY ON KARIAN MULTIPURPOSE DAM CONSTRUCTION PROJECT

Geologic Profile of Karian - Ciuyah Tunnel

JAPAN INTERNATIONAL COOPERATION AGENCY



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FEASIBILITY STUDY ON KARIAN MULTIPURPOSE DAM CONSTRUCTION PROJECT

Geologic Profile of
Cilawang - Cicinta Tunnel

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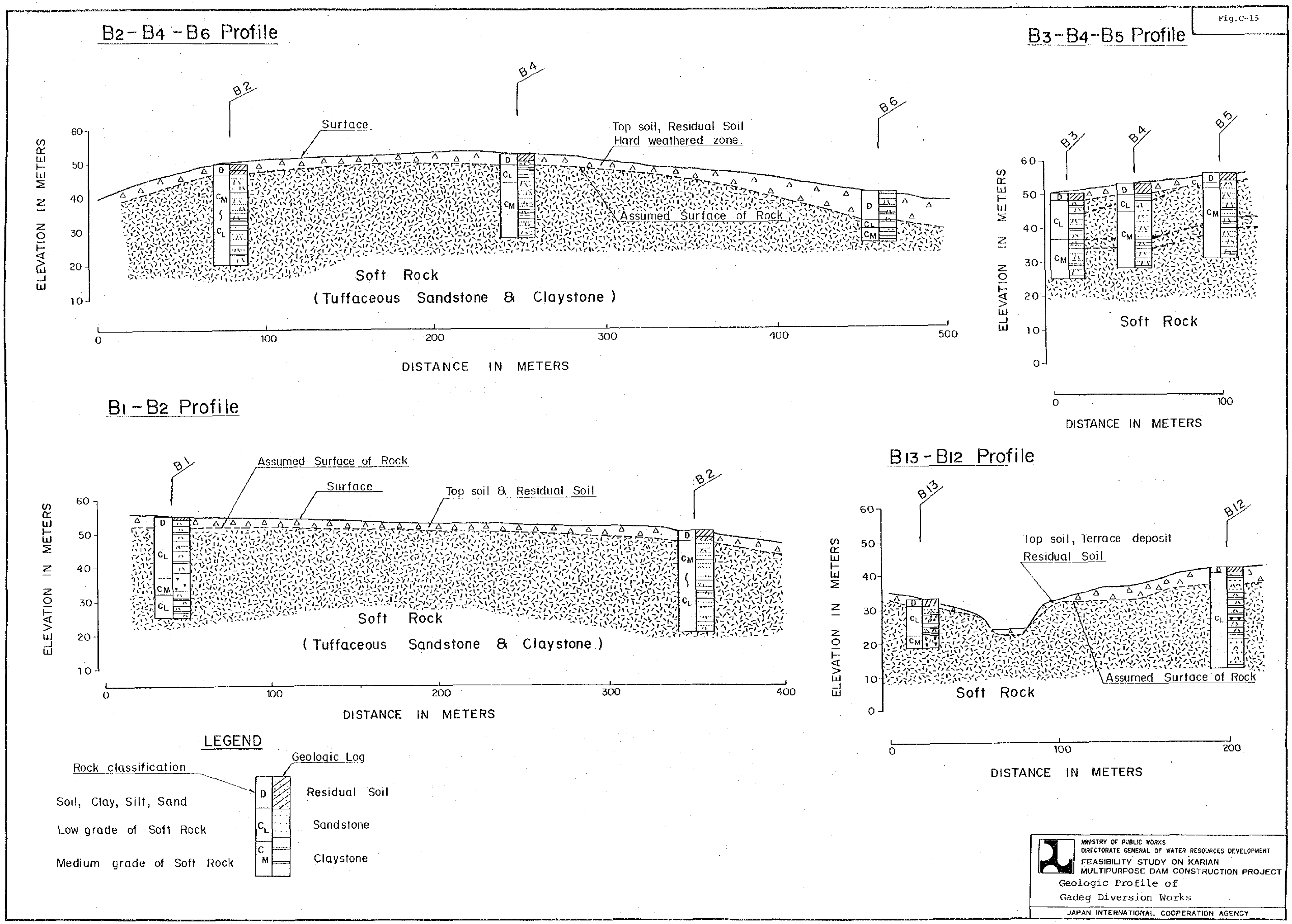
Fig.C-15
B2-B4-B6 Profile
B2
B4
B6
Surface
Top soil, Residual Soil
Hard weathered zone.
Assumed Surface of Rock
Soft Rock
(Tuffaceous Sandstone & Claystone)
ELEVATION IN METERS
DISTANCE IN METERS
B3-B4-B5 Profile
B3
B4
B5
Soft Rock
B1-B2 Profile
B1
B2
Assumed Surface of Rock
Surface
Top soil & Residual Soil
Soft Rock
(Tuffaceous Sandstone & Claystone)
B13-B12 Profile
B13
B12
Top soil, Terrace deposit
Residual Soil
Assumed Surface of Rock
Soft Rock
LEGEND
Rock classification
Geologic Log
Soil, Clay, Silt, Sand
Low grade of Soft Rock
Medium grade of Soft Rock
Residual Soil
Sandstone
Claystone
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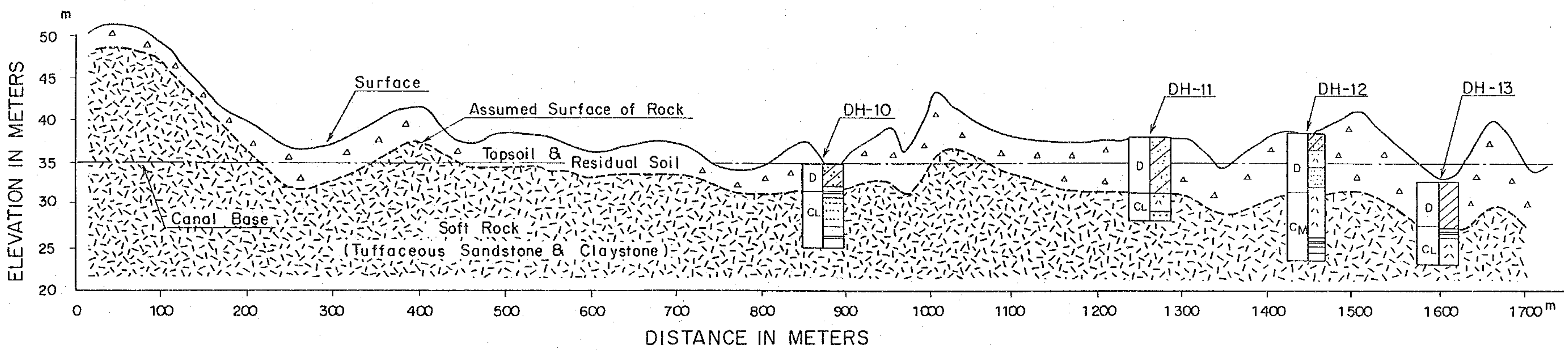
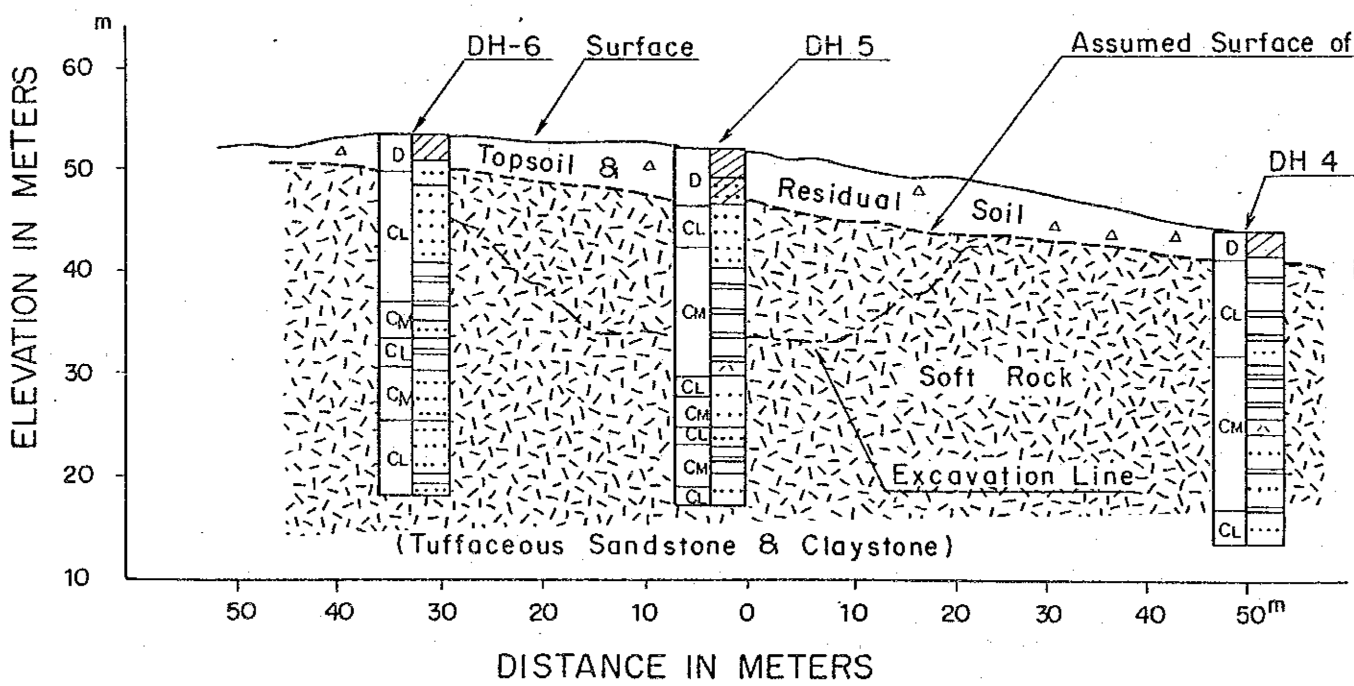
MULTIPURPOSE DAM CONSTRUCTION PROJECT
Geologic Profile of
Gadeg Diversion Works
JAPAN INTERNATIONAL COOPERATION AGENCY

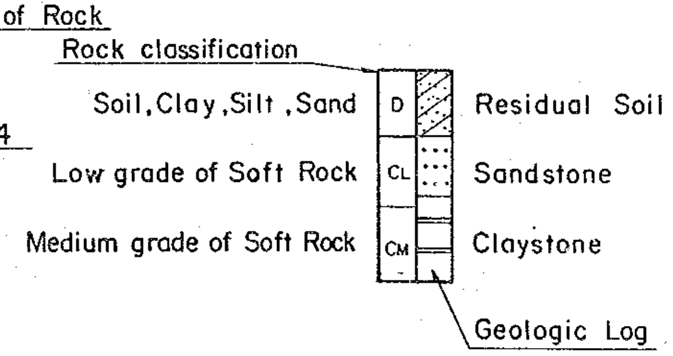
HEAD RACE ROUTE



CROSS SECTION OF HEAD WORKS (Bp+160 m)



