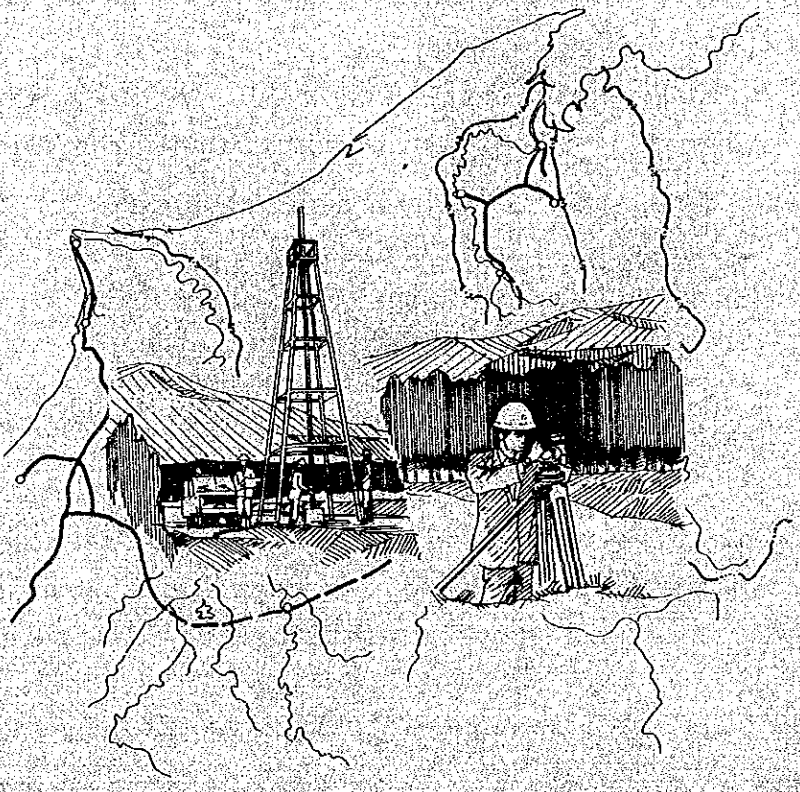
Chapter 5

TECHNICAL STUDY AND ANALYSIS



5-1 GEOLOGY

5-1-1 Outline

Northern Borneo is composed mainly of geologically young sedimentary rocks of Tertiary and Upper Cretaceous age as shown in Table 5-1 and Fig. 5-1.

Table 5-1 PERCENTAGE DISTRIBUTION OF ROCK GROUPS IN NORTHERN BORNEO

Rock Group	Sarawak	Brunei	Sabah	Total
Quaternary	15%	38%	14%	15%
Tertiary & Upper Cretaceous	78	62	74	76
Precretaceous	3	-	-	2
Igneous	4	-	12	7

The Tertiary and Upper Cretaceous rocks are composed mainly of finegrained sandstone alternating with clays or shales. The Quaternary deposits are alluvial and largely derived from the older sedimentary rocks.

The project area is consisted mainly of the alluvial of Quarternary deposits and the Tertiary sedimentry rocks such as shale, sandstone and lignite, but portionally, Precretaceous Limestone.

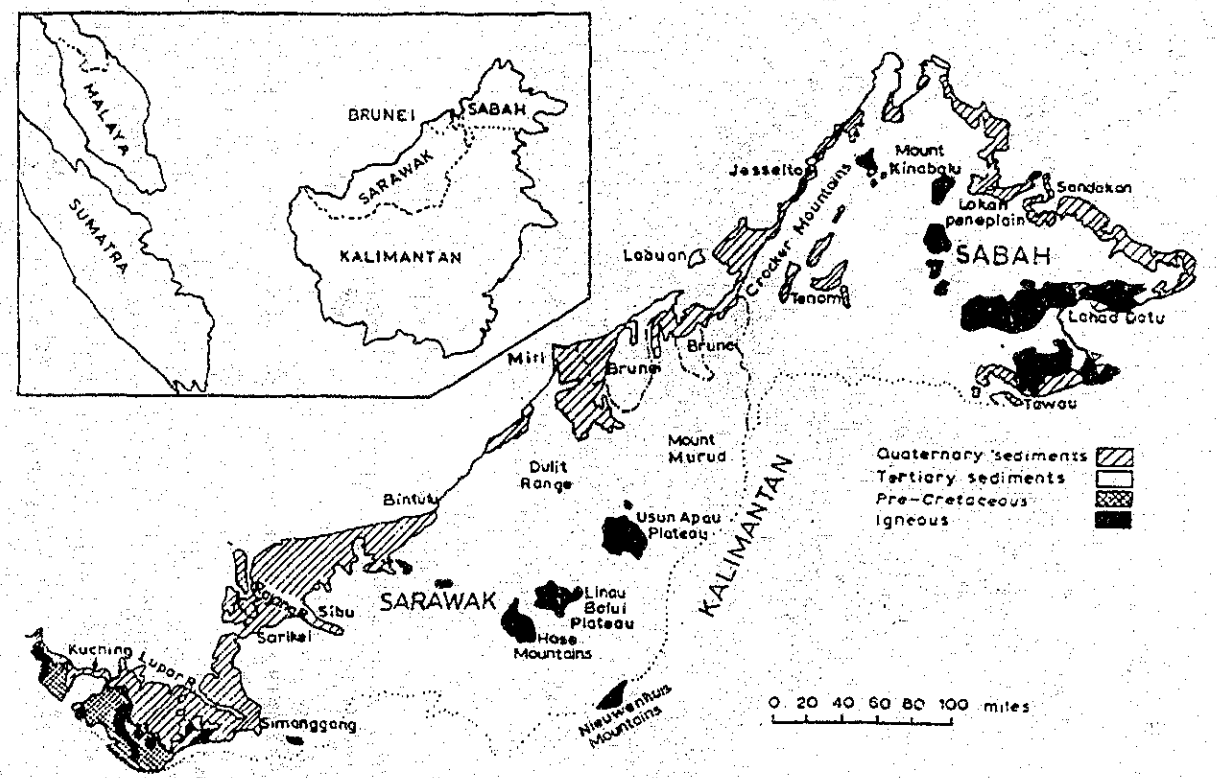
The above Tertiary sedimentary rocks are unsuitable for the use of aggregate materials, because they have not so concreted. On the other hand, although the allivial of Quaternary deposits is not yet concreted, the contained gravel can be used for the purpose.

5-1-2 Mineral Resources in Project Area

As shown in Fig. 5-2, the mineral resources in the project area are limestone, dolomite, phosphate and the like. But since those are concentrically distributed in Mulu National Park, the Allowable mining quantities are necessarilly limited. At present only the limestone

quarried at Batu Gading near Long Lama and Batu Niah near Niah Cave are mainly used for the construction material. It is anticipated that the mineral resources available for the construction in the project area will be confined only to the limestone from the viewpoint of conservation for nature of Mulu National Park.

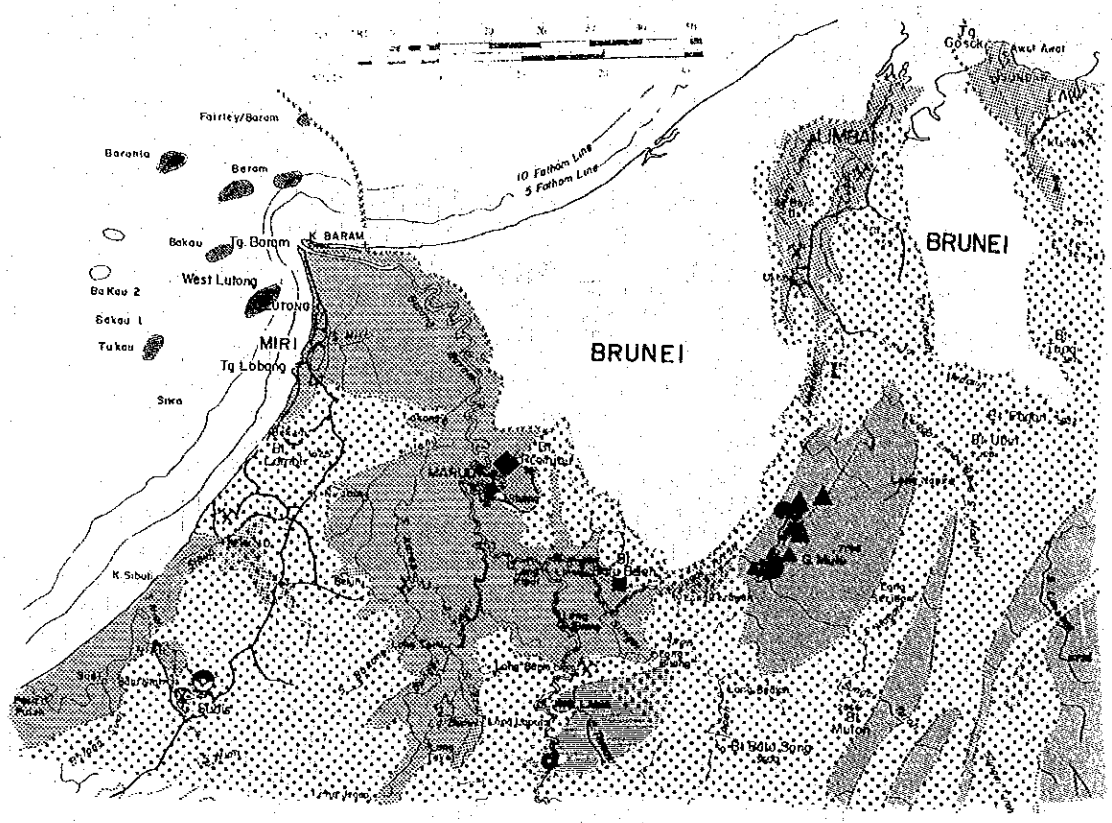
Fig. 5-1 SKETCH MAP SHOWING OF NORTHERN BORNEO



Source: Road Making Materials in Northern Borneo

R R L Road Research Technical Paper No.68

Fig. 5-2 MINERAL RESOURCES MAP



GEOLOGY

- Pleistocene and recent sediment
- Neogene sedimentary rocks (including some late Palaeogene rocks in North Sarawak)
- Palaeogene sedimentary rocks (including some early Neogene rocks, and late Cretaceous rocks in West Sarawak)

	FIELD			WELL	SEEPAGE
	In Production	Potential	Abandoned	Significant hydrocarbon indications	
OIL					
NATURAL GAS				Oil and Gas	
COAL					Occurrence
		Deposit with Proven Reserves		Deposit Worked	Occurrence
PHOSPHATE					
GLASS SAND					
DOLOMITE					
SAND AND GRAVEL					
LIMESTONE					
QUARRY		Operating		Abandoned	

Source: Mineral Resources Map of Sarawak , Malaysia first edition,1976

5-2 SOIL

5-2-1 Outline

Only two sections of project road, Miri/Bintlu Road ∿ Sg. Tinjar (54.5kms) and Limbang ∿ Sg. Limbang (41.0kms) were possible to access to the site by means of a motor car. As for the remainder of intermediate section of 135kms (83 miles) in length, the investigation was performed by a helicopter or a long boat. By the reasons, it is very difficult to get the detailed soil conditions in the limited field investigation period of Phase I.

But happily the precious data was obtained from the soil map with a scale of 1/500,000 of the Department of Agriculture which are made on the basis of the augar boring data to a depth of 1.2m under the ground. The soil classification is subject to "A" Classification of Sarawak Soils, Department of Agriculture, Sarawak, 1966 and Subsequent amendment. According to the soil map, red yellow Podozolic Soils and peat soils are mainly distributed along almost all of the project road, and Grey Soil and recent alluvial soil are found along the big rivers.

Among these soils, the peat soils are most troublesome in the road construction work. The distribution of the soil, with an organic matter content of more than 35% and a thickness of layer of more than 3 meters, is as shown in Fig. 5-3. The zone shall be kept off as much as possible for the route location.

5-2-2 Soil Investigation

The laboratory tests were performed on the soil samples in order to check their properties for the material of embankment and subgrade. The samples are taken out from the 8 points based upon the soil map as shown in Fig. 5-4.

The following tests on British Standard were entrusted to the Central Material Laboratory of the P.W.D.

1) Grain Size Analysis

2) Specific Gravity Test

3) Compaction Test

4) Atterberg Limit Test

5) CBR Test

The test result is summarized in Table 5-2. The value of design CBR of subgrade is determined moderately as shown in the Table 7-4.

5-2-3 Investigation of Foundation Ground for Bridges

The investigation for bridge foundation is planned to be carried out at 5 places in Phase II. In Phase I, informations for the investigation and the length of Sg. Teman Bridge being under construction between Beluru and Sg. Tinjar is executed in the length of 36m (120 feet). It is anticipated that the bearing strata for the every proposed bridge piles will be encountered in the deep level except for that in the vicinity of Mulu National Park, becuase the proposed bridge is located in sites with almost same geotechnical conditions as that of Sg. Teman.

