

A3 RIVER BASIN AND RIVER CHANNEL

A3.1 River Basin

The Limboto-Bolango-Bone (LBB) basin has a total catchment area of about 2700 km² and is shaped rectangle extending about 100 km from east to west, and about 30 km from north to south. The LBB basin consists of the Lake Limboto basin (890 km²), the Bolango River basin (490 km²), and the Bone River basin (1,320 km²). General basin map with river system and basin areas at major sections are shown in Figure A3.1.1 and overall longitudinal profiles of the Bone River system and the Lake Limboto system in Figures A3.1.2 and A3.1.3.

Administratively the LBB basin is located mostly in the south-eastern part of Gorontalo Province (2,400 km²) and small portion in the south-western part of North Sulawesi Province (300 km²). Kabupaten Gorontalo and Kota Gorontalo of Gorontalo Province and Kabupaten Bolaang Mongondow of North Sulawesi Province are related to the basin. Their administrative boundaries in the LBB basin are shown in Figure A3.1.4.

(1) Lake Limboto Basin

The Lake Limboto basin shares western half of the LBB basin with a total catchment area of about 890 km². The major tributaries of the Lake Limboto are the Biyonga River (66 km²), the Meluopo River (27 km²) and the Marisa River (64 km²) from the north, and the Alo-Pohu River, which consists of the Alo River (342 km²) from the north-west and Pohu River (124 km²) from the south-west. There are numerous small tributaries from the southern hill.

(2) Bolango River Basin

The Bolango River originates in the Mt. Lowulowu. It passes through the mountainous areas towards south, joining the Bongo River (81 km²) and the Mongiilo River (262 km²) on the left, until it reaches at the Lomaya weir. Basin area of the Bolango River is 388 km² at the Lomaya weir. The Bolango River joins the Palanggua River (58 km²) at the downstream of the Lomaya weir and flows down to the plain land on the northern part of Gorontalo city. Passing on the west of Gorontalo city, it joins the Tapodu River, outlet channel of Lake Limboto, and empties into the Bone River on the south of Gorontalo city. Basin area of the Bolango River is about 490 km² in total

excluding that of Lake Limboto.

(3) Bone River Basin

The Moloti River which originates in the Mt. Unggiango and the Bulawa River which originates in the Mt. Sula meet together and become the Bone River in the east of the LBB basin. Passing through the mountainous areas towards the west, the Bone River joins the Bulahu River (73 km²), the Olama River (73 km²) and the Bunano River (169 km²) on the right. After flowing towards the west, it reaches at Alale weir. The total basin area of the Bone River is around 1,060 km² at the weir. The Bone River further runs toward west on the south of Gorontalo city and joins the Tamalate River (70 km²) and the Bolango River on the right. Just at the downstream of the confluence with the Bolango River, the Bone River changes its direction towards the south, and finally discharges into the Tomini Bay. The total basin area of the Bone River basin is about 1,320 km² excluding those of the Bolango River and Lake Limboto.

A3.2 Principal Channel Features

River system in the plain area of the LBB basin is shown in Figure A3.2.1. Based on the results of latest river survey conducted by the Study Team, channel characteristics of the major river channels in the Study Area were studied and the results are shown in Table A3.2.1. The channel characteristics include the riverbed slope, river width, mean depth, cross-sectional area, channel slope and existing carrying capacity. The channel characteristics are also illustrated for the selected principal rivers as shown in Figure A3.2.2. They are summarized as follows:

- 1) Bone River:

Riverbed slope	: 1/1800~1/250
River width	: 120m to 220 m
Carrying capacity	: 210 to 870 m ³ /s
- 2) Bolango River:

Lower Reaches: River mouth to confluence of Tapodu River

Riverbed slope	: 1/1400
River width	: 34 m
Carrying capacity	: 175 m ³ /s

Middle Reaches: upstream of confluence of Tapodu River

Riverbed slope	: 1/960~1/150
River width	: 60m to 90 m
Carrying capacity	: 200 to 300 m ³ /s

3) Tamalate River (in Gorontalo City):

Riverbed slope	: 1/1200
River width	: 20m
Carrying capacity	: 50 to 60 m ³ /s

A3.3 Flood and Sediment Disasters**(1) Type of Disaster**

According to the information obtained through field reconnaissance and public consultation, flood, bank erosion and sedimentation are the major types of the disaster in the Study Area.

Flooding: Flooding over the riverine lands is the typical disasters observed in the areas along the river course. These flooding occur because of shortage of channel capacity. Poor drainage due to low-lying topography, natural and artificial channel constriction, and backwater from the main river cause the stagnant of flooded water and local storm water, bringing about inundation disaster.

Bank erosion: Bank erosions are observed in places of the rivers in the Study Area. Bank protection works were implemented to protect residential areas, trunk roads, etc., although these are implemented as remedial measure with less consideration from basin-wide viewpoint.

Sediment: Devastation of watershed due to illegal logging or shifting cultivation increases sediment yield in the watershed and causes sediment deposits in the river channels, farm lands and lake in the lower reaches. A large part of sediment flows in the Lake Limboto and decrease its storage volume. Consequently a haul of fish in the lake decreases and flood regulation function of the lake lowers.

(2) Inundated Area and Causes

Major inundated areas in the LBB basin are southern part of Gorontalo City, middle

reaches of the Bolango River, Limboto City, western part of the Lake Limboto, and Isimu area as shown in Figure A3.3.1. Brief descriptions are given on these major flood prone areas as follows. Among these the disasters in the southern part of Gorontalo City are most serious.

Southern Part of Gorontalo City: In the southern part of Gorontalo city, the Bone, the Bolango and the Tamalate rivers join. Water level is raised due to backwater at the confluence of these rivers and inundation occurs frequently. High tide and sedimentation at the river mouth aggravate the situation.

Middle Reaches of Bolango River: Inundated area extends along the Bolango River from the confluence with the Mongiilo River to the northern part of Gorontalo city. River terrace is formed in this stretch, and flood flow runs along the Bolango River between the river terraces.