LEGEND



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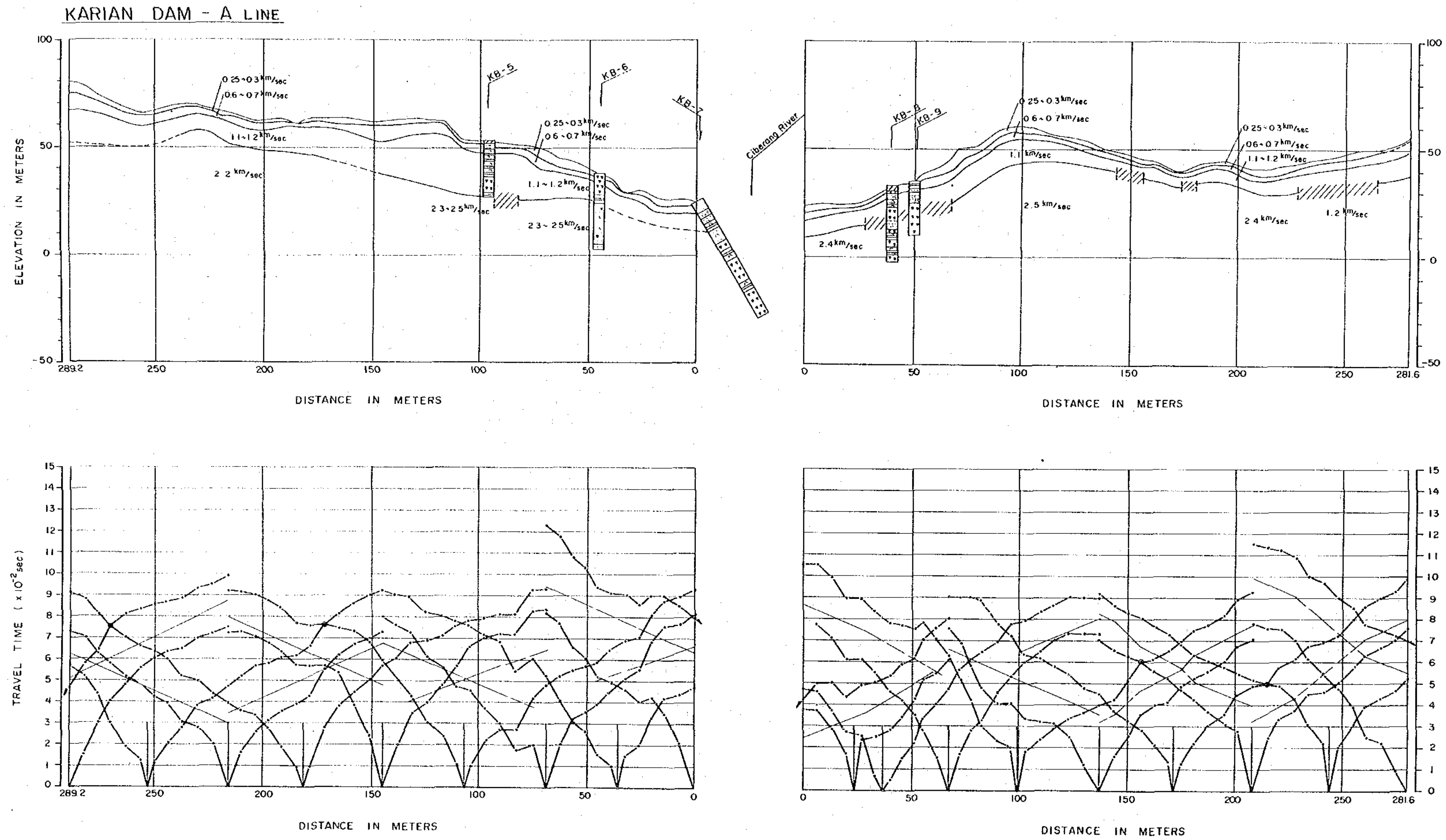
FEASIBILITY STUDY ON KARIAN MULTIPURPOSE DAM CONSTRUCTION PROJECT

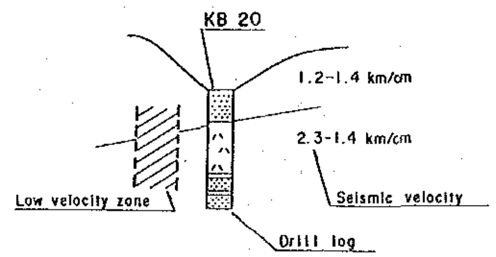
Geologic Profile of Buyut Diversion Works

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig.C-17



LEGEND



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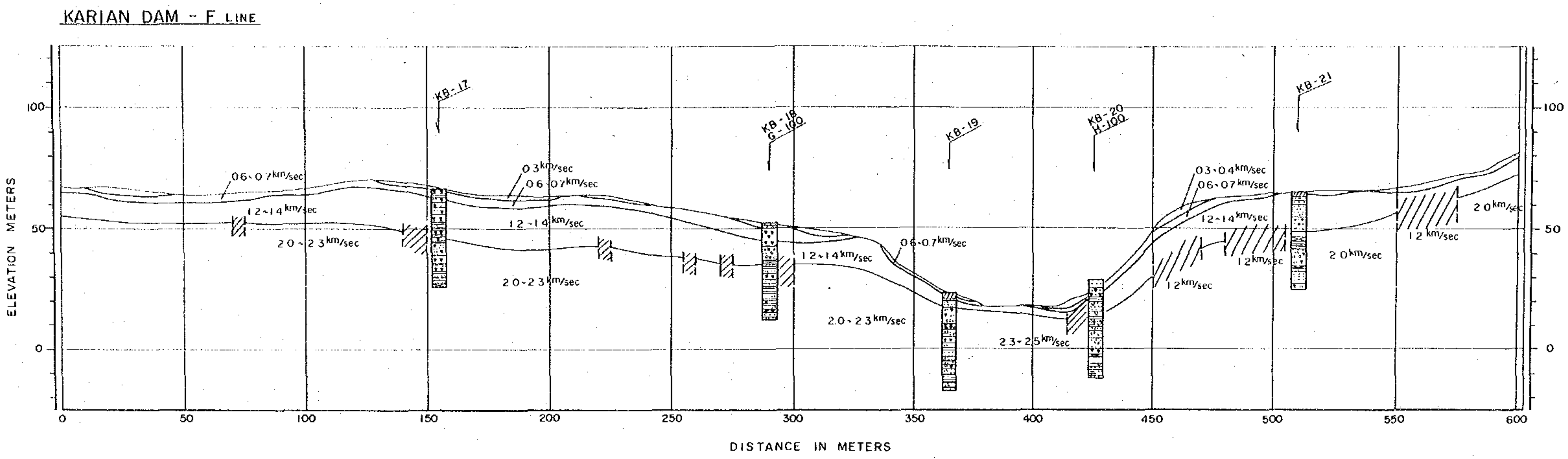
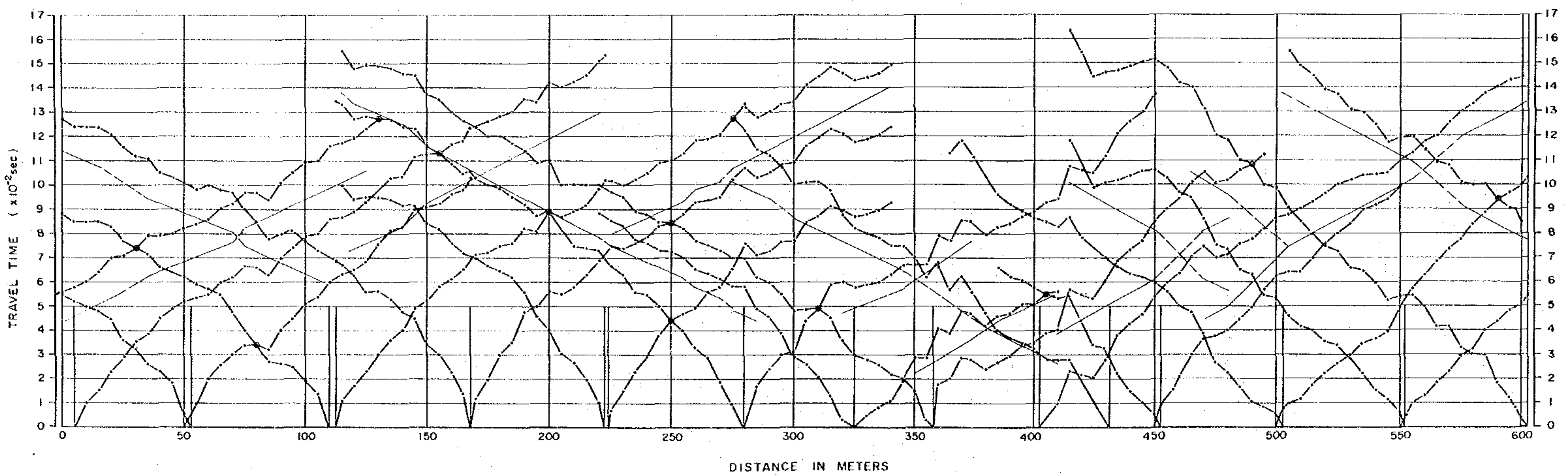
DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT
FEASIBILITY STUDY ON KARIAN
MULTIPURPOSE DAM CONSTRUCTION PROJECT
Geophysical Profile of Karian Dam Site
(Line A,F,G and H) (1/3)

JAPAN INTERNATIONAL COOPERATION AGENCY

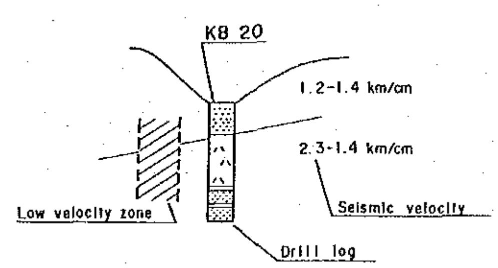
Fig.C-17

KARIAN DAM – F LINE





LEGEND



MINISTRY OF PUBLIC WORKS
DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT
FEASIBILITY STUDY ON KARIAN MULTIPURPOSE DAM CONSTRUCTION PROJECT

Geophysical Profile of Karian Dam Site (Line A,F,G and H) (2/3)