5-2-4 Determination of Foundation Works

To determine the type of foundation for struction, the rotary boring survey with standard penetration test will be performed at the phase II survey for the locations where major bridges and proposed. According to the under construction site the bearing stratum in the study area is presumed about 20 ∿ 30m below the existing surface and the pile foundation work is proposed.

As the piles, considering the langth of pile, quality of materials, driving capacity, moment of inertia, etc. RC pile is determined for the preliminary design.

The comparative studies of various types of piles will be made at the phase II study.

Fig. 5-3 MAP OF SWAMP AREA

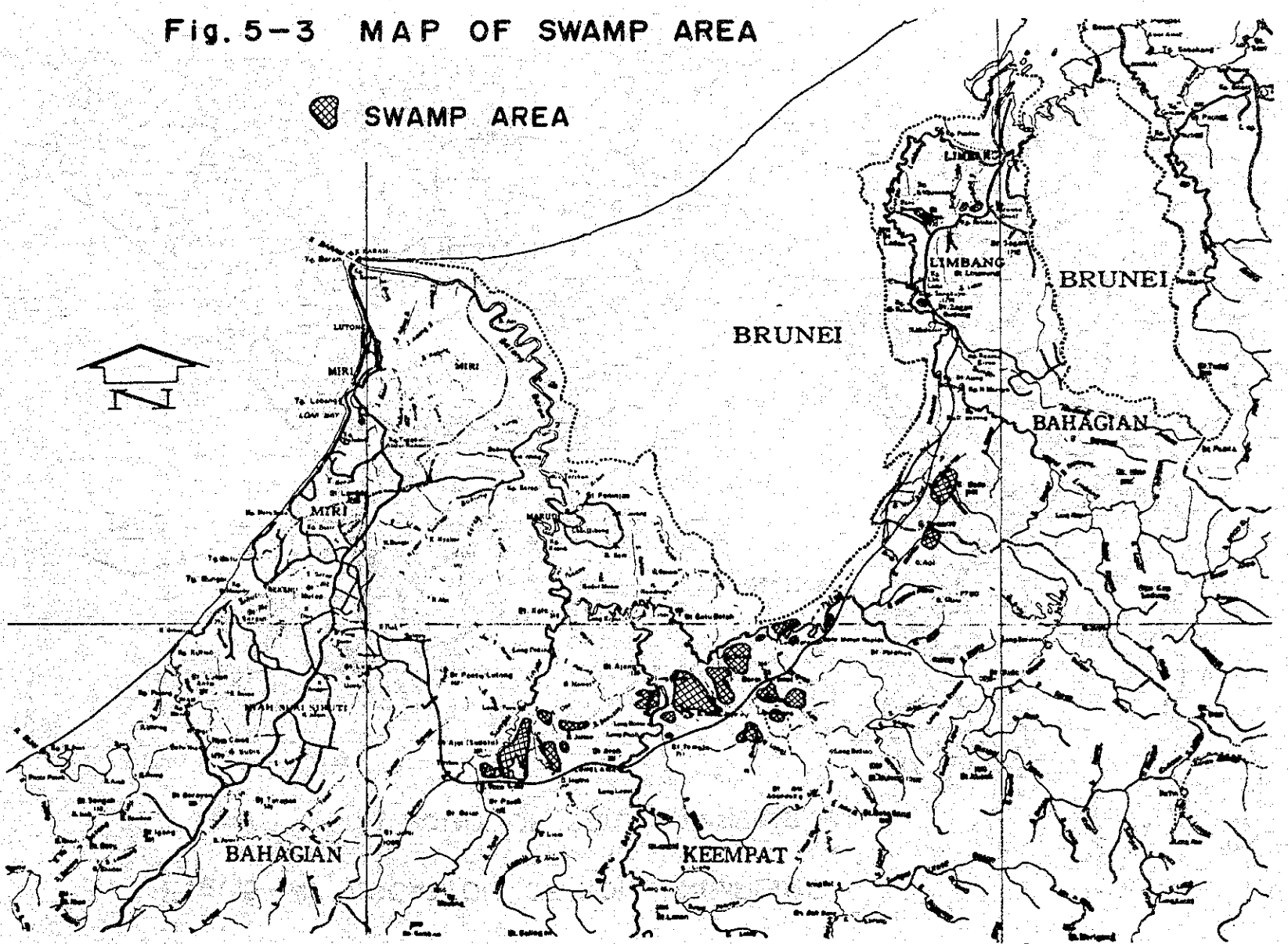


Fig. 5-4 LOCATION OF SOIL SAMPLING

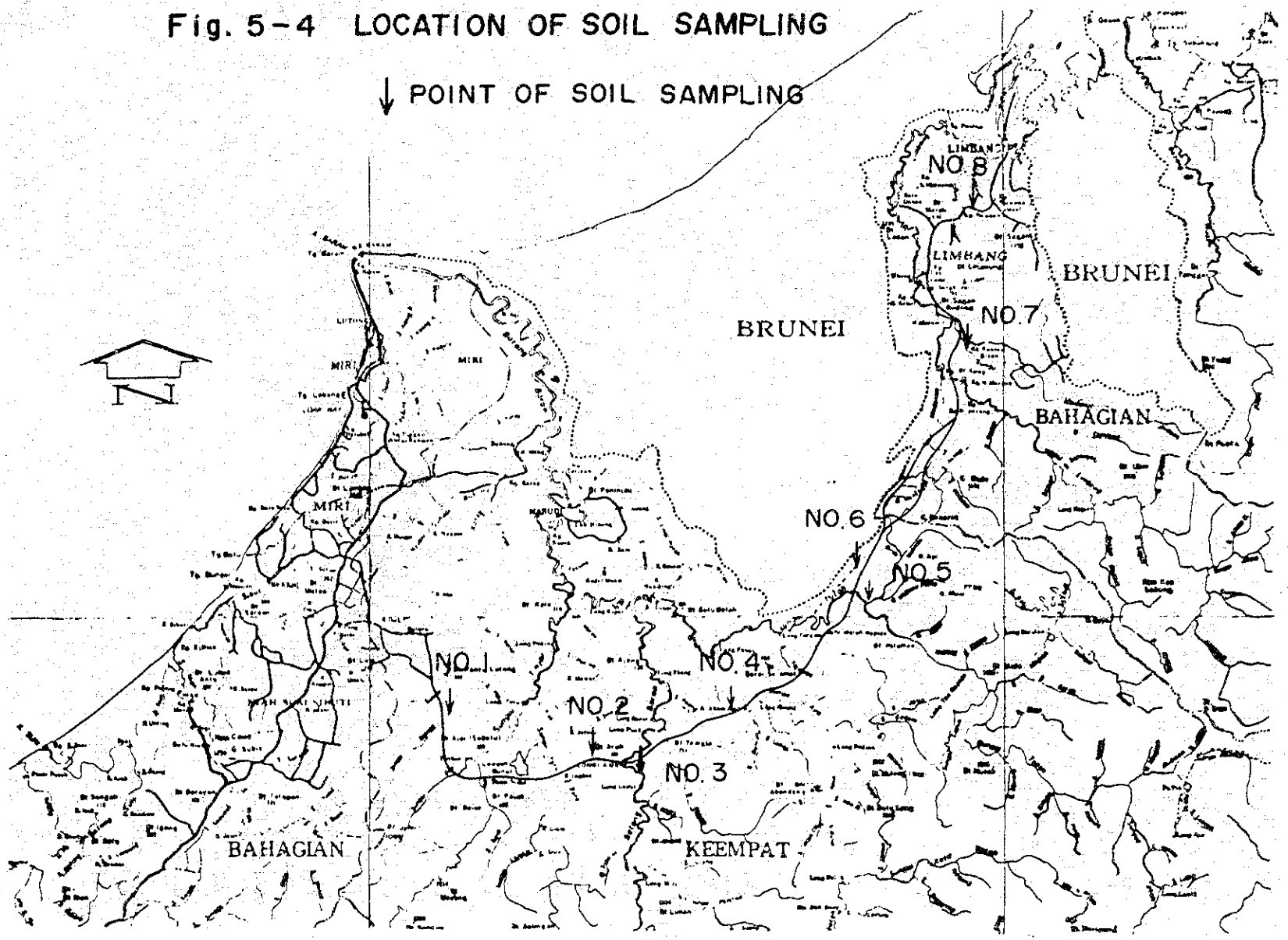


Table 5-2 SUMMARY OF SOIL TEST RESULTS

Sample Spot	Moisture Content (of) (Natural)	Atterberg Limits			S.G.	Compaction			C.B.R.
		L.L.	P.L.	P.I.		O.M.C.	Max. Dry Density g/cm^3	lb/ft^3	
1	23.5	38	23	15	2.65	13%	1.87	117	3
		(Soil type : CI)							
2	32.0	47	30	17	2.65	14	1.81	113	3
		(Soil type : OI & MI to CI)							
3	28.5	44	22	22	2.63	14	1.82	114	3
		(Soil type : CI)							
4	33.5	43	24	19	2.64	17	1.78	111	7
		(Soil type : CI)							
5	9.0	--- N.P. ---			2.65	-	-	-	-
6	39.0	42	25	17	2.65	18	1.76	110	4
		(Soil type : CI to OI & MI)							
7	35.5	67	34	33	2.64	21	1.63	102	4
		(Soil type : OH & MH to CH)							
8	29.0	56	28	28	2.67	16	1.81	113	2
		(Soil type : CH)							

Remarks : L.L. - Liquid Limit, P.L. - Plastic Limit,
P.I. - Plasticity Index, S.G. - Specific Gravity,
O.M.C. - Optimum Moisture Content

5-3 CONSTRUCTION MATERIAL

Since the rocks around the project area are geologically young, it is fairly difficult to obtain the aggregate material of good quality. The quarry sites in the project area are shwon in Fig. 5-4. The quarries of present use or future development potential ty consist of limestone or gravels. In general, those are less suitable for the pavement material. However, according to the test result by P.W.D., it comes evident that the above materials can conform fully with that of British Standard as shwon in Table 5-3.

5-3-1 Quarry of Limestone

An brisk quarry work is carried out at two places, Batu Niah and Batu Gading. The limestone quarry of Batu Niah is under the direct management of P.W.D., and produces crusher run at 75mm (3 inches) in the maximum diameter, at the rate of 1,500 ton/month. It is expected that the quarry will maintain the production rate for other 20 years.

The quarry of Batu Grading is managed by the two private firms, that is, Holly Stone Quarry and Sharikat Betoh Quarry.

Holly Stone Quarry produces 11 sizes of macadam of 300mm (12 inches) in the maximum diameter at the rate of 120,000 ton/year, while Sharikat Betoh Quarry deals 3 kinds of macadam of 25mm (1 inch) in the maximum diameter at 30,000 ton/year.

Both quarries will maintain the curren production rate for the other 20 years.

Since the quarrying of limestone in Mulu National Park area is prohibited, it is required to add the investigation for the quantity and quality of that in Selidong & Karamit, Bukit Gadons Loul and Bandran for this project.

Table 5-3 PHYSICAL PROPERTIES OF QUARRIES AND PITS IN SARAWAK

Division	Quarry Site	A.I.V.	Mod. A.I.V.	A.C.V.	L.A. Abrasion	S.G.	Water Absorption	Government or Private
1st	Stabar Quarry	23%	24%	22%	18%	2.50	1.9%	Government
"	Sinibong Quarry (M24 Bau/Lundu Rd)	17	18	19	-	2.65	2.8	Government
"	M38 Kuching/Serian	12	14	16	14	2.72	0.48	Government
2nd	Sebuyan Quarry	30	-	27	35	2.70	0.4	Government
"	Abok Quarry	17	26	19	20	2.68	1.6	Government
"	Lachau Quarry	18	19	19	18	2.66	1.25	Government
"	Marup Quarry	25	29	22	24	2.68	1.0	Government
"	Kalambi Quarry	25	29	22	24	2.68	0.5	Government
4th	M22 Bintulu/Miri Road	21	25	18	18	2.67	1.2	Government
"	Batu Niah	27	29	26	29	2.65	2.31	Government
"	Batu Gading	24	-	25	-	2.68	0.6	Private
5th	Ukong Gravel	31	33	30	-	2.43	1.4	Government
"	Lubai Tengah Gravel	43	46	40	-	2.62	1.7	Government
"	Berawan/Nanga Medamit Gravel	30	32	28	-	2.64	1.23	Government
"	Lawas/Damit Gravel	32	33	27	49	2.65	2.34	Government
"	Bukit Kubang Gravel	48	50	39	83	2.54	1.8	Government
"	Pandaruan Gravel	36	42	-	-	2.65	2.04	Government
Suitability for Construction	for concreting aggregate	max.45	-	-	-	-	-	
	for structural concrete	max.30	-	-	-	-	-	
	for road sto	-	max.40	-	-	-	-	
	for road surfacing	-	-	max.35	-	-	max.2	
	for road construction	-	-	-	max.50	-	-	
	for road bases	-	-	-	-	-	max.4	

Remarks: 1) A.I.V. - Aggregate Impact Value 2) Mod. A.I.V. - Modified Aggregate Impact Value
3) A.C.V. - Aggregate Crushing Value 4) L.A. Abrasion - Los Angeles Abrasion
5) S.G. - Specific Gravity

5-3-2 Gravel

Gravel is distributed in a formation of terrace or riverbed Sediment.