Limboto City: Limboto city is inundated by flood water from the Biyonga and Meluopo rivers. The flood flow is interrupted by Gorontalo-Isimu road.

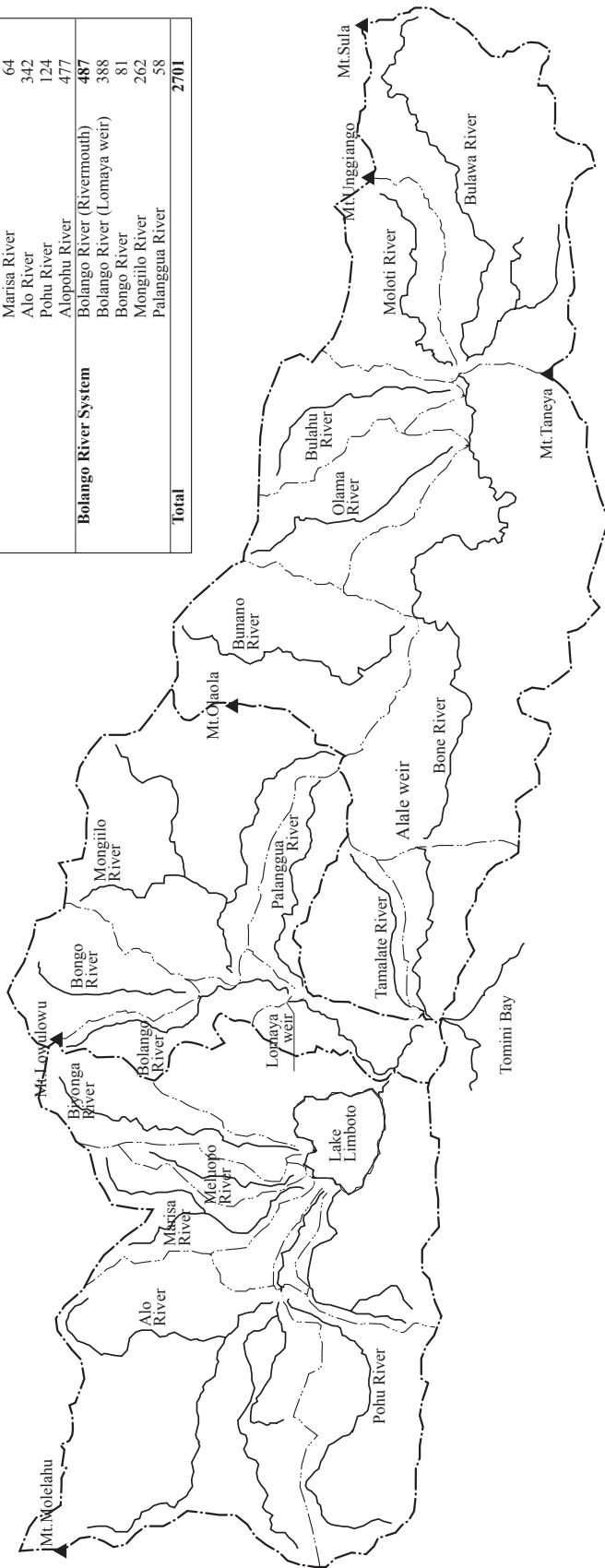
Western Part of Lake Limboto: Western part of the Lake Limboto is inundated due to rising water level of the lake. Inundation in this area lasts for a long time, since the capacity of outlet channel from the lake is small. There would be enough time for evacuation because water level rises slowly.

Isimu area: Isimu area where the tributaries gather is suffering from inundation due to shortage of carrying capacity of river channel and low-lying topography in the area.

