A N N E X M

SOURCES OF CONSTRUCTION MATERIAL

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M 1 INTRODUCTION

M 1.1 Objectives of Survey

This ANNEX presents the result of investigation for preliminary estimates of the qualities and quantities of construction materials at each proposed damsite.

Estimates of design values are also included for impervious core materials.

In this survey, emphasis was placed on investigations of the following:

In case of a rockfill type dam impervious core material and concrete aggregates for the volume of concrete required for other structures, and in case of a concrete gravity type dam, concrete aggregates for the entire volume of concrete required for the dam proper and other structures, with a principal aim being to select sources as close as possible to damsites.

M 1.2 Work Activity

This survey work was carried out from July 20 to Decmeber 27, 1978 and field investigations were made separated into the Northern Region (five sites consisting of Bamseonggol, Inje, Hongcheon, Gujeol and Ganhyeon) and the Southern Region (five sites consisting of Dalcheon, Bonghwa, Imha, Hamyang and Juam). The work activity comprised the following:

Northern Region

(1) Reconnaissance: from July 20 to 30.
(2) Test pitting and smapling: from July 31 to September 8 (This work was performed by counterparts).
(3) Material tests in laboratory: from August 10 to September 16 (at National Construction Research Institute in Korea).
(4) Supplemental reconnaissance: from September 9 to 11.
(5) Evaluation and reporting: from September 12 to 17.

Southern Region

(1) Reconnaissance, test pitting and sampling: from September 18 to November 4 (This work was performed by counterparts).
(2) Material tests in laboratory: from October 4 to November 23 (at National Construction Research Institute in Korea).
(3) Supplemental reconnaissance: from November 5 to 9.
(4) Evaluation and reporting: from November 10 to 16.
(5) Summarization and reporting: from November 15 to December 29.

M 1.3 Investigation Items

Field investigations were conducted first in the vicinity of damsites, then successively extending the area within about 10 km distance from the damsite, as a rule.

For concrete aggregates, river deposits of natural sand-gravel were explored.

In the field, test pits or trenches were dug at representative locations of borrow areas and river deposit sites, and upon examination of materials, sampling was carried out and laboratory tests were performed (see M 3 for test items). Sand-gravel materials were subjected to field sieve tests as required.

Further, quality and available quantity at each source were examined based on results of laboratory tests and field investigations. The allowance in available quantity at the material sources against the design quantity will differ depending on kinds of the materials, but 1.5 to 2.0 times of the design quantity in case of borrow area material and 2.0 to 2.5 times in case of river deposit material were considered as required available quantity.

As for borrow area materials, design values such as shearing strength and coefficient of permeability necessary for dam design were preliminarily estimated (see M 4).

In case of a rockfill type dam, filter material and rock material

will be involved in addition to impervious core material, and with regard to rock materials they are described in ANNEX L.

Special investigations were not made this time regarding filter materials, but it is thought possible to use river deposit materials as filter materials.

M 2 DESCRIPTION OF CONSTRUCTION MATERIAL SOURCES

Herein the general feature of the area explored, quality of material, and available quantity are described in regard to impervious core material and concrete aggregate at each damsites.

Comparisons are also made between approximate design volumes and available quantities for each project site.

Since the number of samples collected at the various areas was small in the present investigations, it can not necessarily be said that the whole picture of each area is presented.

M 2.1 Bamseonggol Damsite

M 2.1.1 General

The Bamseonggol scheme is as indicated in Fig. M 1.1. The Bamseonggol scheme is as indicated in Fig. M 1.1. There are two conceivable damsites in the vicinity. The distance between two sites is approximately 4 km.

The geology in the reservoir site consists mostly of granite and gneiss while there are sedimentary gravels at low-lying terraces along the riverbed. Impervious material of decomposed gneiss is scattered about in the hill area. Five sites were selected as borrow areas and three as river deposits for the upstream and downstream proposed sites (see Fig. M 1.1).

The provisional design quantities of construction materials for the two damsites are as indicated below (The design quantity hereinafter referred to are all provisional values).

For rockfill dam	(Upper Dam)	(Lower Dam)
Impervious core material	420×10^3 m^3	$1{,}100 \times 10^3$ m^3
Concrete structures	170×10^3 m^3	250×10^3 m^3
For concrete gravity dam	**(Upper Dam)**	**(Lower Dam)**
Concrete structures including dam	800×10^3 m^3	$1{,}850 \times 10^3$ m^3

M 2.1.2 Impervious core materials

Five locations were investigated as borrow area sites, the two sites of S-1 and S-4 were selected as borrow areas for the upstream dam scheme. For the downstream dam scheme, all of the sites from S-1 to S-5 were considered, but S-4 and S-5 are at long distances of about 7 to 8 km upstream from the damsite.

The individual borrow areas are described below.

(1) S-1 Area

This location is on the right bank approximately 1.8 km upstream from the upstream damsite comprising a gently-sloped hill area and is adjacent to an existing road.

The materials belong to the SC or SM group under the Unified Soil Classification System and are relatively well-graded. The quantity of material passing No. 200 sieve averages about 30 %. The average thickness of available material is about 3 m. The available quantity is thought to be in excess of 600×10^3 m^3, and this site is the most promising of the five locations.

(2) S-2 Area

The S-2 area is on the left bank at approximately 1 km upstream from the upstream damsite and is in the neighborhood of the intake site in the upper damsite. It is therefore a candidate borrow area in case of the lower dam.

In the soil classification the material belongs to the SM group and grain-size distribution is relatively good. The proportion passing No. 200 sieve is about 30 % and the material is deemed suitable for core materials.

However, accessibility from the downstream damsite is poor.

The average thickness of the available material is 2 to 3 m and around 260×10^3 m^3 would be available.

(3) S-3 Area

The S-3 area is located on the left bank approximately 1 km upstream from the downstream damsite. The soil classifications are SM and SC, the materials being well-graded with large proportions of gravel mixtures, while the amount passing No. 200 sieve is about 25 %.

The average thickness of available material is 1.5 to 2.0 m and the available quantity will be approximately 260 x 10^3 m^3.

(4) S-4 and S-5 Areas

The S-4 area is sited on the slope immediately east of Omiri Village and is approximately 3 km above the upstream damsite. The S-5 area is located to the north of S-4 and is on the right bank 1 km farther upstream.

Sampling was not done at these borrow areas, but the material at S-4 is similar to that at S-1 with a relatively high content of fine grains, while the S-5 area appears to have a high proportion of gravel.

It is thought that the quantities available are approximately 300 x 10^3 m^3 at S-4 and approximately 150 x 10^3 m^3 at S-5.

The results of the survey are summarized in Table M 1.1.

M 2.1.3 Sand and gravel materials

There are two river deposit areas between the upstream and downstream damsites and one above the upstream damsite, all of which are presently being utilized as rice paddies and fields. The sand and gravel consist of gneiss and granite with relatively large gravels.

(1) G-1 Area

This area is a narrow strip of approximately 2-km length on the right bank about 2 km upstream from the upstream damsite. This is in a wide area presently being cultivated as rice paddies

and fields. The maximum diameter of gravel is about 40 to 50 cm, and although flat and elongated pieces are partly contained, the deposit is generally composed of rounded gravel.

The grain-size distribution is as indicated in Table M 6, with gradation coarser than required for concrete. The average thickness of available materials is about 5 m and the total volume is estimated to be approximately 1,200 x 10^3 m^3.

This area is closest to the damsite with good accessibility, and is the most advantageous of the three sites.

(2) G-2 and G-3 Areas

Both of these areas are located between the upstream and downstream damsites with G-2 on the left bank 1.5 km downstream from the upstream damsite and G-3 at a point on the right bank 0.6 km upstream from the downstream damsite. The sand and gravel at the G-2 site are of relatively good grainsize distribution with large proportions of rounded particles. Sand is comparatively of high content of fine grains. The G-3 area is deemed to have materials of almost same quality as at G-2. The thickness of available material is about 5 m at G-2 and about 8 m at G-3 and the available quantities are estimated to be approximately 600 x 10^3 m^3 and 160 x 10^3 m^3, respectively.

Available quantity of sand-gravel for upstream damsite

In case of a rockfill type dam the river deposit at G-1 is of sufficient quantity for the assumed design concrete volume of 170 x 10^3 m^3.

In case of a concrete gravity type dam, the available quantity at G-1 and G-2 would be about 2.2 times for the design concrete volume of approximately 800 x 10^3 m^3, and it is considered sufficient for required concrete aggregates for the upstream plan.

Available quantity of sand-gravel for downstream damsite

In case of a rockfill type dam, the available quantity at G-2 and G-3 will be approximately 3.0 times the design concrete volume of 250 x 10^3 m^3.

In case of a concrete gravity type dam, even if all of the river deposit sites of G-1, G-2 and G-3 are used, the quantity will be only 1.1 times the design concrete volume of approximately 1,850 x 10^3 m^3, being only about one half for the requirement. Therefore, quarry would have to be considered. The results of the survey are summarized in Table M 1.2.

M 2.2 Inje Damsite

M 2.2.1 General

The plan for Inje is as indicated in Fig. M 1.2 with two proposals, Upper and Lower. There is a distance of approximately 4 km between the two sites.

The vicinities of the two proposed damsites show topographies of ridges getting close between both banks. Consequently, suitable borrow areas or river deposits are not available in the neighborhoods of the damsites and it will be unavoidable to seek them at distant points either upstream or downstream.

Five sites were selected as borrow areas and five as river deposits for the upstream and downstream proposed sites in the present explorations, all of which are long distances away.

The approximate provisional design quantities of the dams at two sites are as indicated below.

For rockfill dam	(Upper Dam)	(Lower Dam)
Impervious core material	780 x 10^3 m^3	2,100 x 10^3 m^3
Concrete structures	250 x 10^3 m^3	300 x 10^3 m^3

For concrete gravity dam	(Upper Dam)	(Lower Dam)
Concrete structures including dam	$1,450 \times 10^3$ m^3	$3,400 \times 10^3$ m^3

M 2.2.2 Impervious core material

There was no adequate site as a borrow area in the vicinity of the upstream damsite and three areas were selected in a distance between 5 to 9 km upstream from the damsite.

The downstream damsite did not have any suitable borrow area in its neighborhood and two areas were selected 7 to 8 km downstream from the damsite.

The locations are as indicated in Fig. M 1.2.

The materials at all of these borrow areas consist of decomposed granite.

The features of each borrow areas are as described below.

(1) S-1 Area

This area is located on the right bank approximately 6.5 km upstream from the upstream damsite and is adjacent to the existing road. The material belongs to SC or ML under the Unified Soil Classification System and gradation is relatively good although grains are of fine size. The amount passing No. 200 sieve is 38 % to 55 %.

The average thickness of the available material is 2.5 m and the quantity available is approximately 310×10^3 m^3.

(2) S-2 and S-3 Areas

The S-2 area is on the right bank about 5 m upstream from the damsite, being approximately 100 m higher than the existing road. There will be a problem of accessibility.

The S-3 area is on the right bank about 9 km upstream from the damsite and is at a place adjacent to the existing road.

The available quantities will be approximately 150 x 10^3 m^3 and 100 x 10^3 m^3, respectively. Neither is faborable as a borrow area.

(3) S-4 and S-5 Areas

The S-4 area is at the eastern slope of the confluence with the Bugcheon approximately 7 km downstream from the downstream damsite and comprises a wide hill area. The materials belong to the SC, SM and CL groups according to the Unified Soil Classification System. Material passing No. 200 sieve is 25 % to 50 % and grain-size distribution is relatively good.

The S-5 area is located on the opposite bank of S-4 across a small stream and similarly to S-4. It is a broad area. The material is roughly the same as at S-4.

The average thickness of available material at the two areas is about 2 m, and the available quantities are thought to be in excess of 1,400 x 10^3 m^3 and 800 x 10^3 m^3, respectively.

The total available quantity only at the upstream borrow areas of S-1, S-2 and S-3 is insufficient for the upstream dam scheme, so S-4 (10.5 km downstream) must be added. In this case, the quantity will be about 2.5 times the approximate design volume.

On the other hand, the total available quantity only at the borrow areas of S-4 and S-5 will be insufficient for the upstream dam and it will be necessary to add the upstream S-1 area (10 km). In this case, the available quantity will be about 1.2 times the approximate design volume, which will be still rather short. It is necessary to make further investigations to ascertain quantities.

The results of the survey are summarized in Table M 1.3.

M 2.2.3 Sand and gravel material

Three river deposit sites were selected for the upstream dam. The site G-2 is in the vicinity (1.2 km upstream) of the damsite, but the

available quantity here is small. G-1 and G-3 are at a point 5 km and 8 km upstream, respectively, at the left bank, being distant away from the damsite. G-3 is a long and narrow area extending along the river.

The available quantities are about 500 x 10^3 m^3 at G-1, 50 x 10^3 m^3 at G-2 and 450 x 10^3 m^3 at G-3, respectively.

The sand and gravel consist of granite and gneiss, and although there is partial content of flat pieces of gravel material is sufficiently usable as concrete aggregate. The G-1 area has high gravel content (maximum size 70 cm) at the upstream part and high sand content at the downstream part.

Available quantity of sand-gravel for upstream damsite

In case of a rockfill type dam the available quantity of sand-gravel at G-1 and G-2 is 2.2 times the design concrete volume. Depending on the gradations of the deposit materials this quantity may be insufficient. In such case the G-3 area would be added.

In case of a concrete gravity type dam, the total quantity available at the upstream G-1, G-2 and G-3 areas would be 1,000 x 10^3 m^3, or 0.7 times the design concrete volume, being short for requirement. Even when the sand and gravel at the downstream G-4 and G-5 areas are added the quantity will be only 1.2 times the design concrete volume, still being not enough. The G-4 and G-5 sites are very far away (10 to 11 km) and would be economically injustifiable.

Consequently, in anyway, it will be necessary to consider a separate quarry site in case of a concrete gravity type dam.

Available quantity of sand-gravel for downstream damsite

In case of a rockfill type dam the available quantity from G-1 and G-2 together will be 1.8 times the design concrete volume, and approximately 3.7 times, if G-3 were to be added, sufficiently meeting the requirements. However, all of these sources are long distant (5 to 8.5 km) away from the damsite.

In case of a concrete gravity type dam the design concrete volume would be greatly increased to approximately 3,400 x 10^3 m^3, and there will be a huge shortage even if all of the river deposits from G-1 to G-5 were to be utilized. Therefore, it is unavoidable to consider a separate quarry site. The results of the survey are summarized in Table M 1.4.

M 2.3 Hongcheon Damsite

M 2.3.1 General

The Hongcheon damsite is as indicated in Fig. M 1.3. Quartzite, schist and gneiss are distributed over the reservoir area. The areas are generally hilly. The damsite is at the end of the backwater of Cheongpyeong reservoir while the river gradient is so gentle that there is much sand-gravel depositing in the riverbed.

The approximate design quantities in case rockfill is selected as the dam type will be the following:

Impervious core material	approx.	510 x 10^3 m^3
Concrete structures	approx.	150 x 10^3 m^3

In case concrete gravity is selected as the dam type the total volume of concrete will be the following:

Dam and other structures	approx.	800 x 10^3 m^3

M 2.3.2 Impervious core material

A borrow area was selected at a tableland on the left bank approximately 1.5 km upstream from the damsite. The material is of decomposed gneiss belonging to CL and SC under the Unified Soil Classification System.

Material passing No. 200 sieve amounts to 30 % to 60 %, and consequently, this is a fine-grained soil.

Material close to the ground surface is relatively plastic, but underlying material is slightly plastic.

The available quantity is thought to be in excess of 900 x 10^3 m^3 and about 1.5 times the design quantity. It is considered that adequate supply can be made to meet requirements.

