UNITED NATIONS ECONOMIC COMMISSION FOR AFRICA

THE REPUBLIC OF ZAIRE

TRANSAFRICAN HIGHWAY

FEASIBILITY STUDY

KISANGANI-BANGASSOU

FINAL REPORT

VOL. 3

NOVEMBER 1976

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APPENDEX A

CONTENTS

A.2.1 Estimation of Population of the Direct Influence Area

The Table 2.4.11 in the supporting report indicates the estimation of population and size of the project area which is a basis of calculating the future need of food products. The process of the estimation is as follow:

(i) Administrative zones of the project area of the project road, Banalia, Buta, Aketi and Bondo as previously mentioned are further divided into smaller administrative bodies, so-called "Collectivities". The number of Collectivities coming under the immediate influence of the project road is 4 each in Banalia and Buta, 3 in Aketi and 5 in Bondo out of the total Collectivities belonging to these Zones, the actual number of which is 5, 7, 9 and 10 respectively. The population by Collectivitie in 1970 is shown in the note 1/ of the Table A.2.2.

(ii) The proportion of the number of villages in the influenced area to the total number of villages of each Collectivite is calculated from a map made in about 1960 (see the note 2/ of the Table A.2.2).

(iii) The proportion of the population of the direct influenced area in each Collectivite is calculated by multiplying the total population of the Collectivite in 1970 by the preceding proportion. (Table A.2.2, Note 3/)

(iv) The proportion of the population of the direct influence area to the total pouplation of the administrative Zones is calculated by accumulating the above mentioned pouplation of the influenced area of each Collectivities. (Table A.2.2, Note 4/)

(v) The population of the areas under the direct influence of the project in 1973 is estimated by calculation of multiplying the population of each Administrative Zone in 1973 shown in the Table 2.4.11 by the above proportion.

The above estimate has also been closely checked with the ratio of the road extension in the immediately project area to the total extension of the road in the Collectivite on the assumption that the distribution of the population might be concluded to be proportionate to the extension of the road as the population generally showed even spreading over all the project area. This assumption is comparatively in accord with the result of the above estimate of population based on the number of villages.

The population of the Bondo Zone has such an outstanding difference as between 174,211 in 1970 shown in the note 5/ of the Table A.2.2 and 99,027 in 1973 quoted in the Table 2.4.11, the former being actually too much to be easily explained even from the hist ical view point.

The gap can to a certain extent be explained by the difference of population between in 1970 and 1973 observed in some Collectivities (an example is shown in the case with the Kasai Collectivite in the Table A.2.2 whose population was 43,175 in 1970 but substantially smaller number of 15,145 in 1973). On the other hand, the similar estimation work carried out with the Bondo Zone in 1973 reached the figure of about 40 percent as an estimated ratio of the population of the project area to that of the entire Administrative Zone.

Thus, the estimation of the population in the above rather proved to be so persuasive enough, even with some statistical difficulties as such, that the figure of 35 percent estimated in 1970 might be used as the ratio of the population of the area in the Zone under the immediate influence to the total population of the Bondo Zone.

A.2.2 Proportion of Population of the Area under the Direct Influence of the Project Road to That of Administrative Zone (%)

Administrative Zone	Collectivite along the Project Road	Population in 1970 1/	Population of Direct Influence Area (1970)	
			Ratio (%) 2/	Actual Population 3/
Banalia	Bamanga	30,920	80	24,736
	Banalia - Bamba	16,201	40	6,480
	Baboro	5,865	70	4,106
	Babua de Kole	13,297	60	7,978
	Total Population of Zone	73,612	58 4/	43,300
Buta	Monganzulu	5,019	90	4,517
	Buta Cite	19,371	100	19,371
	Mobati	6,265	10	627
	Nguru	8,184	100	8,184
	Total Population of Zone	63,439	52 4/	32,699
Aketi	Avuru-Gatanga	18,954	80	15,163
	Mobati-Boyele	5,903	40	2,361
	Avuruduma	6,459	80	5,167
	Total Population of Zone	82,795	27 4/	22,691
Bondo	M-Mondila Mobenge	7,004	90	6,304
	Duaru	27,995	80	22,396
	Deni	10,024	60	6,014
	Kasa	43,175	50	21,588
	Soa	5,201	80	4,161
	Total Population of Zone	174,211 5/	35 4/	60,463

A.2.2 Notes:

1/ The influence area involves administraively such zones as Banalia, Buta, Aketi and Bondo which are also sub-divided into the following number of collectivities, five in Banalia, seven in Buta, nine in Aketi and ten in Bondo zones, among which the number of collectivities involved in the influence area are four in Banalia Zone, four in Buta Zone, three in Aketi Zone and five in Bondo Zone and their population in 1970 are shown in the table.

2/ The number of villages were counted for the influence area as well as in each collectivite using an administrtrative plan of 1/5,000 in scale which was drawn in 1960, and the proportion of the number of villages in the influence area in each collectivite to the total number of villages in each respective collectivite.

3/ The population of the influence area in each collectivite was calculated by multiplying the proportion mentioned in 2/ to the population of each collectivite.

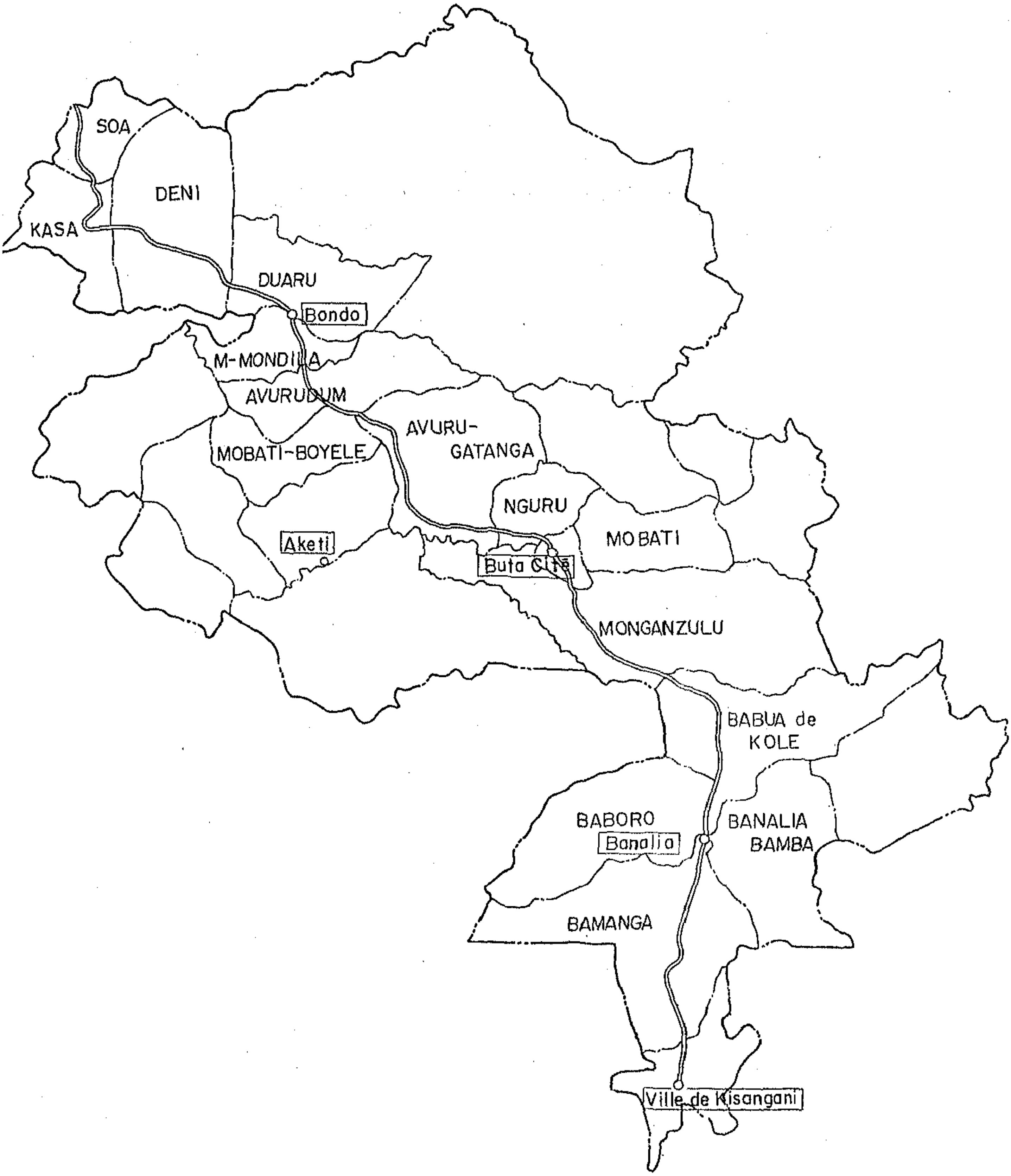
4/ Then the proportion of the population of influence area in each collectivite to the population of the respective zone was calculated.

5/ The population of the influence area in 1973 was calculated by multiplying the proportion calculated in 4/ to the population of each zone in 1973.

A.2.3

COLLECTIVITES ALONG PROJECT ROAD

COLLECTIVITES LE LONG DE LA ROUTE DE PROJET



A.3.1.1 Hydrology

(1) General

As shown in Plate 1.1.1 of the volume 2, this project area lies in the northern part of Congo plateau located approximately in the center of African Continent.

The topography of the Project area is characterized by gentle rise and fall extending from the plateau to highland and the elevation above sea level is in the range of 350 - 590 m.

Therefore, the project site is located at rather high elevations of Congo plateau.

On the east side of Congo plateau, there is a mountain range of 2,100 - 5,000 m elevation including Mt. Ruwenzori (El = 5,119 m). Hence, humid air from the Indian Ocean does not reach inland, being blocked by this mountain range, and humid Guinea Monsoon from the Atlantic Ocean brings rain to this inland area.

Congo plateau is divided into the following zones of meteorological characteristics:

(a) Equatorial plateau of humid tropical forests with much rainfall
(b) Southern plateau of somewhat dry weather
(c) Eastern mountainous zone of somewhat low temperature with samll rainfall
(d) Western coastal zone of transition from humid to dry weather.

This project area lies in Zone(a) above. With southward movement of tropical front from December to March, the project area is covered by the tropical continental air mass. Meantime, the dry tropical maritime air mass penetrates into this area by the prevailing east or southeast wind from the Indian Ocean, and the dry season sets in this area.