Table A3.2.1 CHARACTERISTICS OF EXISTING RIVER CHANNEL

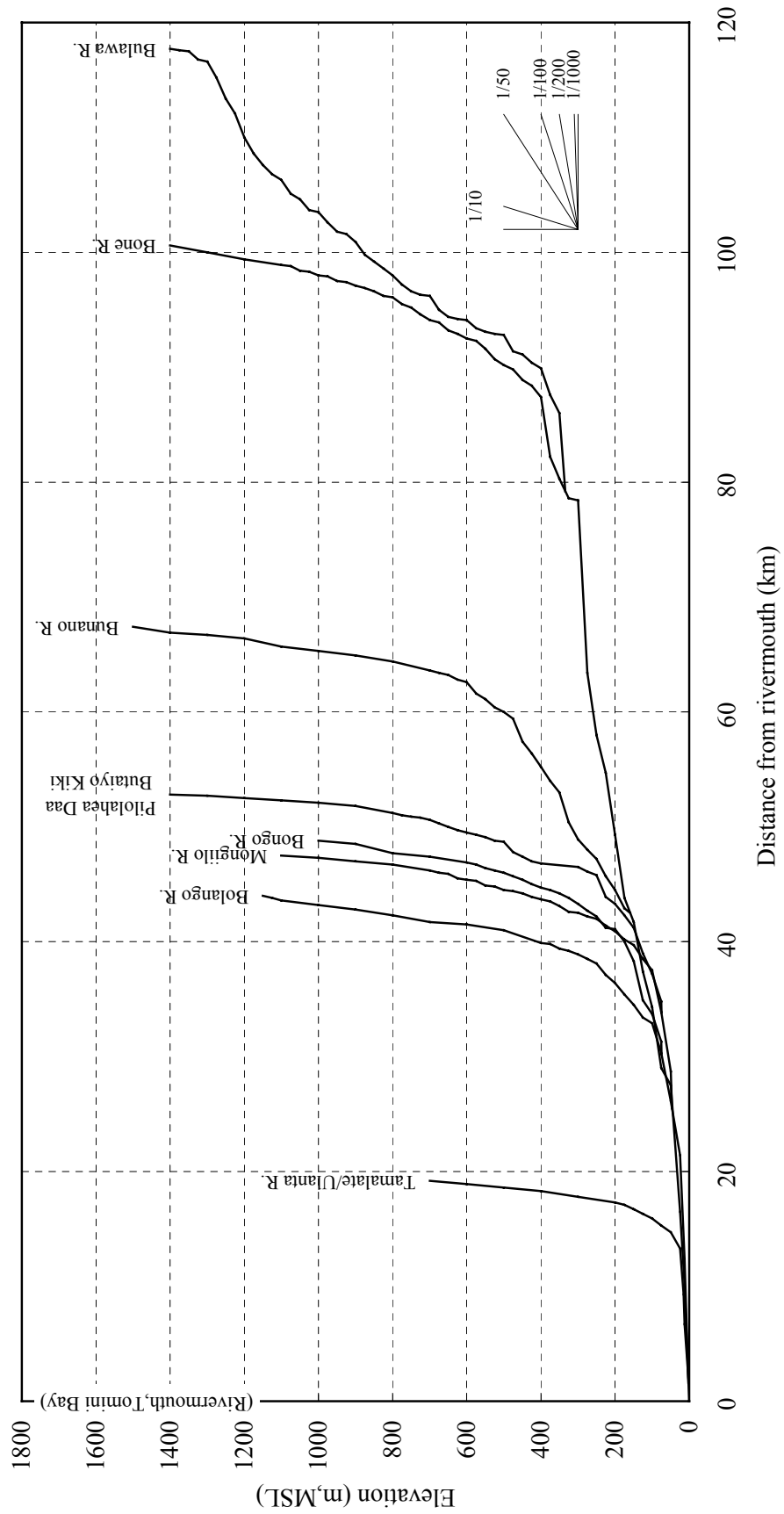
River System	River	From (m)	To (m)	Average Riverbed Slope (1/I)	Average Width (m)	Average Depth (m)	Average Area (m ²)	Average Carrying Capacity (m ³ /s)
Lake Limboto System	Alopohu	0	3,618	1072	32	2.9	102	215
		3,618	9,003	796	33	3.0	105	258
	Alo	9,227	13,638	689	32	2.5	84	198
		0	2,818	470	19	1.5	27	55
	Pohu	0	3,214	737	28	2.0	56	115
		0	3,001	646	18	1.7	39	83
		3,001	6,585	357	27	2.1	63	186
	Biyonga	6,585	8,295	245	29	1.2	36	100
		0	2,181	686	14	0.8	12	18
		2,181	4,101	316	20	1.7	34	93
	Marisa	0	1,451	2476	12	0.8	9	6
		1,451	5,268	478	13	1.4	20	40
	Rintenga	0	7,020	525	9	0.7	11	21
Bolango River System	Bolango	0	5,981	1435	34	2.6	97	175
		5,981	16,884	958	58	2.4	120	247
		16,884	18,725	365	83	1.3	100	205
		18,725	19,608	153	87	1.3	99	311
	Tapodu	0	2,473	6230	24	1.9	45	31
	Siendeng	0	1,328	619	27	1.9	55	115
	Limba	0	2,306	2522	6	0.9	7	5
		2,306	8,141	466	10	0.7	8	10
Bone River System	Bone	0	969	1783	216	2.3	524	871
		969	5,572	815	129	1.5	191	301
		5,572	14,713	529	120	1.2	131	214
		14,713	15,824	247	123	1.1	103	232
	Pangimba	0	6,269	538	9	0.8	8	10
	Tamalate	0	5,653	1163	21	1.7	37	53
		5,653	8,318	692	23	1.6	35	60
		8,318	10,520	340	22	1.1	24	47
		10,520	10,926	112	12	1.5	23	103
	Ulanta	0	3,212	323	11	0.9	9	17
Irrigation Canal	0	1,712	1069	9	1.2	13	17	

River System	River	Area (sq.km)
Bone River System	Bone River (Rivermouth)	1322
	Bone River (Alale weir)	1060
	Moloti River	100
	Bulawa River	282
	Bulahu River	73
	Olama River	73
Lake Limboto System	Bumano River	169
	Tamalate River	70
	Tapodu rivermouth	892
	Biyonga River	66
	Melupo River	27
Bolango River System	Marisa River	64
	Alo River	342
	Pohu River	124
	Alopothu River	477
	Bolango River (Rivermouth)	487
	Bolango River (Lomaya weir)	388
	Bongo River	81
Mongילו River	262	
Palanggua River	58	
Total		2701