M 2.3.3 Sand and gravel material

Three river deposit sites were selected (see Fig. M 1.3). These areas are all in the vicinity of the damsite. G-1 is at the left bank immediately upstream and G-3 is at the left bank 2 km upstream from the damsite. G-2 is located at the right bank side immediately downstream of the damsite.

This area, as a whole, has high sand content with little gravel, but the gravel gradation is good, being not much different from the gradation for concrete aggregate. The gravel has a high content of gneiss and there is a large number of slightly flat pieces.

The available quantities are approximately 300 x 10^3 m^3 at G-1, 800 x 10^3 m^3 at G-2 and 540 x 10^3 m^3 at G-3 for a total of 1,640 x 10^3 m^3.

In case of a rockfill type dam the requirements for the volume of concrete can be met with material from either G-1 or G-2.

In case of a concrete gravity type dam the total available quantity from G-1 to G-3 will be approximately two times the design volume and it is considered possible to meet requirements. Even if the quantity were found insufficient, there are adequate sufficient deposits upstream and downstream of these borrow areas and the project itself will not be adversely affected.

M 2.4 Gujeol Damsite

M 2.4.1 General

The Gujeol damsite is as indicated in Fig. M 1.4. A gentle hilly feature is predominant upstream of the damsite with wide terraces formed at the riverbed. The reservoir area consists of weathered granite, and because of the small catchment area, there is some amount of impurities

mixed in the sand-gravel deposits at the terraces, while weathered rock is likely contained in the gravel.

Consequently, thorough investigations will further be required with respect to suitability as concrete aggregate.

The approximate design quantities in case the dam type is of rockfill type will be 120 x 10^3 m^3 of impervious core material and 100 x 10^3 m^3 of concrete for appurtenant structures.

In case the dam type is to be of concrete gravity type the total volume of concrete for the dam and other structures will be approximately 250 x 10^3 m^3.

M 2.4.2 Impervious core material

A hill area at the right bank side approximately 1.2 km upstream from the damsite was selected as the borrow area. The material is decomposed granite belonging to ML or CL according to the Unified Soil Classification System.

Material passing No. 200 sieve is 50 % to 80 % and the soil on the whole is fine.

There is a high content of smaller gravels down to a depth of not more than 2 m, and good-quality impervious material will be obtained by mixing together the upper and lower layers.

The available quantity is approximately 700 x 10^3 m^3 at an average thickness of 3 m and there is ample quantity for the design volume.

M 2.4.3 Sand and gravel material

Three river deposit sites were selected (see Fig. M 1.4). All are upstream of the dam, G-1, being 3.5 km away at the left bank, G-2, 5.5 km away also at the left bank and, G-3, 5.5 km away at the right bank. All the sites are terraced areas of farm lands. A common feature of the three sites is that the surface portion (depth 1 to 1.5 m) are almost completely of sand with a large portion of fine grains. Since

it is also conceivable that organic matter is contained thorough investigations would be necessary.

The available quantities at G-1, G-2 and G-3 are about 70 x 10^3 m^3, 60 x 10^3 m^3 and 20 x 10^3 m^3, respectively, the total being 150 x 10^3 m^3.

The available quantity compared with the design volume is 1.5 times in case of a rockfill type dam, which is though insufficient, while in case of a concrete gravity type dam it is 0.6 times, being entirely insufficient. Accordingly, it will be necessary to consider a quarry site.

M 2.5 Ganhyeon Damsite

M 2.5.1 General

The Ganhyeon damsite is as indicated in Fig. M 1.5. Large-scale terraces are developed at the river banks upstream and downstream of the damsite and it is sufficiently possible to collect impervious core materials as well as sand and gravel from the vicinity of the dam.

The approximate dam volumes in case of a rockfill type are about 130 x 10^3 m^3 of impervious core material and about 100 x 10^3 m^3 of concrete for appurtenant structures. As for the case of the dam planned as a concrete gravity type the total volume of concrete for the dam and other structures will be approximately 200 x 10^3 m^3.

M 2.5.2 Impervious core material

A borrow area was selected at the southern slope (800 m in straight-line distance) beyond the saddle at the left bank side of the dam axis.

The material is of decomposed granite belonging to SM and SC under the Unified Soil Classification System.

The material passing No. 200 sieve is around 35 % and the gradation is good. The average thickness is about 2 m and the available quantity is in excess of 1,000 x 10^3 m^3 so that there is ample volume for the design quantity.

M 2.5.3 Sand and gravel material

A terrace at the right bank approximately 1 km from the dam was selected as the river deposit site.

The material comprises a sand-gravel layer of granite and gneiss, and although it has the high content of large gravels compared with the adequate gradation of concrete aggregate, the material quality is generally good. The average depth of deposition is large at this site and is thought to be more than 5 m indicating the advantage of this site. The available quantity is estimated to be approximately 870 x 10^3 m^3.

The available quantity is equivalent to more than 8.0 times the concrete volume in case of a rockfill type dam and more than 4.0 times the total concrete volume in case of a concrete gravity type. Then, there is no problem as for supply capacity.

M 2.6 Dalcheon Damsite

M 2.6.1 General

The Dalcheon damsite is as indicated in Fig. M 1.6. The river in the reservoir area has many deposits of sand-gravel with development of terraces at various places along the river banks, and these are being utilized as agricultural land. The geology at the damsite consists of granite, but there is much distribution of gneiss in the reservoir area.

Prospective borrow areas and river deposits are abundant in the vicinity of the damsite.

The design quantities for this project are the following:

For rockfill dam

Impervious core material	270 x 10^3 m^3
Concrete structures	100 x 10^3 m^3

For concrete gravity dam

Concrete structures including dam	450 x 10^3 m^3

M 2.6.2 Impervious core material

Five locations were selected as borrow areas within a 3.5 km upstream and downstream from the damsite. The material is almost entirely of decomposed gneiss and is composed of fine grain soil as a whole.

(1) S-1 Area

The area is situated at a gentle slope on the right bank immediately upstream (0.4 km) of the dam. The material is gravelly silt and a fine grain soil. The proportion of the material passing No. 200 sieve is 50 % to 70 %. The soil belongs to ML under the Unified Soil Classification System and is of low plasticity.

The average thickness is about 1.5 m and the available quantity is approximately 370×10^3 m^3.

(2) S-2 Area

This area is at a point on the left bank approximately 1.5 km upstream from the damsite and consists of micaceous and silty soils which are fine-grained. The proportion passing No. 200 sieve is 50 % to 60 % and the material belongs to SM and MH under the Unified Soil Classification System.

The average thickness is about 1.5 m and the available quantity is approximately 310×10^3 m^3.

(3) S-3 Area

This area is on the left bank immediately downstream of the damsite. The material is coarse-grained compared with those at S-1 and S-2. The proportion passing No. 200 sieve is about 35 %. The material belongs to SM according to the Unified Soil Classification System.

The average thickness is about 1.5 m and the available quantity is approximately 110×10^3 m^3.

(4) S-4 and S-5 Areas

The S-4 area is on the right bank 3.5 km upstream from the

damsite while the S-5 area is on the left bank 1.2 km downstream from the damsite. Sampling was not done in particular at these sites, but it is estimated that the materials are more or less the same as for the other sites.

The average thickness is about 1.5 m and the estimated available quantity approximately 210 x 10^3 m^3 at S-4, while at S-5 these are about 1 m and approximately 75 x 10^3 m^3, respectively.

The total quantity from S-1 to S-5 corresponds to 4 times the design quantity. Even with just the two areas of S-1 and S-2 the volume is approximately 2.5 times and there is adequate supply capacity.

The results of the survey are summarized in Table M 1.5.

M 2.6.3 Sand and gravel material

River deposits are distributed more or less continuously in the river channel from approximately 2.5 km downstream to approximately 4 km upstream.

The materials of the sand-gravel are mainly of gneiss and granite, and the gradations are relatively good.

Five borrow areas were selected, from the most downstream G-1 to the most upstream G-5. The available quantities are approximately 100 x 10^3 m^3 at G-1 with an average thickness of 2.0 m, 50 x 10^3 m^3 at G-2 with an average thickness of 1.5 m, 240 x 10^3 m^3 at G-3 with an average thickness of 2 m, 110 x 10^3 m^3 for G-4 at an average thickness of 2 m, and 440 x 10^3 m^3 at G-5 with an average thickness of 3 m, a total of 940 x 10^3 m^3.

Since the design concrete volume will be approximately 100 x 10^3 m^3 in case of a rockfill type, 350 x 10^3 m^3 at the G-3 and G-4 sites will be adequate for meeting requirements.

As for the case of the dam of a concrete gravity type, the available quantity will be approximately 2.0 times the design volume if all of the five sites are used and it will be enough for adequate supply.

M 2.7 Bonghwa Damsite

M 2.7.1 General

The Bonghwa damsite is as indicated in Fig. M 1.7 with two locations proposed as damsites. The upstream site is the original and the downstream one the alternative. There is a distance of approximately 2.5 km between the two sites.

The geologies of the reservoir areas consist mainly of granite and gneiss which are extensively distributed. Borrow areas were selected in the vicinities of these damsites. The areas comprise decomposed granite or decomposed gneiss.

There are no river deposits at the riverbed upstream and downstream of the two damsites and it will be impossible to collect sand and gravel in the neighborhoods of the damsites.

The approximate design quantities for the two proposals are as indicated below.

	(Upper Dam)	(Lower Dam)
For rockfill dam		
Impervious core material	890 x 10^3 m^3	1,650 x 10^3 m^3
Concrete structures	200 x 10^3 m^3	210 x 10^3 m^3
For concrete gravity dam		
Concrete structures including dam	1,270 x 10^3 m^3	1,790 x 10^3 m^3

M 2.7.2 Impervious core material

(1) S-1 and S-2 Areas

The S-1 area is situated at the northern slope on the left bank approximately 0.6 km upstream from the downstream damsite and the material is of decomposed granite.

Regarding gradations of materials, the upper layer has high content of fines with about 50 % passing No. 200 sieve, while the lower layer is coarse-grained.

The upper-layer material belongs to SM and CL under the Unified Soil Classification System and is of low plasticity as a whole.

The available quantity is approximately 280 x 10^3 m^3.

The S-2 area is at a tableland at the right bank side (approximately 1 km northwest) of the upstream damsite, and the available quantity is approximately 120 x 10^3 m^3, but the gravel content is high and it is judged difficult to use only this material. Therefore, it will be necessary for blend this material with that from another borrow area to be considered.

(2) S-3 Area

This is a vast area located on the right bank side approximately 3 km upstream from the upstream damsite. However, the lower part is of a sand-gravel layer and the thickness of soil which can be used as impervious core material is about 1.0 to 1.5 m.

With regard to the quality of the material, the part close to the river has high content of fine soils with 40 % to 60 % passing No. 200 sieve. The material belongs to SM, ML and CL under the Unified Soil Classification System and is of low plasticity.

On the other hand, the material at the mountain side is well-graded and is a good soil of relatively high content of fines. About 30 % passes No. 200 sieve and the soil belongs to SW and SC according to the Unified Soil Classification System.

The available quantity is approximately 860 x 10^3 m^3.

(3) S-4 and S-5 Areas

The S-4 and S-5 areas are on the left bank 3.0 km and 2.5 km upstream respectively from the upstream damsite.

The material is of decomposed granite at both areas and comprises fine soil. The material belongs to SM or CL according to the Unified Soil Classification System and is of low plasticity.

The available quantities are approximately 500 x 10^3 m^3 at average thickness of 2.5 m for the S-4 Area, and 470 x 10^3 m^3 at average thickness of 1.5 m for the S-5 Area.

The available quantity with all of the borrow areas is approximately 2.5 times the design volume of the upstream dam. Accessibility is poor for both S-1 downstream and S-2 immediately upstream of the damsite and besides, the available quantities are so small that these two areas can be omitted. (Supply capacity will be approximately double the requirement.)

With regard to supply capacity for the downstream dam scheme, all of the borrow areas must be taken into consideration. In this case the quantity available will be approximately 1.35 times and there would be some risk of shortage regarding the supply capacity.

In both cases, it will be advisable to consider blending the materials with that from the various borrow areas. The results of the survey are summarized in Table M 1.6.

M 2.7.3 Sand and gravel material

There is no river deposit area in the vicinities of the two damsites, but as for the upstream damsite, G-1 was selected 7 km downstream, G-2 5 km upstream, and G-3 11 km also upstream. Further, the sand-gravel underlying the impervious core material of the S-3 area was selected as the G-4 area.

Of the above areas, G-2 has a large proportion of mixture of cobble stones.

The available quantities are respectively 40 x 10^3 m^3 at average thickness of 2 m, 30 x 10^3 m^3 at average thickness of 1.5 m, 45 x 10^3 m^3 at average thickness of 1.5 m, and 24 x 10^3 m^3 at average thickness of 1.5 m for a total of 139 x 10^3 m^3.

The available quantity is not sufficient even for the case of the rockfill type dam in the upstream site which has the least design volume, and it will be unavoidable to depend completely on a quarry site.

M 2.8 Imha Damsite

M 2.8.1 General

The Imha damsite is indicated in Fig. M 1.8. The geology of the damsite consists of granite, but the reservoir area is made of diorite and gneiss with partial distribution of limestone.

It was possible to select all borrow areas and river deposit areas within approximately 5 to 6 km upstream of the damsite. However, there is no large borrow area solely capable of meeting the entire requirement, and explorations were conducted for six sites as borrow areas and five sites along the riverbed as river deposits.

The design quantities for this scheme site are the following:

For rockfill dam

Impervious core material	450×10^3 m^3
Concrete structures	140×10^3 m^3

For concrete gravity dam

Concrete structures including dam	680×10^3 m^3

M 2.8.2 Impervious core material

As shown in Fig. M 1.8, six locations upstream of the damsite at either bank of the river were selected as borrow areas.

The material may be divided into granite, diorite and quartzite, all having extremely low content of fines. So, there will be a problem of watertightness.

(1) S-1 Area

This area is located on the left bank at a gentle hill area 2 km upstream from the damsite and is in good accessibility.

The material is of weathered diorite belonging to GP and SM according to the Unified Soil Classification System.

The material is gravelly sand having very little fines with only 1 % to 13 % passing No. 200 sieve, and the gradation is poor.

Consequently, there is a question about the watertightness and it will be necessary to confirm such property by permeability tests.

The average thickness is about 2 m, the available quantity being approximately 250 x 10^3 m^3.

(2) S-2 and S-3 Areas

The S-2 area is on the left bank approximately 1 km upstream from the damsite and is situated at a gently-sloped hill area. The S-3 area is located on the right bank approximately 1 km upstream from the site.

The materials at these areas are of decomposed granite at S-2 and weathered quartzite at S-3. Both belong to SW and SM under the Unified Soil Classification System, has high content of sand and gravelly sand, and there are very few fines. The proportions passing No. 200 sieve are 6 % to 10 %, and similarly to the case of the S-1 area, watertightness will be a question.

The available quantities are approximately 220 x 10^3 m^3 at S-2 and 210 x 10^3 m^3 at S-3.

The amount is approximately 1.8 times the design quantity of 450 x 10^3 m^3 for impervious core material and it is considered possible to supply sufficient amount. However, with regard to quality, it will be necessary to specifically check watertightness. The results of the survey are summarized in Table M 1.7

(3) S-4, S-5 and S-6 Areas

These areas are located 3.5 km, 4.5 km and 5.5 km upstream from the damsite, respectively, and are relatively small. The materials are of weathered diorite and gravelly silts.