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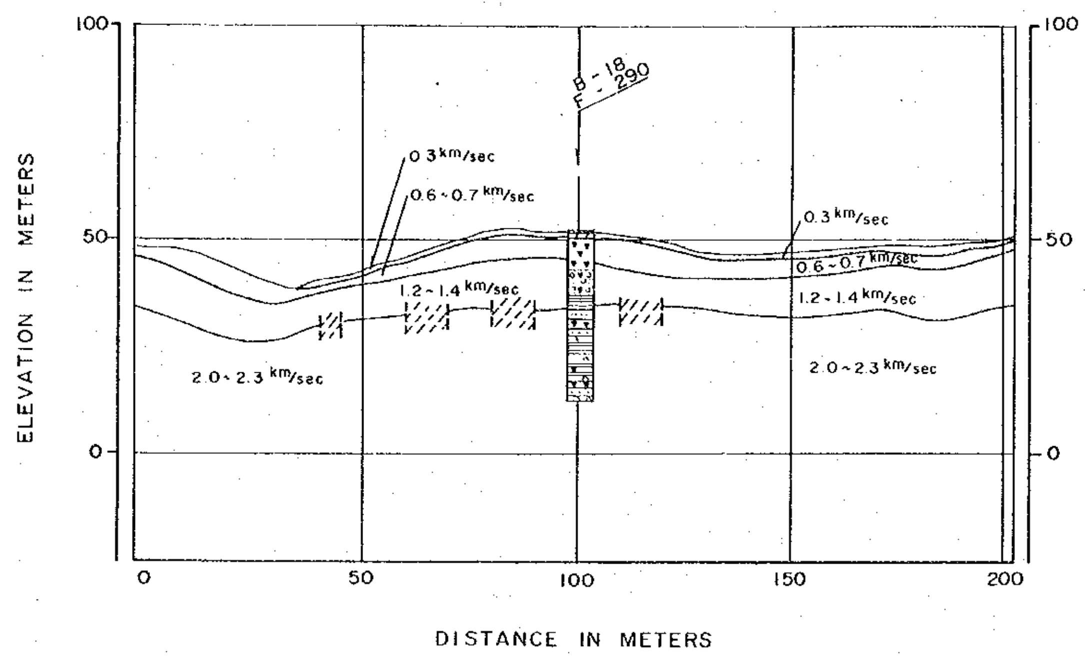
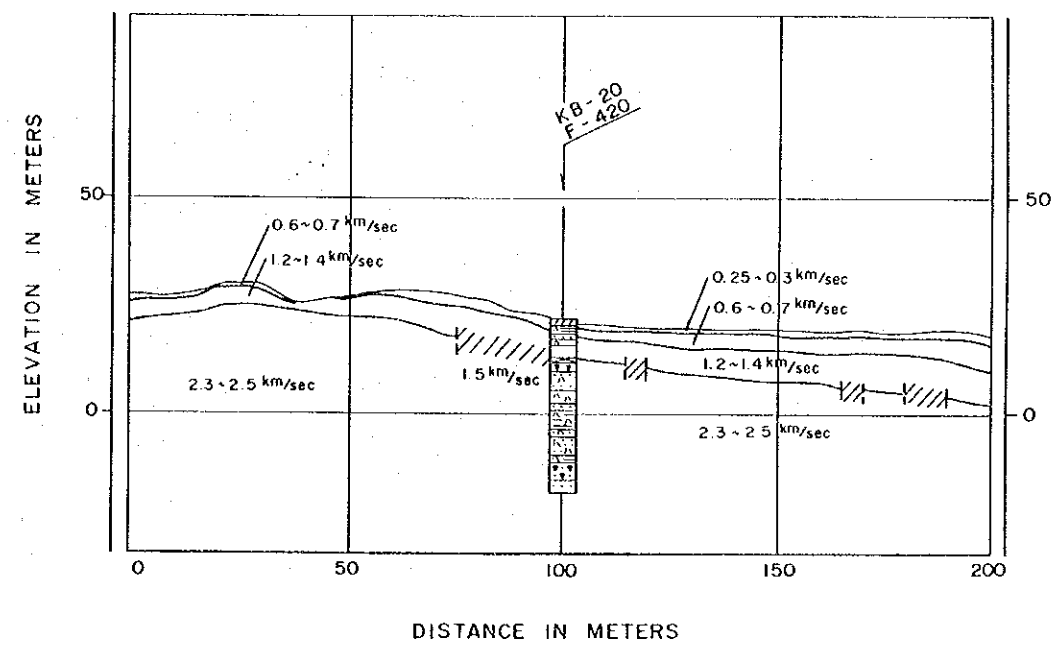
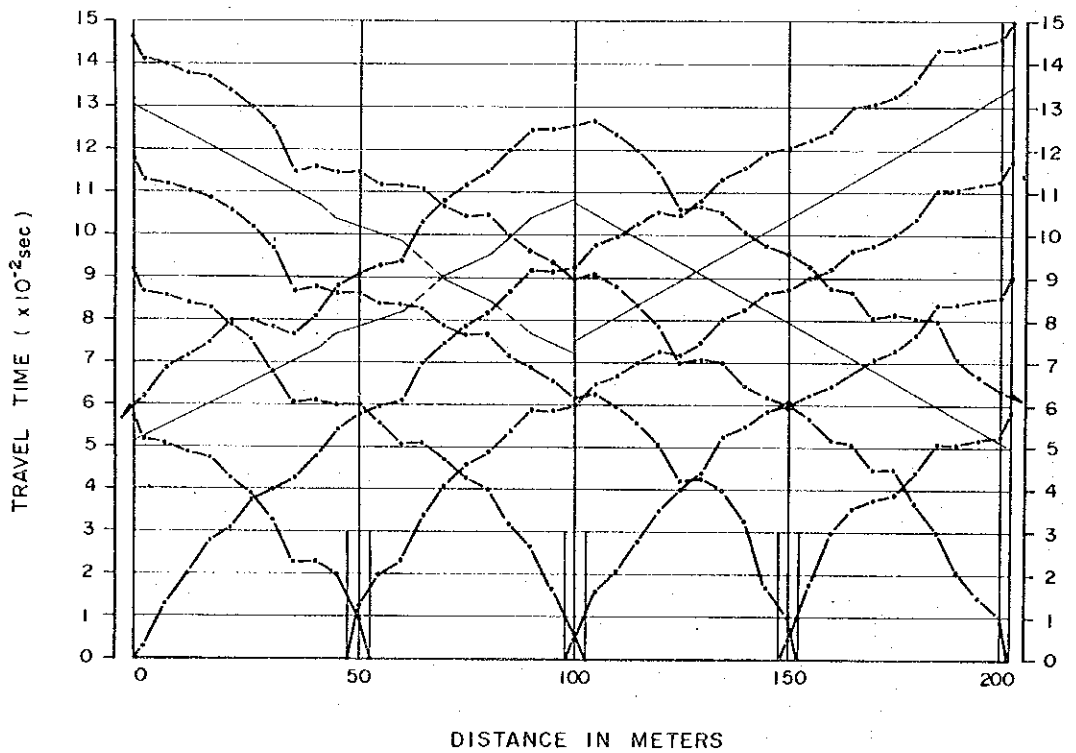
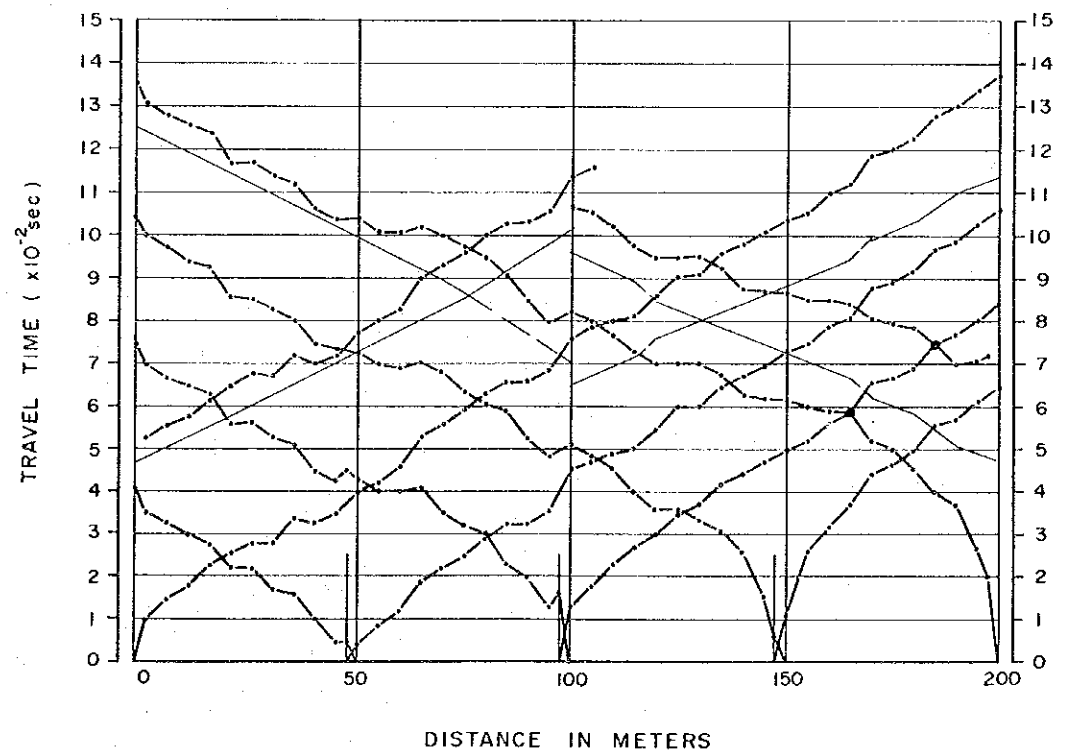
KARIAN DAM - G LINE



KARIAN DAM - H LINE







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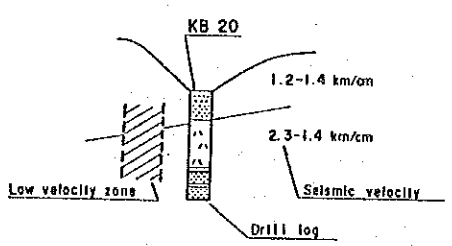

MINISTRY OF PUBLIC WORKS
DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT
FEASIBILITY STUDY ON KARIAN MULTIPURPOSE DAM CONSTRUCTION PROJECT

Geophysical Profile of Karian Dam Site (Line A,F,G and H) (3/3)