From April to November, the Guinea Monsoon from the Atlantic Ocean prevails deep into the interior of the continent because of southward shift of the low atmospheric pressure from Sahara Dessert, bringing rain in this area. The rain is usually accompanied by strong wind and is of a squall nature with thunder.

Kisangani located under the equator, has comparative even rainfall throughout the year.

As one proceeds northward, clearer is the distinction between dry and wet seasons, and the two seasons come in opposite to those prevalent in Kinshasa situated south of the equator.

(2) Temperature

Mean annual temperature of the project area is around 25°C and the difference among the average monthly temperatures is as small as 2°C. However, the annual average maximum temperature of around 30°C differs by somewhat 10°C when it is compared with the annual average minimum temperature of around 20°C.

At Kisangani, temperature at 6 A.M. is the lowest (20°C) and at 2 P.M. is the highest (28°C), thus the difference reaches as much as 8°C.

(3) Rainfall

Annual rainfall in the project area is between 1,500 mm and 1,800 mm. There are three heavy rainfall periods during a year in and around Kisangani, namely in April, August and October - November, while these three vary into two in the area near Bangassou where the two heavy rainfall periods visit in March - May and August - November.

The number of rainy days per month is 10 to 17 days on an average at Kisangani, while at Bondo, the number is nil from December to February and 10 to 20 days for the rest of the year and rainfall is predominant in October. At Kisangani, the rainfall intensity per one rainfall of 4 to 10 mm for a duration of 30 minutes or less occupies 60% of the annual rainfall and that of 4 to 30 mm for a duration of 60 minutes or less, 94%.

Although the wet season is closely related with the south-north movement of tropical front, it is also largely effected by thunder storm or squall caused by strong local convection of air. Because of heavy annual rainfall in this plateau, there has never been absolute deficiency in soil moisture and consequently the climate is characterized by tropical weather of high temperature and humidity. Thus the terrain is covered with tropical forests of tall trees.

During the wet season, rainfall usually starts in midnight and continues to early morning, while in the dry season, it often starts in the afternoon.

Because of abundance of rainfall and variation of temperature within a day, effect of the volume of dew on precipitation in this plateau should not be overlooked. (See A.3.1.2-(1)∿(2))

(4) Humidity and Evaporation

The relative humidity is high throughout the year and there are many places where the monthly average relative humidity exceeds 80%. This phenomenon is attributable to the effect not only of the Guinea Monsoon which brings much humidity but also of the tremendous amount of evaporation from rivers, streams, swamps and vast forests located in this area.

The monthly mean, the maximum and the minimum humidity at Kisangani are 82 - 88 %, 100% and 30 - 40% respectively. Meantime the monthly means and the maximum humidity at Isiro are not very different from those at Kisangani, however the monthly minimum humidity is 17 - 24% during dry seasons and 35 - 40% during wet seasons.

The monthly mean evaporation at Kisangani is 65 - 85 mm and 120 - 150 mm at Bondo in February to March and is 50 - 80 mm for the rest of the year.

(5) Probable Rainfall Intensity

As for rainfall intensity in this area, "L'Intensité des pluies au Congo et au Ruranda-Burundi" by M. Berruex and J. Quordbach has been referred.

From the above literature, the probable rainfall intensity for rainfall durations of 10, 30, 60 and 90 minutes in frequency of 2.5 and 10 years has been derived. The probable rainfall intensity for 60 minutes duration in the return years of 10 is approximately 80 mm/h.

(6) Topography and Vegetation

The project area is divided for description into the following three sections according to their hydrological aspects:

Section between Tshopo and Aruwimi Rivers

The project Road runs on the ridge of gently rolling terrain of 395 - 470 m in elevation with many small undulations. In forests, 5 - 6 m trees grow beneath 20 - 30 m trees and bushes and grasses flourish beneath these trees. The humus layer on the ground is unexpectedly thin in forests because of rapid circulation of organic carbon. The ground surface dries up well in dry seasons, however since not a small area has already been developed as farmland, it seems from hydrological viewpoint that runoff during the wet season takes place soon after the rainfall.

Section between Aruwimi and Likati Rivers

The route runs on a relatively flat terrain of 400 to 470 m in elevation and not a few swamps and marshes are found in the forests on both sides of the route. As the route goes northward, laterite layers increases on the ground and the forests in this section is the densest between Kisangani and Bangassou, with trees of 20 m high closely fill between trees exceeding 40 m beneath which 5 - 10 m bamboo flourishes and the ground is covered with weeds. Bamboo forests are often seen along the route. These four kinds of vegetation retard evaporation during the dry season and the water holding capacity of vegetation gives a large effect on retarding runoff during the wet season. Marshes and swamps in the forests has many pools of water even in the dry season and lend power to regulate runoff as the source of small rivers and streams.

Section between Likati and Bomu Rivers

In this section the route rises as high as 400 - 590 m in elevation and particularly in the area north of Monga many undulations of highland nature are noted. The vegetation consists of sparse trees of 5 - 6 m and bamboo starts to disappear. Vegetation peculiar to savanna starts to be seen with forest existing only by the streams. The ground surface is covered with pampas and streams dry up in the dry season.

Of many rivers and streams crossing the project road, 17 rivers were surveyed hydrologically and hydraulicly. The results of these surveys revealed that these rivers with tremendous area of retardation basins causes much evaporation under prevalent high temperature which in turn keeps the runoff coefficient of flood extremely small.

The middle reaches of the main stream of Zaire River lie in northern hemisphere, and the upper reaches in southern hemisphere, which fact reverses the wet season in the north of the equator from those in the south of the equator. Therefore, in the lower reaches, seasonal runoff during a year varies very little.

(7) Flood Analysis

Flood analysis has been made by obtaining the probable flood volume at specific points from the data on annual maximum flood discharge of many past years at the points. Then, based on these probable flood discharge the probable flood level of the rivers without past data has been assumed. These procedures took the following steps:

Step 1

Flood discharge was estimated from the annual maximum flood levels at Banalia (Aruwimi River), Buta (Rubi River), and Bondo (Uélé River) which were made available by Office des Navigable at Kinshasa.

Data on the annual maximum flood level of Oubangui River and its tributaries were obtained from Office de la Recherche Scientique et Technique Outre-Mer of Republique Centraafricaine.

At the same time, mean precipitation 1/ (Plate A.3.1.2) during the flood season (April - November) of these reaches of the rivers was estimated from which runoff for each river basin of 100 Km^2 for 100 mm precipitation was obtained and plotted to prepare a specific discharge chart during flood seasons (See Plate A.3.1.3).

Step 2

Probable flood discharge was obtained by applying Gumbel's method to the data on annual maximum flood discharge on

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Source: 1/ Bulletin Agricole du Congo Belge Volume 34, September - December, 1943

Aruwimi River (Banalia), Rubi River (Buta), Uélé River (Bondo) and Oubangui River. The results are shown in Plate A.3.14

Step 3

From the area of the reaches of each river, annual mean precipitation in the respective reaches and probable flood discharge obtained by Step 2 above, from which probable flood discharge of the respective river has been derived.

The flood level in the past years at Banalia (as revealed from the interview with a Belgian priest living at the site for the past 27-years) exceeds the 500-year probable flood level (See A.3.1.5, under the heading of Aruwimi River). This seems to be attributable to the application of Manning's formula to such an extremely shallow and wide river as Aruwimi River.

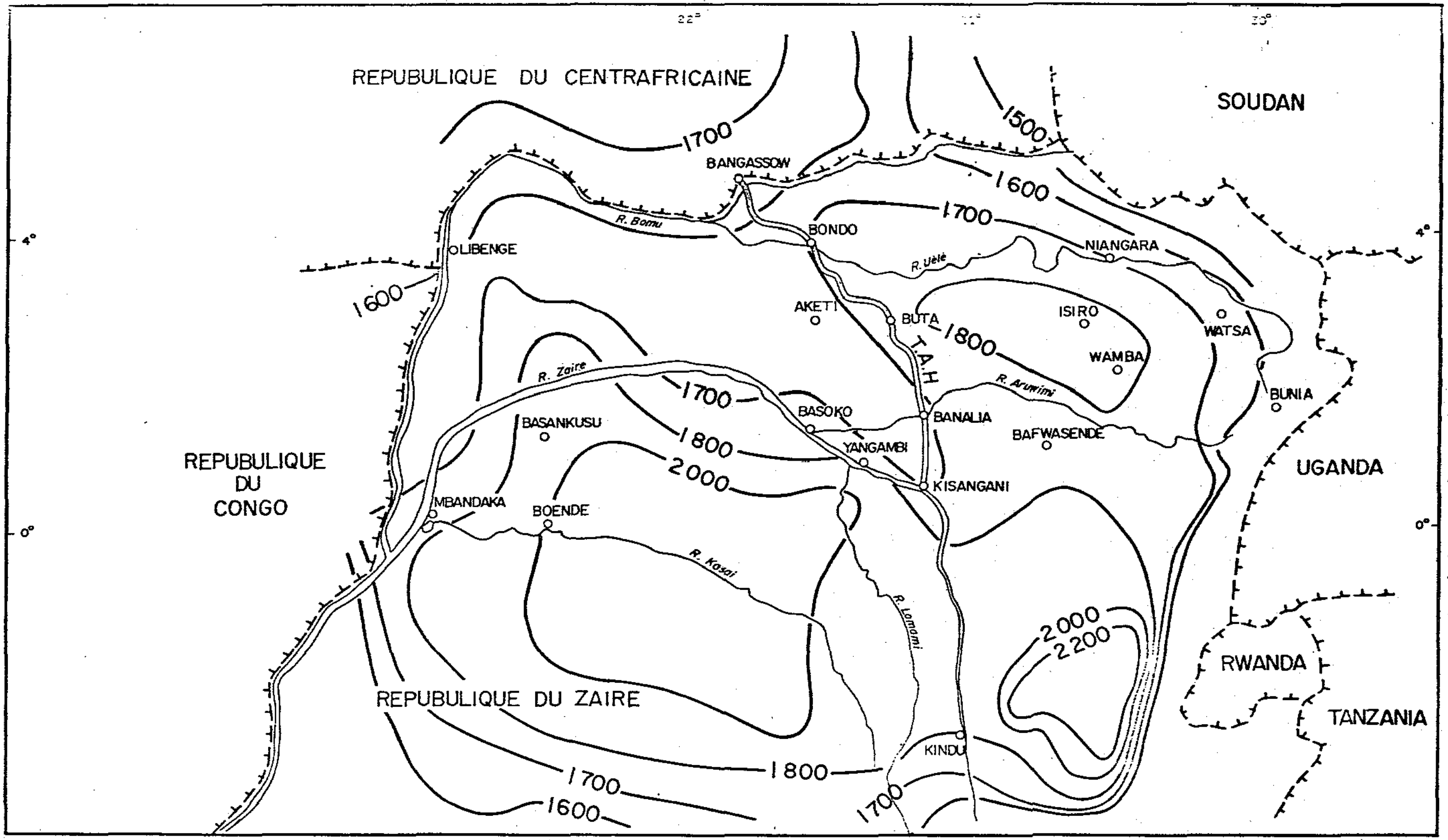
This is to say that after river water overflows a valley formed by scouring in the flooded plain, it seems that the mean velocity of flow becomes extremely small, thereby the rate of raising water level is decreased. However, judging from the course of Aruwimi River, the river bed and the surrounding topography, the water level will not be expected to rise any more than this level.