The available quantities are 50 x 10^3 m^3 at average thickness of about 5 m, 50 x 10^3 m^3 at average thickness of about 2 m, and 60 x 10^3 m^3 at average thickness of about 3 m.

Sampling was not done in particular at these areas.

M 2.8.3 Sand and gravel material

Five river deposit areas were selected almost in a continuous stretch along the river upstream of the dam.

The areas were numbered G-1 to G-5 from immediately above the damsite to approximately 5 or 6 km upstream. The material consists of granite and gneiss, is comparatively well graded, and is good sand-gravel as a whole.

The available quantity is approximately 4.0 times the design concrete volume in case of a rockfill type dam and approximately 1.4 times in case of a concrete gravity type dam. In the latter case the quantity would be rather short for requirement, but since there are river deposits existing here and there upstream of G-5 and downstream of the damsite, a quarry site would be unnecessary.

The results of the survey are summarized in Table M 1.8.

M 2.9 Hamyang Damsite

M 2.9.1 General

The Hamyang damsite is as indicated in Fig. M 1.9. The geology consists of diorite at the damsite and immediately upstream, but further up it consists of gneiss. Montainsides are generally gently sloped.

In the present investigations, four borrow areas and three river deposit areas were explored, but in the vicinity of the damsite there are only two borrow areas, while the three river deposit areas and the remaining two borrow areas are scattered far distant away (10 to 15 km).

The design quantities of this damsite are as indicated below.

For rockfill dam

Impervious core material	570 x 10^3 m^3
Concrete structures	140 x 10^3 m^3

For concrete gravity dam

Concrete structures including dam	910 x 10^3 m^3

M 2.9.2 Impervious core material

As borrow areas, S-1 was selected at the left bank immediately upstream of the damsite and S-2 also at the left bank approximately 4 km upstream.

Other than the above, two locations were investigated as Mumjeongri approximately 11 km downstream from the damsite, but because of the small quantities there and the long distance, these locations were dropped out of consideration.

The material at the S-1 Area is of weathered diorite and is a relatively well-graded soil. It belongs to SC according to the Unified Soil Classification System and the proportion passing No. 200 sieve is around 35 %.

On the other hand, the material at the S-2 Area is of weathered granite with high content of fines, and the proportion passing No. 200 sieve is 40 % to 50 %. It belongs to the MH and SM groups under the Unified Soil Classification System and contains a large proportion of non-plastic fines with a high content of mica. It is desirable for such a material to be used mixed together with other materials as much as possible. Accordingly, blending of the materials from S-1 with S-2 should be considered.

The available quantities at the abovementioned two areas are 400 x 10^3 m^3 for S-1 with an average thickness of 2 m and 480 x 10^3 m^3 for S-2 with an average thickness of 2 m respectively, making a total of 880 x 10^3 m^3.

The above quantity is approximately 1.5 times the design quantity and it is thought adequate as for supply capacity.

M 2.9.3 Sand and gravel material

Since river deposit areas could not be found around the damsite, exploration was extended to a range of about 15 km.

The nearest location is the G-1 area on the right bank approximately 7 km upstream from the damsite. Other than this, there is an area with available quantity of about 600 x 10^3 m^3 at Umbong Myeon approximately 15 km upstream from the damsite. There is also a place where material can be collected, Donggangri approximately 13 km downstream Since both of these are much too distant away from the damsite they were dropped out of consideration.

The material at the G-1 area has low sand content with a large proportion of gravel of the large size (about 30 cm), being poorly graded.

The available quantity is approximately 150 x 10^3 m^3 with an average thickness of 2 m. The supply capacity will be insufficient in both case of the dam type, rockfill or concrete gravity type and a quarry site for concrete aggregate would be required.

M 2.10 Juam Damsite

M 2.10.1 General

The Juam damsite is as indicated in Fig. M 1.10. The damsite has relatively stable slopes at both banks with relatively broad river width. The reservoir and its surrounding area consist of gneiss, and the area is that of a fairly well developed valley plain.

In the present investigations, six locations were explored as borrow areas and two as river deposit areas.

The provisional design quantities of this dam are as indicated below.

For rockfill dam

Impervious core material	460×10^3 m^3
Concrete structures	130×10^3 m^3

For concrete gravity dam

Concrete structures including dam	approx. 650×10^3 m^3

M 2.10.2 Impervious core material

Individual large borrow areas do not exist at this damsite and small ones are scattered.

A total of six locations was explored, one being upstream of the damsite and five downstream (see Fig. M 1.10).

The material is decomposed gneiss at all locations. Areas S-2 and S-6 consist of fine soils while the other areas have comparatively coarse soils.

The various borrow areas are described below.

(1) S-1, S-2 and S-5 Areas

The S-1, S-2 and S-5 areas are all on the left bank downstream from the damsite at distances of 1.5 km, 3.0 km and 3.0 km, respectively.

The materials belong to SM and ML under the Unified Soil Classification System. The material at S-1 is relatively well-graded, but the materials at S-2 and S-5 have too high content of fines and are poorly-graded. The proportions passing No. 200 sieve are 31 %, 54 % and 49 %, respectively.

Since all of these borrow areas are closely located on the left bank, and gradations of the materials differ each other, it is preferable to use in the form of a mixture of the materials in construction.

The available quantities are 270 x 10^3 m^3, 750 x 10^3 m^3 and 180 x 10^3 m^3, respectively, all at average thickness of about 3 m, making a total of 1,200 x 10^3 m^3.

(2) S-3 and S-6 Areas

The S-3 and S-6 areas are on the right bank downstream from the damsite at distances of 1.4 km and 1.0 km, respectively.

The materials at the two areas both belong to SM under the Unified Soil Classification System with proportions passing No. 200 sieve around 20 % for the S-3 material and around 70 % for the S-6 material. The former is of relatively good gradation. Since these two areas are also close each other and the gradations of the materials are different, use after blending two materials should be considered in construction.

The available quantities are approximately 120 x 10^3 m^3 and 90 x 10^3 m^3, respectively, both at average thickness of about 3 m, making a total of 210 x 10^3 m^3.

(3) S-4 Area

This area is on the right bank about 4 km upstream from the damsite. The material belongs to the SM group, the proportion passing No. 200 sieve is approximately 20 %, and the gradation is good. The available quantity is approximately 370 x 10^3 m^3 at an average thickness of about 3 m.

The total volume from the abovementioned six borrow areas is 1,780 x 10^3 m^3, or approximately 3.8 times the design quantity. Requirements would be sufficiently met.

M 2.10.3 Sand and gravel material

Two locations were selected downstream of the damsite as river deposit areas, and other than these, there is no suitable location in the vicinity of the damsite.

The G-1 area is on the right bank approximately 2 km downstream, while the G-2 area is at the opposite bank of G-1.

Practically all of the sand-gravel consists of gneiss, and although the gradation is relatively good, there is a tendency that medium-sized gravel is somewhat lacking.

The available quantities are approximately 110×10^3 m^3 at G-1 and 130×10^3 m^3 at G-2, both with average thickness of about 2 m, making a total of 240×10^3 m^3. For the provisional design concrete volume of 130×10^3 m^3 in case of a rockfill type dam this quantity seems to be insufficient. For the design concrete volume of 650×10^3 m^3 in case the dam type is of concrete gravity, a quarry site will definity be needed.

M 3 RESULTS OF MATERIAL TESTS

M 3.1 Material Tests Performed

M 3.1.1 Sampling

Investigations were made of borrow areas at 43 locations and river deposits at 36 locations for all of the 10 planned sites.

Pitting and trenching were performed at 50 places in borrow areas and 39 places in river deposit areas and respectively collected therefrom were, 47 samples and 13 samples making a total of 60 samples.

At river deposits, field sieve tests were carried out at representative locations among the places where pitting and trenching were performed.

The locations of piting, trenching and sampling are indicated in Figs. M 1.1 through M.1.10. The tabular form of these are as given in Table M 2.

The logs and some descriptions of pits and trenches are as indicated in Figs. M 3.1 through M 3.4.

M 3.1.2 Tests and test methods

The test materials were analyzed by a specialist in the laboratory of the Korean Ministry of Construction (MOC) in Seoul.

All tests were carried out in accordance with the specifications of Korean Industrial Standards (KIS).

The test items and the respective applicable standards are as indicated below.

Borrow Area Material

(1) Specific gravity test (KSF 2308)
(2) Grain size analysis test (KSF 2302)

(3) Moisture content test (KSF 2306)

(4) Liquid limit and plastic limit tests (KSF 2303 and 2304)

(5) Compaction test (KSF 2312)

River Deposit Material

(1) Specific gravity test (KSF 2503)

(2) Grain size analysis test (KSF 2502)

The following should be noted:

(1) The soil classification adopted was the "Unified Soil Classification System".

(2) Compaction tests were performed according to Method of Test for Moisture-Density Relations of Soil Using Rammer.

(3) Molds with inside diameter of 10 cm and a rammer of 2.5 kg were used as testing equipment.

(4) Samples used were of maximum size passing the No. 4 sieve.

M 3.2 Test Results

A summary of the test results for the various damsites are as indicated in Tables M 3 and M 4.

The relations of NWC-OMC in Table M 3 and Table M 5 shows NWC to be considerably higher than OMC for the five northern sites (Bamseonggol-Ganhyeon).

This is thought to be attributable to the fact that the investigations of these five northern sites were conducted in a especially rainy period, while the investigations of the southern sites (Dalcheon-Juam) were done in a relatively dry period.

The details of soil test results of each smaple are shown in Table M 5. The grain-size distribution curves of the test samples (borrow area) are indicated in Figs. M 2.1 though M 2.3.

The sand and gravel test results for each of the samples are shown in Table M 6.

M 4 ESTIMATED DESIGN VALUES OF SOIL MATERIALS

The soil tests performed this time were limited to the simple physical tests. The principal engineering properties of soil, i.e. coefficient of permeability and shear strength (internal friction) were presumed based on the above test results.

The results are as indicated below.

Site	CL*	MDD (g/cm^3)	OMC (%)	K** (cm/s)	∅** (deg)
Bamseonggol	SM-SC	1.75-1.84	11.0-16.1	$1x10^{-6}$	33
Inje	SC	1.74-1.81	14.0-17.7	$1x10^{-6}$	31
Hongcheon	SC	1.47-1.52	20.0-26.7	$5x10^{-7}$	30
Gujeol	CL	1.40-1.69	18.6-29.8	$1x10^{-5}$	28
Ganhyeon	SM	1.62-1.88	12.3-21.0	$1x10^{-7}$	35
Dalcheon	ML	1.35-1.88	13.2-29.6	$5x10^{-7}$	30
Bonghwa	SC	1.55-1.87	14.0-24.0	$5x10^{-7}$	31
Imha	SW-SC	1.69-1.89	10.0-18.9	$5x10^{-4}$	36
Hamyang	SM	1.54-1.69	18.2-24.5	$1x10^{-6}$	31
Juam	SM	1.66-1.82	13.6-20.0	$1x10^{-6}$	33

Remarks; CL : Soil Classification MDD : Maximum Dry Density
OMC : Optimum Water Content K : Coefficient of Permeability
∅ : Shear Strength (Internal friction angle)
* : The soil classifications in this column were obtained by averaging data of borrow areas by damsite and classifying to the Unified Soil Classification System.
** : These design values were presumed using data in "Design of Small Dams" published by the U.S. Department of the Interior Bureau of Reclamation and in others. (Refs. M 1, M 2)
Further with regard to coefficient of permeability and shear strength, these vary depending on density, water content, gradation, grain size, etc. of soil, and sometimes large differences are indicated with similar materials. Accordingly, these values can be utilized only for preliminary design, but in future studies it will be necessary to use values obtained through direct tests on such engineering properties.

M 5 SUMMARY

M 5.1 Supply Capacity of Construction Materials

Out of the 13 damsites, 10 sites have suitable borrow areas capable to supply sufficient imperyious core material in case of rockfill type dams. The sites where the available quantities will be insufficient are three, i.e. Bamseonggol downstream site, Inje downstream site and the Bonghwa downstream site.

However, even though provided with adequate supply capacity, there are sites such as the Inje upstream site which has source 10 km distant away from the damsite, and Hamyang and Imha which have available quantities barely enough for requirement or materials of questionable quality.

On the other hand, regarding supply capacity for concrete aggregates considering river deposits, even in the cases of rockfill type dams with relatively small volumes of concrete required, Gujeol, Juam, Hamyang and the upstream and downstream sites of Bonghwa have insufficient or somewhat insufficient quantities.

In case of the concrete gravity dam type, the sites with sufficient capacity (including cases of somewhat insufficient but barely adequate capacity) are the four of the Bamseonggol upstream site, Hongcheon, Ganhyeon and Dalcheon. The others are sites which cannot help but rely on quarry sites.

M 5.2 Quality

The materials in borrow areas are almost all decomposed granite or decomposed gneiss with relatively fine-grained materials predominant. The soil components consist of clayey sands, silty sands of sand-clay mixtures, and practically all are concentrated in the SM, SC, ML and CL groups under the Unified Soil Classification System.

Some soils are low plastic showing low plasticity indeces as shown in Table M 5. These soils may be weak to piping. This defect is now stood with by careful compaction, smooth trimming of abutment and zoning

with sufficient thickness of transition zone. Examples of high dams constructed with low plastic core materials are shown in Table 7.

Examined by site, Imha stands out as being problematic. The material consists of poorly-graded gravel and gravel sand-clay mixtures, and there is a question with respect to watertightness. (Coefficient of permeability was estimated at around 5×10^{-4}, see M 4.) Consequently, it will be necessary for confirmations to be made by carrying out permeability tests.

Since the materials of other sites are relatively high in content of fines (50 % or more passing No. 200 sieve), and low to medium-plasticity materials are predominant, it is necessary to consider mixing with materials in underlying layers high in gravel content, or mixing with coarse fractions of other borrow areas. By doing so, impervious core material of improved gradation and good quality as a whole can be obtained.

The river deposit materials investigated this time consisted of granite, gneiss or sandstone, and gradations are good as a whole (see Table M 6). Regarding particle shapes, flat gravels characteristic of gneiss are contained, but they will be usable as concrete aggregate since soft particles are few.

M 5.3 Future Studies

The following points should be investigated in future project studies.

(1) Planning of test pits on grid systems at principal sites for investigation of available quantities or borrow area and river deposit materials.

(2) Deep excavation of test pits at borrow areas to confirm qualities of materials at underlying portions.

(3) Execution of permeability tests on borrow area materials of the Imha area.

(4) Thorough analyses of gradations for necessary sites in consideration of use of river deposit materials as filter materials.

(5) Execution of permeability tests in view of questionable water-tightness of borrow area materials of principal sites comprised of decomposed granite.

REFERENCES

M 1 DESIGN OF SMALL DAMS, Chapter 4, e. published by U.S. Department of the Interior Bureau of Reclamation, Translated by the Japanese National Committee on Large Dams, 1970.

M 2 DESIGN STANDARDS FOR LAND IMPROVEMENT PROJECTS, Part 3, Design, Vol. 1, Fill Dam, published by Agricultural Land Bureau, Ministry of Agriculture and Forestry, 1966.

M 3 10TH INTERNATIONAL CONGRESS ON LARGE DAMS, (Montreal 1970) Volume 1 Question No. 36.