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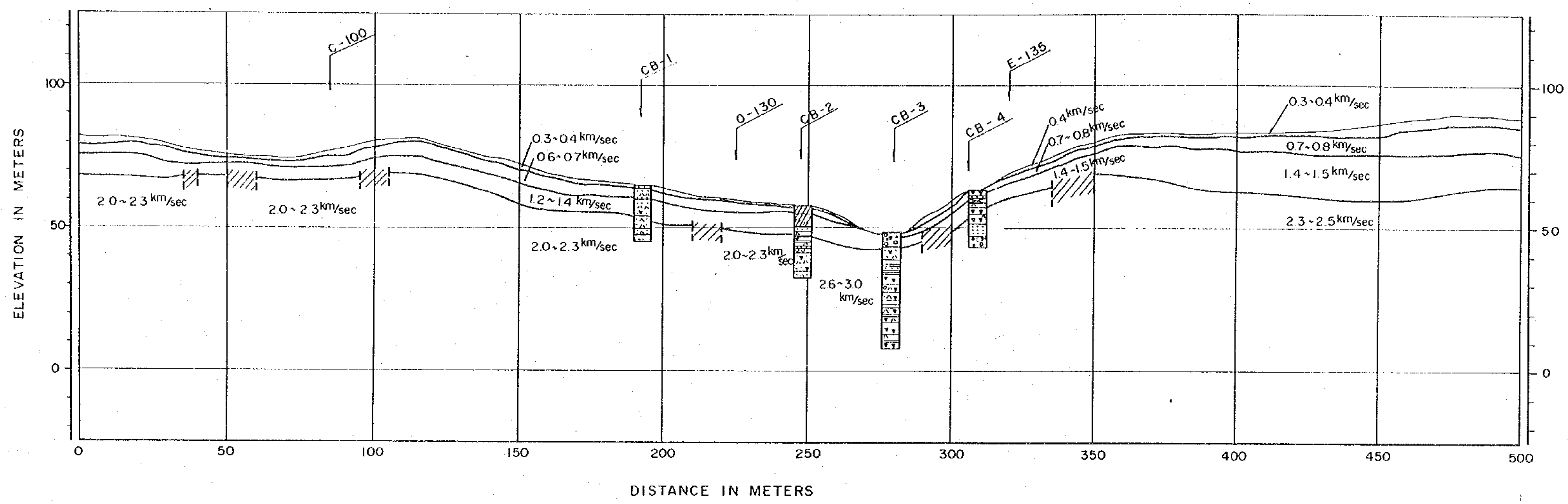
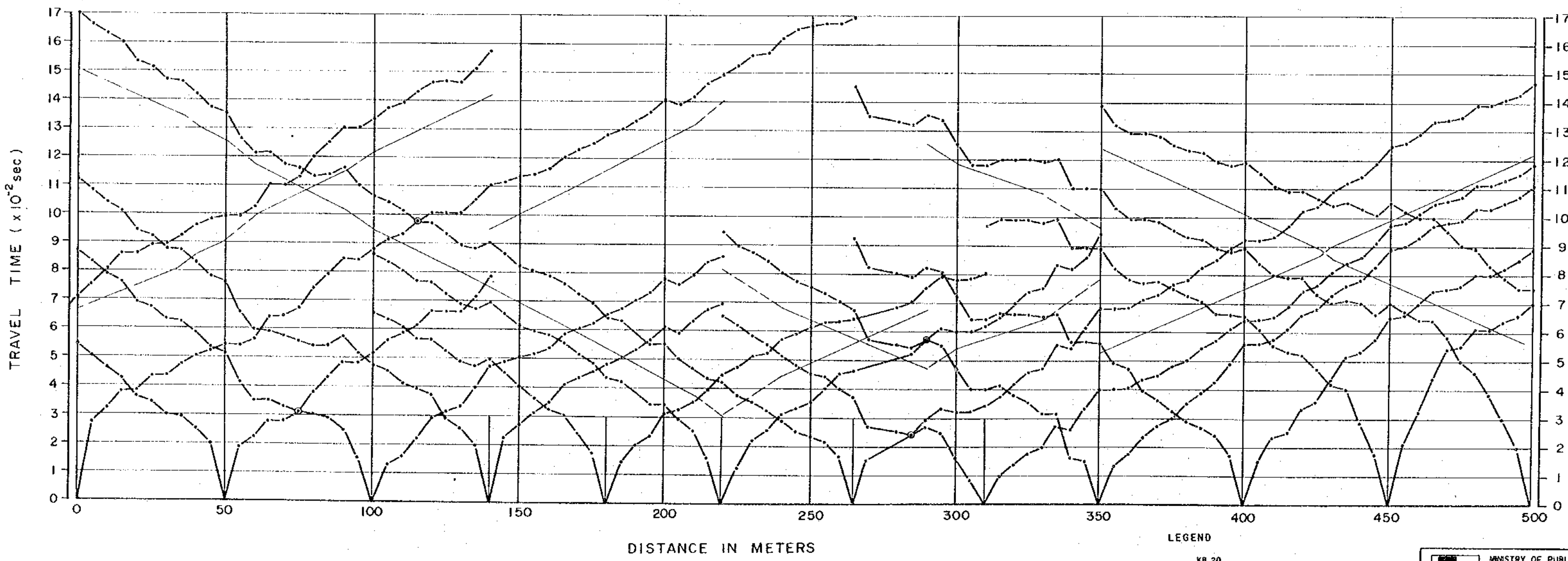
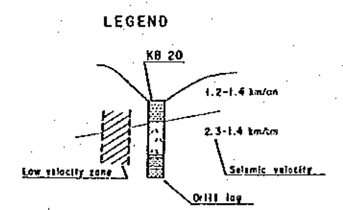
Fig.C-18

CILAWANG DAM - A LINE







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FEASIBILITY STUDY ON KARIAN MULTIPURPOSE DAM CONSTRUCTION PROJECT

Geophysical Profile of Cilawang Dam Site (Line A,B,C,D and E) (1/3)

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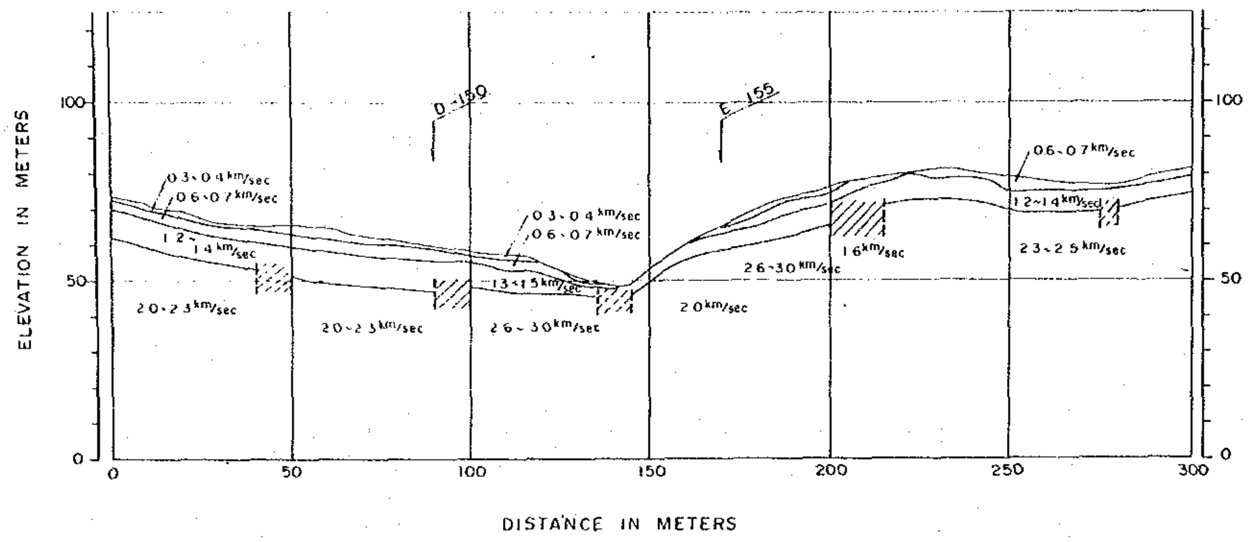
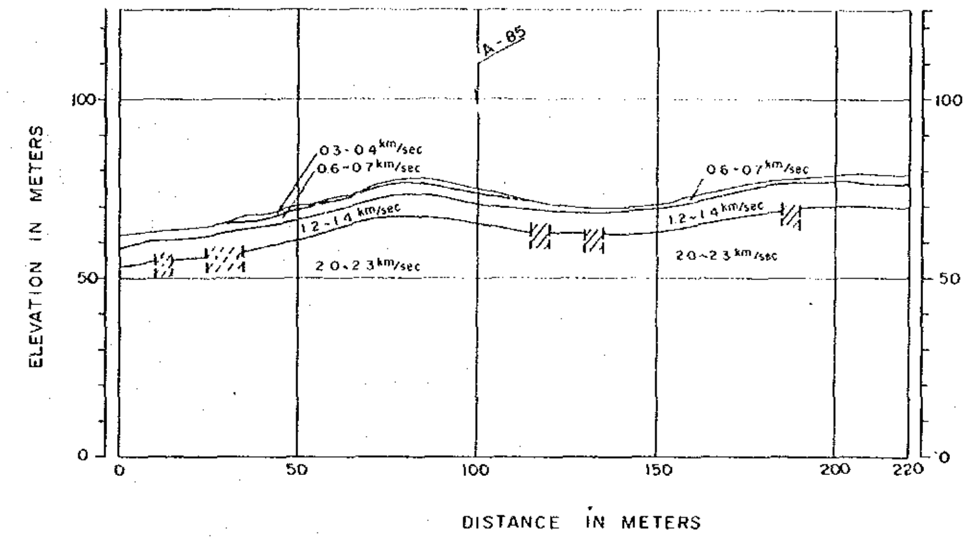
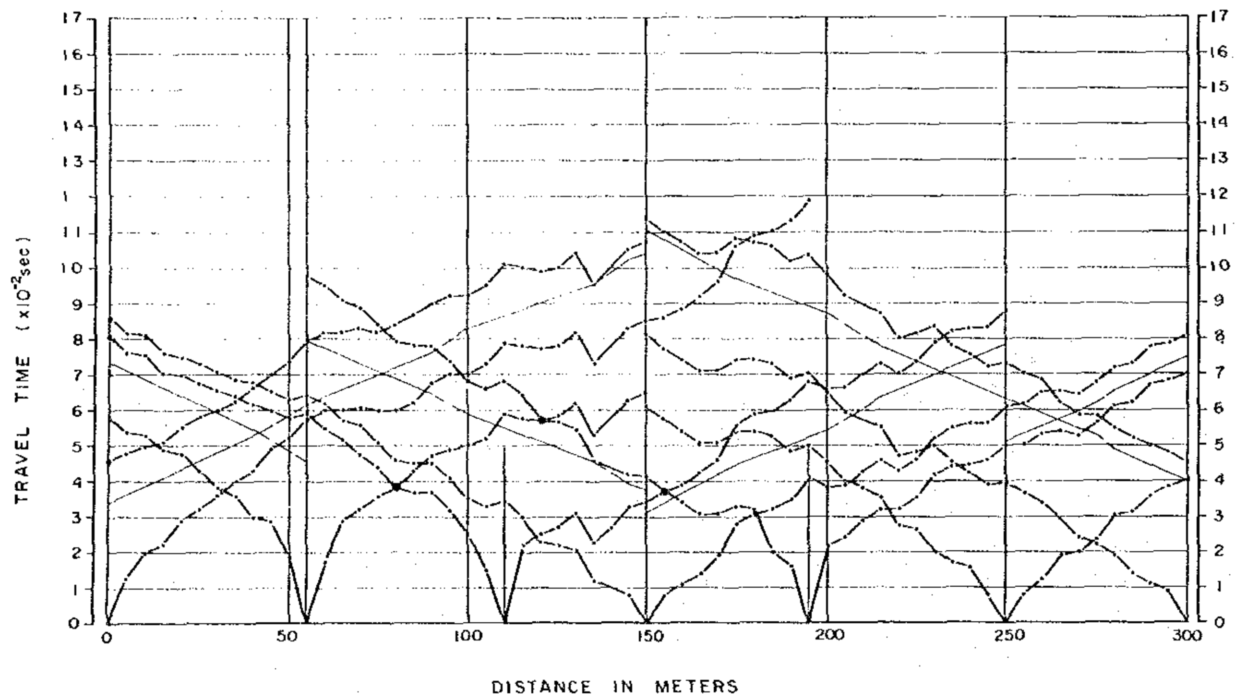
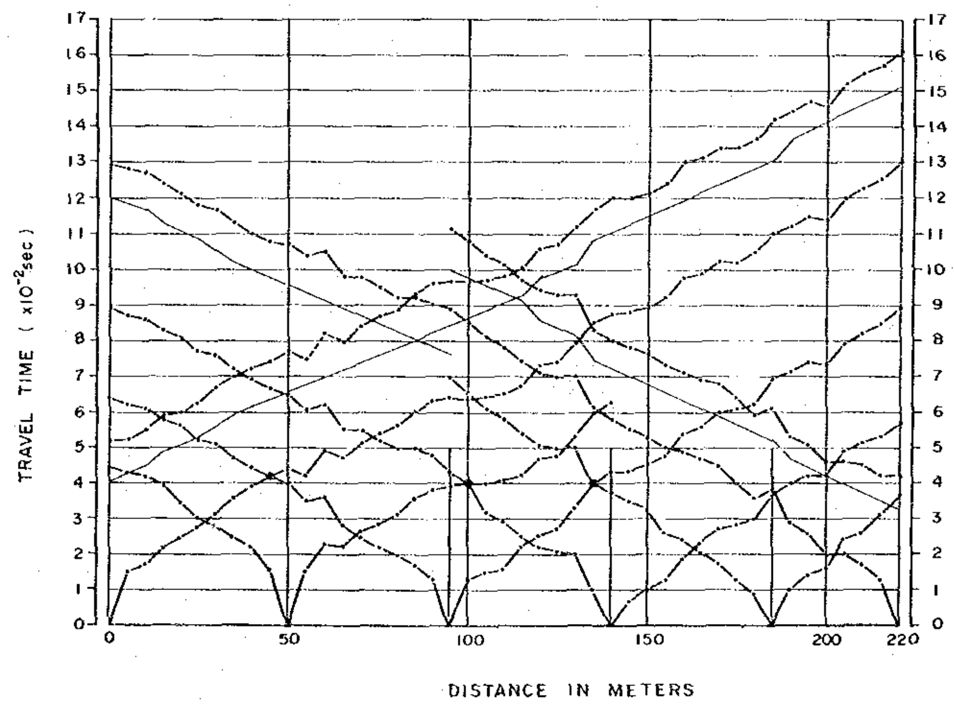
CILAWANG DAM - B LINE