Zambeke River, Kole River and Tele River are spaced each other at an interval 30 - 40 Km and have very similar geology, topography, vegetation and weather conditions, and the maximum flood level in the past years for each river coincided with 20 - 10 year probable flood level.

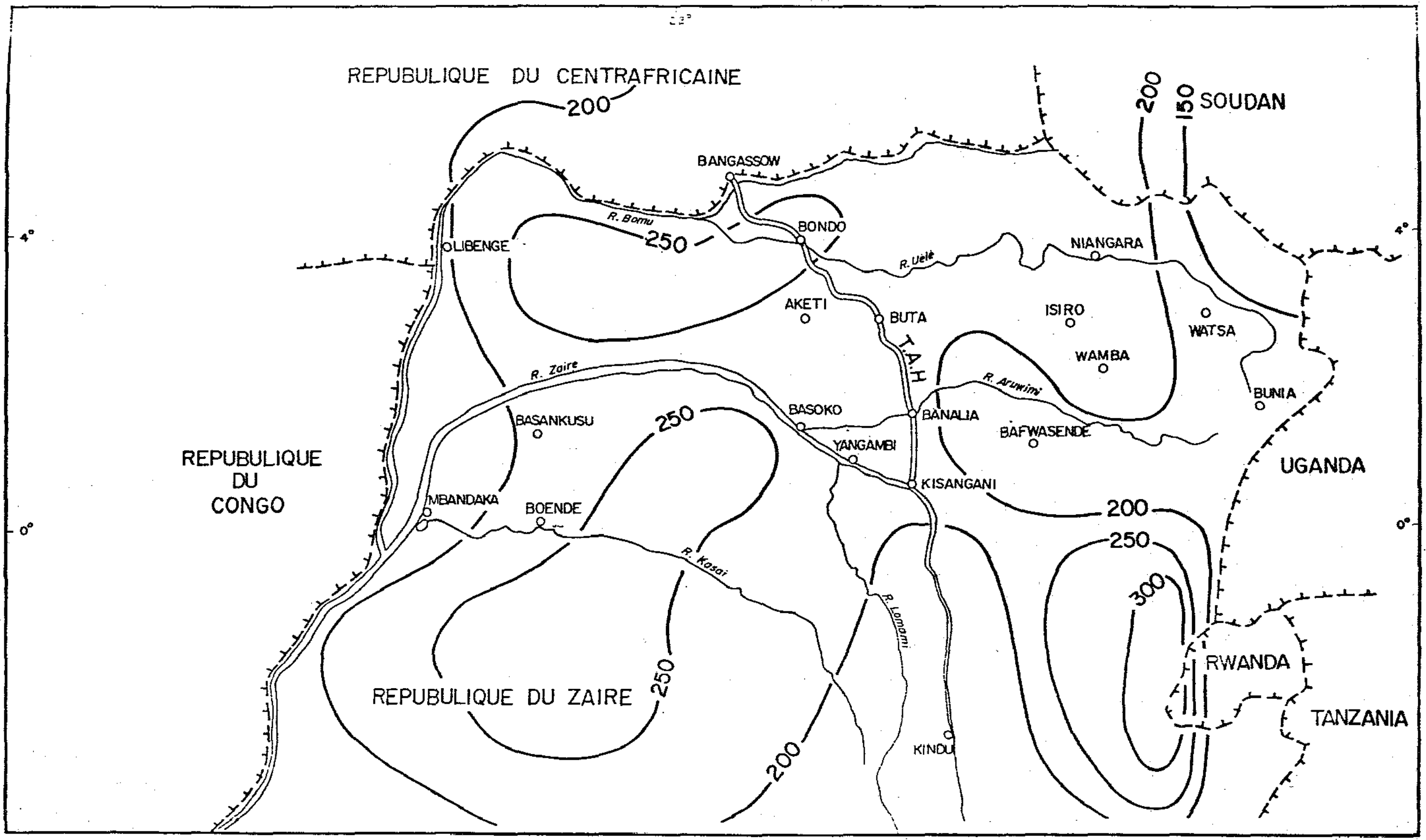
Meantime, although Yeme River is under conditions similar to those of the above three rivers, because of its particularly small area of basin (181 Km^2), maximum flood level in the past seems to have coincided with the 50-year probable flood level.

As for Makala River, Longa River, Koteli River and Bili River, all of which flow on low land, the effect of the area of their basins on maximum flood level is not entirely evident as shown A.3.1.6.

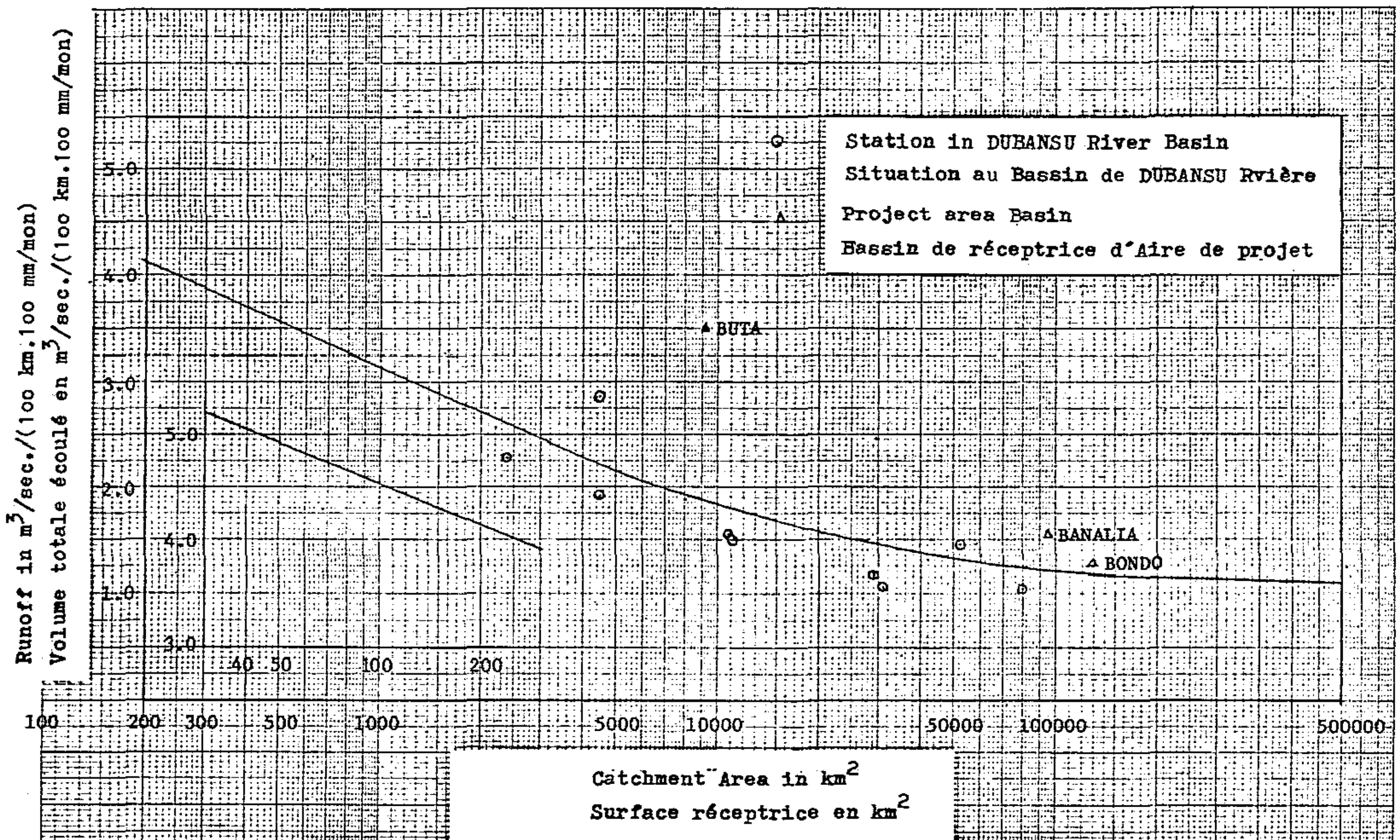
The probable flood discharge, the probable flood water level, the maximum flood water level experienced in the past and the elevation at the bottom of bridge girders of the entire rivers are shown in A.3.1.5-(1)∿(3).