Table M 1.1 SUMMARY OF SURVEY RESULTS
(Bamseonggol Borrow Areas)

Borrow Area	Distance from Dam Site (km)	Available Volume (m^3) Average Thickness (m)	Depth of Stripping (m)
(Upstream Dam Site)			
S-1	1.8	600,000 (3m)	0.5
S-4	3.0	300,000 (3m)	0.5
Total		900,000	
(Downstream Dam Site)			
S-1	5.8	600,000 (3m)	0.5
S-2	2.5	260,000 (2.5m)	0.5
S-3	1.0	260,000 (2.0)	0.8
S-4	7.0	300,000 (3.0)	0.5
S-5	8.0	150,000 (2.0)	0.8
Total		1,570,000	

Remarks ; The available quantity of 900,000 m^3 for the upstream dam is approximately double the design volume and is deemed sufficient to meet requirements.
The available quantity of 1,570,000 m^3 for the downstream dam is approximately 1.4 times the design volume and there is a risk of a shortage. There will be a necessity for investigations to be made in the future to gain a grasp of the quantity.

Table M 1.2 SUMMARY OF SURVEY RESULTS
(Bamseonggol River Deposits)

River Deposit	Distance from Dam Site (km)	Available Volume (m^3) Average Thickness (m)	Depth of Stripping (m)
(Upstream Dam Site)			
G-1	2.0 (U.R.) *	1,200,000 (5m)	0.5
G-2	1.5 (D.L.) *	600,000 (5m)	0.5
Total		1,800,000	
(Downstream Dam Site)			
G-1	6.0 (U.R.)	1,200,000 (5m)	0.5
G-2	2.0 (U.L.)	600,000 (5m)	0.5
G-3	0.6 (U.R.)	160,000 (8m)	1.0
Total		1,960,000	

Remarks ; * U.S. = Upstream Right Bank D.L. = Downstream Left Bank

Table M 1.3 SUMMARY OF SURVEY RESULTS
(Inje Borrow Areas)

Borrow Area	Distance from Dam Site (km)	Available Volume (m^3) Average Thickness (m)	Depth of Stripping (m)
(Upstream Dam Site)			
S-1	6.5 (U.R.)	310,000 (2.5)	0.5
S-2	5.0 (U.R.)	150,000 (1.5)	0.8
S-3	9.0 (U.R.)	100,000 (1.5)	0.8
S-4	10.5 (D.R.)	1,400,000 (2.0)	0.5
Total		1,960,000	
(Downstream Dam Site)			
S-4	7.0 (D.R.)	1,400,000 (2.0)	0.5
S-5	8.0 (D.R.)	800,000 (2.0)	0.5
S-1	10.0 (U.R.)	310,000 (2.5)	0.5
Total		2,510,000	

Table M 1.4 SUMMARY OF SURVEY RESULTS
(Inje River Deposits)

River Deposit	Distance from Dam Site (km)	Available Volume (m^3) Average Thickness (m)	Depth of Stripping (m)
(Upstream Dam Site)			
G-1	5.0 (U.L.)	500,000 (5m)	0.5
G-2	1.2 (U.R.)	50,000 (3m)	0.3
G-3	8.0 (U.L.)	450,000 (5m)	0.3
Total		1,000,000	
(Downstream Dam Site)			
G-1	8.5 (U.L.)	500,000 (5m)	0.5
G-2	5.0 (U.R.)	50,000 (3m)	0.3
G-4	7.0 (D.L.)	560,000 (5m)	0
G-5	10.0 (D.L.)	200,000 (3m)	0.3
Total		1,300,000	

Table M 1.5 SUMMARY OF SURVEY RESULTS
(Dalcheon Borrow Areas)

Borrow Area	Distance from Dam Site (km)	Available Volume (m^3) Average Thickness (m)	Depth of Stripping (m)
S-1	0.4 (U.R.)	370,000 (1.5m)	0.3
S-2	1.5 (U.L.)	310,000 (1.5m)	0.3
S-3	0.5 (D.L.)	110,000 (1.5m)	0.5
S-4	3.5 (U.R.)	210,000 (1.5m)	0.5
S-5	1.2 (D.L.)	80,000 (1.0m)	0.3
Total		1,080,000	

Table M 1.6 SUMMARY OF SURVEY RESULTS
(Bonghwa Borrow Areas)

Borrow Area	Distance from Dam Site (km)	Available Volume (m^3) Average Thickness (m)	Depth of Stripping (m)
(Upstream Dam Site)			
S-1	2.0 (D.L.)	280,000 (2m)	0.5
S-2	1.0 (U.R.)	120,000 (1m)	0.3
S-3	3.0 (U.R.)	860,000 (1m)	0.5
S-4	3.0 (U.L.)	500,000 (2.5m)	0.3
S-5	2.5 (U.L.)	470,000 (1.5m)	0.5
Total		2,230,000	
(Downstream Dam Site)			
S-1	0.6 (U.L.)	280,000 (2m)	0.5
S-2	3.5 (U.R.)	120,000 (1m)	0.3
S-3	5.5 (U.R.)	860,000 (1m)	0.5
S-4	5.5 (U.L.)	500,000 (2.5m)	0.3
S-5	5.0 (U.L.)	470,000 (1.5m)	0.5
Total		2,230,000	

Table M 1.7 SUMMARY OF SURVEY RESULTS
(Imha Borrow Areas)

Borrow Area	Distance from Dam Site (km)	Available Volume (m^3) Average Thickness (m)	Depth of Stripping (m)
S-1	2.0 (U.L.)	250,000 (2m)	0.5
S-2	1.0 (U.L.)	220,000 (2m)	0.3
S-3	1.0 (U.R.)	210,000 (3m)	0.3
S-4	3.5 (U.R.)	50,000 (5m)	0.5
S-5	4.5 (U.L.)	50,000 (2m)	0.3
S-6	5.5 (U.R.)	60,000 (3m)	0.5
Total		840,000	

Table M 1.8 SUMMARY OF SURVEY RESULTS
(Imha River Deposits)

River Deposit	Distance from Dam Site (km)	Available Volume (m^3) Average Thickness (m)	Depth of Stripping (m)
G-1	1.0	170,000 (3m)	0.5
G-2	2.5	130,000 (3m)	0.5
G-3	3.5	270,000 (3m)	0.5
G-4	3.5	190,000 (3m)	0.5
G-5	5.0	190,000 (2.5m)	0.3
Total		950,000	

Table M 2 LIST OF SAMPLES

Site Name	Numbering Area	Numbering Sample	Sampling at	Depth	Test Carried Out A	B	C	D	E	F
Bamseonggol	Ba.S-1	S1-1	B.A	3.0	0	0		0	0	0
		S1-2	B.A	2.0	0	0		0	0	0
	Ba.S-2	S2-1U	B.A	1.6	0	0		0	0	0
		S2-1U	B.A	1.6	0	0		0	0	0
	Ba.S-3	S3-1	B.A	1.1	0	0		0	0	0
	Ba.G-1	G1-1	R.D	1.0			0			
	Ba.G-2	G2-1	R.D	1.1			0			
Inje	In.S-1	S1-1U	B.A	2.2	0	0		0	0	0
		S1-1L	B.A	2.2	0	0		0	0	0
	In.S-4	S4-1	B.A	3.0	0	0		0	0	0
		S4-2U	B.A	2.0	0	0		0	0	0
		S4-2L	B.A	2.0	0	0		0	0	0
	In.G-1	G1-1	R.D	1.0			0			
	In.G-4	G4-1	R.D	1.2			0			
		G4-2	R.D	3.0			0			
Hongcheon	Ho.S-1	S1-1	B.A	4.3	0	0		0	0	0
		S1-2	B.A	2.0	0	0		0	0	0
	Ho.G-1	G1-1	R.D	1.0			0			
		G1-2	R.D	1.0	0	0				
	Ho.G-2	G2-1	R.D	2.0			0			
		G2-2	R.D	1.1			0			

Remarks:

Depth : Depth under surface
B.A : Borrow area
R.D : River deposit

A:Specific Gravity.
B:Grain Size Distribution (at Laboratory).
C:Grain Size Distribution (at field).
D:Moisture Content.
E:Consistency.
F:Compaction.

Table M 2 Continued (2)

Site Name	Numbering Area	Numbering Sample	Sampling at	Depth	Test Carried Out A	B	C	D	E	F
Gujeol	GU.S-1	S1-1U	B.A	3.0	0	0		0	0	0
		S1-1L	B.A	3.0	0					
		S1-2	B.A	2.0	0					
	GU.G-1	G1-1	R.D	2.0	0	0				
Ganhyeon	Ga.S-1	S1-1	B.A	2.6	0	0		0	0	0
		S1-2	B.A	3.3	0	0		0	0	0
	Ga.G-1	G1-1	R.D	3.5			0			
		G1-2	R.D	1.0			0			
Dalcheon	Da.S-1	S1-1	B.A	2.0	0	0		0	0	0
		S1-2	B.A	1.6	0	0		0	0	0
	Da.S-2	S2-1	B.A	1.7	0	0		0	0	0
		S2-2	B.A	2.0	0	0		0	0	0
	Da.S-3	S3-1	B.A	2.0	0	0		0	0	0
	Da.G-3	G3-1~4	R.D	2.0			0			
		G3-4	R.D	0.9	0	0				
	Da.G-4	G4-1	R.D	1.7	0	0				
Bonghwa	Bo.S-1	S1-1	B.A	1.5	0	0		0	0	0
		S1-2	B.A	1.7	0	0		0	0	0
	Bo.S-3	S3-1	B.A	1.3	0	0		0	0	0
		S3-2	B.A	1.3	0	0		0	0	0
		S3-3	B.A	0.6	0	0		0	0	0
		S3-4	B.A	1.0	0	0		0	0	0
	Bo.S-4	S4-1	B.A	1.1	0	0		0	0	0
		S4-2	B.A	1.7	0	0		0	0	0
	Bo.S-5	S5-1	B.A	1.4	0	0		0	0	0
	Bo.G-2	G2-1	R.D	1.1	0	0				
	Bo.G-3	G3-1~3	R.D	0.8			0			
		G3-2	R.D	1.5	0	0				

Table M 2 Continued (3)

Site Name	Numbering Area	Numbering Sample	Sampling at	Depth	Test Carried Out A	B	C	D	E	F
	BoG-4	G4-1	R.D	1.7	0	0	0			
Imha	Im.S-1	S1-1	B.A	1.8	0	0		0	0	0
		S1-2U	B.A	2.0	0	0		0	0	0
		S1-2L	B.A	2.0	0	0		0	0	0
	Im.S-2	S2-1	B.A	1.5	0	0		0	0	0
		S2-2	B.A	1.4	0	0		0	0	0
	Im.S-3	S3-1	B.A	1.0	0	0		0	0	0
	Im.G-1	G1-1	R.D	2.1	0	0				
		G1-1~2	R.D	1.3			0			
	Im.G-2	G2-1	R.D	1.8	0	0				
		G2-1~2	R.D	0.9			0			
Hamyang	Ha.S-1	S1-1	B.A	2.0	0	0		0	0	0
		S1-2	B.A	3.0	0	0		0	0	0
	Ha.S-2	S2-1	B.A	2.0	0	0		0	0	0
		S2-2	B.A	2.5	0	0		0	0	0
	Ha.G-1	G1-1	R.D	1.4	0	0				
		G1.1~2	R.D	2.0			0			
		G1-2	R.D	2.0	0	0				
Juam	Ju.S-1	S1-1	B.A	1.8	0	0		0	0	0
	Ju.S-2	S2-1	B.A	1.4	0	0		0	0	0
	Ju.S-3	S3-1	B.A	1.8	0	0		0	0	0
	Ju.S-4	S4-1	B.A	1.5	0	0		0	0	0
	Ju.S-5	S5-1	B.A	1.4	0	0		0	0	0
	Ju.S-6	S6-1	B.A	1.0	0	0		0	0	0
	Ju.G-1	G1-1	R.D	1.5	0	0				
		G1-1~2	R.D	1.0			0			
	Ju.G-2	G2-1	R.D	1.7	0	0				
		G2-1~2	R.D	1.0			0			

Table M 3 SUMMARY OF SOIL TEST RESULTS

Site	CL	Spec. Grav. g/cm^3	NWC %	OMC %	MDD g/cm^3	Passing No. 200 Sieve,%
Bamseonggol	SM-SC	2.64-2.71	14.2-19.3	11.0-16.1	1.75-1.84	23-45
Inje	SC	2.64-2.69	18.6-23.3	14.0-17.7	1.74-1.81	24-55
Hongcheon	SC	2.61-2.68	23.9-39.2	20.0-26.7	1.47-1.52	33-64
Gujeol	CL	2.67-2.70	24.1-38.0	18.6-29.8	1.40-1.69	51-80
Ganhyeon	SM	2.61-2.70	17.8-30.4	12.3-21.0	1.62-1.88	15-27
Dalcheon	ML	2.63-2.72	13.6-38.5	13.2-29.6	1.35-1.88	34-68
Bonghwa	SC	2.63-2.72	7.4-24.1	14.0-24.0	1.55-1.87	14-80
Imha	SW-SC	2.65-2.70	5.6-16.0	10.0-18.9	1.69-1.89	1-13
Hamyang	SM	2.64-2.67	7.0-53.9	18.2-24.5	1.54-1.69	36-53
Juam	SM	2.65-2.67	11.2-23.7	13.6-20.0	1.66-1.82	23-70

Remarks ; CL : Soil Classification
Spec. Grav.: Specific Gravity
NWC : Natural Water Content
OMC : Optimum Moisture Content
MDD : Maximum Dry Density

Table M 4 SUMMARY OF SAND AND GRAVEL TEST RESULTS

Site	Specific Gravity (g/cm^3)	Grain Size (%) -76.1 mm (3 in)	-38.1 mm (1-1/2 in)	-19.0 mm (3/4 in)	-4.76 mm (No. 4)
Bamseonggol	-	52	41	33	20
Inje	-	62	51	42	32
Hongcheon	2.62	90	71	49	35
Gujeol	2.62	100	72	34	24
Ganhyeon	-	68	49	38	32
Dalcheon	2.68	90	64	45	26
Bonghwa	2.55	84	67	52	34
Imha	2.63	67	62	38	17
Hamyang	2.66	79	48	30	6
Juam	2.68	87	62	41	19

Remarks : The figures for grain size are average values of the results of laboratory sieve tests and field sieve tests at each dam sites.