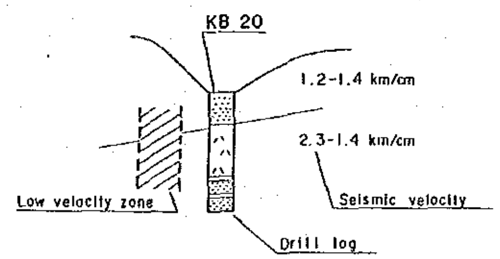
CILAWANG DAM - C LINE







LEGEND



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DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT
FEASIBILITY STUDY ON KARIAN
MULTIPURPOSE DAM CONSTRUCTION PROJECT

Geophysical Profile of Cilawang Dam Site
(Line A,B,C,D and E) (2/3)

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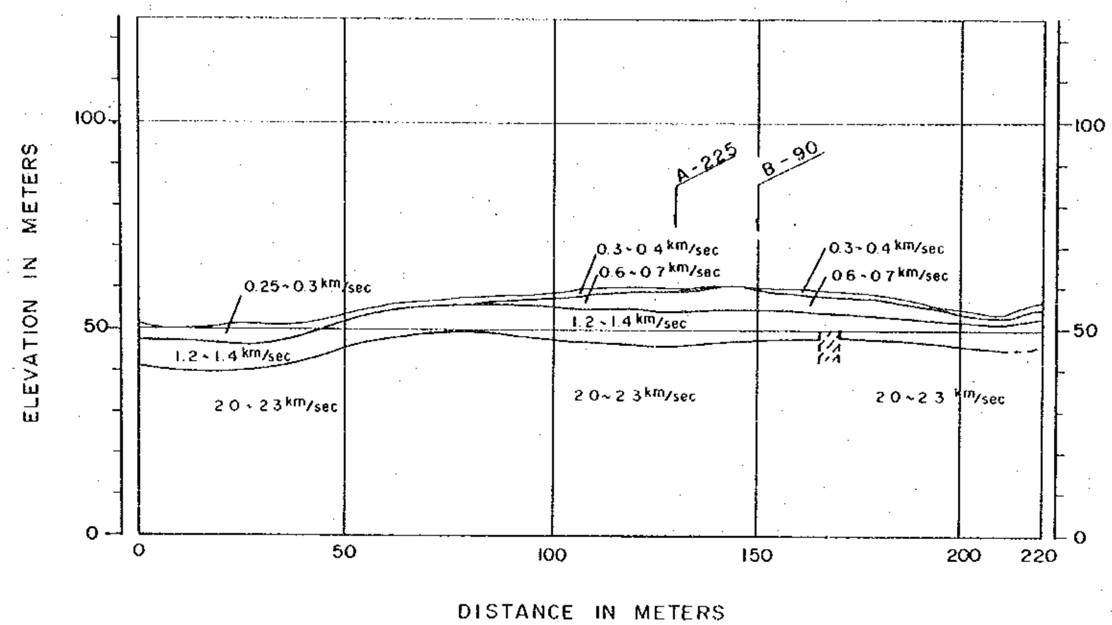
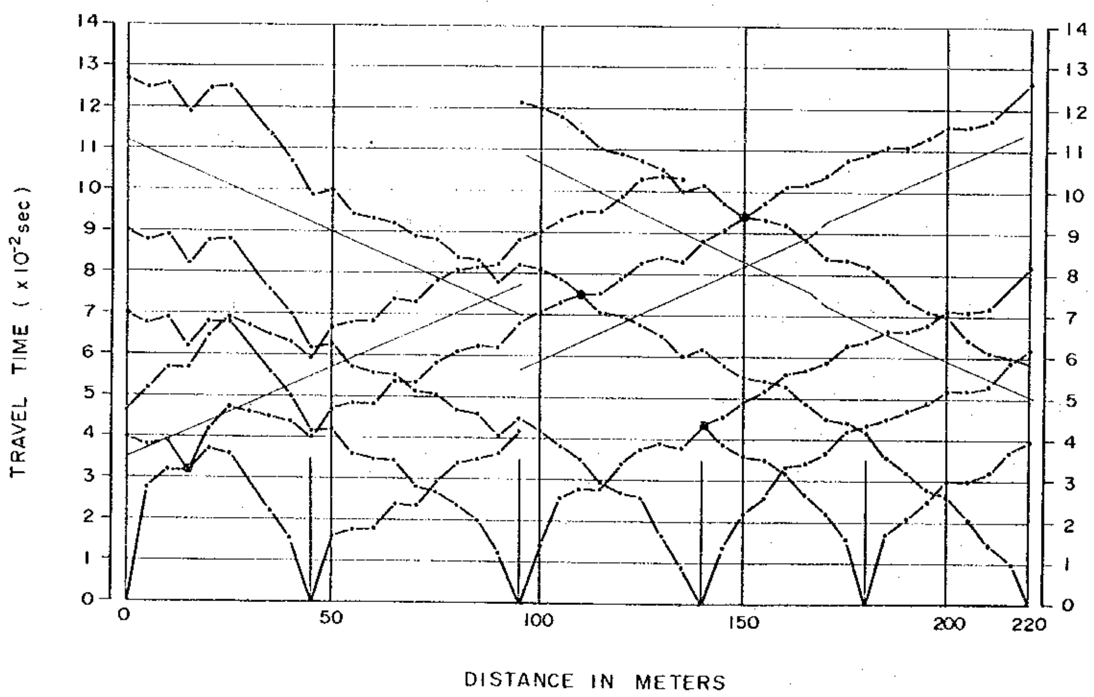
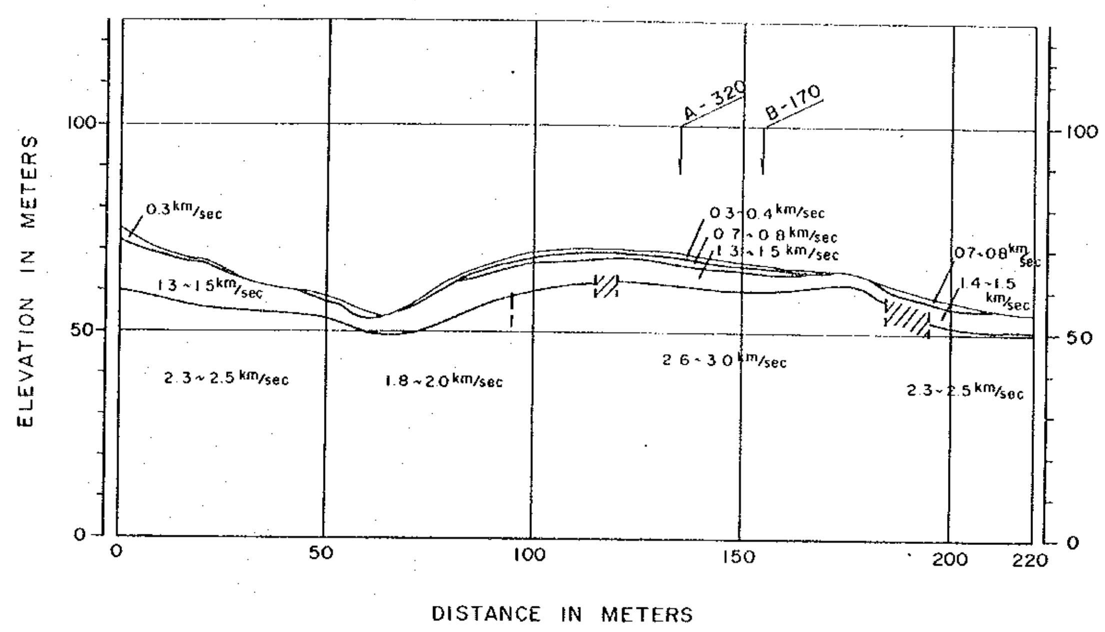
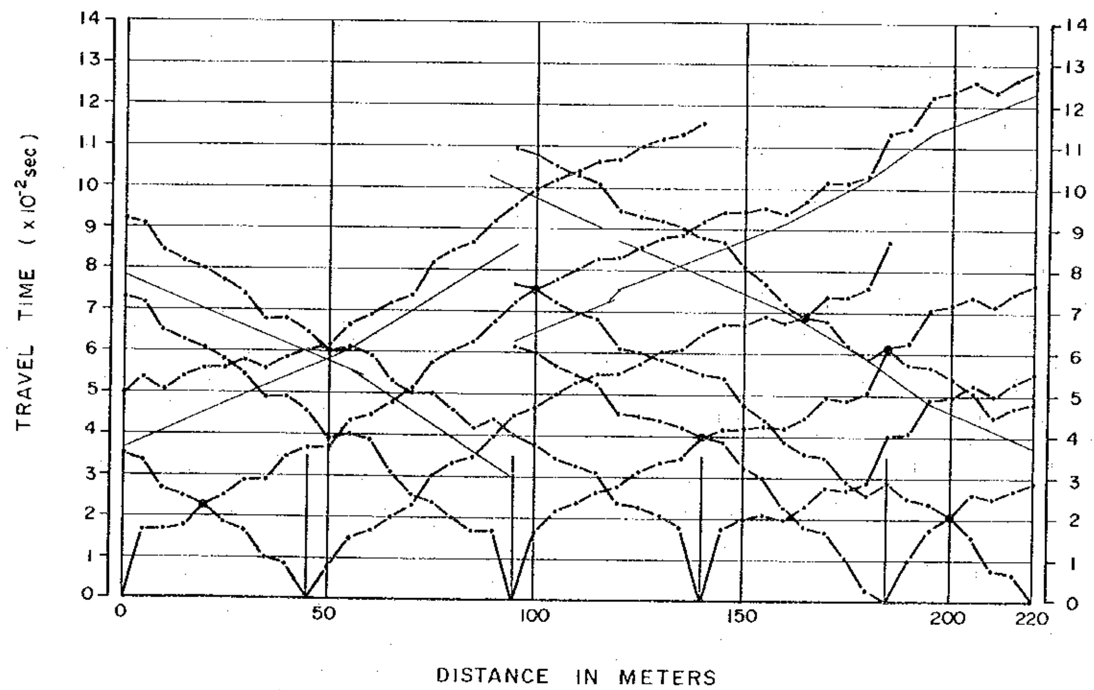
CILAWANG DAM - D LINE