A.3.1.2-(1) Isohyet (Annual)
Isohyētes (Annuel)

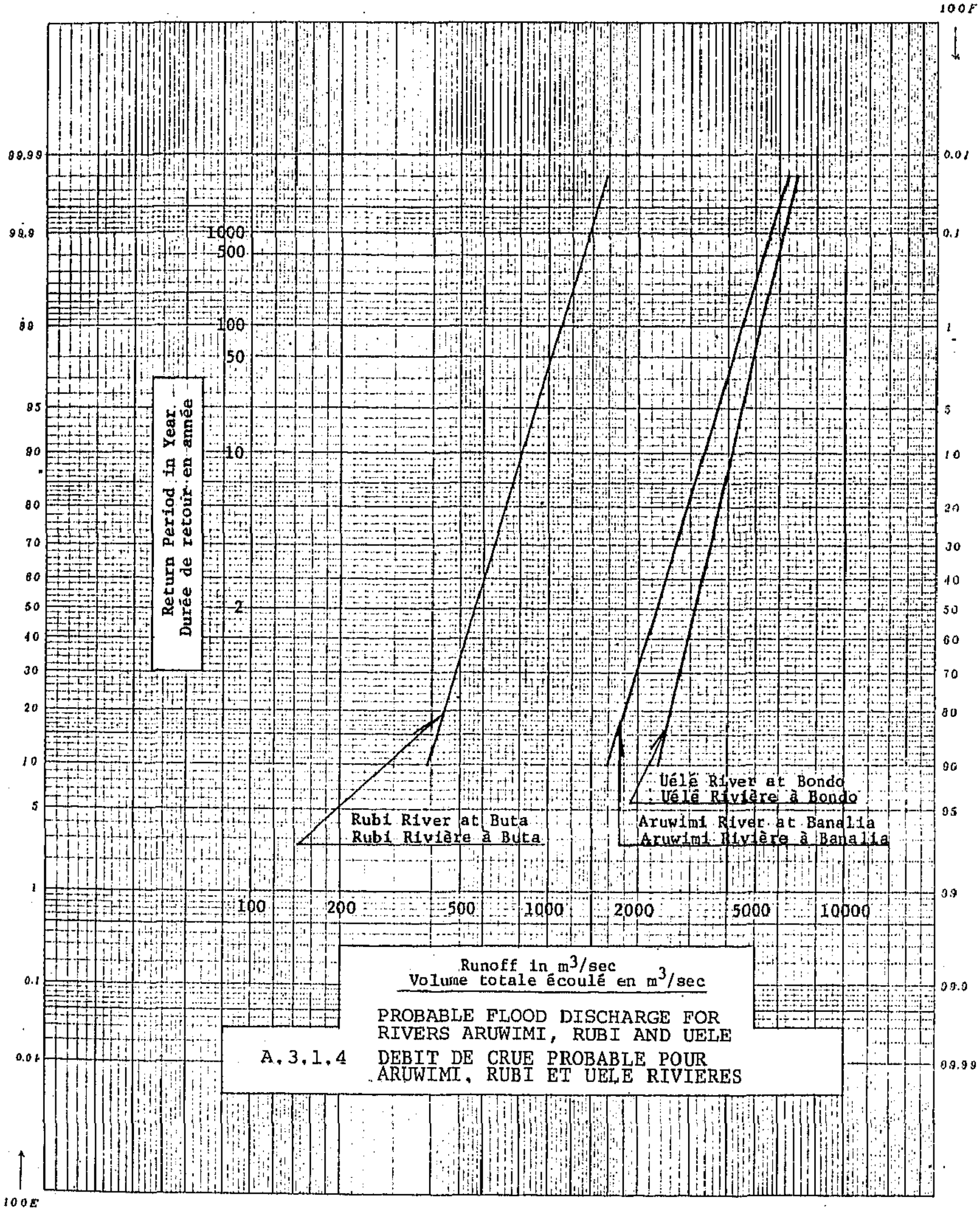


A.3.1.2-(2) Isohyet (October)
Isohyêtes (Octobre)



A.3.1.3 SPECIFIC DISCHARGE FOR FLOOD SEASON

DEBIT SPECIFIQUE POUR PERIODE DE CRUES



A.3.1.4 PROBABLE FLOOD DISCHARGE FOR RIVERS ARUWIMI, RUBI AND UELE
DEBIT DE CRUE PROBABLE POUR ARUWIMI, RUBI ET UELE RIVIERES

$\log x \longrightarrow$

$$100F \equiv 100 \times \int_{-\infty}^{\log x} u \, dx \qquad 100F \equiv 100 \times \int_{\log}^{+\infty} u \, dx \qquad u \equiv \frac{1}{\sqrt{2\pi}} e^{(\log x)^2/2}, \ x > 0$$

A.3.1.5 Detail Descriptions of Main Rivers

Note: A; Probable flood return period (years)
B; Probable flood discharge (m^3/sec)
C; Probable high water level (m)
D; Girder height of existing bridge (m)
E; Highest high water level (m)
F; Water level(observed by survey team) (m)
G; Observation date
H; Rainfall depth in flood season
I; River bed
J; Coefficient roughness
K; Water surface slope

River: Aruwimi   Catchment area: 95,850 km^2
Place: Banalia   Distance from Kisangani: 129.0 km

A	B	C	D	E	F	G	H	I	J	K
2	2,333	415.82			414.12	29 Jan	168 mm/Mon.	Soil	0.04 - 0.05	El.414.0 : 1/4,000 El.418.0 : 1/3,000
5	2,908	416.32								
10	3,288	416.62								
20	3,653	416.92								
50	4,126	417.32								
80	4,366	417.40								
100	4,480	417.50								
200	4,833	417.65								
500	5,298	417.90								
				419.40						

River: Lindi   Catchment area: 44,300 km^2
Bridge: Lindi   Distance from Kisangani: 36.8km

A	B	C	D	E	F	G	H	I	J	K
2	1,134	387.9			384.7	4 Mar	157 mm/Mon.	Rock El.385.5 m	0.026 - 0.04	El.390.0 : 1/2,500 1/1,500
5	1,413	388.5								
10	1,598	388.8								
20	1,775	389.0								
50	2,005	389.5								
80	2,121	389.7								
100	2,177	389.8								
200	2,348	390.1								
500	2,574	390.4		390.4						
			393.4							

River: Zambeke   Catchment area: 550 km^2
Bridge: Zambeke   Distance from Kisangani: 159.1 km

A	B	C	D	E	F	G	H	I	J	K
2	82	412.35			409.90	9 Feb	168 mm/Mon.	Soil and Rock	0.035 - 0.04	El.410.0 : 1/4,000 El.415.0 : 1/2,000
5	104	412.70								
10	117	412.95								
20	130	413.20		413.20						
50	149	413.50								
80	157	413.60								
100	162	413.65								
200	174	413.82								
500	191	414.05								
			415.00							

River: Gula   Catchment area: 410 km^2
Bridge: Gula   Distance from Kisangani: 58.2 km

A	B	C	D	E	F	G	H	I	J	K
2	62	3.3			420.1	4 Mar	157 mm/Mon.	Soil	0.035 - 0.04	El.420.1 : 1/4,000 1/2,500
5	78	3.65								
10	88	3.75								
20	98	4.05								
50	112	4.2								
80	118	4.35								
100	122	4.4								
200	131	4.5		423.5						
500	144	4.75								
			424.0							

River: Kole   Catchment area: 270.0 km^2
Bridge: Kole   Distance from Kisangani: 196.4 km

A	B	C	D	E	F	G	H	I	J	K
2	48	432.80			430.4	10 Feb	168 mm/Mon.	Soil	0.035 - 0.05	El.430.0 : 1/10,000 EL.434.0 : 1/2,000
5	61	433.20								
10	68	433.40		433.40						
20	76	433.60								
50	87	433.85								
80	92	434.00								
100	95	434.05	434.1							
200	102	434.20								
500	112	434.30								

River: Tele
Bridge: Tele

Catchment area: 3,650 km^2
Distance from Kisangani: 235.85 km

A	B	C	D	E	F	G	H	I	J	K
2	278	435.14			432.0	8 Feb	185 mm/Mon.	Rock	0.026 - 0.04	El.432 : 1/3,000 El.437 : 1/1,500
5	349	435.60								
10	397	435.95		435.9						
20	443	436.30								
50	502	436.60								
80	532	436.70	436.70							
100	540	436.90								
200	591	437.05								
500	649	437.25								

River: Kotili
Bridge: Kotili

Catchment area: 680 km^2
Distance from Kisangani: 352.05 km

A	B	C	D	E	F	G	H	I	J	K
2	84.5	385.90			381.60	4 Feb	185 mm/Mon.	Soil	El.381.0 : 0.03 El.387.0 : 0.035	El.381.0 : 1/10,000 El.387.0 : 1/3,000
5	108.0	386.50								
10	120.0	386.70								
20	134.0	387.00								
50	152.0	387.30								
80	165.0	387.50								
100	172.0	387.70	387.60	387.6						
200	184.0	387.90								
500	199.0	388.10								

River: Bilo
Bridge: Bilo

Catchment area: 480 km^2
Distance from Kisangani: 390.5 km

A	B	C	D	E	F	G	H	I	J	K
2	50	393.60			389.8	4 Feb	182 mm/Mon.	Soil	0.03 - 0.04	El.390.0 : 1/10,000 El.394.0 : 1/3,000
5	63	393.80								
10	72	394.00								
20	81	394.10	394.30							
50	93	394.40		394.40						
80	98	394.50								
100	102	394.60								
200	110	394.70								
500	120	394.90								

River: Makala
Bridge: Makala

Catchment area: 86 km^2
Distance from Kisangani: 327.5 km

A	B	C	D	E	F	G	H	I	J	K
2	15	392.35			389.9	3 Feb	185 mm/Mon.	Soil	0.03 - 0.035	El.390.0 : 1/6,000 El.393.0 : 1/2,000
5	19	392.55								
10	22	392.70								
20	24	392.80								
50	28	392.85								
80	29	392.90								
100	30	393.00	393.0	393.00						
200	33	393.05								
500	35	393.20								

River: Longa
Bridge: Longa

Catchment area: 680 km^2
Distance from Kisangani: 332.3 km

A	B	C	D	E	F	G	H	I	J	K
2	84.5	396.90			393.50	3 Feb	185 mm/Mon.	Soil	0.03 - 0.035	El.393.5 : 1/5,000 El.398.0 : 1/2,500
5	108.0	397.30								
10	120.0	397.50								
20	134.0	397.70								
50	152.0	397.90		398.00						
80	165.0	398.10								
100	172.0	398.20	398.20							
200	184.0	398.30								
500	199.0	398.50								

River: Yeme
Bridge: Yeme

Catchment area: 181 km^2
Distance from Kisangani: 309.1 km

A	B	C	D	E	F	G	H	I	J	K
2	34	399.45			397.25	8 Feb	185 mm/Mon.	Soil	0.03 - 0.04	El.397.0 : 1/6,000 El.401.0 : 1/2,000
5	43	399.75								
10	48	399.90								
20	54	400.05								
50	62	400.30		400.30						
80	65	400.40								
100	67	400.45								
200	72	400.55								
500	79	400.72								
			401.50							

River: Rubi
Bridge: Buta

Catchment area: 9,090 km^2
Distance from Kisangani: 323.85 km

A	B	C	D	E	F	G	H	I	J	K
2	571	391.40			386.70	2 Feb	185 mm/Mon.	Rock	0.03 - 0.04	El.387.0 : 1/4,000 El.395.0 : 1/3,000
5	719	392.10								
10	817	392.60								
20	911	393.0		392.70						
50	1,033	393.50								
80	1,095	393.80								
100	1,124	393.95								
200	1,215	394.35								
500	1,335	394.90								
			395.70							

River: Likati
Bridge: Likati

Catchment area: 7,160 km^2
Distance from Kisangani: 464.3 km

A	B	C	D	E	F	G	H	I	J	K
2	466	389.40			384.70	11 Feb	182 mm/Mon.	Soil and Rock	0.03 - 0.035	El.385.0 : 1/4,000 El.393.0 : 1/2,000
5	586	390.00								
10	666	390.50								
20	743	390.80								
50	843	391.20		391.30						
80	873	391.40								
100	917	391.50								
200	991	391.70								
500	1,089	392.10								
			393.30							