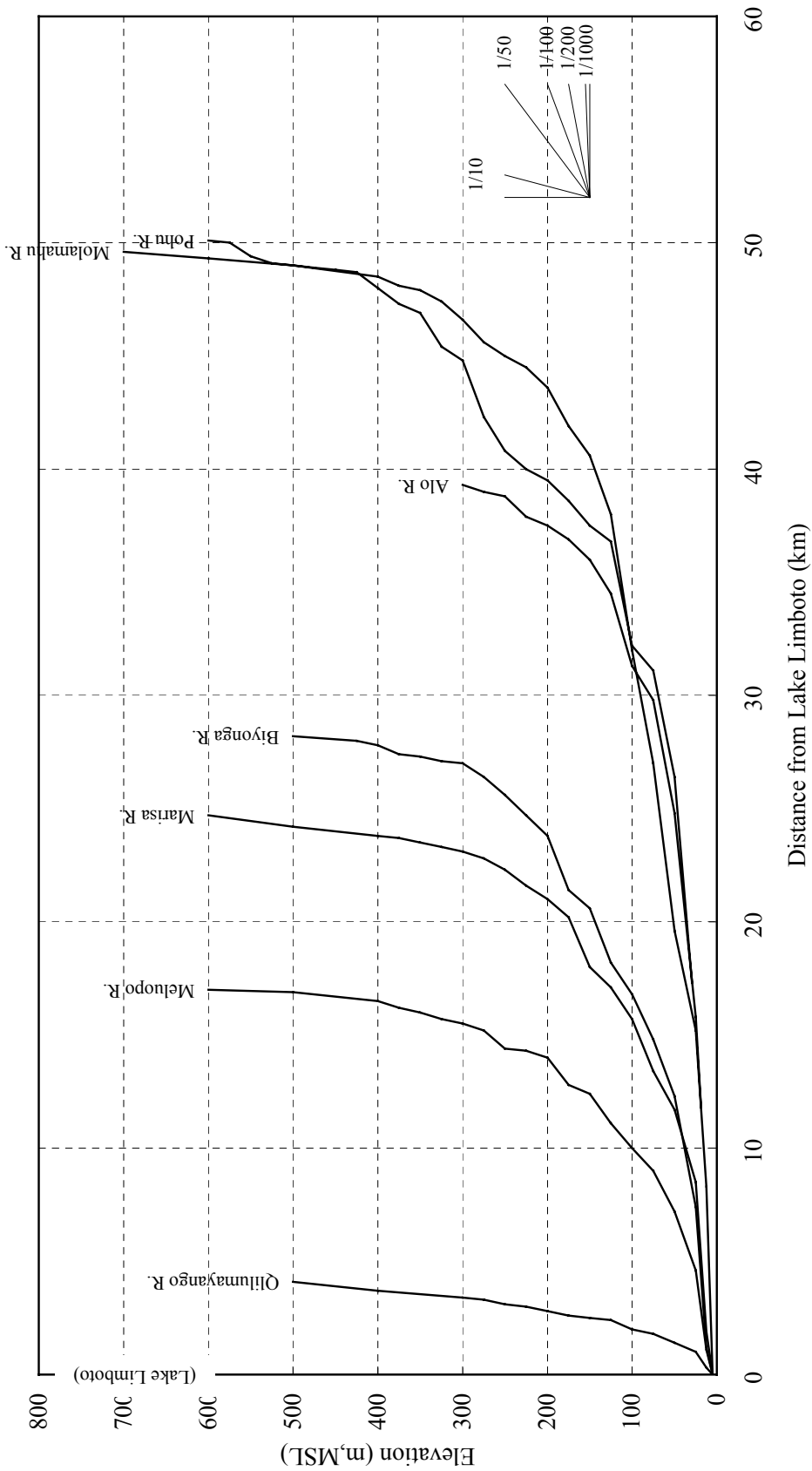
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Figure A3.1.1
RIVER BASIN BOUNDARIES



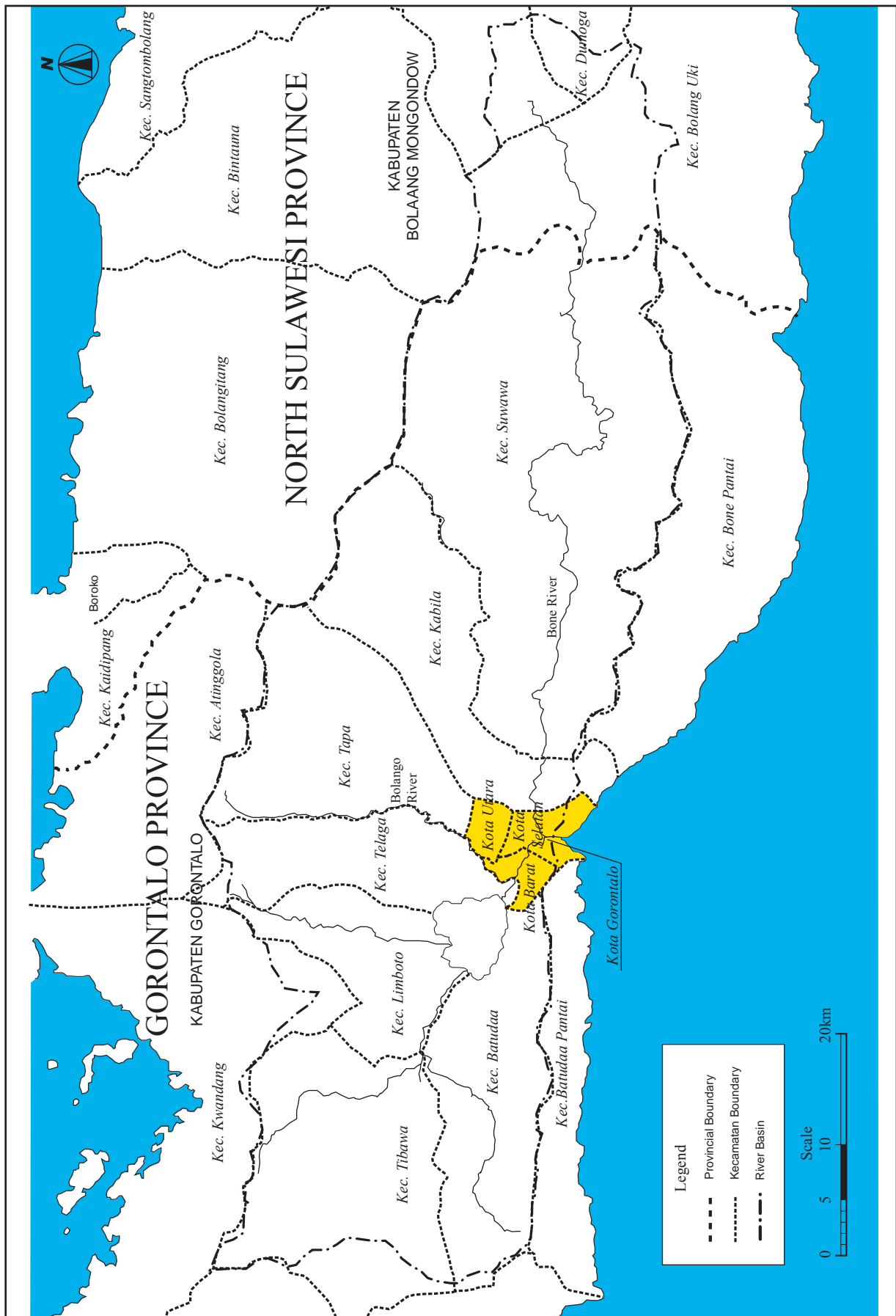
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Figure A3.1.2
OVERALL LONGITUDINAL PROFILE :
BONE - BOLANGO RIVER SYSTEM