Table M 5 RESULTS OF SOIL TESTS

Site Name	Borrow area No.	Sample No.	Depth (m)	CL	NWC (%)	Spec. Grav. (g/cm^3)	Atterberg Limit LL	PL	PI	Grain Size (m/m) -38.1 (1½in)	-19.0 (3/4in)	-4.76 (NO4)	-0.074 (NO200)	OMC (%)	MDD (g/cm^3)
Bam-seonggol	Ba.S-1	S1-1	1.0-2.0	SC	17.5	2.71	28.8	19.9	8.9	100	100	97	45	13.5	1.80
	"	S1-2	1.0-1.7	SM	19.3	2.67	28.4	23.8	4.6	100	99	94	23	13.5	1.82
	Ba.S-2	S.2-1U	0.5-1.1	SM	16.2	2.69	25.7	NP		100	98	88	40	16.1	1.77
	"	S.2-1L	1.1-1.6	SM	14.2	2.67	24.4	NP		97	81	63	23	11.0	1.84
	Ba.S-3	S.3-1	0.8-1.1	SM-SC	18.1	2.64	25.4	18.7	6.7	96	92	67	24	15.5	1.75
Inje	In.S-1	S.1-1U	0.4-1.0	SC	19.0	2.64	26.2	15.8	10.4	100	100	98	38	14.1	1.81
	"	S.1-1L	1.5-2.2	ML	19.2	2.67	28.9	NP		100	100	100	55	16.2	1.75
	In.S-4	S.4-1	2.3-3.0	SM-SC	23.0	2.69	27.8	21.2	6.6	100	90	74	24	17.7	1.74
	"	S.4-2U	0.5-1.0	SC	23.3	2.67	30.5	20.3	10.2	100	100	97	37	15.5	1.78
	"	S.4-2L	1.5-2.0	CL	18.6	2.67	25.2	15.4	9.8	100	94	82	52	16.0	1.77
Hong-cheon	Ho.S-1	S.1-1	2.5-3.0	CL	39.2	2.68	35.9	18.8	17.1	100	100	100	64	26.7	1.47
	"	S.1-2	1.0-1.5	SC	23.9	2.61	36.1	20.9	15.2	100	100	100	33	20.0	1.52
Gujeol	Gu.S-1	S.1-1U	0.5-1.0	CL	29.8	2.70	42.2	23.7	18.5	100	100	100	74	24.7	1.50
	"	S.1-1L	1.4-2.0	CL	38.0	2.70	46.0	29.5	16.5	100	100	100	51	29.8	1.40
	"	S.1-2	1.0-1.6	CL	24.1	2.67	34.4	27.0	7.4	100	100	100	80	18.6	1.69
Gan-hyeon	Ga.S-1	S.1-1	1.3-1.8	SM	17.8	2.61	32.8	NP		100	100	97	15	12.3	1.88
	"	S.1-2	1.2-2.0	SC	30.4	2.70	36.8	17.4	19.4	100	100	94	27	21.0	1.62
Dal-cheon	Da.S-1	S.1-1	0.7-1.3	ML	24.1	2.63	38.7	NP		100	100	98	68	21.1	1.56
	"	S.1-2	1.0-1.6	ML	13.6	2.70	22.8	NP		100	99	86	54	14.6	1.85
	Da.S-2	S.2-1	0.6-1.3	SM	15.6	2.72	28.0	21.3	6.7	100	100	99	47	13.2	1.88
	"	S.2-2	1.2-1.8	MH	38.5	2.69	55.2	NP		100	100	81	59	29.6	1.35
	Da.S-3	S.3-1	1.3-1.9	SM	17.9	2.65	34.8	NP		100	97	96	34	18.2	1.70

Remarks ; Depth : Depth of sampling Spec., Grav. : Specific Gravity CL : Unified Soil Classification

NWC : Natural Water Content LL : Liquid Limit PL : Plasticity Limit

PI : Plasticity Index OMC : Optimum Moisture Content MDD : Maximum Dry Density.

Table M 5 Continued

Site Name	Borrow area No.	Sample No.	Depth (m)	CL	NWC (%)	Spec. Grav. (g/cm^3)	Atterberg Limit LL	PL	PI	Grain Size (m/m) -38.1 (1½in)	-19.0 (3/4in)	-4.76 (NO4)	-0.074 (NO200)	OMC (%)	MDD (g/cm^3)
Bong-hwa	Bo.S-1	S.1-1	0.9-1.5	SC	11.4	2.68	27.4	20.4	7.0	100	78	70	47	16.0	1.77
	"	S.1-2	1.1-1.7	CL	18.3	2.72	27.2	19.3	7.9	100	99	86	51	16.0	1.67
	Bo.S-3	S.3-1	0.7-1.3	SM-SC	12.2	2.70	25.0	19.1	5.9	100	87	78	31	14.0	1.87
	"	S.3-2	0.8-1.3	SM-SC	12.6	2.72	28.0	23.6	4.4	100	92	73	32	15.6	1.83
	"	S.3-3	0.2-0.6	SM	12.7	2.66	20.2	17.2	3.0	100	98	95	41	14.5	1.85
	"	S.3-4	0.5-1.0	ML-CL	15.8	2.68	22.4	16.6	5.8	100	100	100	60	17.5	1.75
	Bo.S-4	S.4-1	0.6-1.1	SM	7.4	2.70	NP	NP		93	86	75	14	14.8	1.84
	"	S.4-2	1.0-1.5	SC	24.1	2.65	44.1	29.8	14.3	100	100	100	46	24.0	1.55
	Bo.S-5	S.5-1	0.8-1.4	CL	18.9	2.63	29.6	17.8	11.8	100	100	99	80	19.1	1.65
Imha	Im.S-1	S.1-1	1.2-1.8	GP	12.8	2.69	NP	NP		87	76	48	1	18.9	1.69
	"	S.1-2U	1.0-1.6	SP	16.0	2.67	27.0	23.7	3.3	100	100	58	4	16.7	1.74
	"	S.1-2L	1.7-2.0	SC	13.8	2.67	28.2	19.7	8.5	100	83	57	13	15.9	1.79
	Im.S-2	S.2-1	0.9-1.5	SW-SC	11.9	2.70	NP	NP		100	100	94	10	16.5	1.83
	"	S.2-2	0.8-1.4	SW-SC	7.8	2.65	NP	NP		100	100	92	9	10.0	1.89
	Im.S-3	S.3-1	0.5-1.0	SW-SC	5.6	2.65	NP	NP		100	100	82	6	12.0	1.85
Ham-yang	Ha.S-1	S.1-1	1.5-2.0	SC	28.0	2.67	35.8	24.4	11.4	100	100	91	36	19.7	1.69
	"	S.1-2	2.3-3.0	SC	20.6	2.65	44.9	36.3	8.6	100	100	99	36	18.2	1.66
	Ha.S-2	S.2-1	1.4-2.0	MH	53.9	2.66	64.5	NP		100	100	100	53	24.5	1.55
	"	S.2-2	1.8-2.5	SM	7.0	2.64	50.8	NP		100	100	100	38	23.6	1.54
Juam	Ju.S-1	S.1-1	0.5-1.8	SM	14.9	2.66	29.4	NP		100	100	97	31	15.3	1.78
	Ju.S-2	S.2-1	0.5-1.2	ML	11.4	2.65	40.0	NP		100	100	100	54	20.0	1.66
	Ju.S-3	S.3-1	0.8-1.8	SM	13.8	2.67	24.1	NP		100	100	93	23	14.0	1.82
	Ju.S-4	S.4-1	1.0-1.5	SM	11.2	2.66	29.2	NP		100	98	94	22	14.0	1.79
	Ju.S-5	S.5-1	0.8-1.3	ML	23.7	2.67	40.8	NP		100	100	97	49	15.5	1.78
	Ju.S-6	S.6-1	0.5-1.0	CL	20.6	2.66	33.7	19.2	14.5	100	100	98	70	13.6	1.81

Table M 6 RESULTS OF SAND AND GRAVEL TESTS

Site Name	River deposit No.	Sample No.	Depth (m)	Specific Gravity (g/cm^3)	Maximum Size (cm)	Grain Size (mm) -76.1 (3in)	-38.1 (1½in)	-19.0 (3/4in)	-4.76 (NO4)	Remarks
Bam-seonggol	Ba.G-1	G1-1	1.0	-	20-30	38	30	22	6	Field Sieve Test
	Ba.G-2	G2-1	1.1	-	20-30	67	53	44	35	"
Inje	In.G-1	G1-1	1.0	-	30-40	51	44	37	30	Field Sieve Test
	In.G-4	G4-1	1.2	-	20-30	60	48	40	32	"
		G4-2	3.0	-		75	61	50	35	"
Hong-cheon	Ho.G-1	G1-1	1.0	-		93	77	62	44	Field Sieve Test
		G1-2	1.0	2.62	15-20	100	72	34	24	Laboratory Test
	Ho.G-2	G2-1	2.0	-	30-40	68	48	37	34	Field Sieve Test
		G2-2	1.1	-		100	88	66	41	"
Gujeol	Gu.G-1	G1-1	2.0	2.62	20-30	100	90	60	37	Laboratory Test
Ganhyeon	Ga.G-1	G1-1	3.5	-	30-40	68	49	40	36	Field Sieve Test
		G1-2	1.0	-	30-40	68	50	37	28	"
Dalcheon	Da.G-3	G3-1 4	2.0	-		93	71	49	28	Field Sieve Test
		G3-4	0.9	2.69	15-25	88	68	48	27	Laboratory Test
	Da.G-4	G4-1	1.7	2.68	20-30	79	54	38	23	"
Bong-hwa	Bo.G-2	G2-1	1.1	2.63	50-60	93	80	58	37	Laboratory Test
	Bo.G-3	G3-1 3	0.8	-	15-30	75	59	47	33	Field Sieve Test
		G3-2	1.5	2.63		72	42	28	13	Laboratory Test
	Bo.G-4	G4-1	1.7	2.49	20	100	92	85	63	"
		"	1.7	-		81	61	42	28	Field Sieve Test

Table M 6 Continued

Site Name	River deposit No.	Sample No.	Depth (m)	Specific Gravity (g/cm^3)	Maximum Size (cm)	Grain Size (mm) -76.1 (3in)	-38.1 (1½in)	-19.0 (3/4in)	-4.76 (NO4)	Remarks
Imha	Im.G-1	G1-1	2.1	2.64		87	64	38	8	Laboratory Test
		G1-1 2	1.3	-	15-20	81	50	30	15	Field Sieve Test
	Im.G-2	G2-1	1.8	2.63	15-20	93	74	47	27	Laboratory Test
		G2-1 2	0.9	-	15-20	94	63	38	19	Field Sieve Test
Ham-yang	Ha.G-1	G1-1	1.4	2.66		81	44	18	2	Laboratory Test
		G1-1 2	2.0	-	30-40	64	37	24	14	Field Sieve Test
		G1-2	2.0	2.67		94	66	48	3	Laboratory Test
Juam	Ju.G-1	G1-1	1.5	2.68		92	51	25	2	Laboratory Test
		G1-1 2	1.0	-		86	76	69	61	Field Sieve Test
	Ju.G-2	G2-1	1.7	2.69		99	75	37	9	Laboratory Test
		G2-1 2	1.0	-	20-30	73	48	34	24	Field Sieve Test

Table M 7 EXAMPLES OF HIGH DAMS WITH LOW PLASTIC CORE MATERIAL

Name of Dam	Dam Height (m)	Unified Classification	Liquid Limit	Plasticity Limit	Plasticity Index
Oroville	224	CL & CL-ML	28	21	7
Goscheneralp	155		20	15	5
Swift	153	SC - SM			5
Miboro	131	ML	35	30	5
Trinity	122	CL - ML	28	22	6
Messaure	103	SC - SH		22	5
Round Butte	132			20	5

Source : Ref. M 3

Table M 8 AVAILABLE QUANTITY AT EACH BORROW AREA

Site Name	Area Name	Number of pits	Area in m^2	Depth in m	Volume in m^3
Bamseonggol	Ba.S-1	2	200,000	3.0	600,000
	Ba.S-2	1	104,000	2.5	260,000
	Ba.S-3	1	130,000	2.0	260,000
	Ba.S-4	-	100,000	3.0	300,000
	Ba.S-5	-	75,000	2.0	150,000
Inje	In.S-1	3	120,000	2.5	300,000
	S-2	-	100,000	1.5	150,000
	S-3	-	67,000	1.5	100,000
	S-4	4	700,000	2.0	1,400,000
	S-5	-	400,000	2.0	800,000
Hongcheon	Ho.S-1	2	300,000	3.0	900,000
Gujeol	Gu.S-1	3	235,000	3.0	700,000
Ganhyeon	Ga.S-1	2	500,000	2.0	1,000,000
	S-2	-	80,000	1.5	120,000
Dalcheon	Da.S-1	2	250,000	1.5	370,000
	S-2	2	210,000	1.5	310,000
	S-3	1	75,000	1.5	110,000
	S-4	-	140,000	1.5	210,000
	S-5	-	80,000	1.0	80,000
Bonghwa	Bo.S-1	2	140,000	2.0	280,000
	S-2	-	120,000	1.0	120,000
	S-3	4	860,000	1.0	860,000
	S-4	2	200,000	2.5	500,000
	S-5	1	315,000	1.5	470,000
Imha	Im.S-1	2	125,000	2.0	250,000
	S-2	2	110,000	2.0	220,000
	S-3	1	70,000	3.0	210,000
	S-4	-	10,000	5.0	50,000
	S-5	-	25,000	2.0	50,000
	S-6	-	20,000	3.0	60,000
Hamyang	Ha.S-1	2	200,000	2.0	400,000
	S-2	1	240,000	2.0	480,000
Juam	Ju.S-1	1	90,000	3.0	270,000
	S-2	1	250,000	3.0	750,000
	S-3	1	40,000	3.0	120,000
	S-4	1	125,000	3.0	370,000
	S-5	1	60,000	3.0	180,000
	S-6	1	30,000	3.0	90,000

Table M 9 AVAILABLE QUANTITY AT EACH RIVER DEPOSIT

Site Name	Area Name	Number of pits	Area in m^2	Depth in m	Volume in m^3
Bamseonggol	Ba.G-1	1	240,000	5.0	1,200,000
	G-2	1	120,000	5.0	600,000
	G-3	-	20,000	8.0	160,000
Inje	In.G-1	3	100,000	5.0	500,000
	G-2	-	17,000	3.0	50,000
	G-3	-	90,000	5.0	450,000
	G-4	2	112,000	5.0	560,000
	G-5	-	67,000	3.0	200,000
Hongcheon	Ho.G-1	2	100,000	3.0	300,000
	G-2	2	160,000	5.0	800,000
	G-3	-	135,000	4.0	540,000
Gujeol	Gu.G-1	2	35,000	2.0	70,000
	G-2	2	30,000	2.0	60,000
	G-3	1	7,000	3.0	20,000
Ganhyeon	Ga.G-1	2	175,000	5.0	870,000
	G-2	-	100,000	3.0	300,000
Dalcheon	Da.G-1	-	50,000	2.0	100,000
	G-2	-	35,000	1.5	50,000
	G-3	4	120,000	2.0	240,000
	G-4	1	55,000	2.0	110,000
	G-5	-	147,000	3.0	440,000
Bonghwa	Bo.G-1	-	20,000	2.0	40,000
	G-2	1	20,000	1.5	30,000
	G-3	3	30,000	1.5	45,000
Imha	Im.G-1	2	57,000	3.0	170,000
	G-2	2	45,000	3.0	130,000
	G-3	-	90,000	3.0	270,000
	G-4	-	65,000	3.0	190,000
	G-5	-	75,000	2.5	190,000
Hamyang	Ha.G-1	2	75,000	2.0	150,000
Juam	Ju.G-1	2	55,000	2.0	110,000
	G-2	2	45,000	3.0	130,000