(1) Terrace Sediment

The Terrace Sediment was formed in the Quarternary, and is distributed in the sites shwon in Fig. 5-5.

3 gravel pits exist, that is, Lubai Tengah, Ukong Quarry and M15 Berawan Nanga Medamit Rd. in the side of Limbang.

The materials from those sites are available for the subbase course. And also they can be utilized for the material of surface course except that from Lubai Tengah. Besides, they can be utilized for the lower subbase without screening.

In addition to the above quarries, there are potential gravel pits for construction use in the Terrace of Temasok and Middle Limbang Valley, for which a further investigation shall be needed.

(2) Riverbed Sediment

The flow of rivers in the project area are generally gentle, so the sediments of gravel are found expecially in the riverbed of Sg. Tutoh, Sg. Melinau and Sg. Medalam which running near the mountainous area.

The possibility for use of these gravels will be determined based on the study on the access roads to the sites and the distributed conditions of material itself.

In the upstream from Long Terawan, the quantity of 10,000 to 20,000m^3 is deposited, but its quarring work faces the problem of access road, which will be dealt with in Phase II.

5-3-3 Aggregate Supply and Construction Method

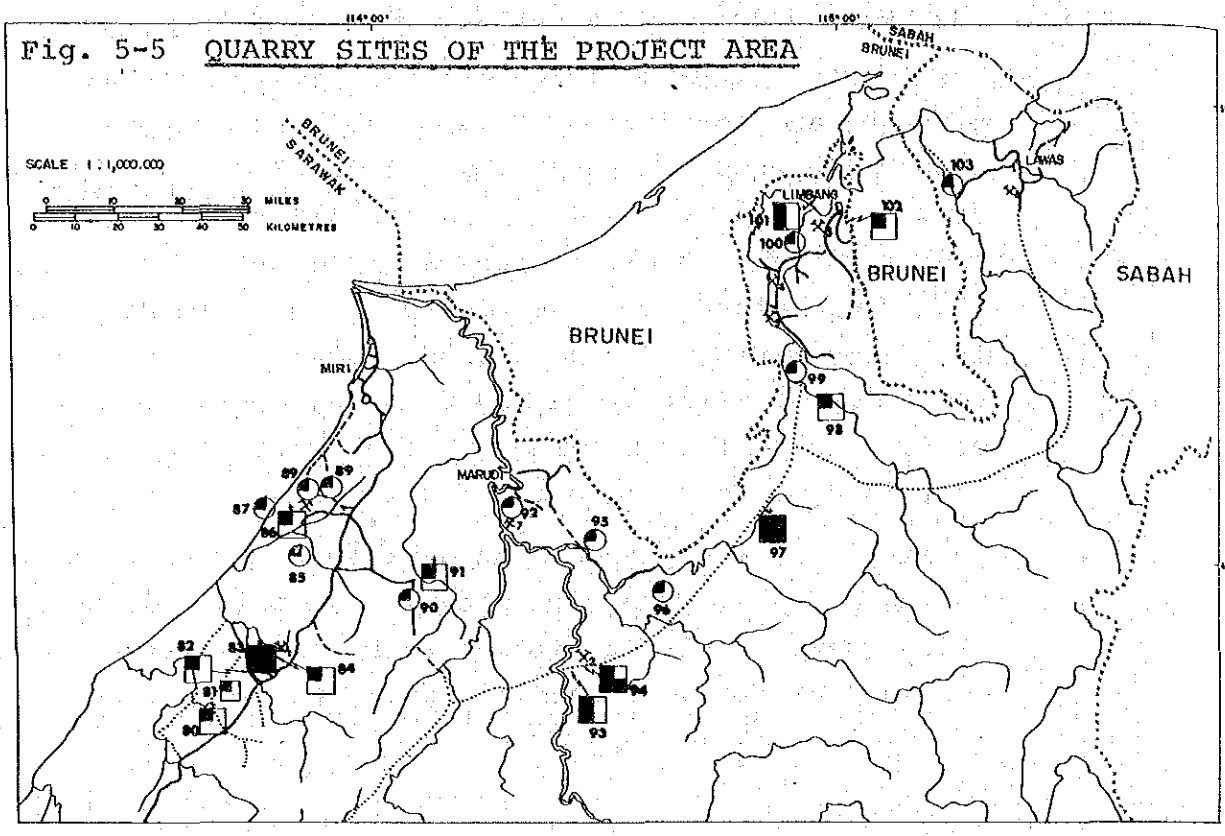
The quantity of aggregate material for the use of pavement and concrete of this project is estimated as around 700,000m^3. It will be practical and effective to make a mass production at a few limitted numbers of quarry for the supply of such a large quantity of material. Therefore, each section is planned to be located in a same maximum distance from a quarry for the transportation of material in order to reduce the construction cost. The following Table 5-5 shows the location of quarries and their covering section.

In addition, although the deposit amount of Batu Niah and Batu Gading have been clearly investigated, that of Ukong Quarry shall be checked in Phase II, becuase a considerably large amount of which has been already quarried up to date.

Table 5-5 QUARRY SITES AND THEIR COVERING SECTIONS

Quarry Site	Covering Section
1. Batu Niah	Miri Bintulu Road-Beluru-Sg.Tinjar
2. Batu Gading	Sg.tinjar-B.Baram-Sg.Apoh-Sg.Tutoh-Border of 4th Division and 5th Division
3. Ukong Quarry	Border of 4th Division and 5th Division-Sg.Limbang -Batu Danau-Ukong-Limbang

Fig. 5-5 QUARRY SITES OF THE PROJECT AREA



Rock Type	Quality	Quantity
Limestone	Average	Million Cubic Yards
Gravel & Limestone	Poor	>10
		5 - 10
		1 - 5
		<1

Average - means rock may be suitable for use in road base course and surfacing, and as concrete aggregates and blockstones for load bearing structural uses in minor engineering works.

Poor - means rock may be suitable for use as road fill, in road sub-base course and possibly base course.

Existing Quarry Sites

Government Quarries

(4th Div.)

- ⚒ 7 Marudi Quarry
- ⚒ 1 Niah Quarry (M.65 M/B Rd.)

(5th Div.)

- ⚒ 6 Lawas/Damit Rd. (M.5-1/2) River Gravel
- ⚒ 3 Lubai Tengah
- ⚒ 4 Ukong Quarry
- ⚒ 5 M.15 Berawan/Nanga Medamit Rd.

Private Quarries

(4th Div.)

- ⚒ 2 Holly Stone Quarry
- 84 Kong Thai Sawhill

Potential Quarry Sites

80. Sungai Kurong, Niah
81. Sungai Lembong, Suai Area
82. Sungai Semilau, Yong Choon Jin Quarry Niah
83. Gunung Subis (National Park)
84. Kong Thai Sawmill (Miri) Sdn. Bhd.
85. Bulak Setap, Sibuti
86. Trusan Limestone, Miri
87. Tanjong Batu, Miri
88. Seraya Limestone, Miri
89. Kedulit Sandstone, Miri
90. Beluru Sandstone
91. Beluru Limestone
92. Lubok Nibong, Marudi
93. Bukit Betok, Marudi
94. Bukit Besungai, Marudi
95. Tutoh Valley
96. Temasok, Limbang
97. Melinau Limestone, Limbang
98. Selidong and Keramit Limestone, Limbang
99. Middle Limbang Valley
100. Tempas Hill, Limbang
101. Bukit Gadong Laul, Limbang
102. Panduran, Limbang
103. Trusan River, Limbang

Note: ⚒ Existing Quarry
+ Abandoned Quarry
* Indicates Possible Use of Rock

5-4 HYDROLOGICAL INVESTIGATION

5-4-1 Climate in Project Area

Generally in the East Malasia, the rainy season ranges from October to January and from april to June, while the dry season lies from February to March and from July to September. However, especially in the project area, the monthly rainfall is of such a large magnitude as to make the period of both seasons indistinguishable. In Phase I the investigation of rainfall was carried out mainly, but in Phase II the climatic data such as the temperature, wind direction and velocity is to be collected. The rainfall of representative points in the project area is taken out from the Hydrological Year Book of the State of Sarawak (1975) as shwon in Table 5-5. The isohyet line chart of 1975 is shown in Fig. 5-6, so the rainfall of new road construction section is found as 3,500 ∿ 4,000mm (140 ∿ 160 inches). In addition the observation stations of rainfall are lcoated shown in Fig. 5-7.

5-4-2 Present Condtions of Main Rivers

In the area, as shown in Fig. 5-7 there flow the large rivers, B. Baram and its tributaries Sg. Tinjar, Sg. Teru, Sg. Apoh and Sg. Tutoh, and also Sg. Limbang and its tributaries, Sg. Medamit and Sg. Medalam.

In those basins, the river courses meander to a large extent and have not necessarilly reached to the table state due to those very gentle gradient. Sicne the basins have been flooded in many places, the close investigation is required to determine the location of route. B. Baram, running in the west of Long Lama situated at teh center of the project area, is a large river with a width of, 150m, river course of 400km in its upstream side and basin area of around 9,500km^2. The division of span and other design factors for the bridge over B. Baram shall be determined taking into

account the possibility of transportation of wood subject to the future development of forest in the upstream side.

Next to B. Baram, Sg. Tutoh is a large river. At crossing point of the bridge, navigation of a large vessel or a raft is improssible because of a thick sediment on its riverbed (gravel less than 20cm in the diameter). At present it permits only a long boat to pass.

Consequently it is needed to pay a sufficient consideration for the span division of the proposed bridge, but at the same time, the counterplan against driftwood shall be prepared as it is located close to the mountains.

The rivers, Sg. Medamit, Sg. Limbang and Sg. Medalam are very close to the mountains, so their water levels change up and down to a large extent, and also they have many driftwood which couses the difficulties of the naviagation at many points.

Especially in the rivers Sg. Medamit and Sg. Limbang, there has been adopted a method to lumber a piece of wood in a uniform length and to let it indivisually flow on the river, so an attention shall be paid to the location of piers for the proposed crossing bridges.

5-4-3 Observation of River Discharge and Specific Discharge Diagram

The observation of discharge of the two large rivers, B. Baram and Sg. Limbang, which running through the project area, are being made at the five stations. The location and period of observation are shwon in Fig. 5-7. Fig. 5-8 shows the observed discharge and specific discharge diagram based upon the catchment area.

In making the specific discharge diagram, although the relationship between the discharge and water level is obtained as largest one among the practically observed figures are adopted as a discharge, because the reliability of the discharge become poorer when the water level become higher.

Table 5-5 RAINFALL DATA (1957 - 1975)

Station & Name		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
4 - 34 Long Teru	Years Recorded	3	6	7	5	6	7	7	6	7	7	7	4	
	Mean (in)	8.87	6.66	9.75	14.46	8.84	9.68	8.64	6.89	10.30	12.23	15.72	13.26	125.28 (3,132mm)
	Daily Max.(in)	2.94	2.45	3.72	3.95	2,80	3,04	4.06	2.60	4.39	4.35	5.12	2.72	
	Mean Rainy Days	14	13	15	19	18	15	14	13	18	17	19	21	
4 - 9 Long Lama	Years Recorded	12	14	15	14	15	16	16	14	12	12	10	9	
	Mean (in)	15.29	12.37	12.27	15.78	16.48	13.17	9.76	11.10	10.90	16.69	18.03	17.81	169.95 (4,249mm)
	Daily Max.(in)	8.00	9.00	4.80	4.52	7.52	5.98	4.93	8.45	5.15	4.80	5.16	7.14	
	3 hrs. Max.(in)	-	1.35	1.55	2.88	1.16	1.19	3.70	-	-	1.45	-	-	
	1 hr. Max.(in)	-	1.00	1.25	1.18	1.15	1.19	2.65	-	-	1.00	-	-	
	Mean Rainy Days	16	14	15	14	16	14	13	14	14	18	18	19	
4 - 17 Long Pamai	Years Recorded	11	11	11	11	11	13	11	10	9	12	9	7	
	Mean (in)	19.15	10.89	12.28	15.67	12.76	9.84	8.02	7.40	13.45	19.12	16.96	19.36	164.90 (4,122mm)
	Daily Max.(in)	17.90	4.22	7.15	6.65	6.13	4.50	5.70	3.65	4.46	7.49	5.75	4.91	
	Mean Rainy Days	17	13	14	17	15	12	12	10	16	18	20	21	
5 - 16 Long Belong	Years Recorded	4	5	5	5	5	5	5	5	5	5	5	4	
	Mean (in)	12.98	14.01	14.51	13.42	15.51	10.27	11.57	15.01	18.94	15.72	16.62	17.01	158.56 (3,964mm)
	Daily Max.(in)	4.40	4.21	7.25	3.55	4.05	3.72	5.05	4.03	6.09	3.89	4.12	3.48	
	Mean Rainy Days	16	17	18	20	22	16	17	18	23	19	21	24	
5 - 12 NG. Medamit	Years Recorded	12	12	12	13	13	13	13	13	13	13	13	13	
	Mean (in)	14.26	11.12	9.88	15.00	15.95	10.66	10.60	13.32	16.28	15.33	16.08	18.21	166.69 (4,242mm)
	Daily Max.(in)	6.70	3.67	5.12	4.53	5.95	5.30	4.85	6.25	5.30	4.84	4.85	5.40	
	3 hrs. Max.(in)	3.50	-	-	2.80	3.00	-	-	-	-	-	-	-	
	1 hr. Max.(in)	2.35	-	-	2.45	2.75	-	-	-	-	-	-	-	
	Mean Rainy Days	13	12	13	15	16	12	12	14	16	17	17	17	

The specific discharge at 4 stations is plotted in Fig. 5-9 showing precious data of the largest flood in the past in Sarawak.