River: Likati
Bridge: Libogo

Catchment area: 6,360 km^2
Distance from Kisangani: 477.65 km

A	B	C	D	E	F	G	H	I	J	K
2	424	390.70			388.90	11 Feb	182 mm/Mon.	Soil	0.03 - 0.05	El.389.0 : 1/4,000 El.393.0 : 1/2,000
5	533	391.10								
10	606	391.30		391.50						
20	676	391.70								
50	768	391.90								
80	813	392.10								
100	835	392.20								
200	902	392.30								
500	992	392.60								
			393.00							

River: Uélé
Place: Bondo

Catchment area: 131,520 km^2
Distance from Kisangani: 524.3 km

A	B	C	D	E	F	G	H	I	J	K
2	3,030	470.44			465.54	19 Feb	182 mm/Mon.	Rock	0.03 - 0.035	1/4,000 - 1/2,500
5	3,558	471.00								
10	3,907	471.30		471.55						
20	4,242	471.70								
50	4,676	472.00								
80	4,876	472.10								
100	5,001	472.20								
200	5,325	472.40								
500	5,752	472.60								

River: Bili
Place: Faka

Catchment area: 19,300 km^2
Distance from Kisangani: 633.6 km

A	B	C	D	E	F	G	H	I	J	K
2	620	464.70			464.00	24 Feb	161 mm/Mon.	Soil	0.032 - 0.05	1/10,000 - 1/5,000
5	751	465.00								
10	837	465.10								
20	919	465.30								
50	1,026	465.50								
80	1,080	465.60								
100	1,106	465.65								
200	1,186	465.70		465.73						
500	1,291	465.90								

River: Oubangui(Bomu)
Place: Bangassou

Catchment area: 115,000 km^2
Distance from Kisangani: 722.2 km

A	B	C	D	E	F	G	H	I	J	K
2	2,770	473.40			469.42	26 Feb	161 mm/Mon.	Soil and Rock		
5	3,356	473.85								
10	3,740	474.10								
20	4,107	474.25		474.42						
50	4,585	474.45								
80	4,826	474.55								
100	4,943	474.60								
200	5,300	474.70								
500	5,769	474.80								

A.3.1.6

Basin Area and Flood Discharge of Makala, Longa, Koteli and Bili Rivers

Bassin superficiêl et débit de crue de la rivière Makala Longa, Koteli et Bili

River Name Nom de rivières	Basin Area Bassin Superficiel (km^2)	Flood Water Level Niveau à l'eau (m)	Flood Discharge Débit de crue (m^3/sec)	Return Period Durée de retour (years / années)
Makala	86	393.0	30	100
Longa	680	398.0	152	50
Koteli	680	387.6	172	100
Bili	480	394.4	93	50

Note: Flood water levels are indicated in altitude above sea level.

Niveaux à l'eau ont indiquê dans l'alitude au dessus de niveau usagé

A.3.2.1 Geological Survey

(1) General

Mechanical boring was not carried out on the Project Road but geological data obtained in advance and ground surface observation was the chief item of geological survey.

The geology around the Project Road consists of (i) Schist, quartzite, sandstone and conglomerate which are distributed as surface layer over-lying (ii) the base rock of a composite of Palaeozoic green rock, acidic rock and basic igneous rock. These rocks may be divided into in upper layer consisting mainly of sandstone and quartzite and a lower layer chiefly comprising alternation of sandstone and quartzite and schist combined with lentiform conglomerate.

The base rock line (line of interface between the base rock and the overlying layer) connects Likati with a point approximately 35 Km east of Buta and the base rock is classified mainly into granite and gneiss.

The Project Road is located along the strike of the lower layers between Kisangani and Likati and outcrops of base rock are observed north of Likati.

Such difference in rock formation between zones north and south of Likati gives a large effect on surface soils.

(2) Geology by Section

° Kisangani - Banalia

The geology in this section comprises light blue sandstone of inter-mediate and coarse grains and reddish brown micaceous schist both of clear texture. On this stretch, sandstone and sandy schist are found in the river-beds of Tshopo, Longola and Aruwimi, while micaceous schist in the river-bed of Lindi. Strike and dip of the lower layer are respectively N80°E and 25°S in the vicinity of Tshopo River, and N20°W and 15°E in the vicinity of Lindi River, however, the dip is almost level in the stretch north of Lindi River. (See Photo. 16)

° Banalia - Buta

Rock outcrops are seldom seen on the ground in this stretch, however sandy schist is found 1.6 m - 1.8 m below ground surface from the vicinity of PK 315 to the bank of Rubi River and the outcrops of sandy schist along the river-bed of Rubi is almost horizontal. Laterite layer develops on the ground surface along the route.

Along Route #445, base rock such as granite and gneiss appears on the ground surface at the point 35 Km east of Buta.

° Buta - Dulia

Reddish schist appearing as shale of insufficient metamorphosis is distributed in the vicinity of PK 3, PK 8 and PK 22 - PK 23, but outcrops are seldom seen.

° Dulia - Likati

The geology is similar to that of Buta - Dulia section, and outcrops of reddish schist are seen in the vicinity of PK 23 and PK 40.

° Likati - Bondo

Most of this stretch is located on the base rock, where granite and gneiss are distributed. The surface of a part of these granite and gneiss has been weathered into laterite, some of which have been excavated for use as materials for road maintenance. On the road surface of the section between PK 78 and PK 93 in the north of Likati are some stretches of sandy materials which were formed with sand developed from weathered granite. In the vicinity of Bondo many outcrops of granite are seen on both banks and river-bed of Uélé River.

° Bondo - Monga

There are many outcrops of granitic gneiss in the sections between PK 152 and PK 165 and between PK 191 and PK 235, from which fact it seems that the surface soil layer is not thick. Lateritic soils are widely distributed along the route and quartzite and amphibolite with a strike of N50°E and a dip of 55°N are found to distribute at the junction of Gungu River and Bili River in the north of Bondo.

° Monga - Bangassou

The geology of this stretch comprises granitic gneiss, but in the vicinity of Monga and in the river-bed of Bili River and as the road approaches to Ndu through PK 295 - PK 300 and PK 307, gneiss containing much biotite and hornblende begins to be distributed. Outcrops of gneiss of similar composition are found in the river-bed of Bomu River on the border. (See A.3.2.2)