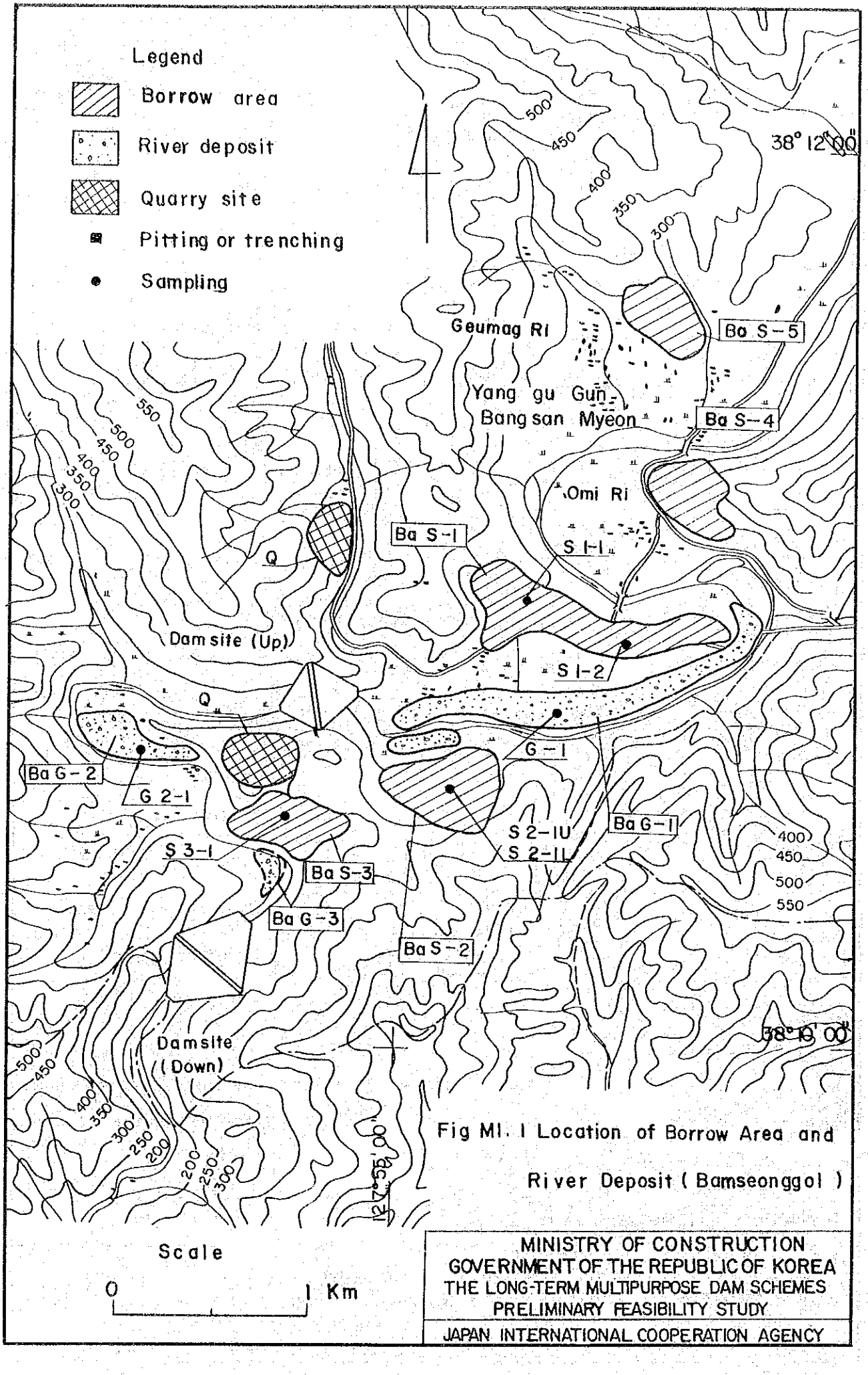

Fig MI. 1 Location of Borrow Area and River Deposit (Bamseonggol)

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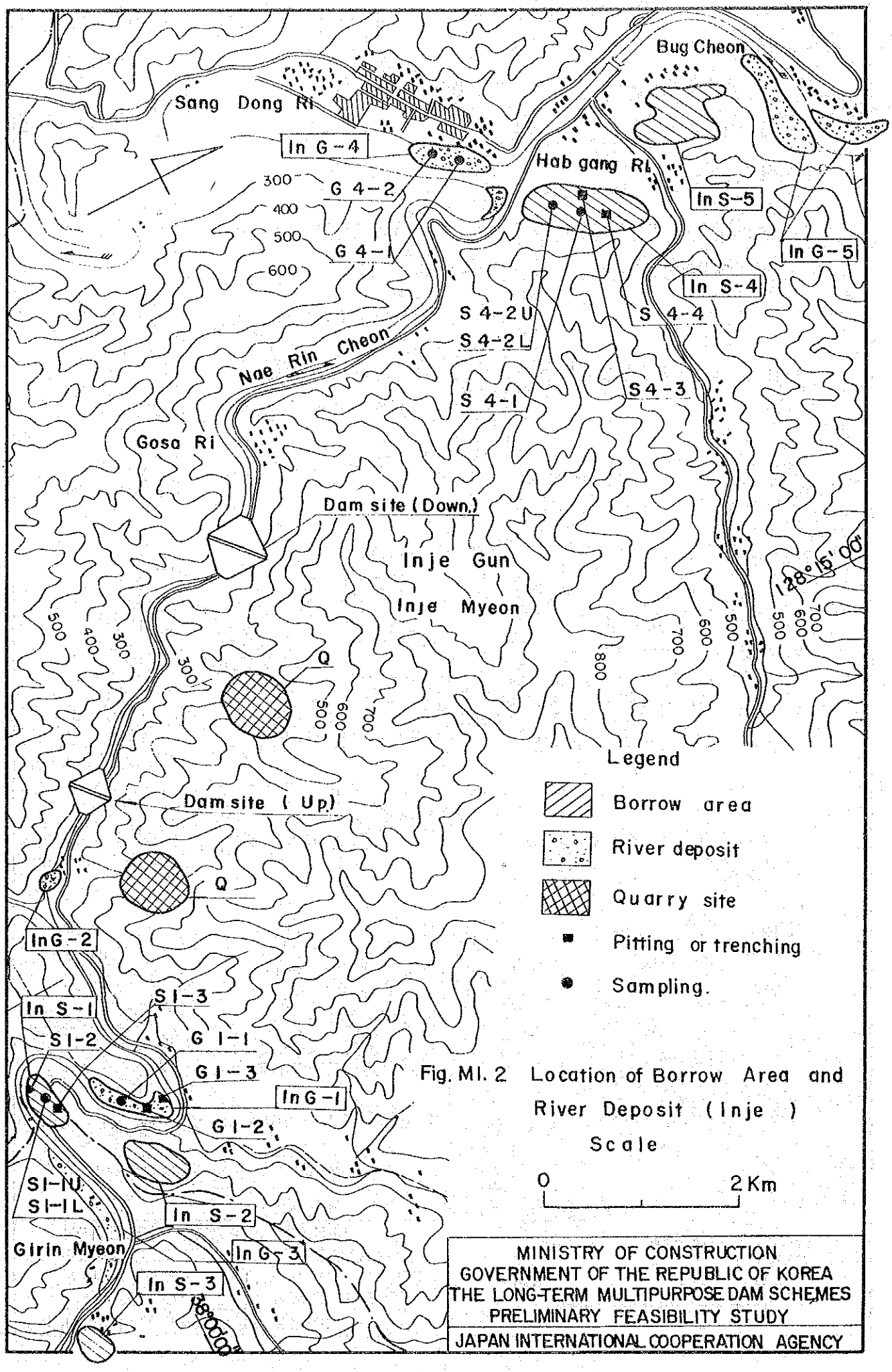

Fig. MI. 2 Location of Borrow Area and River Deposit (Inje)
Scale

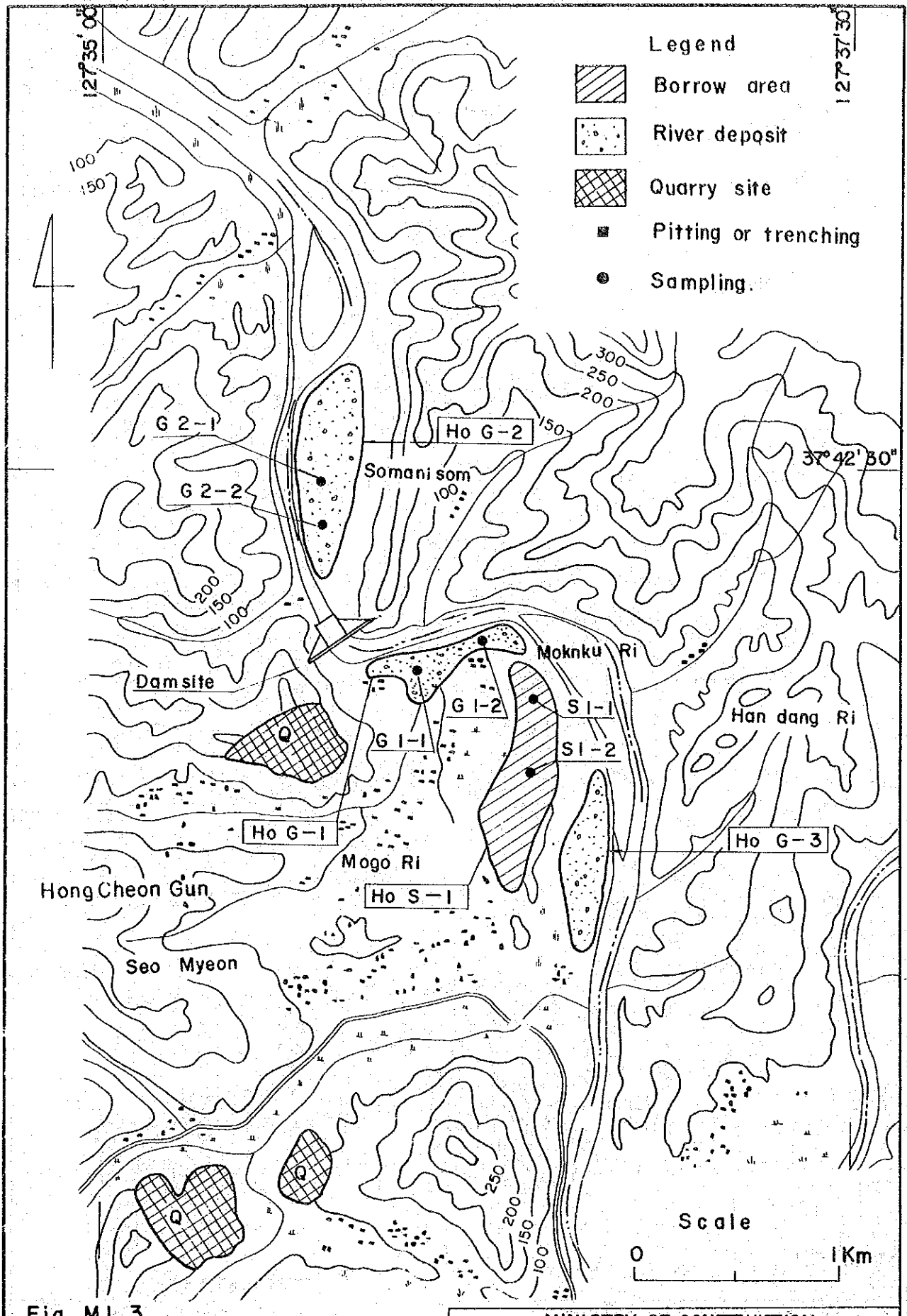

Fig. M1. 3
Location of Borrow Area and River Deposit (Hong cheon)

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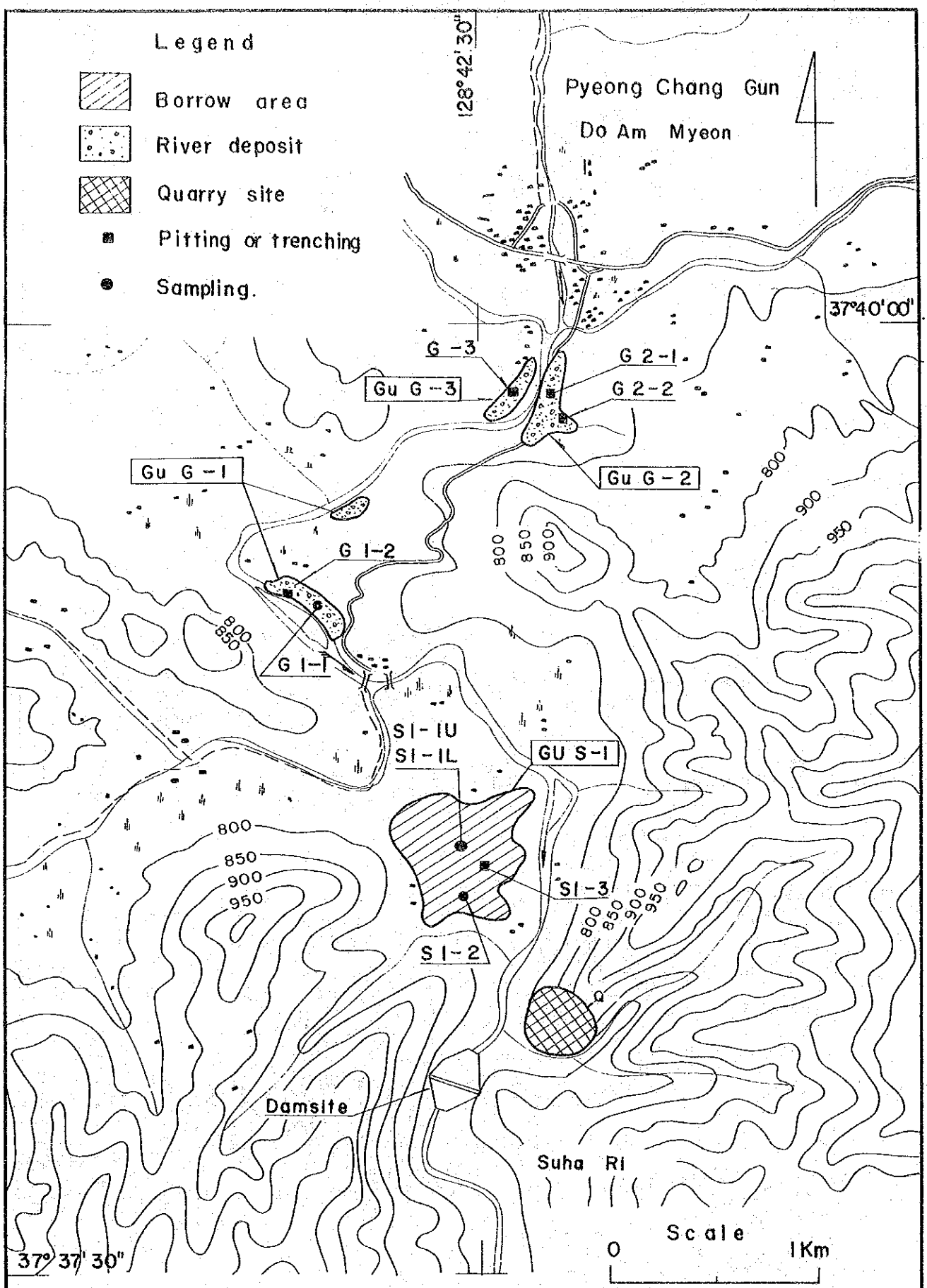

Fig. MI. 4
Location of Borrow Area and River Deposit (Gujeol)