Table 5-6 DISCHARGE STATION & OBSERVED PERIOD

Station No.	Station	Cathcment Area	River	Reriod of Availabe Records
L/4- 8	Lio Matu	2,562km^2	B. Baram	July 1966 - Dec. 1975
L/4- 9	Long Pilah	8,933	B. Baram	Jan. 1967 - Dec. 1975
L/4-10	Long Jegan	2,433	Sg. Tinjar	Jan. 1967 - Dec. 1975
L/4-11	Long Teraman	2,688	Sg. Tutoh	Jan. 1967 - Dec. 1975
L/5- 5	Nanga Medamit	2,812	Sg. Limbang	Jan. 1967 - Dec. 1975

5-4-4 Discharge at Proposed Sites for Bridge in Large Rivers

Table 5-7 shows the investigation results found in the main rivers in the proposed area through studies in Phase I.

From the table and the flood record of 1962 together, the discharge at the proposed site of bridges for the main rivers is computated as shown in Table 5-8. As a design discharge the largest figure among (a), (b) and (c) shall be picked out, and adopted with a safety factor. However, only the approzimate figure of discharge is obtained yet in the stage of Phase I, because there may be questions in assuming the magnitude of gradient of riverbed and roughness coefficient.

Table 5-7 MAIN RIVER SURVEY DATA

No.	Name of River	Station	Nearest Village	Width of River	Width of Flood	Description of Site: Stream	Description of Site: Existing Structure
1.	Sg. Salu	*1) +1,000 (0.7m)	R. Peng Barat	9.0m	-	Muddy small stream	Wooden Br. ℓ = 12m b = 3.7
2.	Sg. Teman	*2)+23,500 (14.6m)	R. Kodis	11.8m	50m	Muddy stream	Temporary Timber Bridge New Bridge under construction
3.	Sg. Bakong	*2)+36,000 (22.4m)	R. Jampi	23.6m	-	Muddy stream Gravel on bed Driftwood	Temporary Timber Bridge New Bridge under construction
4.	Sg. Kelulit	*2)+44,000 (27.3m)	-	11.8m	-	Muddy stream	Temporary Timber Bridge New Bridge under planning
5.	Sg. Bok	*2)+49,000 (30.5m)	R. Pagan	26.0m	-	Muddy stream	Temporary Steel Bridge New Bridge under planning
6.	Sg. Tinjar	*2)+53,500 (33.3m)	Long Tulungan	93.0m	200m	Muddy stream	New Bridge under planning by Australian Colombo Plan
7.	Sg. Tru (Teru)	+66,000 (41.0m)	R. Ingkot	15m	45m	Muddy stream Meandering flow	-
8.	Batang Baram	-78,500 (48.8m)	Long Lama	150m	250m	Muddy stream	-
9.	Sg. Apoh	+103,500 (64.3m)	R. Akan Ajang	25m	75m	Muddy stream	-

*1) Miri. Bintulu Rd. ∿ Beluru (L = 18.0km)

*2) Beluru ∿ Sg. Tinjar (L = 35.5km)

No.	Name of River	Station	Nearest Village	Width of River	Width of Flood	Description of Site	
						Stream	Existing Structure
10.	Sg. Tutoh	+133,000 (82.7m)	-	50m	-	Clear stream Gravel on bed	-
11.	Sg. Medalam	+163,500 (101.6m)	-	20m	-	Muddy stream Driftwood	-
12.	Sg. Limbang	+177,500 (110.3m)	R. Pakatom	70m	-	Muddy stream	-
13.	Sg. Medamit	+185.5 (115.3m)	R. Nanga Awang	15.0m	45m	Clear stream Gravel on bed	-
14.	Sg. Lubang	+192,400 (119.6m)	Ng. Medamit	6.0m	400m	Muddy small stream	Steel Girder Br. Wooden Floor ℓ = 7.2 b = 3.7
15.	Sg. Polub Merah	+197,500 (122.7m)	Kpg. Lubok Lasas	6.0m	-	Gravel on bed Muddy stream	Steel Girder Br. Wooden Floor ℓ = 7.2 b = 3.7
16.	Sg. Mengari	+202,500 (125.9m)	Kpg. Tanjong Liman	6.0m	-	Muddy stream	Steel Girder Br. Wooden Floor ℓ = 7.2 b = 3.7
17.	Sg. Palas	+209,300 (130.1m)	-	3.5m	-	Gravel on bed small stream	Wooden Bridge ℓ = 3.9 b = 3.8
18.	Sg. Berleras	+212,500 (132.1m)	-	2.5m	-	Muddy very small stream	Wooden Bridge ℓ = 3.0m b = 3.7
19.	Sg. Lubai	+213,800 (132.9m)	-	33.0m	-	Muddy stream	Steel Girder Br. (3 spans) Wooden Floor ℓ = 35.2 b = 3.7

No.	Name of River	Station	Nearest Village	Width of River	Width of Flood	Description of Site: Stream	Description of Site: Existing Structure
20.	Sg. Melaban	+215,750 (134.1m)	-	15.0m	-	Muddy stream	Steel Girder Br. Wooden Floor ℓ = 15.8 b = 3.7
21.	Sg. Bakol	+218,300 (135.7m)	Kpg. Bakol	10.0m	-	Bed Rock Gravel on bed	Steel Girder Br. Wooden Floor ℓ = 12.7 b = 3.8
22.	Sg. Brangas	+219,000 (136.0m)	Kpg. Bakol	9.0m	-	Muddy stream	Steel Girder Br. Wooden Floor ℓ = 9.9 b = 3.7
23.	Sg. Berawan	+220,900 (137.3m)	Kpg. Berawan	15.0m	-	Muddy stream	Steel Girder Br. Wooden Floor ℓ = 17.3 b = 3.7
24.	Sg. China	+225,250 (134.0m)	Limbang	6.0m	-	Muddy small stream	Wooden Br. ℓ = 9.0
25.	Sg. Poyan	+229,000 (142.3m)	Limbang	12.0m	-	Muddy stream	Temporary Bridge New Bridge under construction

Table 5-8 DISCHARGE CALCULATED

No.	River	Catchment Area	Discharge by Specific Discharge	Discharge by Flood Record in 1962	Discharge by Table
		km^2	m^3/S	m^3/s	
1	Sg. Teru	546	190	No Record	No Record
2	B. Baram	9,548	1,400	8,800	6,600
3	Sg. Apoh	912	320	No Record	350
4	Sg. Tutoh	2,555	640	No Record	1,580
5	Sg. Limbang	1,977	590	No Record	1,470

Note: 1. Catchment Area of the Bridge Site is shown in Fig.
2. Catchment Area is reviewed in Phase II.

The close investigation, in particular, of the bridge site of B. Baram flowing the vicinity of Lona Lama, which is planned as the sub-center of the state of Sarawak, is proposed to be carried out in Phase II.

Fig. 5-6 ISOHYETAL MAP OF SARAWAK 1975

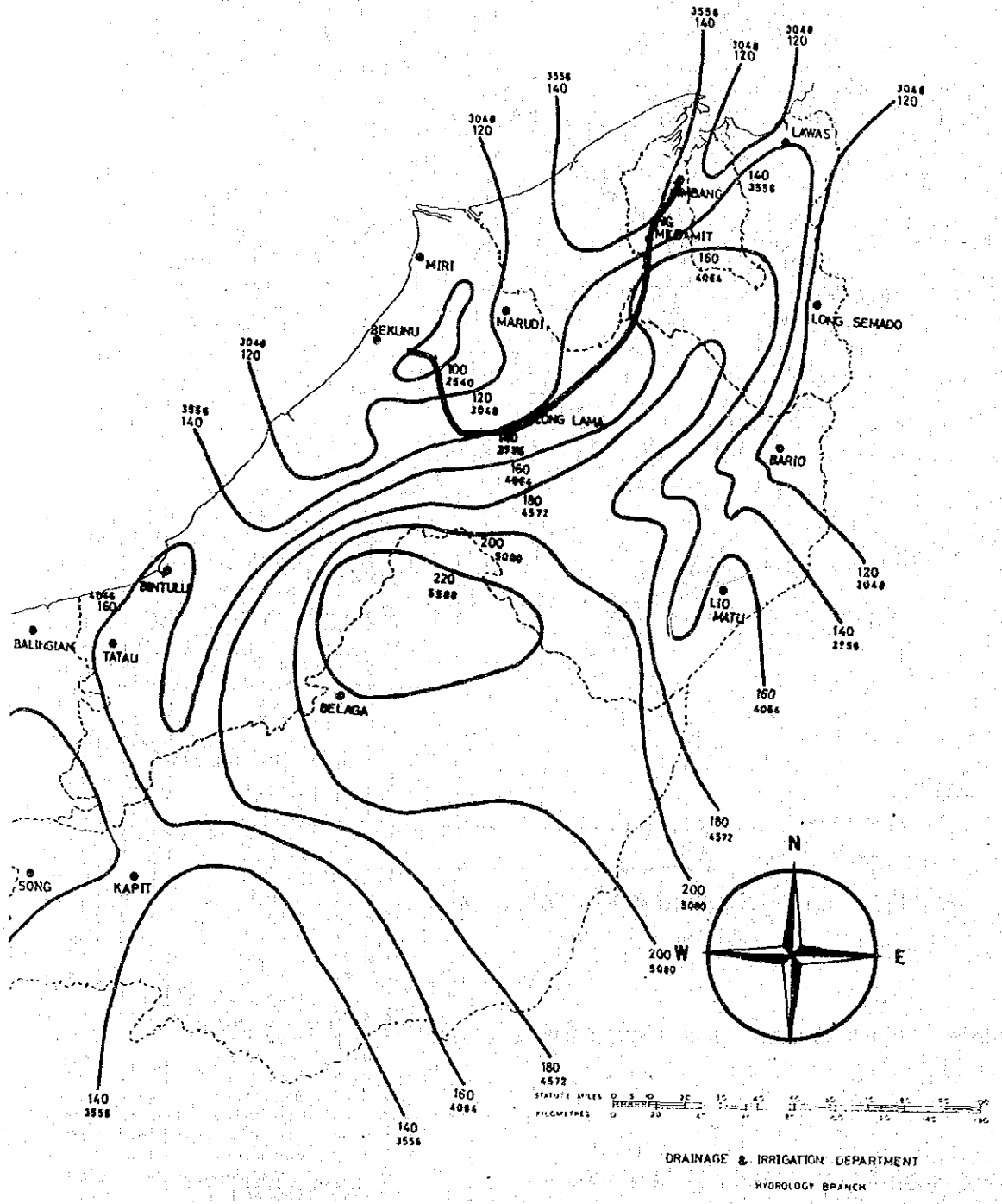
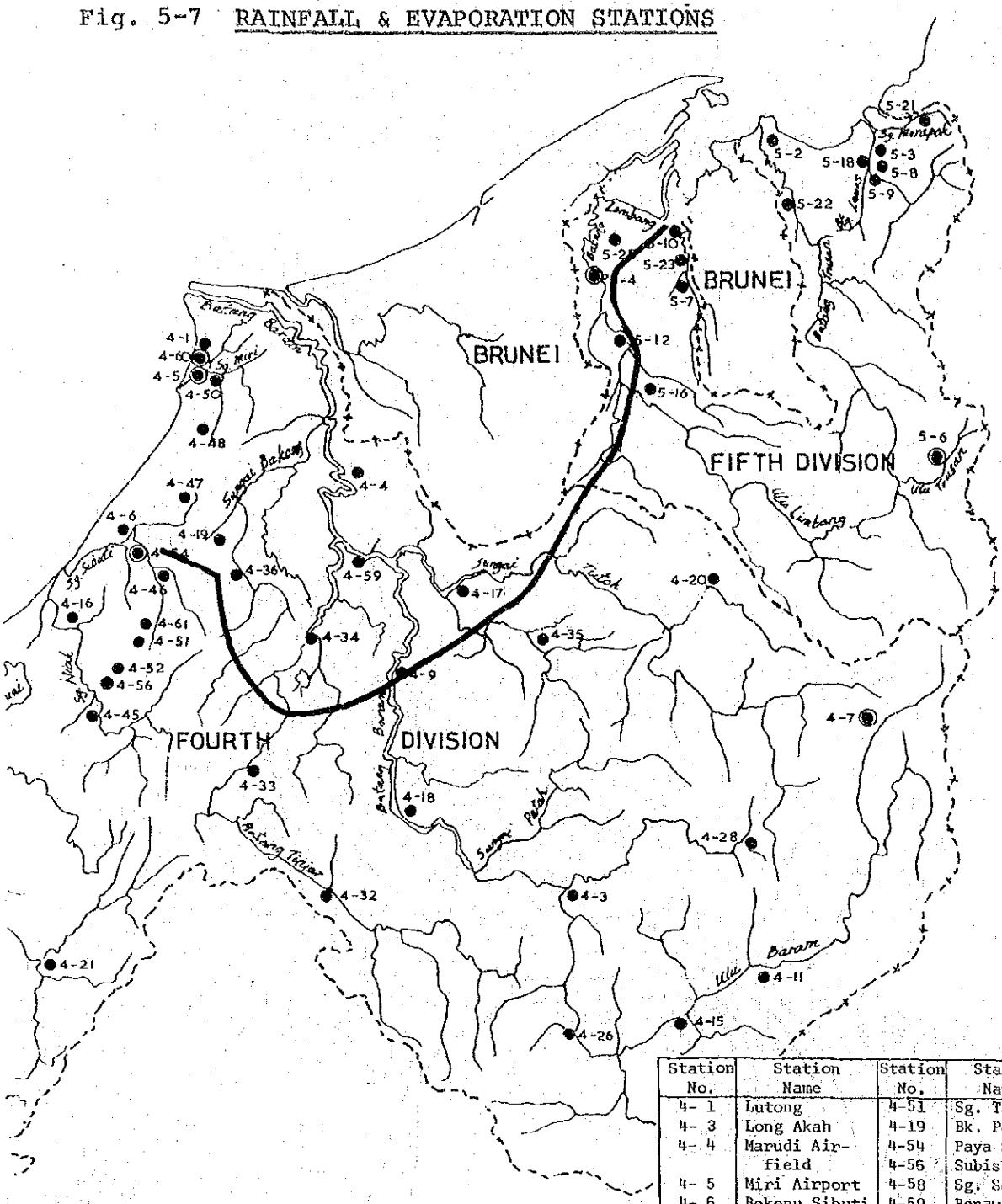