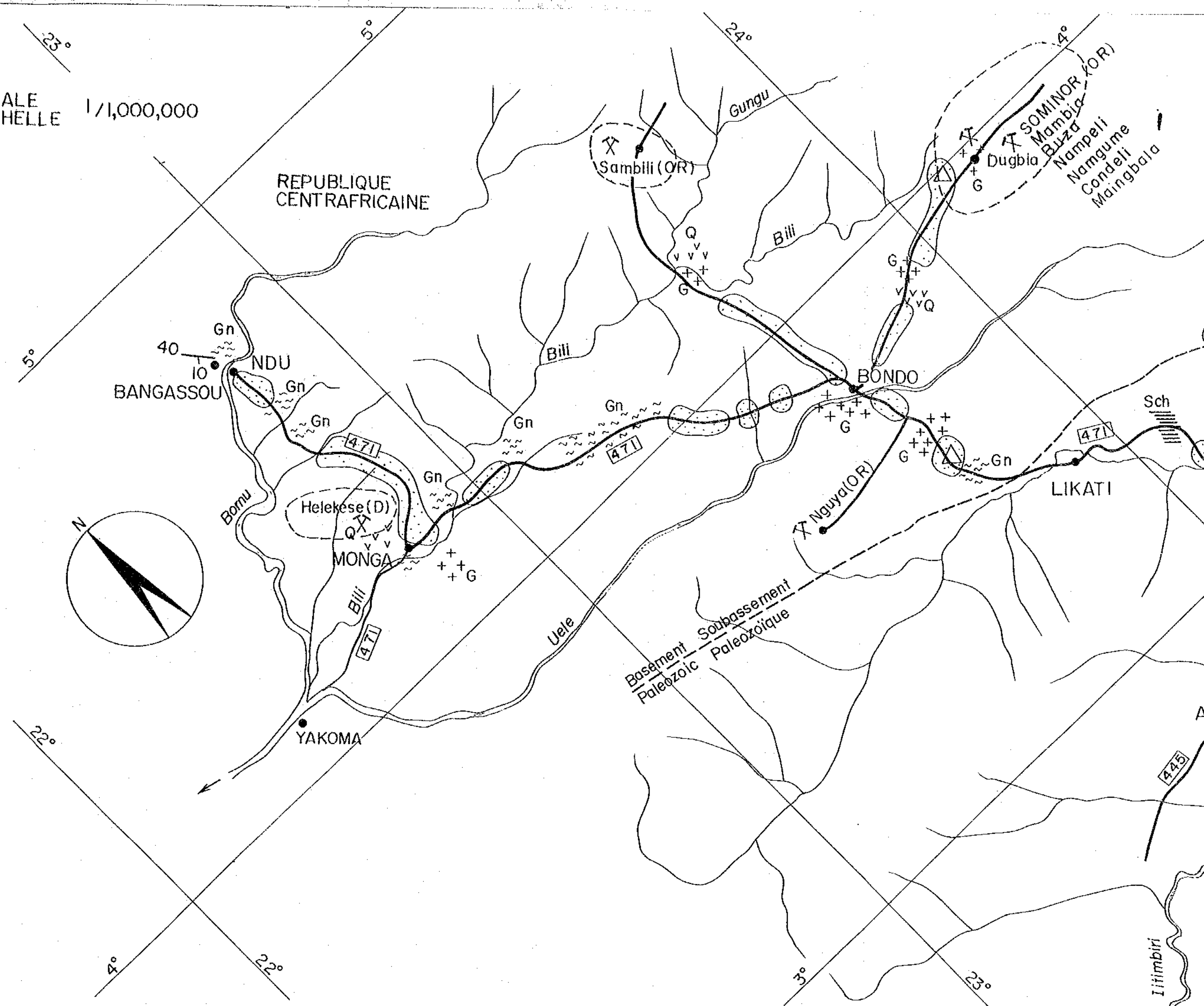
GEOLOGIC ROUTE MAP

CARTE GEOLOGIQUE DE LA ROUTE

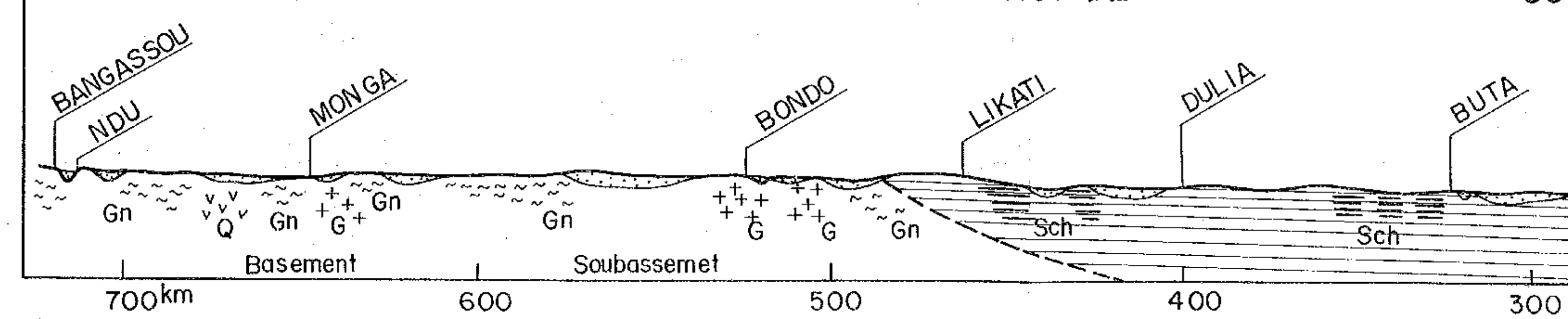
SCALE / ECHELLE 1/1,000,000

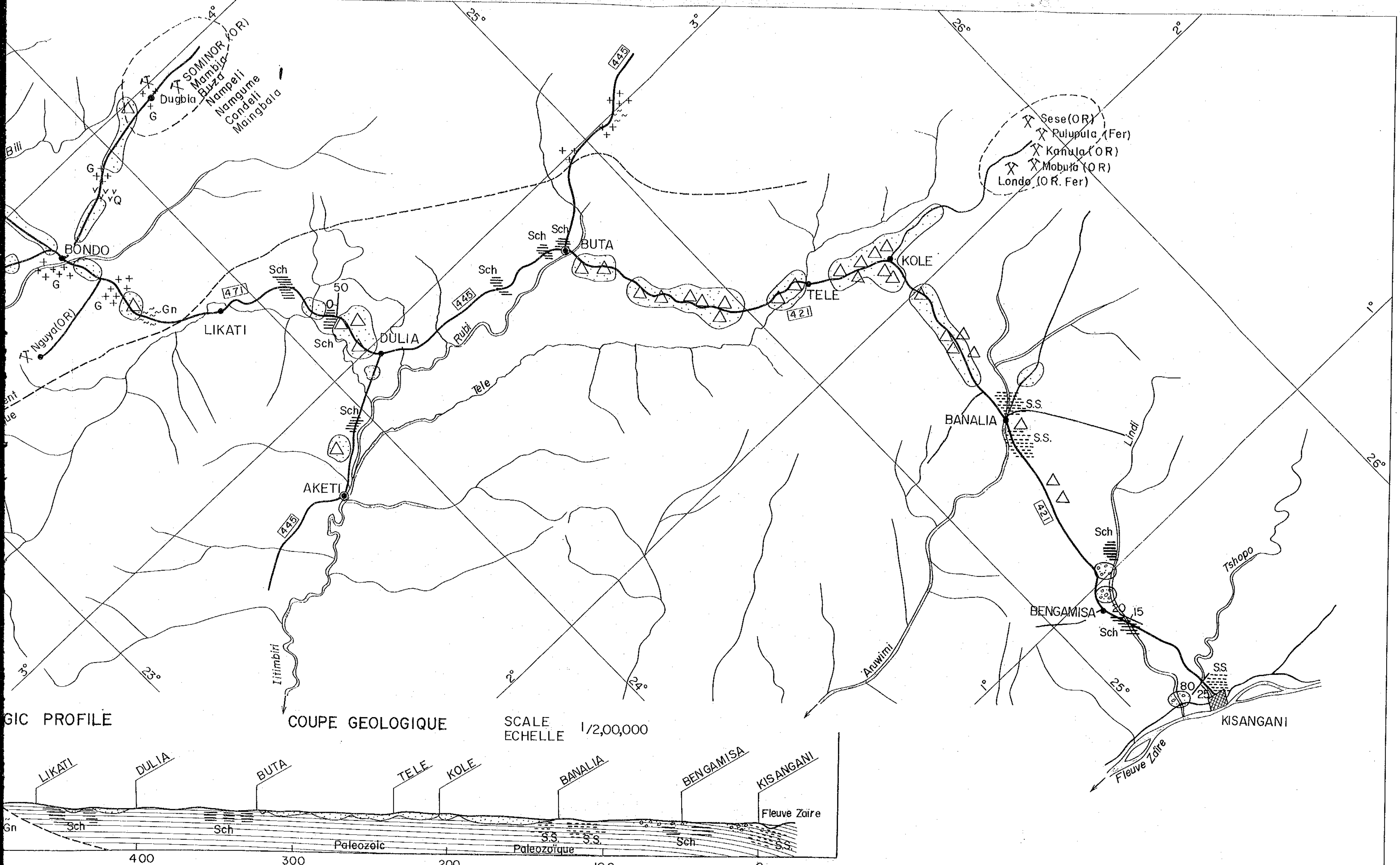
LEGEND	LEGENDE
Gravel Borrow Pit	Fouille d'Emprunt des Gravier
Laterite Borrow Pit	Fouille d'Emprunt des Latērite
Laterite	Latērite
Old Mine Area: O R (Gold), Fer (Iron), D (Diamand)	Aire en Mine Ancienne: O R, Fer, D (Diamant)

Paleozoic Paleozoique	S.S.	Sand stone Grēs
	Sch	Schist Schiste
Basement Soubasement	G	Granite Granitaire
	Q	Quartzite
	Gn	Gneiss



GEOLOGIC PROFILE





GIC PROFILE

COUPE GEOLOGIQUE

SCALE
ECHELLE 1/2,00,000

PLATE
PLANCHE A.3.2.2

A.3.3.1 Soil Survey and Results of Laboratory Tests

(1) General

Soil survey consists of soil distribution survey along the proposed Project Road and the following tests which are required to obtain fundamental soil constants in the selection of pavement type.

° Auger boring	44 places
° Pit excavation	10 places
° Field C.B.R. Test	5 places
° Laboratory C.B.R. Test	20 samples
° Soil stability treatment Test	3 samples
° Specific gravity of soil, soil grading, L.L. and P.L. Tests	40 samples

In view of the length of the route and the time available for survey, auger boring was carried out tentatively at 15 Km intervals. In cases when the boring reaches below underground water level or the boring encounters hard layer which makes further boring impossible, pit excavation was carried out to confirm soils features. The depth of auger boring was limited to 3 m where there is no obstruction. (See Photo. 15)

Field C.B.R. tests were conducted, using the weight of Toyota landcruiser as the reacting weight. Since no trouble is anticipated in the stage of design regarding such hard material with much bearing capacity as laterite, field C.B.R. tests were carried out mainly for silty soils. Incidentally, the test data on laterite conducted by Laboratoire Nationale show C.B.R. values of more than 70%.

Soil stability treatment test with cement was conducted to obtain fundamental data required for study of the type and thickness of pavement, since soil stabilization with cement is often used for upper base course of pavement in this country.

As it was judged that silty soils have problems on the aspect of bearing capacity, two samples out of three taken were of silty soils and the remaining one sample was gravelly soils. Cement stabilization treatment test and physical tests of the soil samples taken were conducted by Laboratoire Nationale in Kinshasa.

Since these soils survey activities were carried out for the project in the stage of feasibility study, the tests were of approximate nature and therefore more precise tests will have to be conducted in the stage of working design.

This is especially true of the boring test at the locations where permanent structures are to be built.

(2) Soil Distribution

Soils surveyed along the Project Road between Kisangani and Bangassou are classified into the following types of soils, reflecting underlying geological structure and geological characteristics:

- Laterite
- Silty soils, fine sand
- Gravelly soils

The distribution of these soils is shown on plans (Scale: 1:50,000) in the Appendices (B.1.1 - B.1.19), which indicate location of borings, soil profile and soil nature.

Generally, as the route goes northward, laterite becomes predominant. Especially in the sections between Kisangani and Banalia and between Buta and Dulia, the road is mostly covered with silty soils.

The followings are the aspects of soil distribution in each section of the route:

° Tshopo River - Banalia (PK 3.6 - PK 129)
The road in this section is covered with fine soils of a mixture of silt, fine sand and clay. However, depending on the location, sandstone, limonite and sandy gravel or laterite appear to be underlying 0.5 m to 2.0 m below the surface layer. In any case this section of the route will have a fill composed chiefly of fine materials of low stability. During the survey, weathered sandstone belt appeared 2 m below the surface at PK 8 and sandy gravel of quartz nature 1.6 m below the road surface at PK 45. The underground water level, where the water table is shallow, was found 1.5 m below ground in the wet season. (See B.1.1 - B.1.4)

° Banalia - Buta (PK 129 - PK 324)
In general, silty soils and laterite are evenly distributed on the road surface in this section of the route. Where soils of fine granules are observed on the surface, transition to laterite or weathered sandstone is often found below such surface soils.

Although depending on the topography, stretches of road composed of fine-grain soils turn into muddy pools during the wet season. This is especially true in the section between PK 225 and PK 260.

Sandstone was found below 1.6 m thick sandy clay layer at PK 315 and below 1.8 m thick sandy clay layer at PK 321. Although these sandstones are weathered and brittle, such rocks seems to be fresh as the depth increases. Judging from the results of soil survey at these two points and from sandstone outcrops in the riverbed of Rubi, it is highly possible that sandstone is widely distributed below the ground surface in the vicinity of Buta. (See B.1.4 - B.1.9)

° <u>Buta - Dulia</u> (PK 0.0 - PK 75.5)
The road surface of this section is covered with silty soils fine sand or silt mixed with gravel and no laterite is observed. The thickness of these layers is mostly more than 3 m. (See B.1.9 - B.1.11)

° <u>Dulia - Likati</u> (PK 0.0 - PK 65.5)
Silty soils cover the road surface between Dulia and PK 6. In the section between PK 6 and PK 12, the road surface is covered with laterite. Three borrow pits are existent in this section which is composed of laterite and the depth of possible borrow of materials is about 2 m. Laterite and silty soils appear alternately on the road surface between PK 12 and Likati, and the thickness silty soils is generally less than 2 m and transition to laterite is often observed below the silty soil layer. In the vicinity of Likati River, sandy soil deposit is observed.