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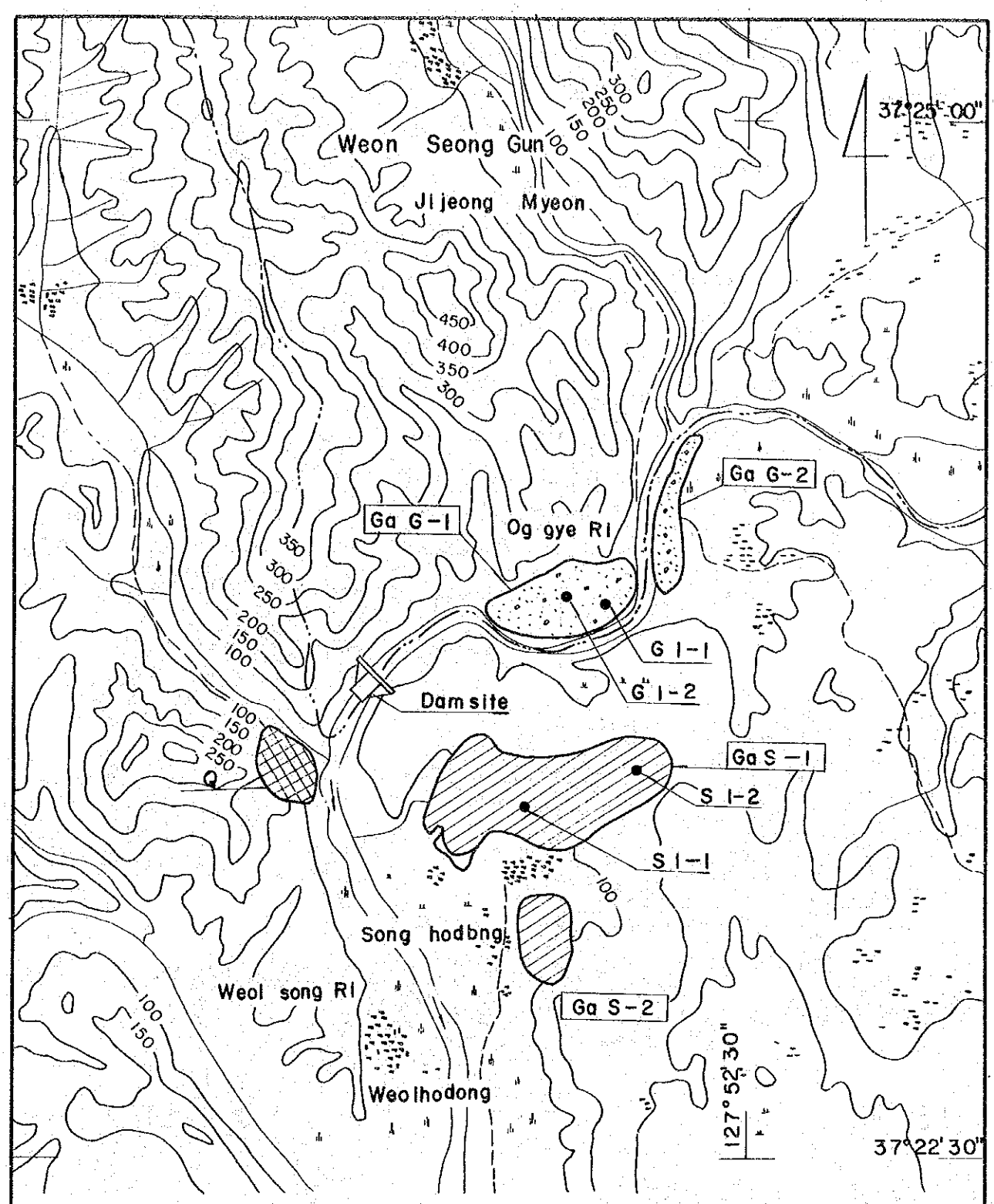

Legend

- Borrow area
- River deposit
- Quarry site
- Pitting or trenching
- Sampling.

Fig MI. 5 Location of Borrow Area and River Deposit (Ganhyeon)

Scale

0 1 Km

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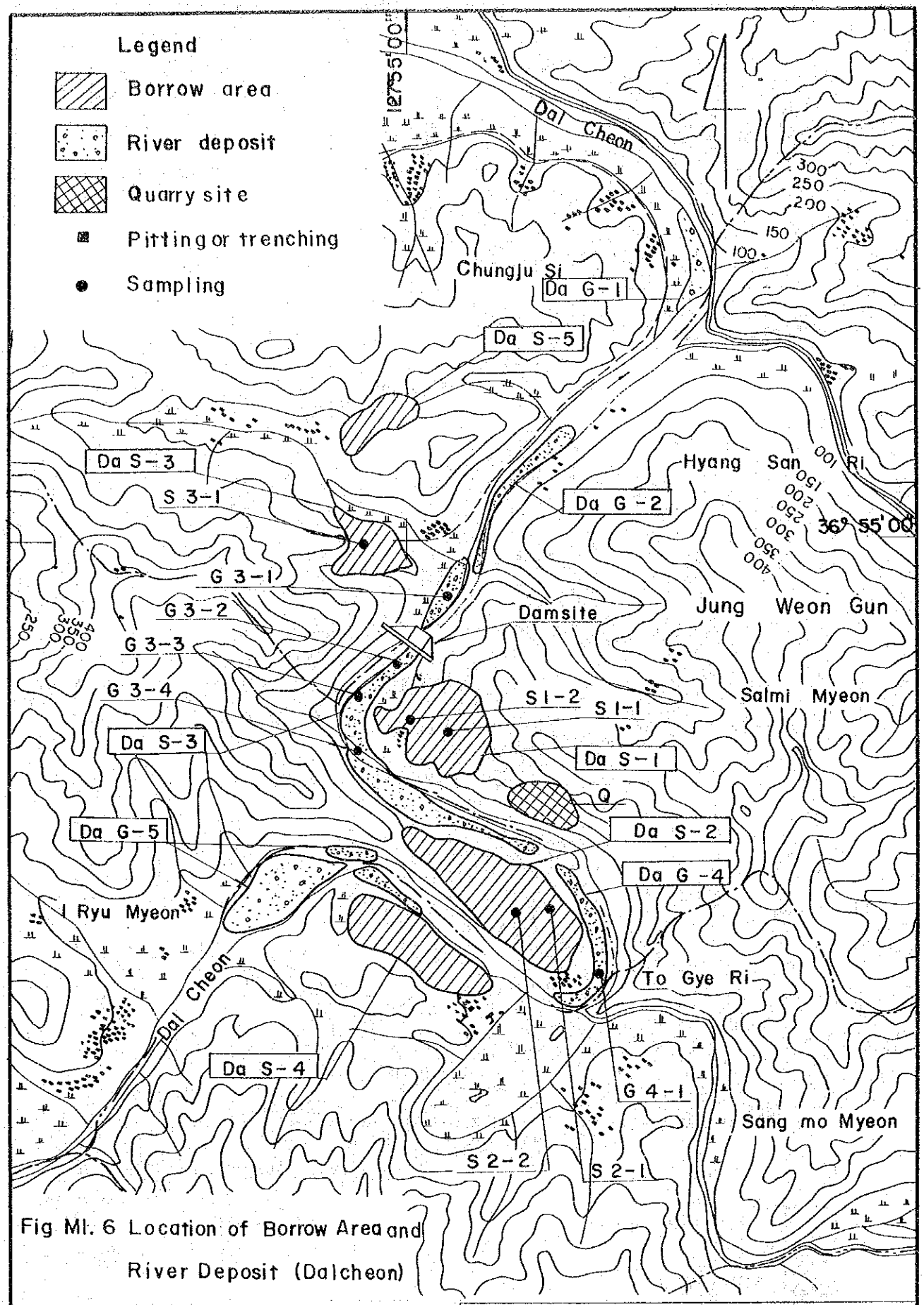

Fig MI. 6 Location of Borrow Area and River Deposit (Dalcheon)

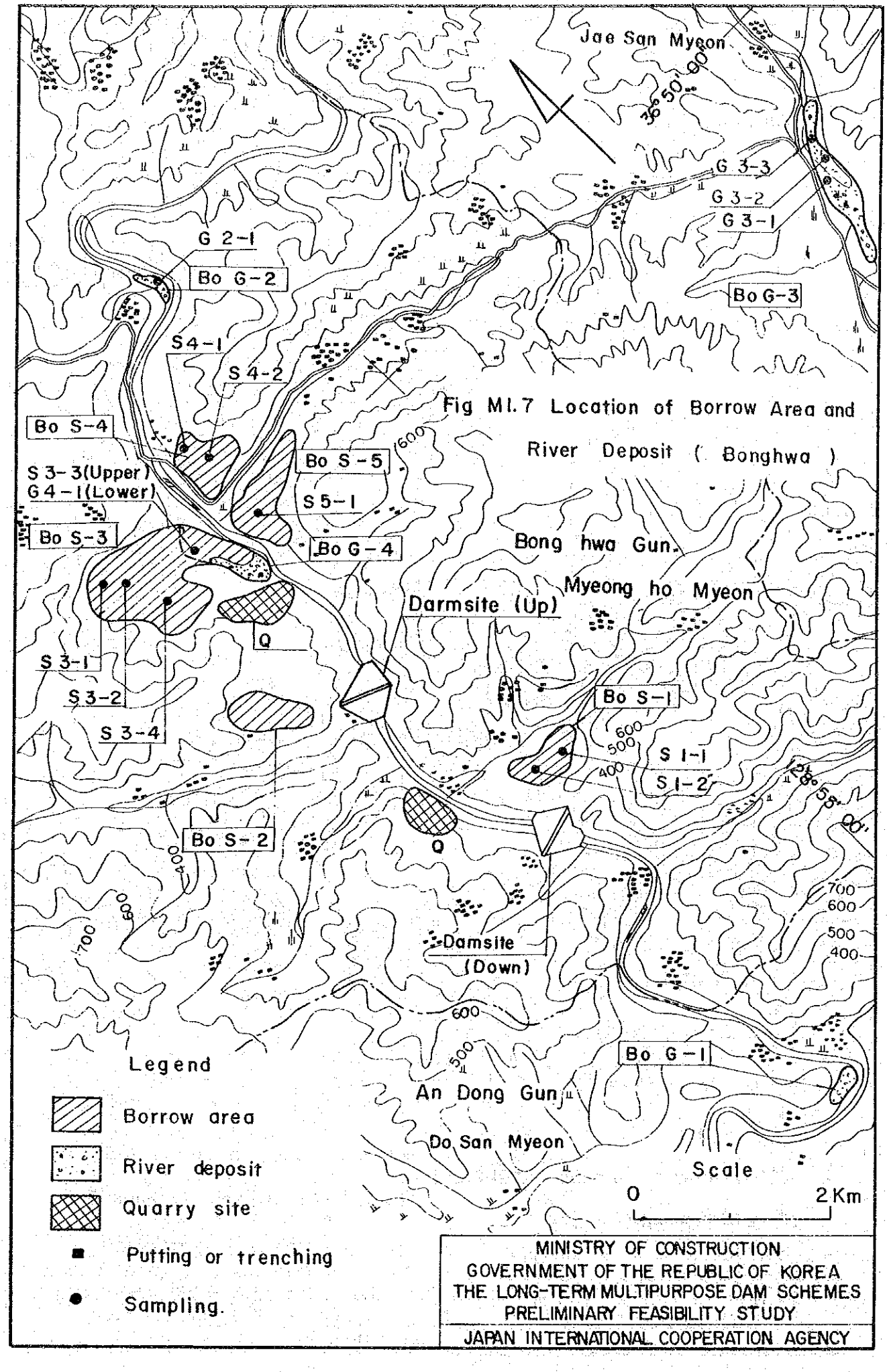

Fig MI.7 Location of Borrow Area and River Deposit (Bonghwa)

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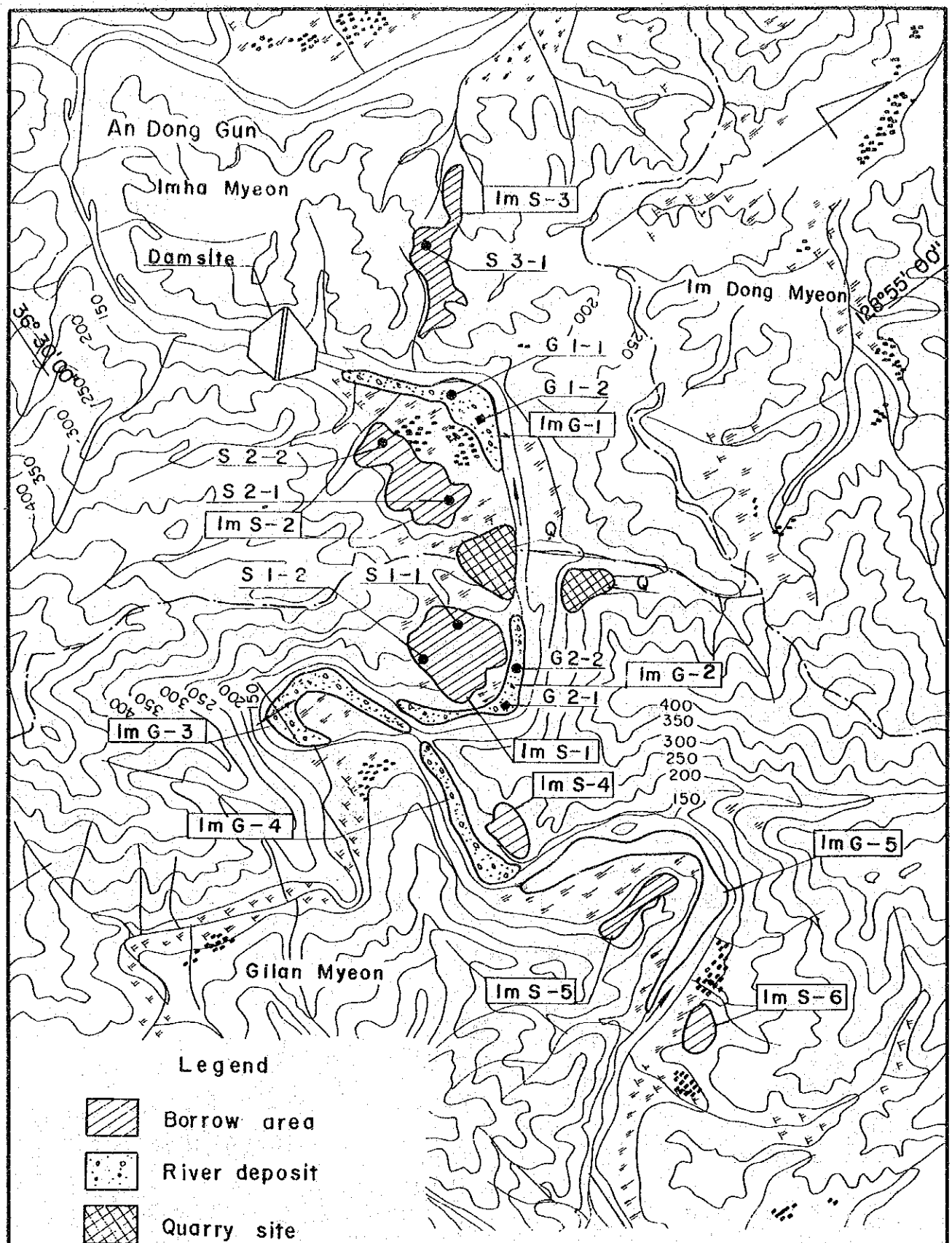

Fig MI. 8 Location of Borrow Area and River Deposit (Imha)