CILAWANG DAM-E LINE





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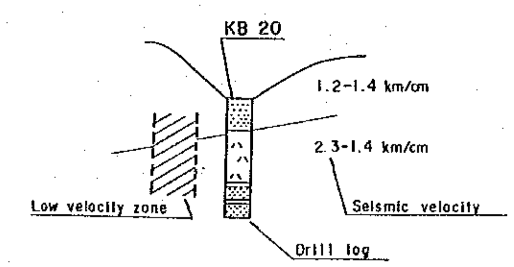

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FEASIBILITY STUDY ON KARIAN MULTIPURPOSE DAM CONSTRUCTION PROJECT

Geophysical Profile of Cilawang Dam Site (Line A,B,C,D and E) (3/3)

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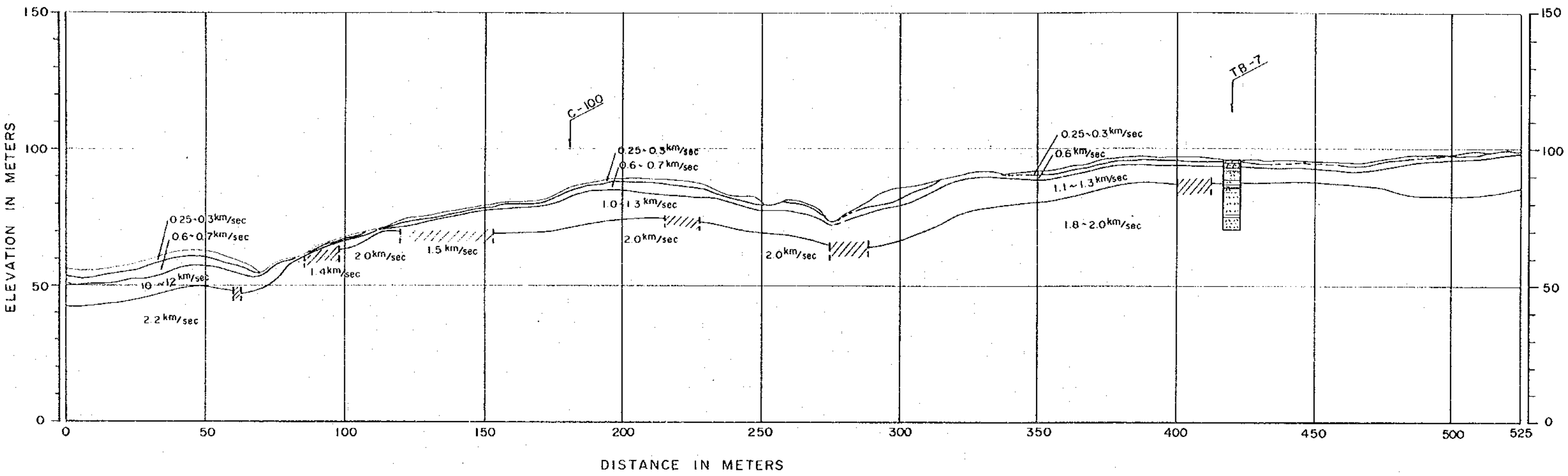
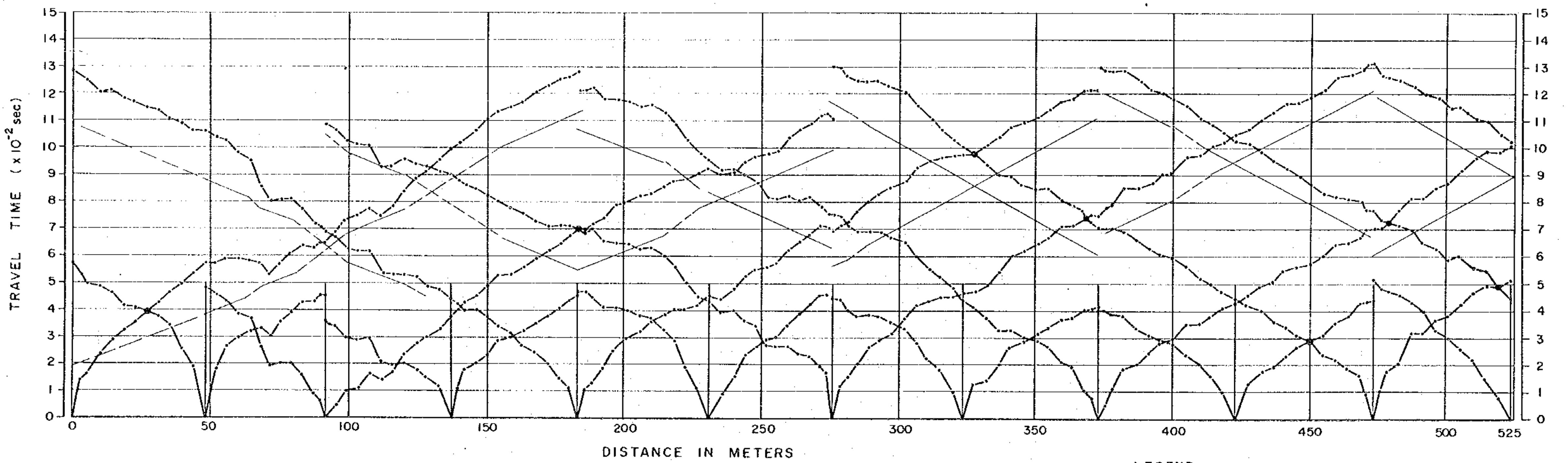
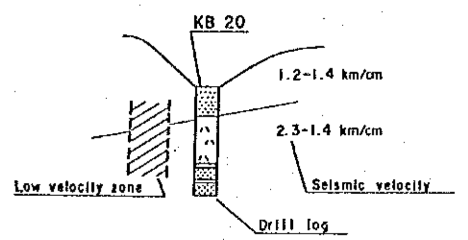
KARIAN-CIUYAH TUNNEL-A LINE (1/3)





LEGEND



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FEASIBILITY STUDY ON KARIAN MULTIPURPOSE DAM CONSTRUCTION PROJECT

Geophysical Profile of Karian - Ciuyah Tunnel (Line A,B,C,D,E,F and G) (1/7)