As shown the plan, outcrops of limonite appears even on the surface of the existing road, and while some places of good road surface are observed, the roads where silty soils are distributed are easily turned into muddy conditions, making passage of vehicles impossible except for four-wheel drive vehicles.

Muddy condition is remarkable especially in the section between PK 25 and PK 45. (See B.1.11 - B.1.12)

° <u>Likati - Bondo</u> (PK 65.5 - PK 125.0)
The road surface is predominantly composed of laterite from PK 65 to PK 70 and of silty soils from PK 70 northwards to the vicinity of PK 87. There are numerous muddy places between PK 70 and PK 80 and without four-wheel driven vehicles, passage is impossible. (See Vol. 2, Photo. 2) Sandy soils are frequently observed between PK 87 and PK 104 and especially in the vicinity of PK 90, small gravel is distributed, which is suitable for base course and road-bed.

As the route approaches Uélé River, the outskirts of Bondo, granite outcrops are often observed. On the both banks of Uélé River thick layer of silty soils are distributed. (See B.1.12 - B.1.14)

° Bondo - Monga (PK 125.0 - PK 250.0)
In general, laterite is predominant in this section of the route. Silty soils are distributed in the section between PK 132 and PK 139 and between PK 166 and PK 175, where laterite is observed, outcrops of limonite are often seen on the surface of the existing road. (See B.1.14 - B.1.17 & Photo. 17)

° Monga - Ndu (PK 250.0 - PK 322.4)
Laterite is again predominant in this section. Although the road is covered with silty soils at several locations, the road surface is maintained in good conditions because of predominance of laterite. (See B.1.17 - B.1.19)

(3) Soil Nature

Soil samples taken by auger borings or spot excavations were subjected to the following soil tests at Laboratoire Nationale:

- ° Soil stabilization treatment test by use of cement
- ° Soil classification test (Sieve analysis, Atterberg's limits, Specific gravity of soil granules)
- ° Compaction test and C.B.R. test

The results of the above tests are shown in A.3.3.2 - A.3.3.3. The following characteristics have been revealed regarding the soil nature from the test results.

° Samples regarded as silty soils are noticeable in terms of the number of the samples. They are A-6 and A-7-6 according to AASHO classification and SC according to Casagrande classification. These categories represent clayly sand or mixture of poorly graded sand and clay, which are generally applicable or not applicable for subgrade or base course materials depending on grading distribution.

- From the results of compaction test of silty soils, the optimum water content (Wopt) of 13 - 16% and the maximum dry density (rd max) of 1.85 - 1.87 t/m^3 have been obtained.

- Lateritic soils of coarse grain or sandy gravel is grouped in A-2-7 and A-2-6 categories according to AASHO classification, which is regarded generally good for subgrade materials and the laboratory C.B.R. test-value also exceeds 80%. Meantime, compaction tests revealed that Wopt = 8.3% and rd max = 2.10 t/m^3.

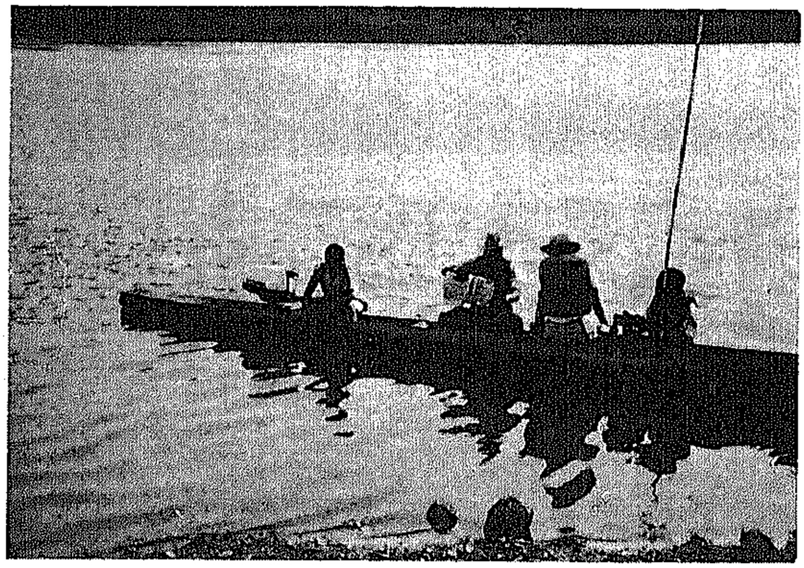


Photo. 14. River Surveying on River Bomu

Photo. 15. Augur Boring at PK 45
(between Buta and Dulia)

Photo. 16. Outcrop of Schist in River Lindi
(between Kisangani and Banalia)

Photo. 17. Limonite Deposit at PK 295 (between Monga and Ndu)

A.3.3.2 Data List of Soil Tests (1)
Liste des données d'essai des sols (1)

Location / Emplacement	Grading / Granulométrie: Gravel / Gravier (%)	Sand / Sable (%)	Silt / Sol silteur (%)	Atterberg's Limits / Limites d'Atterberg: L.L (%)	P.L (%)	I.P (%)	Specific Gravity / Poids spécifique Gs	Classification: AASHO	Casagrande
Kisangani									
+ 15 km	3	62	(35)	30	15	15	2.63	A-6	SC
+ 30	15	60	(25)	34	17	17	2.62	A-2-6	SC
+ 45	2	78	(20)	24	14	10	2.61	A-2-4	SC
+ 60	2	63	(35)	37	16	21	2.64	A-6	SC
+ 75	6	44	(50)	37	17	20	2.64	A-6	CL
+ 90	0	65	(35)	27	18	9	2.60	A-4	SC
+ 105	3	62	(35)	31	15	16	2.64	A-6	SC
+ 120	2	63	(35)	34	20	16	2.63	A-6	SC
+ 136	2	68	(30)	42	23	19	2.64	A-2-7	SC
+ 150	1	59	(40)	43	22	21	2.62	A-7-6	SC
+ 165	0	65	(35)	27	13	14	2.65	A-6	SC
+ 180	28	32	(40)	44	24	20	2.82	A-7-6	SC
+ 272	80	6	(14)	54	25	29	3.15	A-2-7	GC
+ 285	70	10	(20)	70	38	32	3.31	A-2-7	SC
+ 300	2	18	(80)	41	18	23	2.64	A-7-6	CL
+ 315	13	42	(45)	32	11	21	2.68	A-6	SC
+ 321	34	36	(30)	43	21	22	2.83	A-2-7	SC
Buta									
+ 15	0	80	(20)	33	17	16	2.61	A-2-6	SC
+ 34	1	64	(35)	39	21	18	2.61	A-6	SC
+ 45	1	74	(25)	28	15	13	2.61	A-2-6	SC
+ 60	1	76	(23)	35	17	18	2.61	A-2-6	SC

Note: L.L: Liquid Limit / Limite de liquidité
P.L: Plastic Limit / Limite de plasticité
I.P: Plasticity Index / Indice de plasticité

A.3.3.2 Data List of Soils Tests (2)

Liste des données d'essai des sols (2)

Location Emplacement	Grading Granulométrie: Gravel Gravier (%)	Sand Sable (%)	Silt Sol silteur (%)	Atterberg's Limits Limites d'Atterberg: L.L (%)	P.L (%)	I.P (%)	Specific Gravity Poids spécifique Gs	Classification Classification: AASHO	Casagrande
Buta + 75 km	0	90	(10)	24	13	11	2.62	A-2-6	SM
Dulia + 30	0	60	(40)	36	17	19	2.64	A-6	SC
+ 45	0	75	(25)	28	11	17	2.61	A-2-6	SC
+ 63	32	41	(27)	29	13	16	2.73	A-2-6	SC
+ 89	67	29	(4)	23	11	12	2.63	A-2-6	SW
+ 105	65	21	(14)	47	20	27	2.92	A-2-7	SC
+ 120	1	39	(60)	45	24	21	2.63	A-7-6	CL
+ 135	24	41	(35)	46	24	22	2.66	A-7-6	SC
+ 150	65	20	(15)	33	13	20	2.84	A-2-6	SC
+ 165	70	15	(15)	32	17	15	3.08	A-2-6	GC
+ 180	32	30	(38)	41	17	24	2.77	A-7-6	SC
+ 195	31	34	(35)	38	18	20	2.85	A-6	SC
+ 210	40	45	(15)	25	10	15	2.77	A-2-6	SC
+ 224	25	33	(42)	41	18	23	2.77	A-7-6	SC
+ 238	20	48	(32)	35	20	15	2.73	A-2-6	SC
+ 253	22	44	(34)	45	25	20	2.71	A-7-6	SC
+ 266	90	5	(5)	36	17	19	3.27	A-2-6	GW
+ 285	2	33	(65)	43	19	24	2.79	A-7-6	CL
+ 301	14	31	(55)	51	32	19	2.84	A-7-5	CH
+ 318	36	28	(36)	51	26	25	2.85	A-7-6	SC

A.3.3.3

Data Lists of Soils Tests

(C.B.R. Tests & Stabilization Tests with Cement)

Listes des données d'essai des sols

(C.B.R. & Essais de stabilisation au ciment)

Location / Emplacement	Yd max	C. B. R. Wopt	C. B. R. 0.95 γd - max	C.B.R.	Stabilization with Cement (unconfined compression strength) / Stabilisation au ciment (Résistance à la compression simple) — Cement / Ciment 2% qu(kg/cm^2) 7 days / jours	Cement / Ciment 2% qu(kg/cm^2) 3-4 days / jours	Cement / Ciment 2% Es(kg/cm^2) 7 days / jours	Cement / Ciment 2% Es(kg/cm^2) 3-4 days / jours	Cement / Ciment 4% qu(kg/cm^2) 7 days / jours	Cement / Ciment 4% qu(kg/cm^2) 3-4 days / jours	Cement / Ciment 4% Es(kg/cm^2) 7 days / jours	Cement / Ciment 4% Es(kg/cm^2) 3-4 days / jours	Cement / Ciment 6% qu(kg/cm^2) 7 days / jours	Cement / Ciment 6% qu(kg/cm^2) 3-4 days / jours	Cement / Ciment 6% Es(kg/cm^2) 7 days / jours	Cement / Ciment 6% Es(kg/cm^2) 3-4 days / jours
	(t/m^3)	(%)	(t/m^3)	(%)												
Kisangani																
+ 75 km	1.87	13.2	1.78	17	7.2	1.0	1,670	1,560	17.0	7.1	4,500	1,650	27.1	16.8	3,270	2,170
+ 300	1.87	15.8	1.76	9.5	8.7	-	2,150	-	15.8	6.3	4,800	1,660	24.8	17.7	3,910	3,300
Dulia																
+ 89	2.10	8.3	2.00	86	8.5	4.5	1,860	1,400	18.2	10.6	5,860	2,750	38.2	29.1	3,590	4,570