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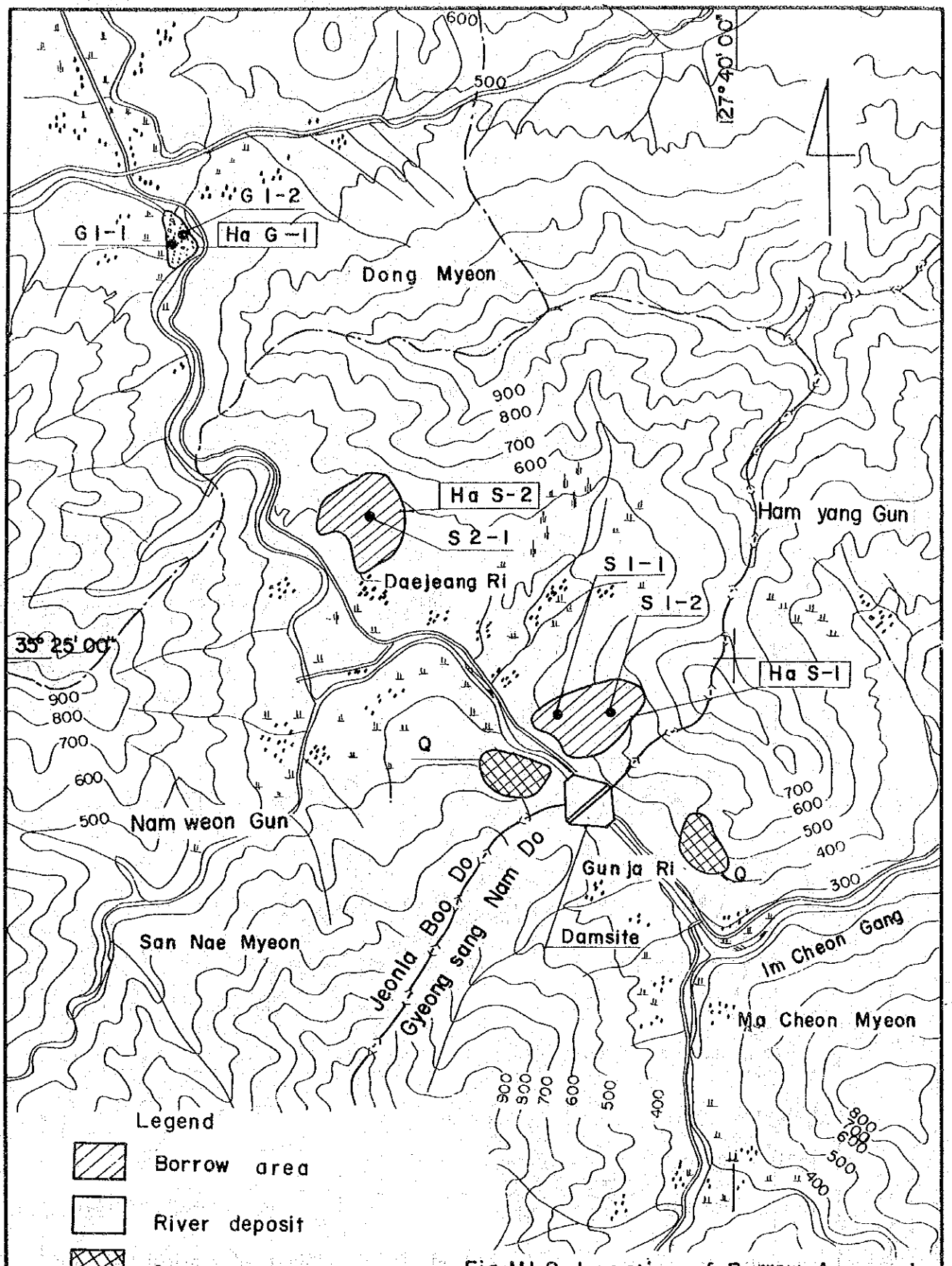

Fig MI.9 Location of Borrow Area and River Deposit (Ham yang)

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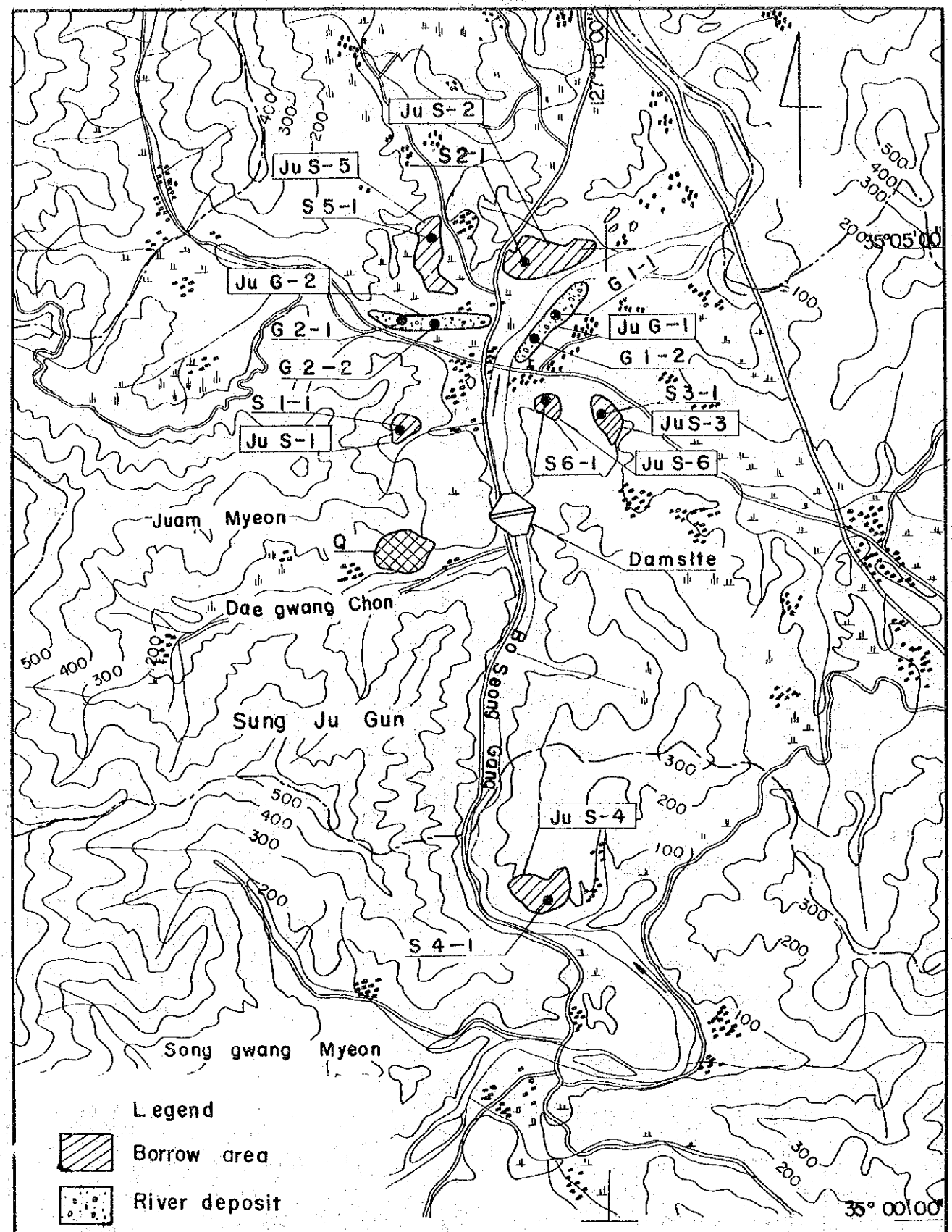

Fig. MI.10 Location of Borrow Area and River Deposit (Juam)

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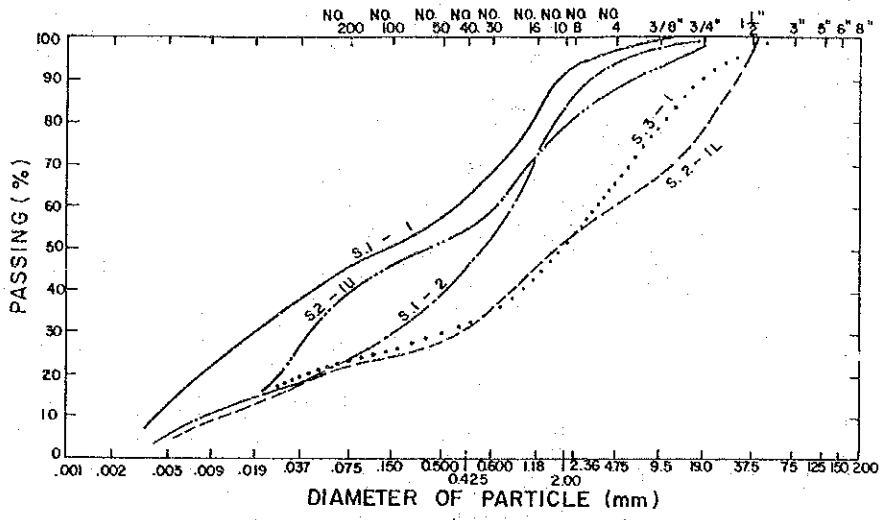

Fig. M2.1 Gradation Curve (Bamseonggol)

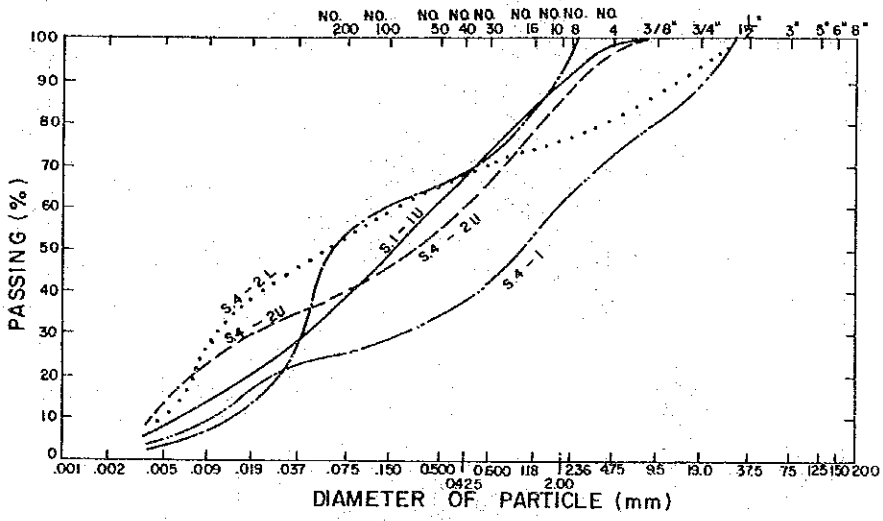

Fig. M2.2 Gradation Curve (Inje)

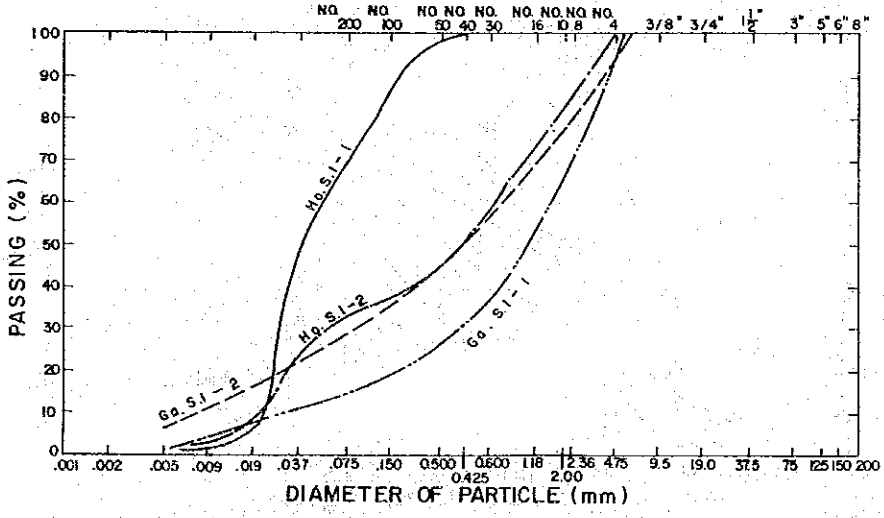

Fig. M2.3 Gradation Curve
(Hongcheon and Ganhyeon)

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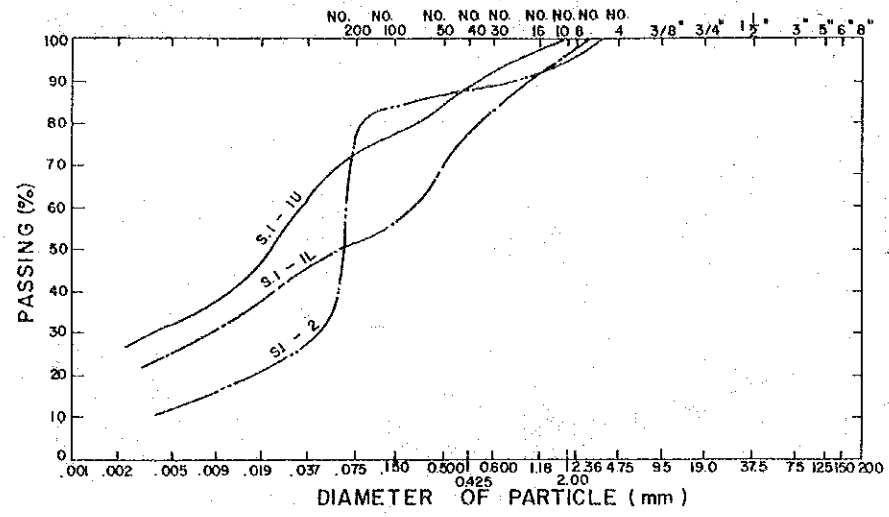

Fig. M 2.4 Gradation Curve (Gujeol)

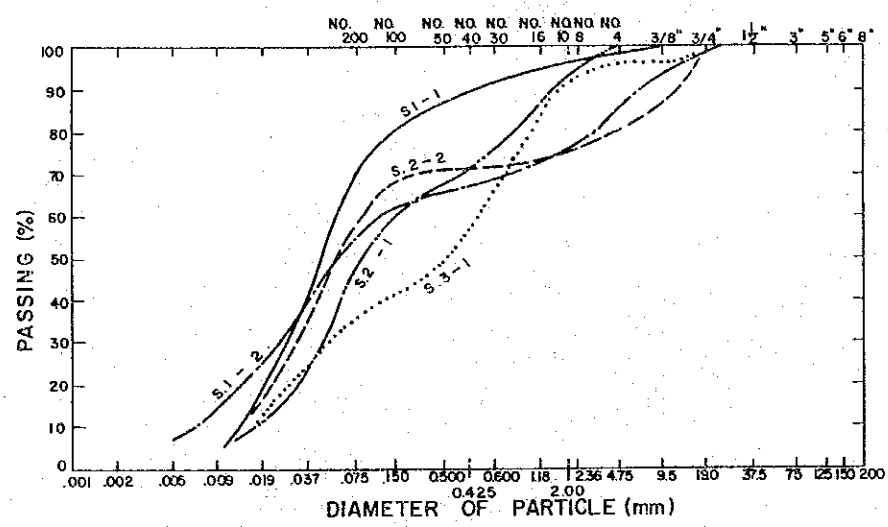

Fig. M2.5 Gradation Curve (Dalcheon)

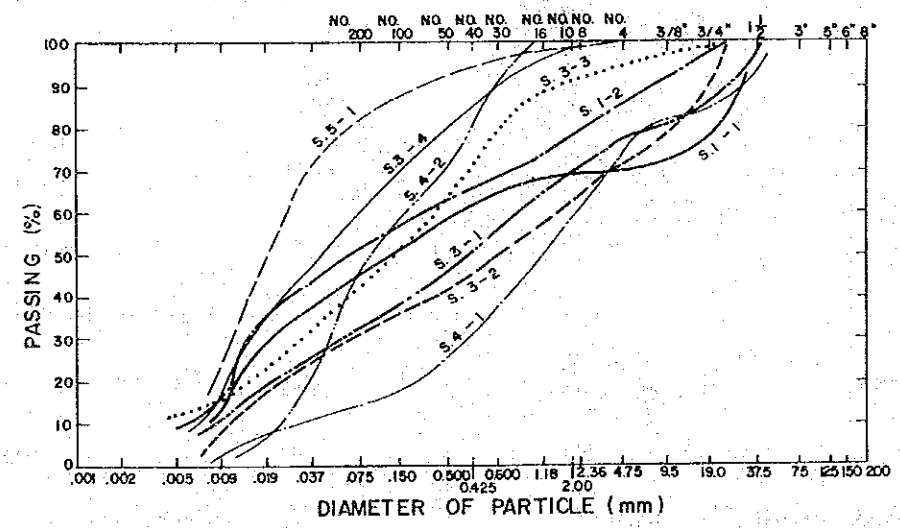

Fig M2.6 Gradation Curve (Bonghwa)

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