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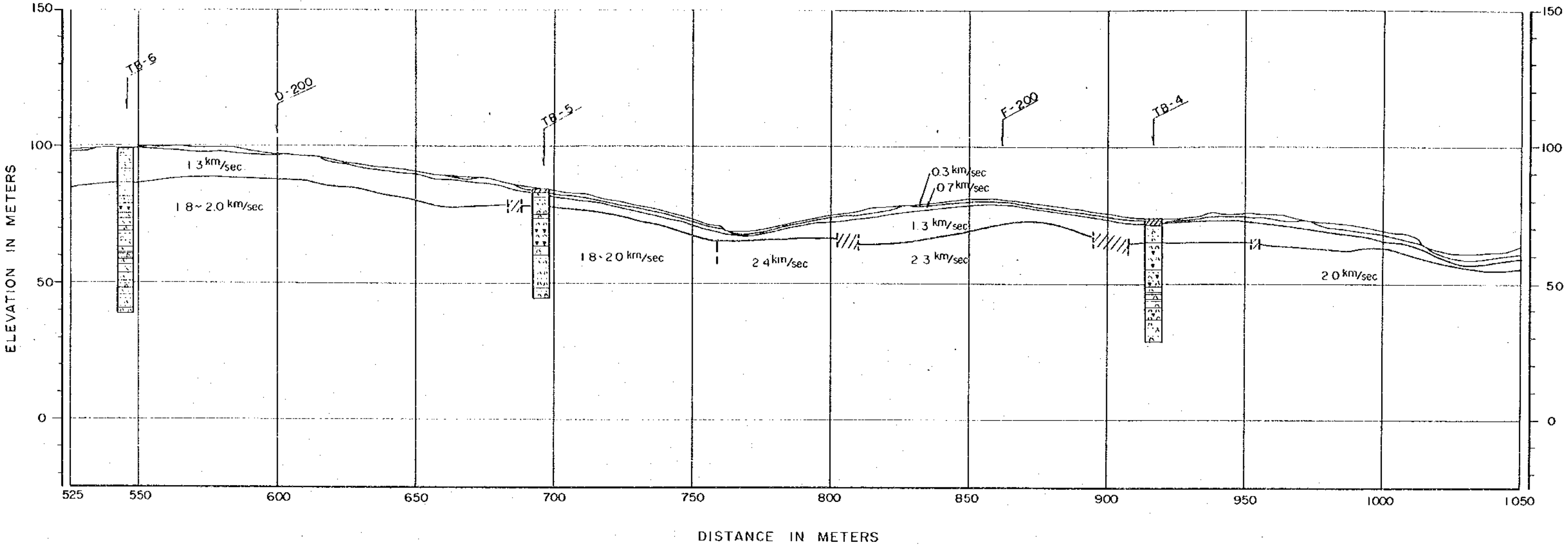
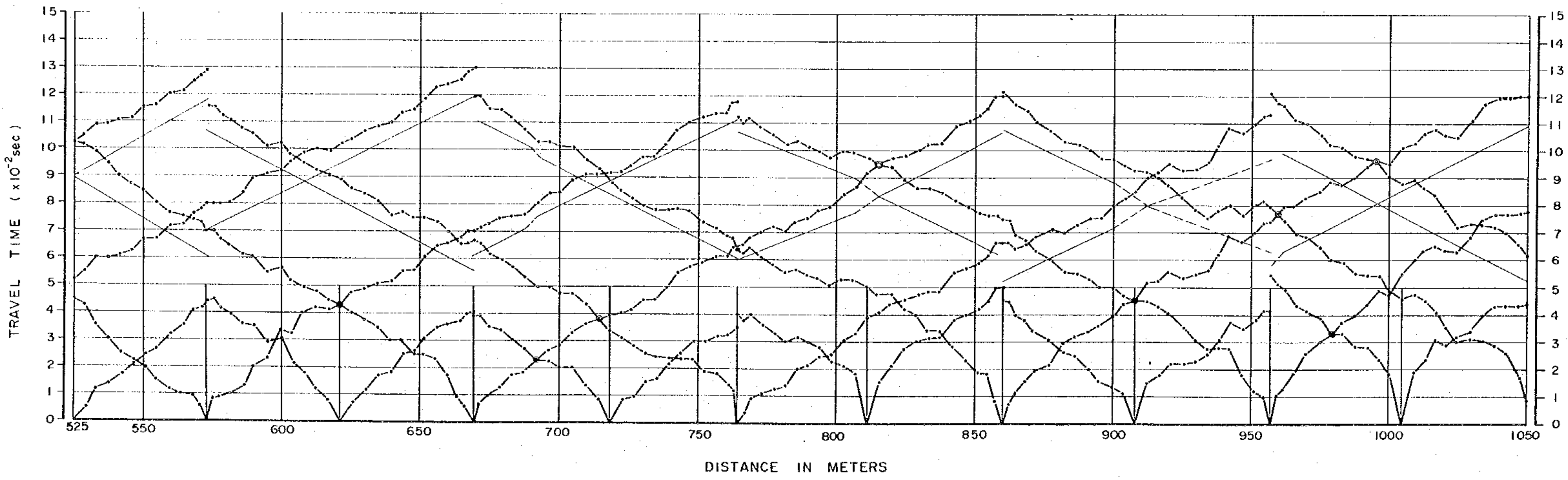
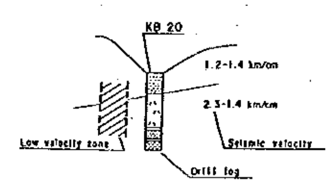
Fig.C-19

KARIAN - CIUYAH TUNNEL - A LINE (2/3)





LEGEND



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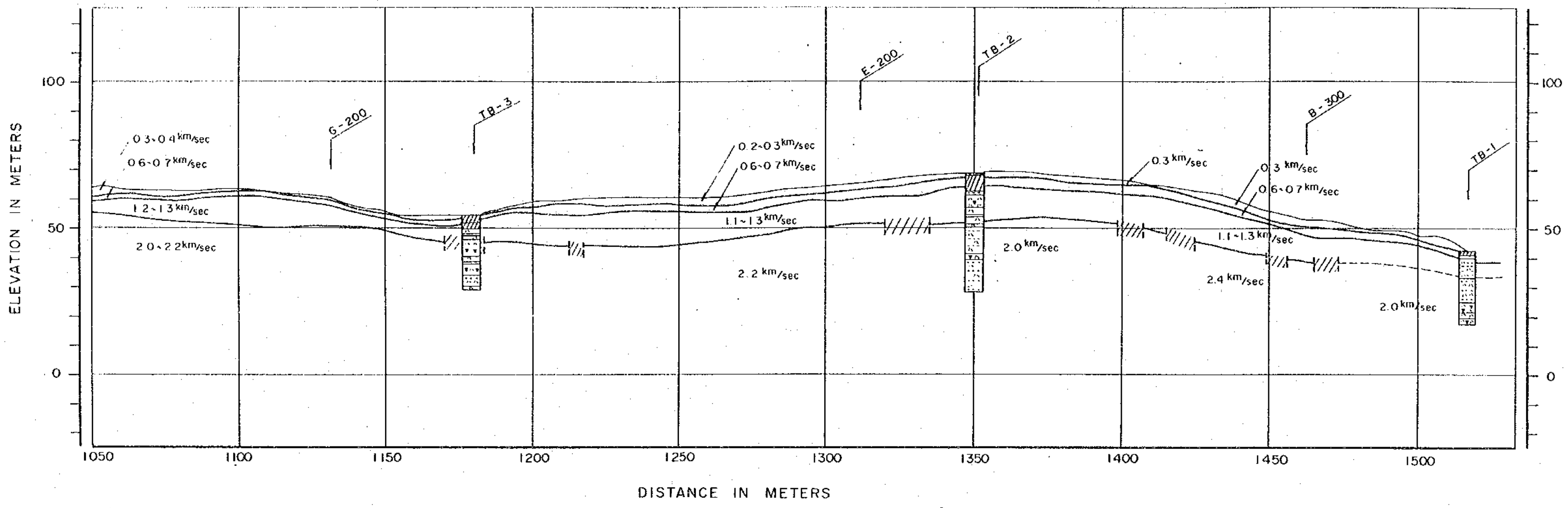
DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT
FEASIBILITY STUDY ON KARIAN
MULTIPURPOSE DAM CONSTRUCTION PROJECT

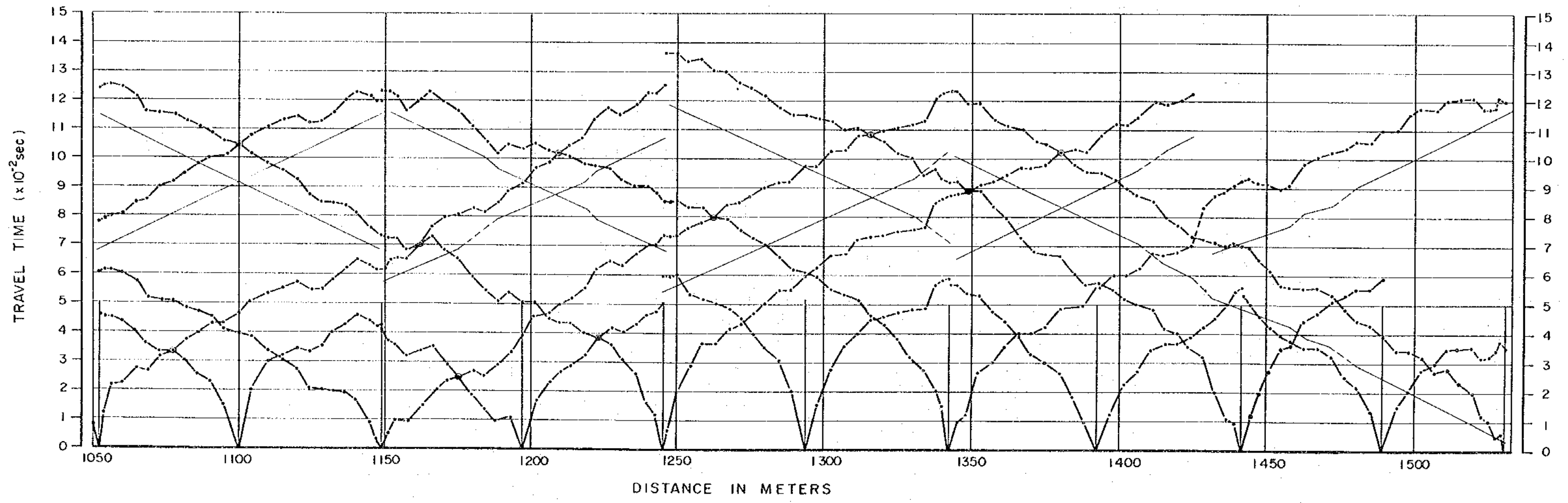
Geophysical Profile of Karian - Ciuyah Tunnel (Line A,B,C,D,E,F and G) (2/7)

JAPAN INTERNATIONAL COOPERATION AGENCY

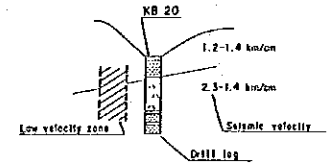
Fig.C-19

KARIAN - CIVYAH TUNNEL - A LINE (3/3)