Fig. 5-7 RAINFALL & EVAPORATION STATIONS



LEGEND

PROJECT ROAD .....

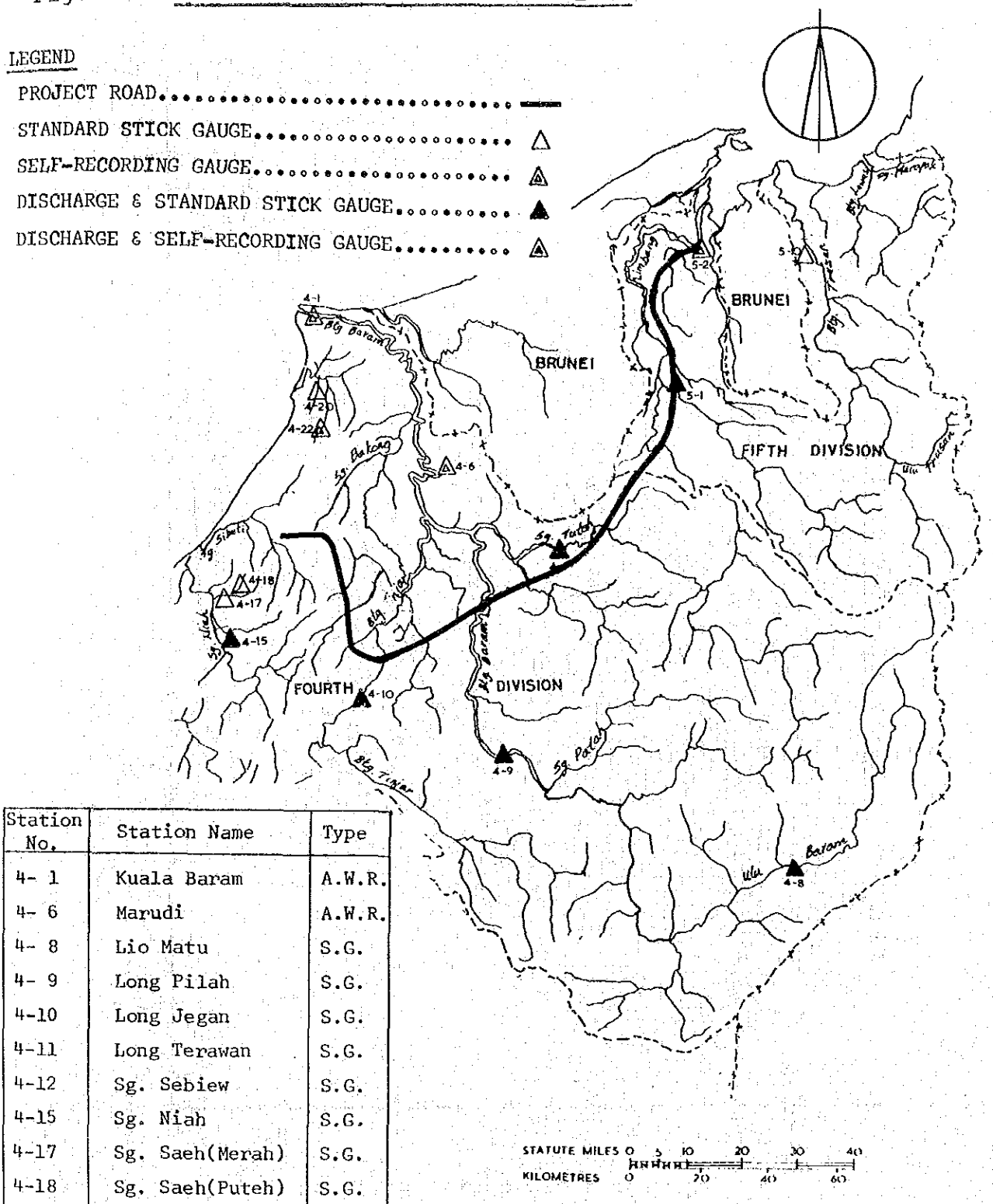
RAINFALL STATION.....

RAINFALL with EVAPORATION STATION..

Station No.	Station Name	Station No.	Station Name
4- 1	Lutong	4-51	Sg. Tangit
4- 3	Long Akah	4-19	Bk. Peninjau
4- 4	Marudi Air-field	4-54	Paya Selanyau
		4-56	Subis
4- 5	Miri Airport	4-58	Sg. Sebiew
4- 6	Bekenu Sibuti	4-59	Benawa
4- 7	Bario	4-60	D.I.D. Barrack
4- 9	Long Lama		
4-11	Lio Matu	4-61	Cattle Area
4-15	Long Moh	5- 2	Sundar
4-16	Niah	5- 3	Lawas Estate
4-17	Long Panai	5- 4	Ukong
4-18	Long Pilah	5- 6	Long Semadoh
4-20	Long Seridan	5- 7	Kubong
4-21	Tubau	5- 8	Lawas Reservior
4-23	Sebauh		
4-26	Long Anap	5- 9	Lawas Air-field
4-28	Long Leliang		
4-32	Long Subing	5-10	Limbang P/House
4-33	Long Jegan		
4-34	Long Teru	5-12	Ng. Medamit
4-35	Long Atip	5-16	Long Belong
4-36	Beluru	5-18	Lawas Depot
4-45	Sg. Niah	5-21	Merapok
4-46	Sg. Sibuti	5-22	Trusan
4-47	Sarawak Oil Palm	5-23	Pandaruan
		5-25	Lubai Tengah
4-48	Lambir		
4-50	Kpg. Wireless		
4-52	Landang III		

Source : HYDROLOGICAL YEAR BOOK, SARAWAK 1975

Fig. 5-8 WATER LEVEL & DISCHARGE STATIOND



Station No.	Station Name	Type
4- 1	Kuala Baram	A.W.R.
4- 6	Marudi	A.W.R.
4- 8	Lio Matu	S.G.
4- 9	Long Pilah	S.G.
4-10	Long Jegan	S.G.
4-11	Long Terawan	S.G.
4-12	Sg. Sebiew	S.G.
4-15	Sg. Niah	S.G.
4-17	Sg. Saeh(Merah)	S.G.
4-18	Sg. Saeh(Puteh)	S.G.
4-20	Sg. Dalam	S.G.
4-22	Sg. Liku	A.W.R.
5- 1	Ng. Medamit	S.G.
5- 2	Limbang	A.W.R.
5-10	Btg. Trusan	S.G.

Note:

A.W.R. - Automatic Weekly Recorder

S.G. - Stick Gauge

Source : HYDROLOGICAL YEAR BOOK, SARAWAK 1975

Fig. 5-9 SPECIFIC DISCHARGE DIAGRAM

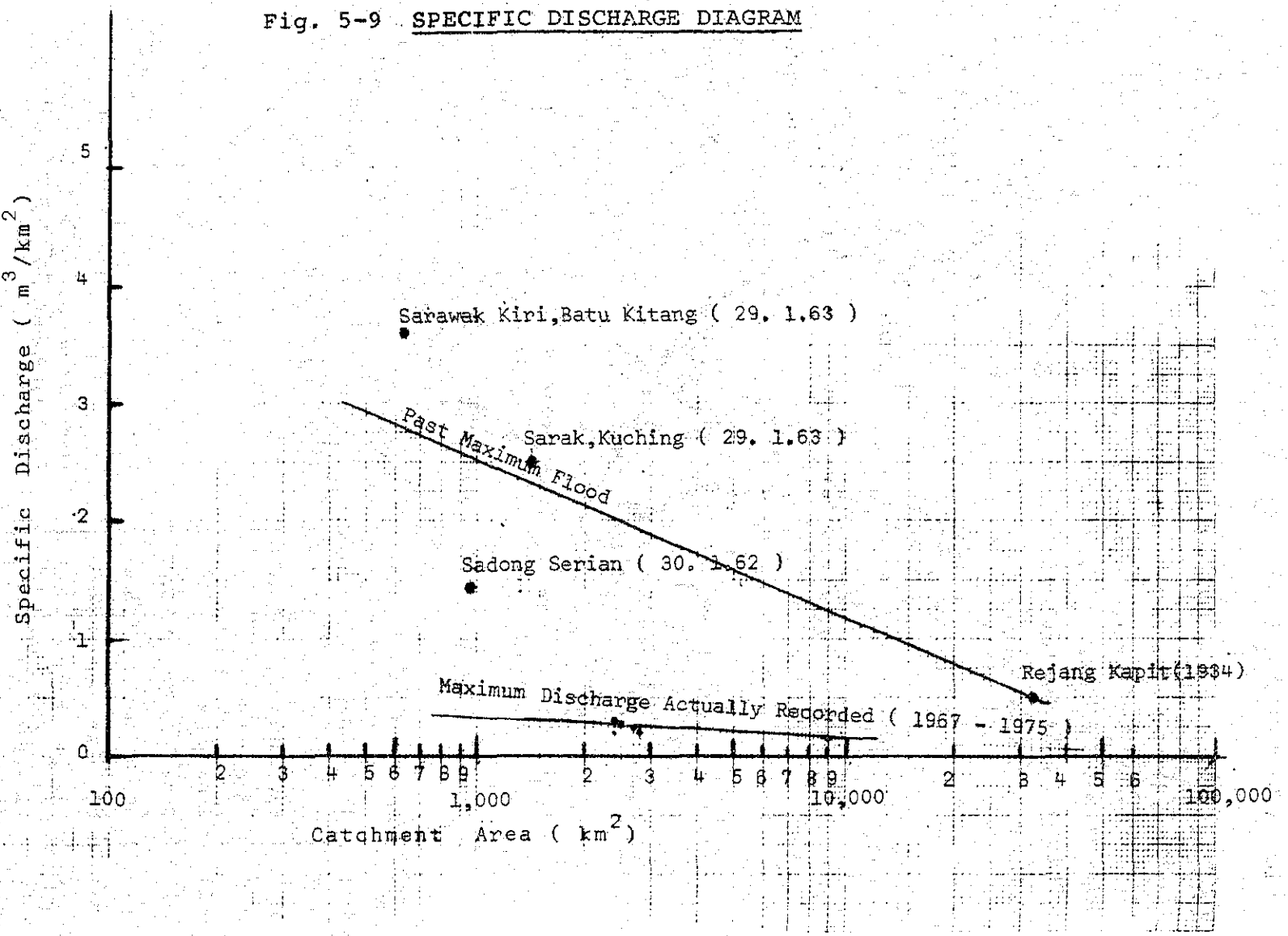


Fig. 5-10 CATCHMENT AREA AT 5 MAJOR BRIDGE SITES

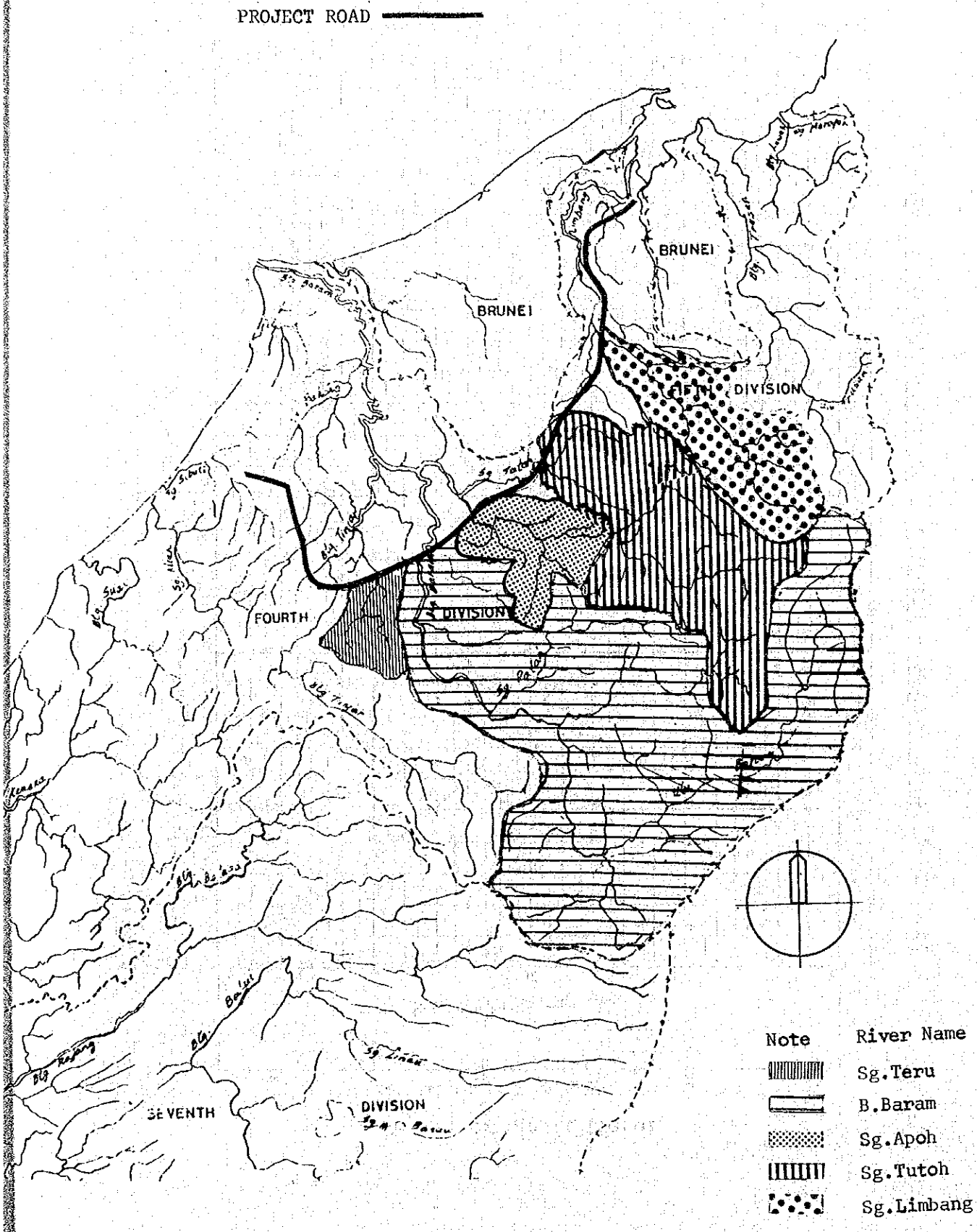


Fig. 5-11 WATER STAGE - DISCHARGE AT LONG PILAH OF B. BARAM

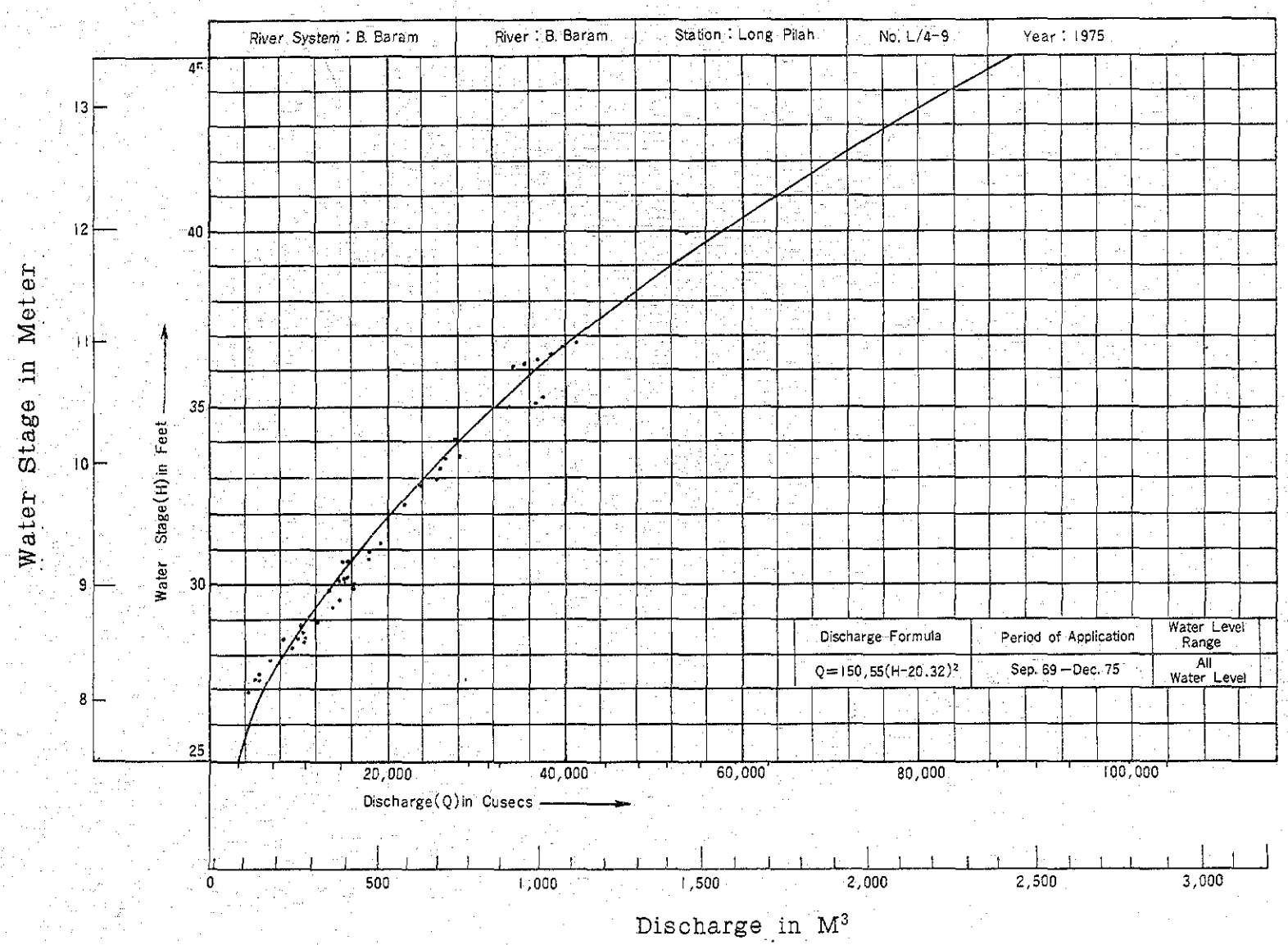


Fig. 5-12 WATER STAGE - DISCHARGE AT LONG JEGAN OF Sg. TINJAR

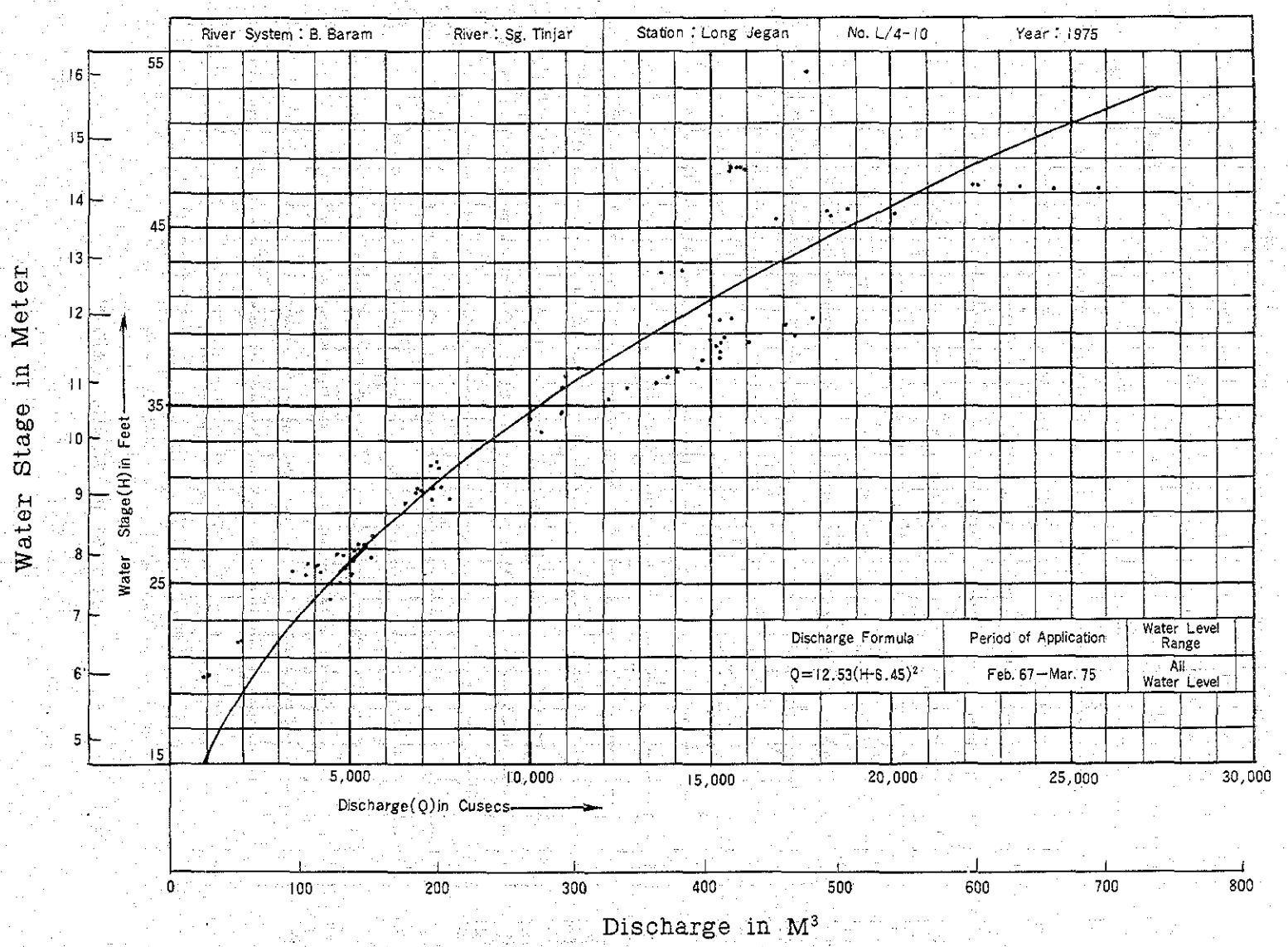


Fig. 5-13 WATER STAGE - DISCHARGE AT LIO MATOH OF B. BARAM

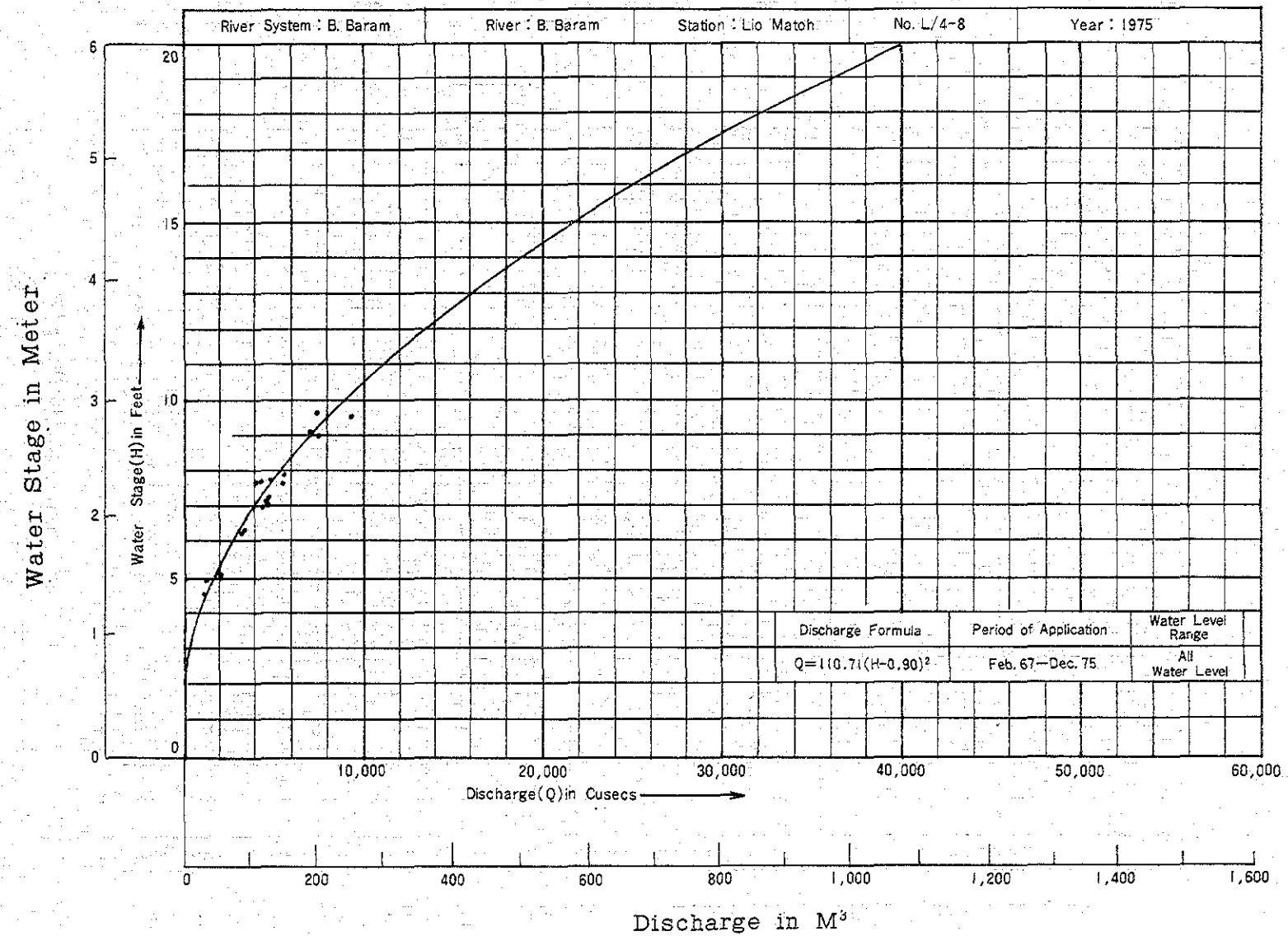


Fig. 5-14 WATER STAGE - DISCHARGE AT LONG TERAWAN OF Sg. TUTOH

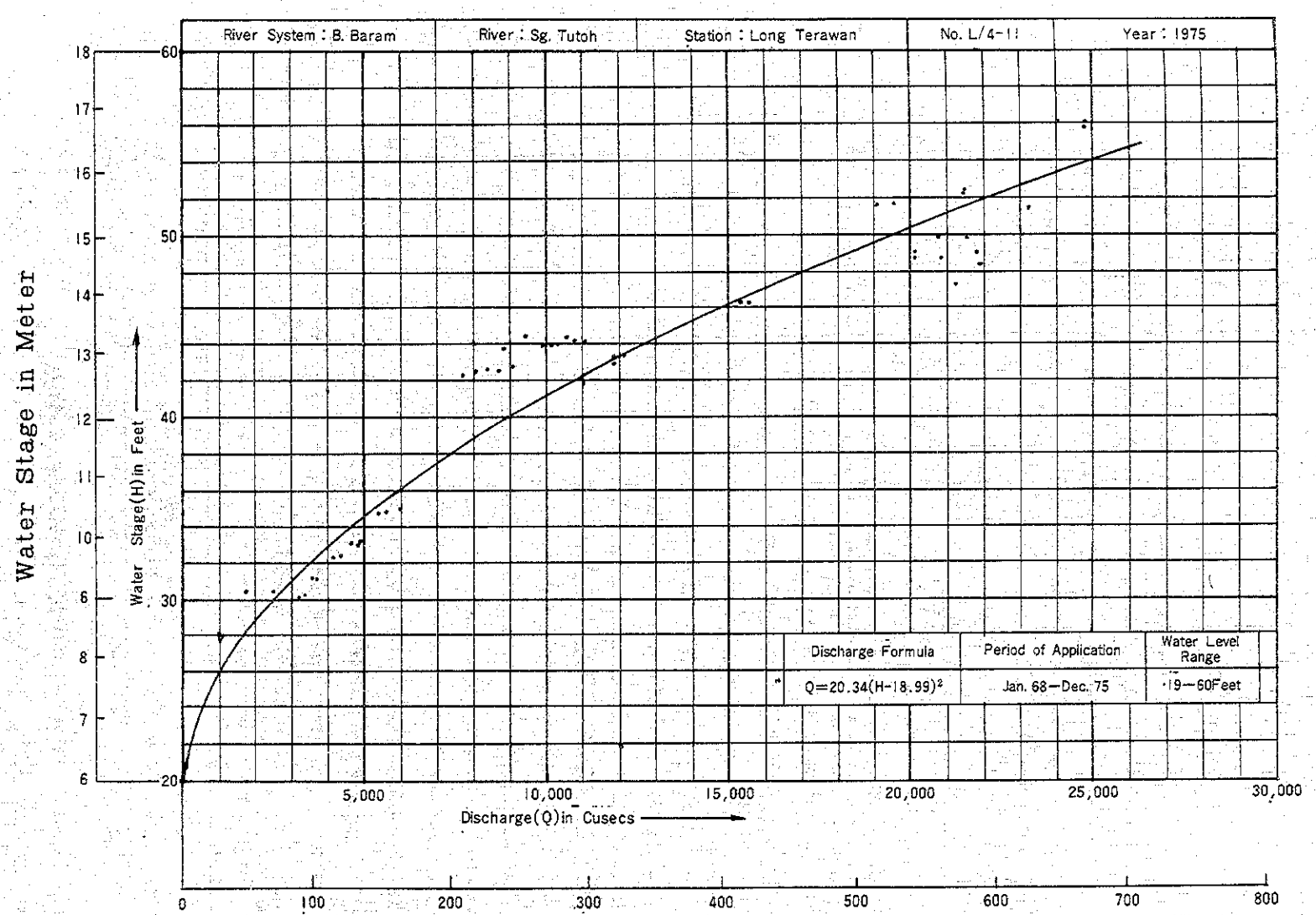
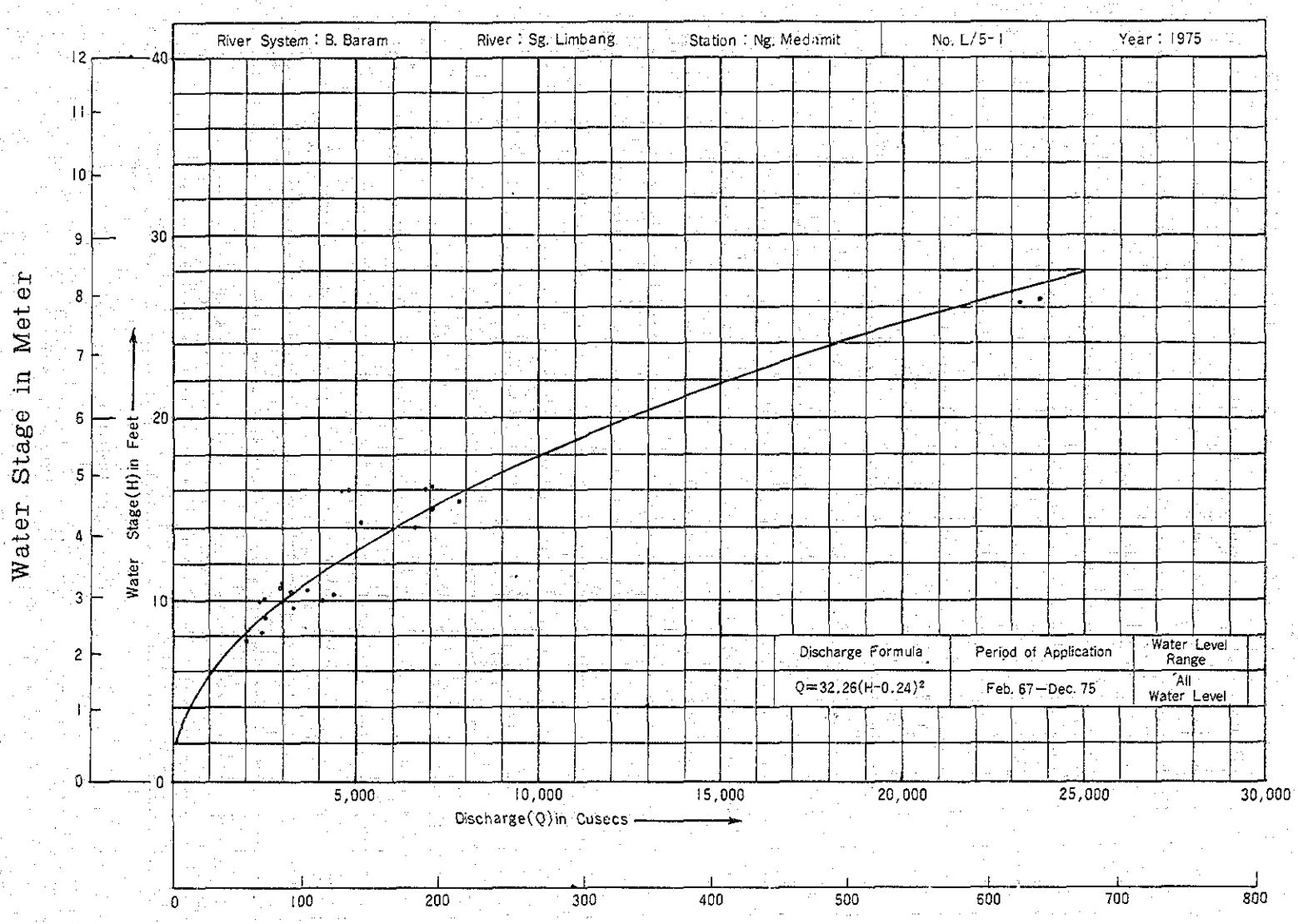


Fig. 5-15 WATER STAGE - DISCHARGE AT Ng. MEDAMIT OF Sg. LIMBANG



5-5 LOCAL CONTRACTORS AND IMPLEMENTATION SYSTEM

5-5-1 Local Contractor

The contractors registered in the P.W.D. of the state of Sarawak are shown in Table 5-9.

Table 5-9 LOCAL CONTRACTORS IN SARAWAK

	Engineering	Building	Road Quarry Earthworks	Contract Price (M$)
Class. A	5 (18)	12 (31)	2 (13)	100,000 -
Class. B	2 (8)	4 (8)	1 (3)	100,000 - 2,000,000
Class. BX	4 (6)	9 (20)	1 (2)	100,000 - 1,000,000
Class. C	10 (19)	9 (24)	4 (10)	50,000 - 500,000
Class. D	4 (21)	8 (35)	1 (10)	25,001 - 250,000
Class. E	10 (19)	22 (42)	13 (20)	25,001 - 150,000
Class. EX	20 (56)	50 (248)	17 (30)	25,000 - 50,000
Class. F	26 (62)	85 (66)	23 (44)	- 25,000

Note: 1. West Malaysia & Overseas Contractors are involved.
2. ( ) Temporary Registered Contractors are involved.
3. Class. depends on the Contract Price.

Source: Public Works Department List of Registered Constructions Head I, II & III Feb. 1975.

The number of local contractors registered in the Class A, B and BX is large in the engineering works, but small in the road constructions, which accords with the fact that the construction works of structure are mainly undertaken by the local constractors, while those of road itself are managed directly by the P.W.D. in the road construction. The local contractors may use the construction machinery of the P.W.D. with a mechanic on lease as their holding numbers of them are not so large.

5-5-2 Implementation System

Construction and supervision of roads are carried out by the P.W.D. Sarawak.

As aforestated, the earthwork and pavement are directly managed by the P.W.D. However, they will be changed from by the direct management to be the contract one

according to the increase of construction work quantities in the future.

Since the local contractors are poor in the experience of construction, the introduction of overseas techniques will be needed.

Moreover, the bottlenecks of road construction lie in the shortage of labourer, especially in a mechanic, and the insufficient supply of spair parts for equipments.

The training of personnel required for the mechanized construction be tackled as soon as possible by both governmental authorities and private firms to cope with the increase of construction, since it will need the long period.

As a result, it may be most preferable that the construction of this project will be undertaken by the joint-benture system between the overseas and local firms at present stage.

In Phase I, the estimate of construction cost is made on an assumption that it will be performed only by the overseas contractors.