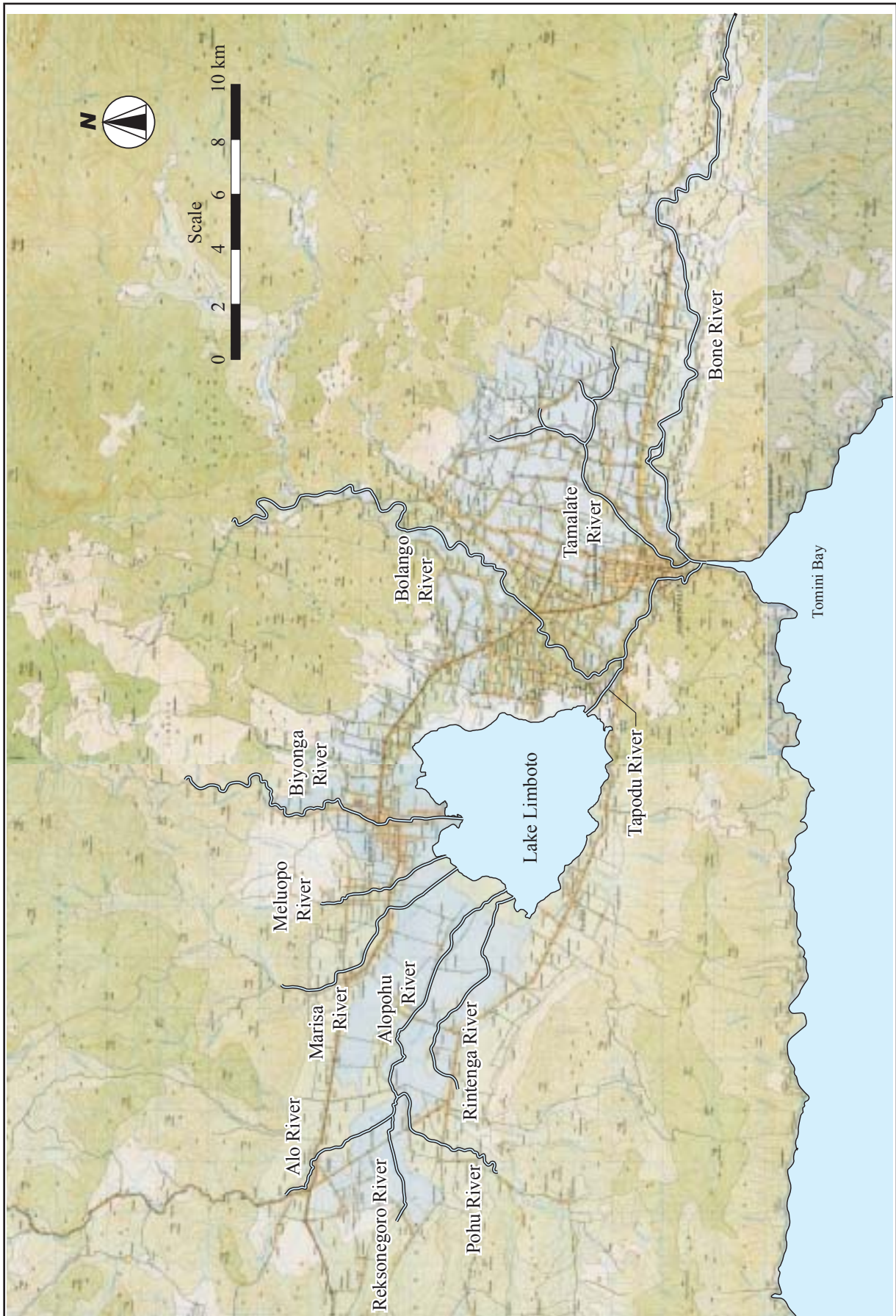
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Figure A3.1.3
OVERALL LONGITUDINAL PROFILE :
LAKE LIMBOTO SYSTEM