LEGEND



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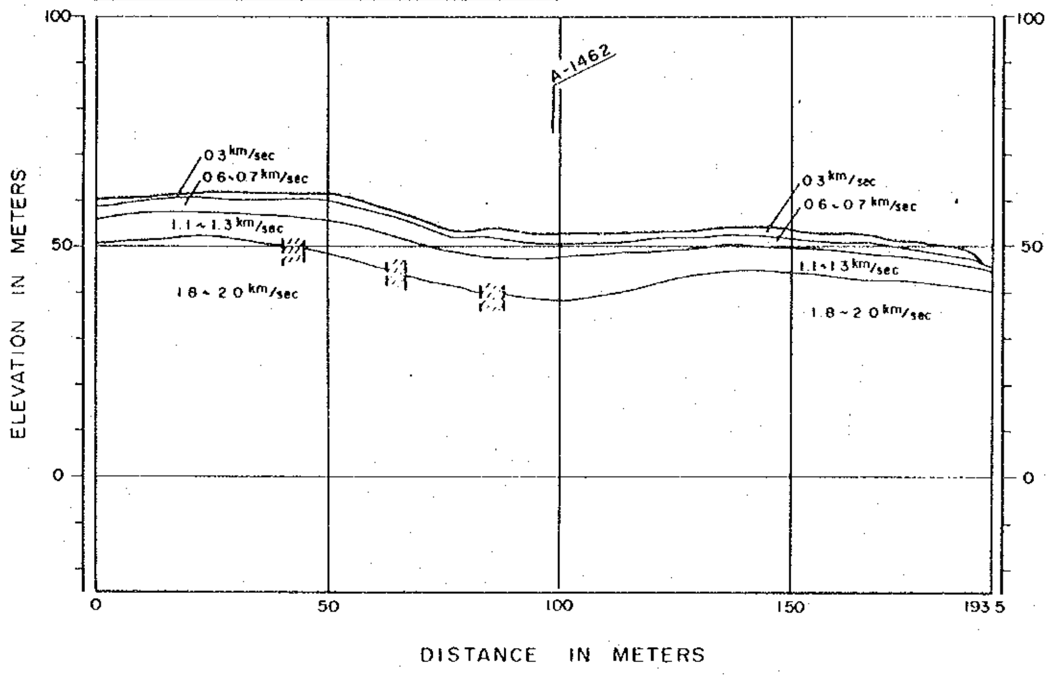
Geophysical Profile of Karian - Ciuyah Tunnel (Line A,B,C,D,E,F and G) (3/7)

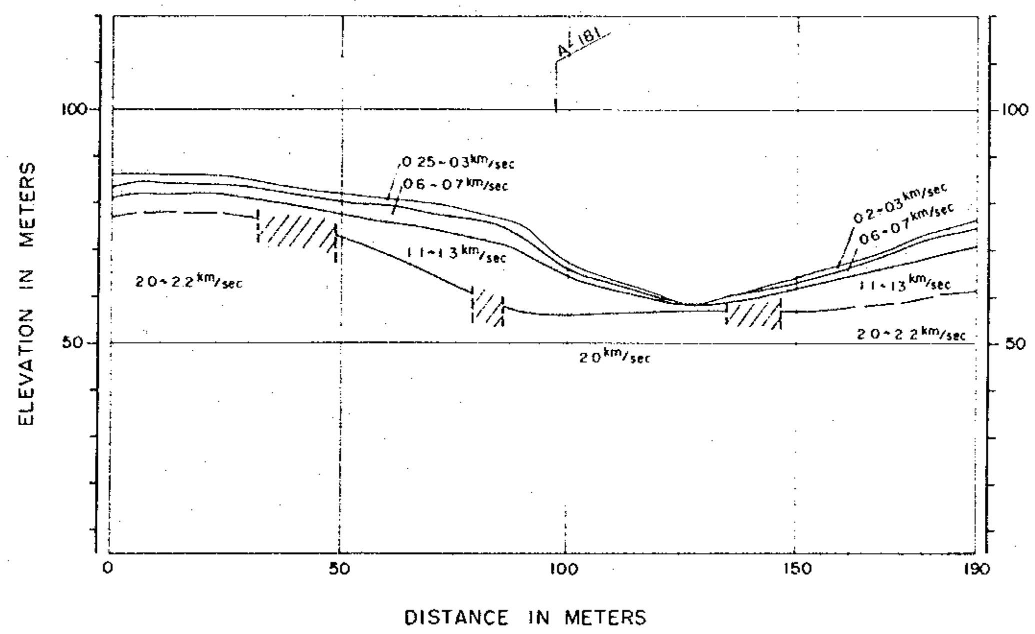
JAPAN INTERNATIONAL COOPERATION AGENCY

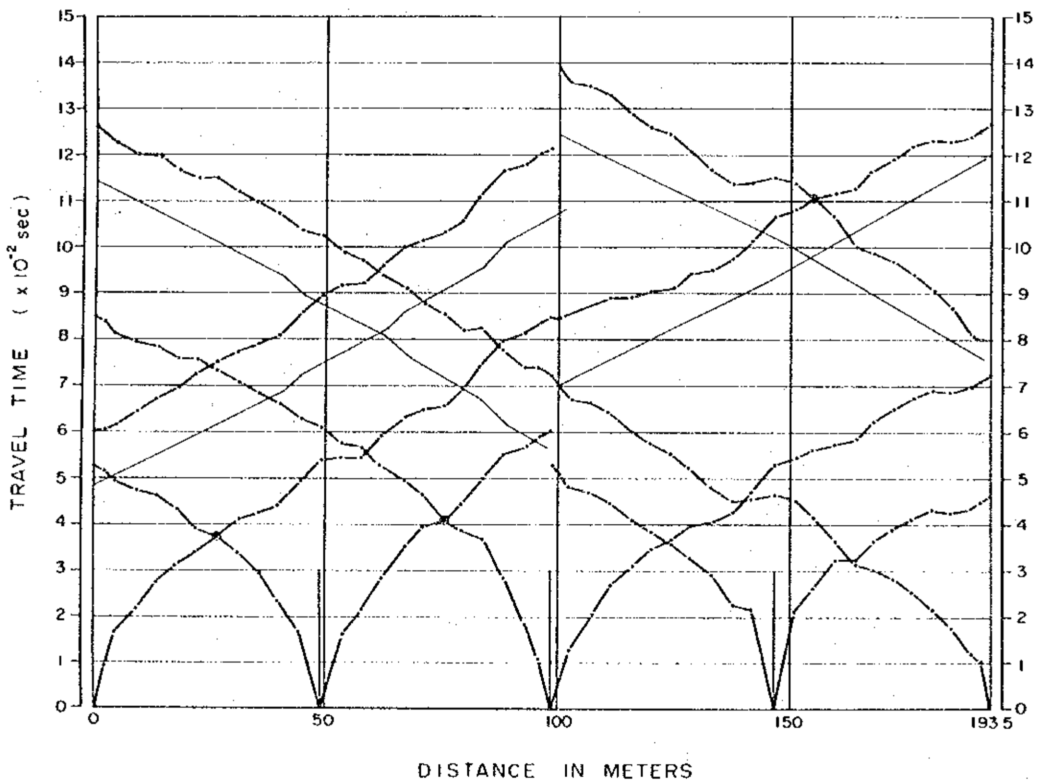
Fig.C-19

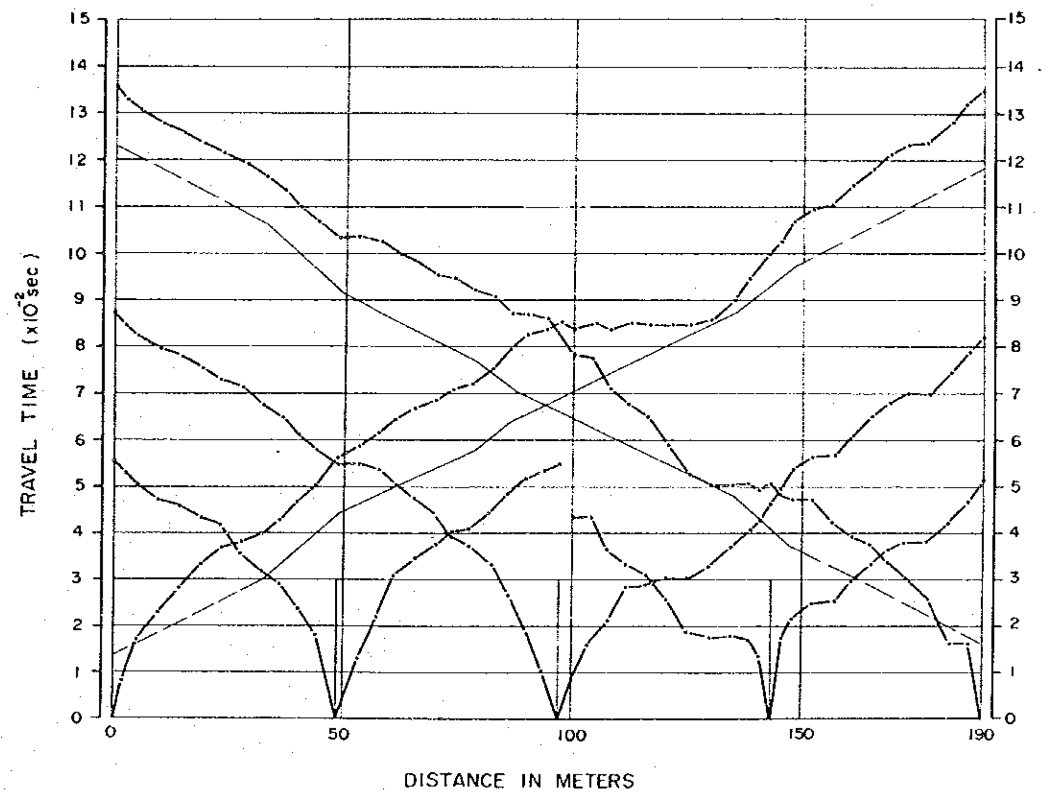
KARIAN - CIUYAH TUNNEL - B LINE



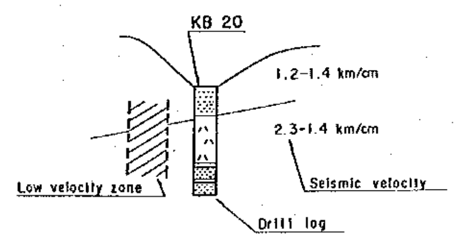
KARIAN - CIUYAH TUNNEL - C LINE







LEGEND



MINISTRY OF PUBLIC WORKS
DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT
FEASIBILITY STUDY ON KARIAN
MULTIPURPOSE DAM CONSTRUCTION PROJECT

Geophysical Profile of Karian - Ciuyah Tunnel (Line A,B,C,D,E,F and G) (4/7)

JAPAN INTERNATIONAL COOPERATION AGENCY