The following types of construction organization will be taken into account for the review in Phase II:

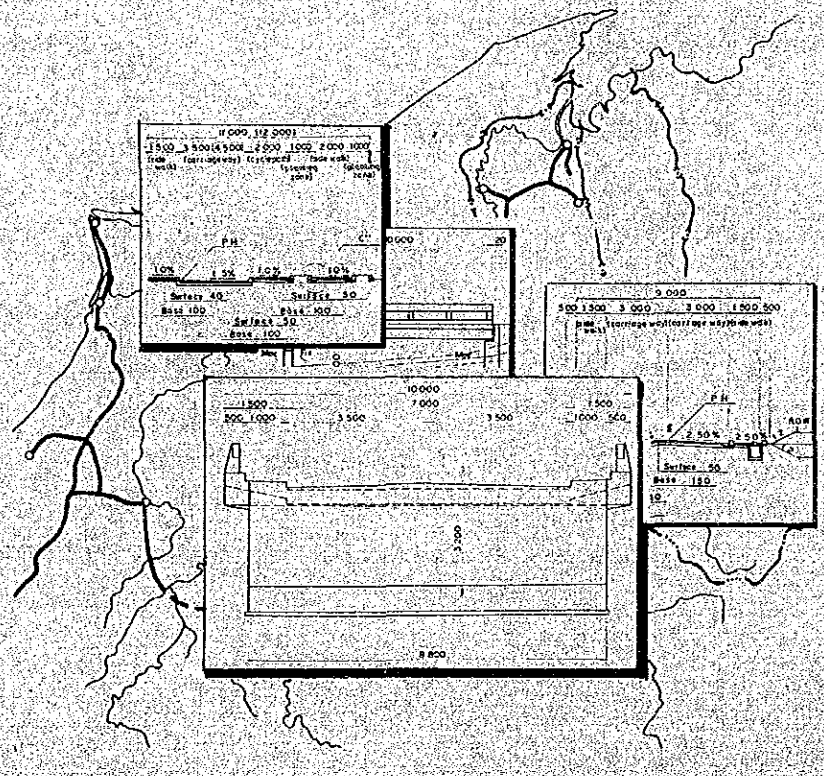
(1) Direct management by the P.W.D. in the earthwork and pavement work

(2) Joint-venture system between overseas and local contractors

(3) Overseas contractors

Chapter 6

DESIGN CRITERIA



6-1 TOPOGRAPHICAL SITUATION IN STUDY AREA

As identified from 1:50,000 scale topographic maps through site reconnaisance, the physical features of the study area where the trunk road is planned may be classified into flat terrain of 15∿30m (50∿100 feets) in elevation, rolling terrain of 30∿100m (100∿300 feets) in elevation and mountainous terrain of over 100m (300 feets) in elevation.

The topographical situation of the proposed construction sections are summarised as shown in Table 6-1.

Table 6-1 TOPOGRAPHICAL SITUATION OF EACH SECTION

Section No.	Section	Length		Topographical Situation
1	Miri-Bintulu Road ∿ Beluru	km 18.0	Mile (11.2)	Flat
2	Beluru ∿ Sg. Tinjar	35.5	(22.1)	Flat, Rolling
3	Sg. Tinjar ∿ Batang Baram	25.0	(15.5)	Flat, Rolling
4	Batang Baram ∿ Sg. Apoh	24.3	(15.1)	Flat, Rolling
5	Sg. Apoh ∿ Sg. Tutoh	29.7	(18.5)	Flat, Rolling
6	Sg. Tutoh ∿ Sg. Medalam	29.5	(18.3)	Rolling, Mountinous
7	Sg. Medalam ∿ Sg. Limbang	25.7	(16.0)	Flat, Rolling
8	Sg. Limbang ∿ Limbang	41.0	(25.5)	Flat, Rolling

6-2 GEOMETRIC DESIGN CRITERIA

In the state of Sarawak the existing geometric design criteria applicable in the design of roads are as shown in Table 6-2. Since the said criteria do not differentiate the standard for different terrain, it is necessary to establish a new set of criteria for each type of terrain.

Table 6-2 lists for reference the design criteria adopted by various countries.

6-3 THE ESTABLISHMENT OF NEW GEOMETRIC DESIGN CRITERIA

With the criteria of the P.W.D Sarawak as the base, and making due reference to the standards of the various countries above, a new set of criteria is established to meet the requirements of the local topographical situation as listed in Table 6-1.

In this study, the terrain is classified into flat, rolling and mountains and the corresponding items including design speed, traffic lane width, maximum gradient and its length, the width of the road bed, the width of shoulder, the sight distance, the minimum curve radius, the transition curve, and the vertical curve are established as described below.

(1) Design Speed

In the criteria of P.W.D. Sarawak, the design speed of 80 kph (50 mph) is adopted for the design of trunk road standard. That is adopted for the flat terrain, and according to the topographical situation, a design speed of 64 kph (40 mph) is adopted for rolling and that of 48 kph (30 mph) for mountainous terrain. It is considered that this standard will satisfactorily provide the necessary service but will redue the construction cost considerably.

(2) Composition of traffic lane width

The width of the traffic lane has to be so determined as to provide ample allowance for the passing and overtaking of vehicles. AASHO standard states that the ideal width for all classes of roads is 12 feet (3.66m) which is also adopted in the P.W.D. Sarawak so that the total width of a two-lane road is 7.32m (24 feet).

The width of shoulder is adopted the standard of P.W.D. Sarawak for flat and rolling terrains, but for the road sections on mountainous terrain, a width of 1.22m (4 feet) is adopted, considering the relation between

construction cost and service to traffic.

(3) Minimum Curve radius

It is desirable that the curve radius be as large as possible for the horizontal alignment if the topographical situation permit. The following points are taken into consideration in the determination of the minimum curve radius.

a) The comfort to the road users is to be maintained.
b) The value adopted is to be an easily applicable value, so that it can be easily made applicable to the entire road section.

(4) Width of right-of-way

In the Trunk Road Standard of P.W.D. Sarawak, the width of right-of-way is stipulated to be in the range of 61m - 46m (200 - 150 feet). For the design purpose, the minimum width for flat and rolling terrain is determined at 61m (200 feet) and that for mountainous terrain is determined at 46m (150 feet).

(5) Traffic capacity

As shown in Chapter 4, the forecast future traffic demand is expected to be small. For the determination of the traffic capacity of the road under study, the calculation is made according to the Geometric design criteria by Ministry of Construction of Japan.
The results and shown in Table 6-3.

Table 6-2 DESIGN STANDARD

		RECOMMENDED DESIGN STANDARD			PUBLIC WORKS DEPT SARAWAK				MINIMUM GEOMETRIC DESIGN STANDARD FOR NEW ROADS IN RURAL AREAS									AASHO			DESIGN STANDARD IN JAPAN		
					TRUNK ROAD		FEEDER ROAD		05			04			03								
1	TERRAIN	F	R	M	-		-		F	R	M	F	R	M	F	R	M	F	R	M			
2	DESIGN SPEED	80 (50)	64 (40)	48km/H (30MPH)	80 km/H	(50 MPH)	48~64 km/H	(30~40 MPH)	96 (60)	80 (50)	64 km/H (40 MPH)	80 (50)	64 (40)	48km/H (30MPH)	80 (50)	64 (40)	48km/H (30MPH)	80 (50)	64 (40)	48km/H (30MPH)	80	60	50km/H
3	PAVEMENT TYPE	-			-		-		-			-			-			-			-		
4	SURFACE WIDTH (PAVEMENT WIDTH)	7.32m	(24)		7.32m	(24)	4.27 m	(14)	7.32m	(24)		6.71m	(22)		6.10m	(20)		7.32 (24)	6.70 (22)	6.10m (20)	7.00	6.50	6.00m
5	USABLE SHOULDER	3.05 (10)	3.05 (10)	1.22m (4)	3.05	(10)	2.44 m	(8)	3.05 (10)	3.05 (10)	1.22m (4)	2.44 (8)	2.44 (8)	1.22m (4)	1.83 (6)	1.83 (6)	0.92mm (3)	3.66 (12)	3.05 (10)	1.83m (6)	1.75	1.25	1.25m
6	FORMATION WIDTH	13.42 (44)	13.42 (44)	9.76m (32)	13.42	(44)	9.15 m	(30)	14.64 (48)	14.64 (48)	10.98m (36)	12.81 (42)	12.81 (42)	10.37m (34)	10.98 (36)	10.98 (36)	9.15m (30)	14.64 (48)	12.81 (42)	9.76m (32)	10.5	9.0	8.5m
7	CENTRAL RESERVATION	-			-		-		-			-			-			-			-		
8	RESERVE WIDTH	61/46m		(200/150)	61/46m	(200/150)	40/30m	(132/99)	40m	(132)		40/30m	(132/100)		30m	(100)		37/30m	(120/100)		-		
9	MAXIMUM GRADIENT NORMAL / ABSOLUTE	4	6	9%	5% / 8%		5% / 10%		3	5	8%	4	6	9%	4	6	9%	4	6	9%	4 / 7	5 / 8	6% / 9%
10	CRITICAL GRADE LENGTH	336 (1,100)	183 (600)	122m (400)	-		-		519 (1,700)	244 (800)	153m (500)	336 (1,100)	183 (600)	122m (400)	336 (1,100)	183 (600)	122m (400) ft	336 (1,100)	183m (600)	-	400	300	300m
11	STOPPING SIGHT DIST. - MIN.	107 (350)	84 (275)	61m (200)	-		-		145 (475)	107 (350)	84m (275)	107 (350)	84 (275)	61m (200)	107 (350)	84 (275)	61m (200)	107 (350)	84 (275)	61m (200)	110	75	55m
12	PASSING SIGHT DIST. - MIN.	549 (1,800)	458 (1,500)	336m (1,100)	244m	(800)	168 m	(550)	641 (2,100)	549 (1,800)	458m (1,500)	549 (1,800)	458 (1,500)	336m (1,100)	549 (1,800)	458 (1,500)	336m (1,100)	549 (1,800)	458 (1,500)	336m (1,100)	550	350	250m
13	MINIMUM RADIUS NORMAL / ABSOLUTE	305 (1,000)	229 (750)	153m (500)	305m / 228m	(1,000 / 750)	213m / 152m	(700 / 500)	317 (1,040)	214 (700)	131m (430)	214 (700)	131 (430)	70m (230)	214 (700)	131 (430)	70m (230)	214 (700)	131 (430)	70m (230)	280	150	100m
14	TRANSITION CURVES MIN. L	73 (240)	64 (210)	55m (180)	-		-		82 (270)	73 (240)	64m (210)	73 (240)	64 (210)	55m (180)	73 (240)	64 (210)	55m (180)	46 (150)	38 (125)	31m (100)	70	50	40m
15	WIDENING	-	0.9 (3)	1.4m (4.5)	According to M.O.T. Tables		According to P.W.D. Tables		-	-	0.6m (2)	-	0.9 (3)	1.4m (4.5)	-	0.9 (3)	1.4m (4.5)		-		-	-	0.5m
16	SUPERELEVATION MAX./MIN.	1 : 10			1:12 (8.3%)/1:38 (2.6%)		1:12 (8.3%)/1:30 (3.3%)		1 : 10			1 : 10			1 : 10			0.50	0.58	0.66	7/2	6/2	5/2%
17	CAMBER CROSS FALL	1 : 38			1:38 (2.6%)		1:30 (3.3%)		1 : 40			1 : 40			1 : 30			2%			2%		
18	VERT CURVES CREST MIN.	26 (85)	17 (55)	9m (28)	-		-		49 (160)	26 (85)	17m (55)	26 (85)	17 (55)	99m (28)	26 (85)	17 (55)	9m (25)	26 (85)	17 (55)	9m (28)	R=3,000m	1,400	800
	SAG MIN.	23 (75)	17 (55)	11m (35)	-		-		32 (105)	23 (75)	17m (55)	23 (75)	17 (55)	11m (35)	23 (75)	17 (55)	11m (35)	23 (75)	17 (55)	11m (35)	R=2,000m	1,000	700

Note: The figures in parenthesis show the values in feets.

Table 6-3 DESIGN TRAFFIC CAPACITY ANALYSIS

Item	Design Speed (km/h)	Lane Width (m)	Lateral Clearance		Heavy Vehicle		Coefficient of Adjustment					Basic Capacity (Veh./h)	Possible Capacity (Veh./h)	Design Level	Adjustment of Design Level	Design Capacity (Veh./h)
			Left (m)	Right (m)	% of H.V.	Passenger Car Equivalent	Lane Width	Lateral Clearance	Heavy Veh.	Condition of Sight	Total					
					PT	ET	γL	γC	γT	γI		CB	C			CD
2-Lane, two Way	80	3.66	3.05	0	15.0	2.0	1.00	1.00	0.87	1.00	0.87	2500	2175	1	0.75	1630
	48	3.66	1.22	0	30.0	3.5	1.00	0.98	0.57	1.00	0.56	2500	1400	1	0.75	1050

$$\gamma T = \frac{100}{100 - PT + ET\ PT}$$

Where γT; Coe-ficient of adjustment for heavy vehicles.
PT; Percentage of heavy vehicles.
ET; Passenger car equivalent of heavy vehicles.

$$C = CB \times \gamma L \times \gamma C \times \gamma I \times \gamma T$$

Where γL; Coefficient of adjustment for lane width.
γC; Coefficient of adjustment for lateral clearance.
γI; Coefficient of adjustment for condition of sight.
γT; Coefficient of adjustment for heavy vehicles.

CB; Basic capacity
C; Possible capacity
CD; Design Capacity (Veh./hour)

Fig 6-1 TYPICAL CROSS SECTION