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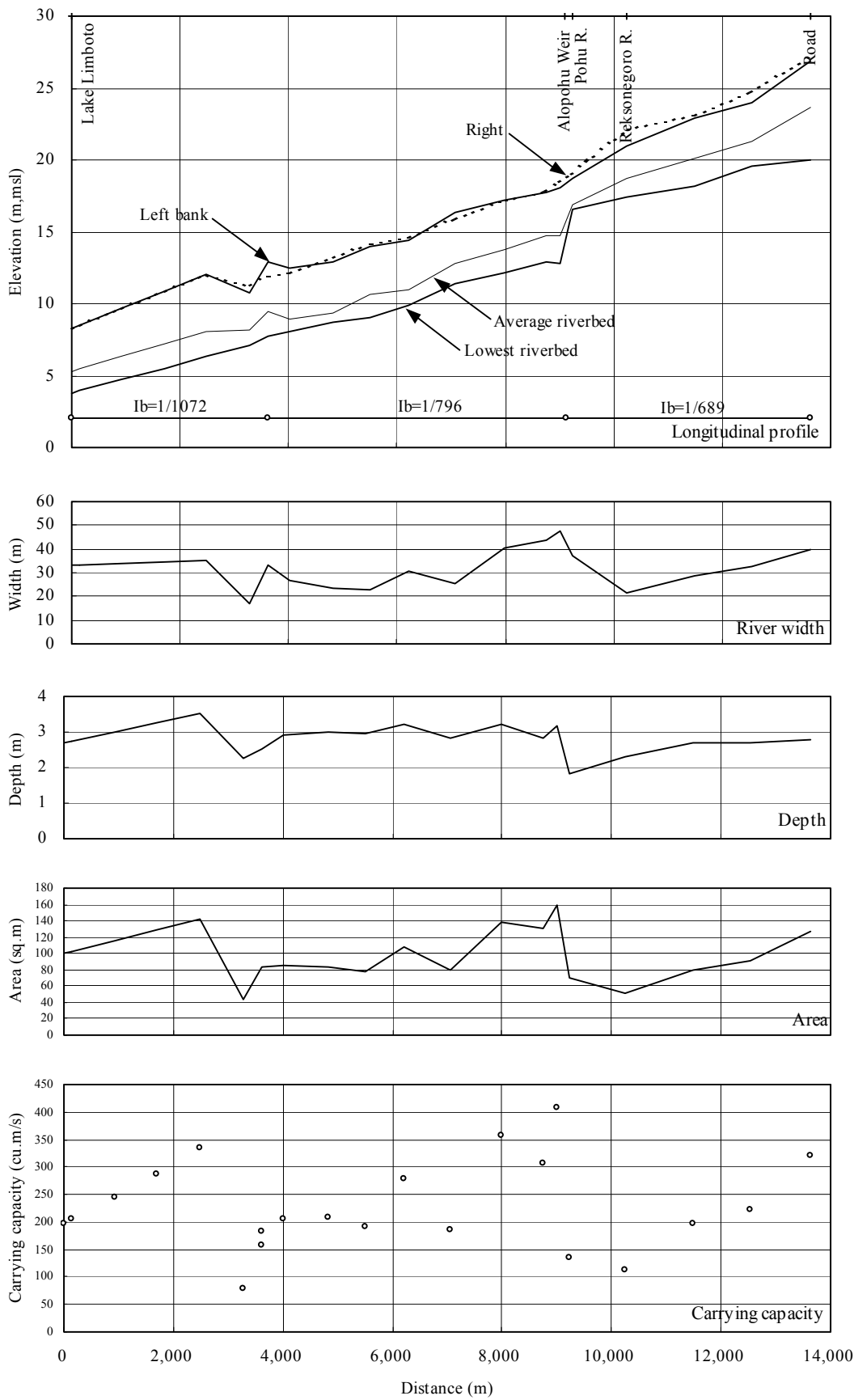
Figure A3.1.4 ADMINISTRATIVE BOUNDARIES OF LBB BASIN



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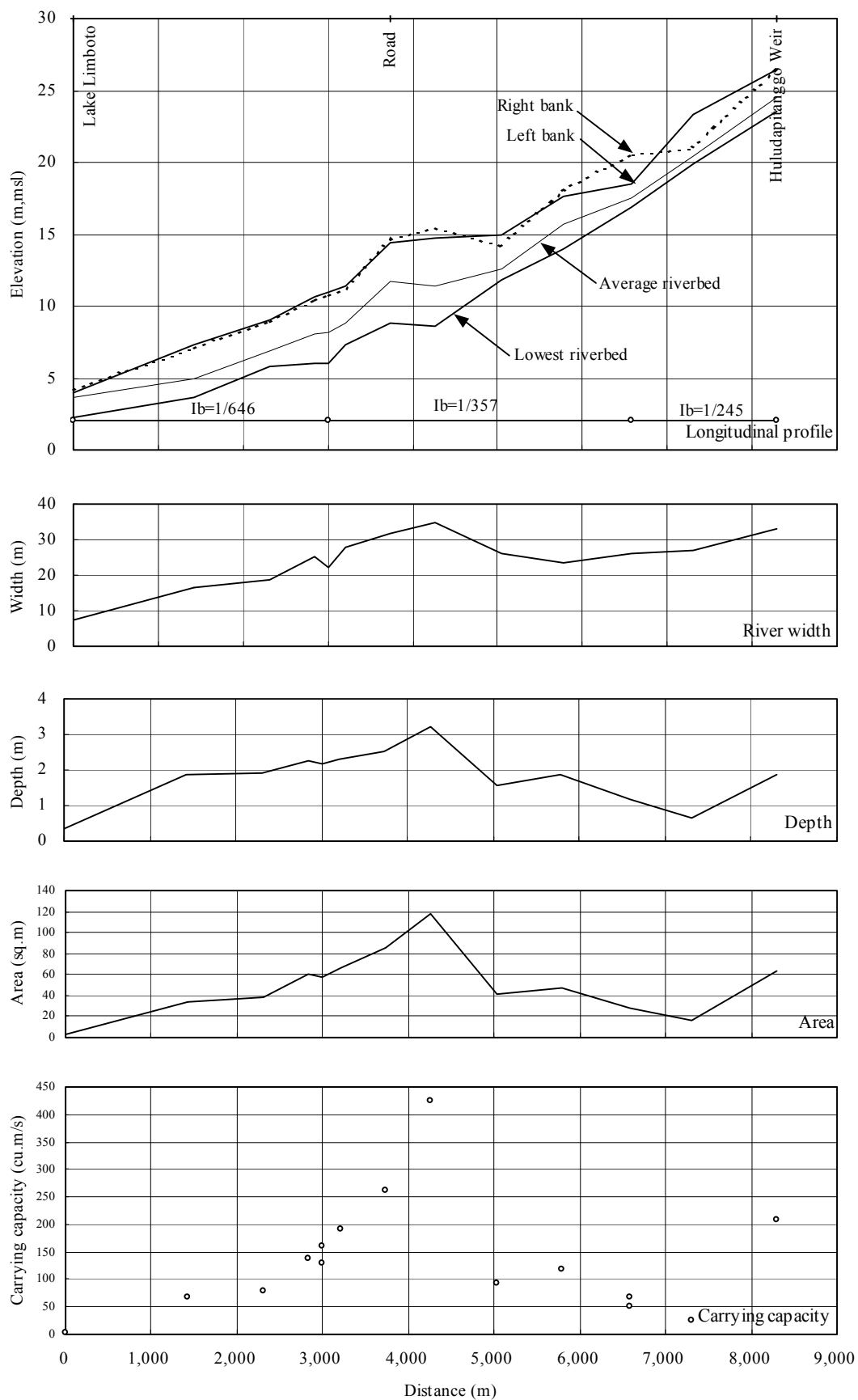
Figure A3.2.1