Note:
- Yd max: Maximum dry density / Densité sèche maximum
- Wopt: Optimum moisture content / Teneur en eau optimum
- qu: Unconfined compression strength / Résistance à la compression simple
- Es: Modulus of deformation / Module de déformation

A.3.4.1

Shortening Rate and It's Minimum Economic Limit by "Short-Cut" of Selected Locations

Taux du raccourcissement et l'Economique limitée minimum de "Short-Cut" d'emplacements choisis

L_1: Length of Existing Road
Longueur de route existante

L_2: Length of Improved Road
Longueur de route améliorée

q: Shortening Rate
Taux du raccourcissement

Q: Minimum Economic Limit of Short-Cut
Economique limitée minimum de "Short-Cut"

No. Nº.	Section Tronçon	Station Point d'Etude		L_1	L_2	q	Q	Pavement Type / Type du revêtement
		(PK)	(PK)	(km)	(km)	(%)	(%)	
1	10	25.0 -	29.0	4.0	3.75	6.3	6.7	III
(2)	10,9	36.9 -	50.2	13.3	12.0	9.8	7.3	I
3	9	52.5 -	57.0	4.5	4.25	5.6	6.2	I, III
(4)	9	57.2 -	59.4	2.2	1.7	22.7	6.0	III
5	9	65.0 -	72.0	7.0	6.6	5.7	6.0	III
6	9	81.0 -	87.0	6.0	5.7	5.0	6.0	III
7	9	115.0 -	122.0	7.0	6.8	2.9	6.0	III
8	9	123.8 -	127.0	3.2	3.0	6.2	6.4	I
(9)	8	152.0 -	158.7	6.7	5.6	16.4	9.6	III, I
10	8	164.0 -	166.0	2.0	1.9	5.0	9.2	II, III
(11)	8	182.0 -	189.8	7.8	6.6	15.4	9.6	I, III
(12)	8,7	203.6 -	214.6	11.0	9.4	14.5	10.0	I
13	6	245.0 -	250.5	5.5	5.15	6.4	6.5	I, III
14	6	254.0 -	256.0	2.0	1.9	5.0	6.8	II
15	6	260.0 -	266.0	6.0	5.6	6.7	6.8	II
16	6	269.0 -	282.0	13.0	12.2	6.2	6.8	II
17	6	286.0 -	295.0	9.0	8.7	3.3	6.8	II
18	6	304.5 -	310.5	6.0	5.9	1.7	6.7	I, III
19	5	11.0 -	13.0	2.0	1.75	12.5	16.1	I
20	5	22.0 -	28.0	6.0	5.6	6.7	16.1	I
21	4	3.85-	7.0	3.15	3.1	1.6	22.2	I
22	4	15.4 -	17.5	2.1	2.0	4.8	19.4	III

(continued / continuée)

No. N°.	Section Tronçon	Station Point d'Etude (PK)	(PK)	L_1 (km)	L2 (km)	q (%)	Q (%)	Pavement Type / Type du revêtement
23	4	43.35-	46.6	3.25	3.05	6.2	21.1	I, III
24	4	57.0 -	64.0	7.0	6.1	12.9	20.4	I, III
25	3	91.0 -	94.0	3.0	2.9	3.3	20.4	I
26	3	96.0 -	99.0	3.0	2.9	3.3	20.3	II
27	3	102.0 -	110.0	8.0	6.8	15.0	20.3	II
28	3	115.0 -	119.0	4.0	3.4	15.0	19.6	II, III
29	2	135.5 -	140.5	5.0	4.4	12.0	20.2	I, III
30	2	143.0 -	148.0	5.0	4.7	6.0	22.6	I
(31)	2	152.6 -	155.8	3.2	2.4	25.0	22.6	I
32	2	157.0 -	159.2	2.2	2.05	6.8	22.6	I
33	2	160.5 -	164.0	3.5	3.35	4.3	22.6	I
34	2	166.0 -	170.0	4.0	3.65	8.7	20.0	I, III
35	2	174.0 -	181.0	7.0	6.3	10.0	21.6	I, III
36	2	183.0 -	189.0	6.0	5.6	6.7	22.6	I
37	2	196.0 -	208.0	12.0	11.0	8.3	21.9	I, III
38	2	210.0 -	223.0	13.0	12.0	7.7	22.6	I
39	2	229.0 -	233.8	4.8	3.85	19.8	20.9	I, III
40	2	234.0 -	240.0	6.0	4.9	18.3	22.6	I
41	2	242.5 -	244.5	2.0	1.85	7.5	22.6	I
42	2, 1	247.0 -	252.0	5.0	3.0	40.0	18.8	I, III
43	1	256.5 -	262.5	6.0	5.5	8.3	25.3	IV
(44)	1	274.0 -	284.3	10.3	7.5	27.2	25.3	IV
45	1	291.0 -	295.1	4.1	3.7	9.8	21.0	I, III
46	1	297.0 -	303.0	6.0	5.3	11.7	21.5	I, III
47	1	306.0 -	311.0	5.0	4.4	12.0	20.0	I
48	1	316.0 -	322.0	6.0	5.5	8.3	22.3	I, III

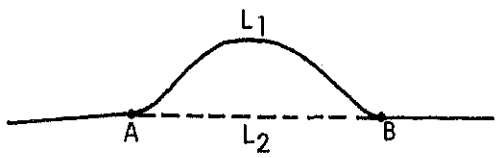
Note: 1. Locations encircled are evaluated to be economical if improved. (7 locations)
Les endroits encerclés sont évalués être economiques si améliorés. (7 endroits)

2. The Short-Cut at No. 42 location is a kind of by-pass around Monga which is scheduled to be implemented in the future. (See B.1.17)
Le raccourci à l'endroit No.42 est une sorte de déviation autour de Monga qui est prévue pour être implanté dans le futur. (See B.1.17)

3. The minimum economic limit of Short-Cut was calculated as follow:
L'economique limite minimum du raccourci ont été calculés ci-dessous.

L_1: Existing Road / Route existante

L_2: Improved Road / Route améliorée



For Widening Section:
Pour élargissement partiel:

L_1: Length of Widening Section of Existing Road
Longueur d'élargissement partiel de Route existante

For Re-aligned Section:
Pour re-aligné partiel:

L_2: Length of Re-aligned Section
Longueur de re-aligné partiel

C_1, C_2: Improvement Cost per km
Coût d'amélioration par km

M_1, M_2: Maintenance Cost per km
Coût d'entretien par km

R_1, R_2: Operating Cost of Vehicle per km
Coût du fonctionnement de véhicule par km

T_1, T_2: Time Cost of Vehicle per km
Coût du temps du véhicule par km

* It is assumed that improvement cost is invested in the first year, and maintenance cost, operating and time cost of vehicle during the project life of 27 years are calculated according to the estimated traffic by section and accumulated after being discounted at the rate of 12% to the present value. The values of Q by route section and by pavement type are shown in A.3.4.2.

Il a été décidé que le coût d'amélioration est investi dans la première année et que le coût d'entretien, le coût opération et de temps des véhicules pendant la durée du projet de 27 années, ont été calculés en acord avec le trafic éstimé de tronçon et accumulé après éscompté au pourcentage de 12% à la valeur présente. Valeurs de Q par tronçon de route et par type du pavé ont indiqué dans A.3.4.2.

The condition of Short-Cut to be justified economically is as follow:

La condition être de "Short-Cut" est justifié économiquement est comme suit:

$$L_1(C_1 + M_1 + R_1 + T_1) \geqq L_2(C_2 + M_2 + R_2 + T_2)$$

$$\therefore \quad \frac{C_1 + M_1 + R_1 + T_1}{C_2 + M_2 + R_2 + T_2} \geqq \frac{L_2}{L_1}$$

$$\therefore \quad \frac{(C_2 + M_2 + R_2 + T_2) - (C_1 + M_1 + R_1 + T_1)}{C_2 + M_2 + R_2 + T_2} \leqq \frac{L_1 - L_2}{L_1}$$

Since,
Depuis, $M_2 = M_1 \qquad R_2 = R_1 \qquad T_2 = T_1$

then,
alors, $\frac{C_2 - C_1}{C + M + R + T} \times 100 \leqq \frac{L_1 - L_2}{L_1} \times 100 = q$

$$Q = \frac{C_2 - C_1}{C + M + R + T} \times 100\%$$

A.3.4.2

Minimum Economic Limit of Short-Cut by Section, by Pavement Type

Economique limitée minimum de "Short-Cut" par tronçon, par type de pavage

Section / Tronçon	Pavement Type / Type de pavage	C_2 (Z)	C_1 (Z)	$C_2 - C_1$ (Z)	S=M+R+T (Z)	$C_2 + S$ (Z)	$Q=\frac{C-C_1}{C_2+S}$ (%)
10	I	110,447	76,588	33,859	354,880	465,327	7.3
	III	148,549	114,690	33,859	354,880	503,429	6.7
9	I	105,268	75,832	29,436	354,880	460,148	6.4
	III	132,030	102,594	29,436	354,880	486,910	6.0
8	I	96,303	79,253	17,050	75,852	172,155	9.9
	II	96,757	79,706	17,050	75,852	172,609	9.9
	III	124,426	107,376	17,050	75,852	200,278	8.5
7	I	90,500	73,873	16,627	75,852	166,352	10.0
6	I	80,181	69,584	10,597	75,852	156,033	6.8
	II	80,635	70,037	10,597	75,852	156,487	6.8
	III	91,521	80,924	10,597	75,852	167,373	6.3
5	I	74,020	58,390	15,630	22,920	96,940	16.1
4	I	74,756	53,929	20,827	18,894	93,650	22.2
	III	88,364	67,537	20,827	18,894	107,258	19.4
3	I	77,456	57,799	19,657	18,894	96,350	20.4
	II	77,910	58,252	19,657	18,894	96,804	20.3
	III	91,971	72,314	19,657	18,894	110,865	17.7
2	I	70,552	52,345	18,207	9,968	80,520	22.6
	III	83,707	65,500	18,207	9,968	93,675	19.4
1	I	74,766	57,784	16,982	9,968	84,734	20.0
	III	86,559	69,577	16,982	9,968	96,527	17.6
	IV	57,075	40,093	16,982	9,968	67,043	25.3