RIVER SYSTEM IN PLAIN AREA



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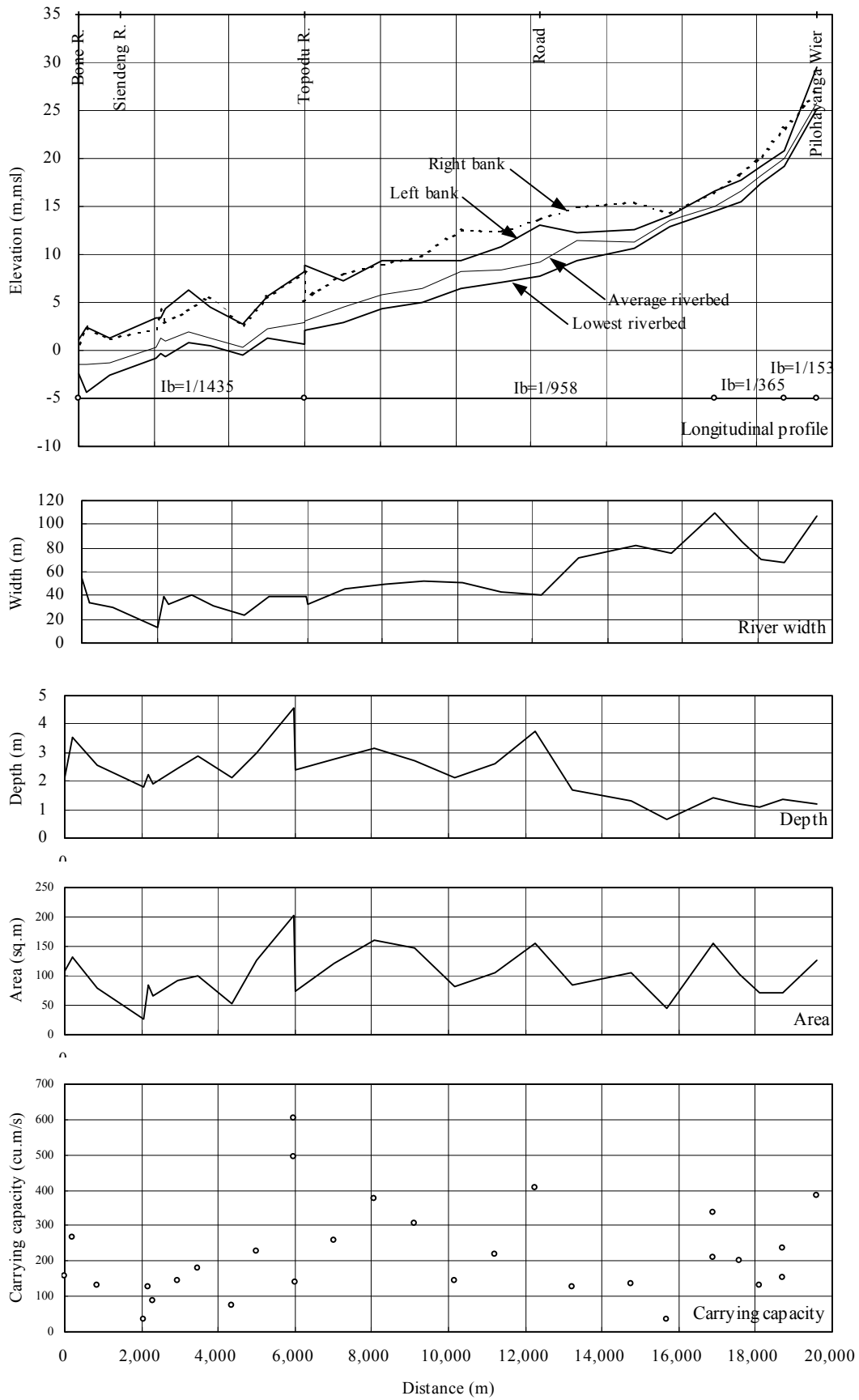
Figure A3.2.2
CHANNEL CHARACTERISTICS
(1/5 : ALOPOHU RIVER)



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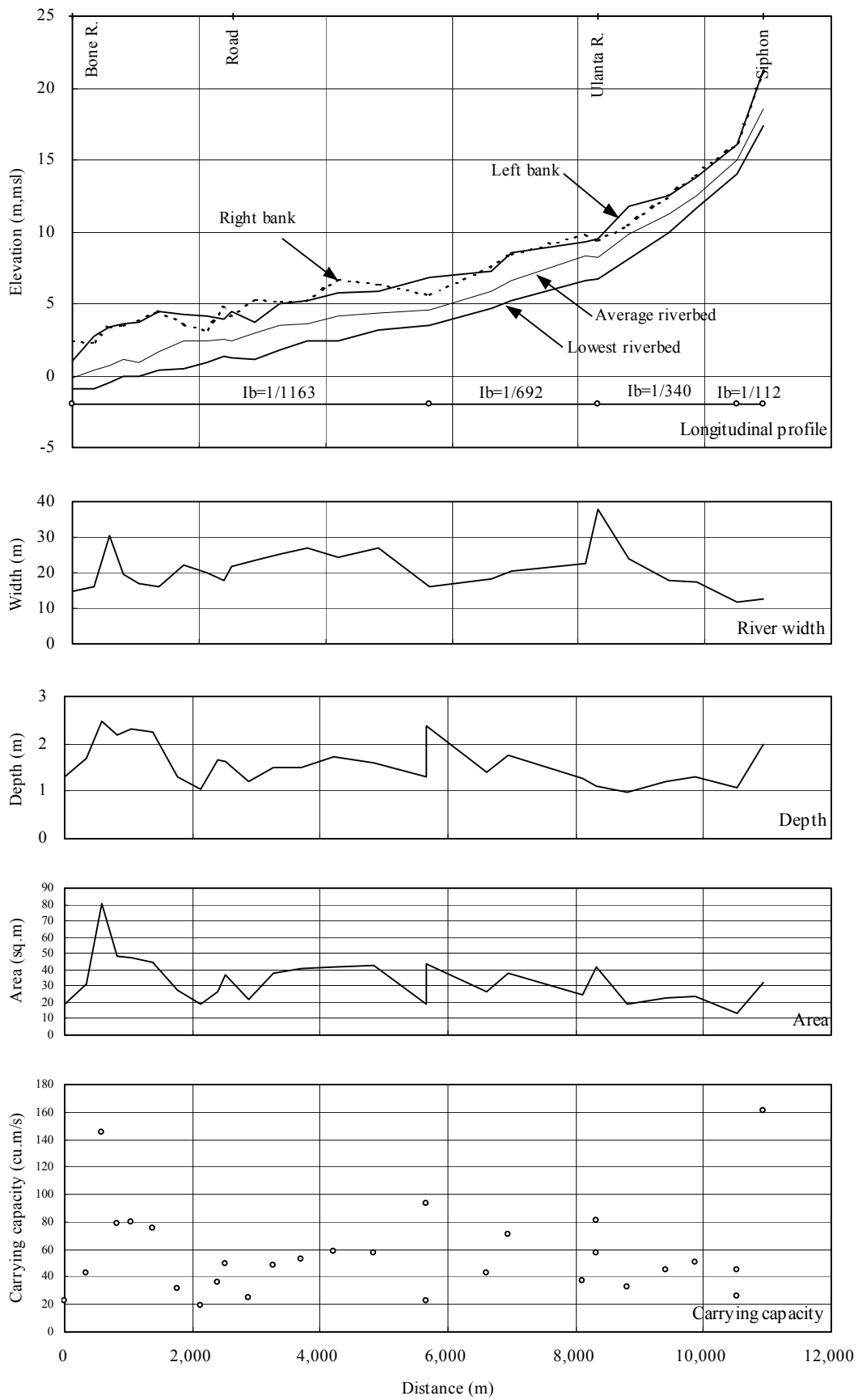
Figure A3.2.2
CHANNEL CHARACTERISTICS
(2/5 : BIYONGA RIVER)



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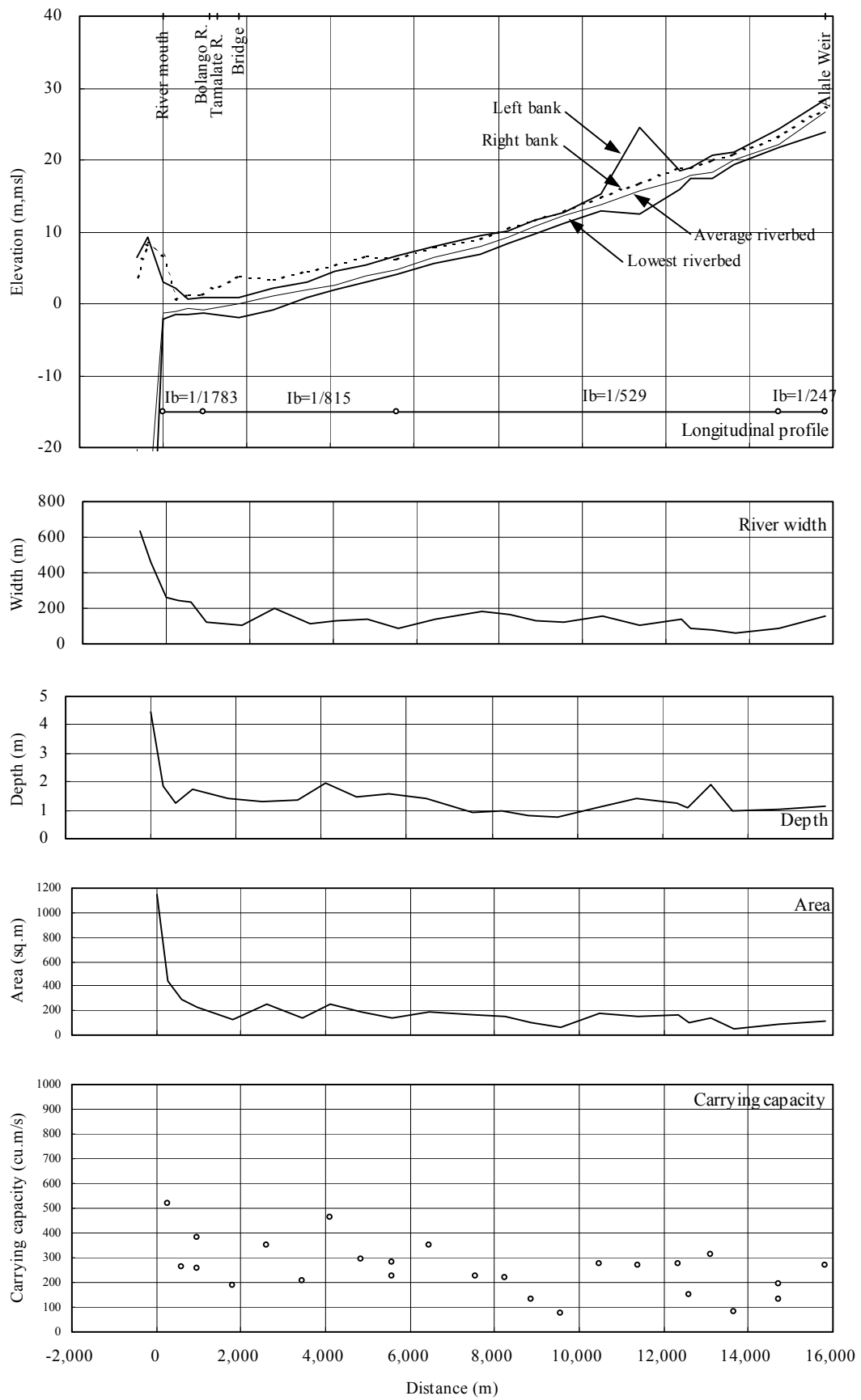
Figure A3.2.2
CHANNEL CHARACTERISTICS
(3/5 : BOLANGO RIVER)



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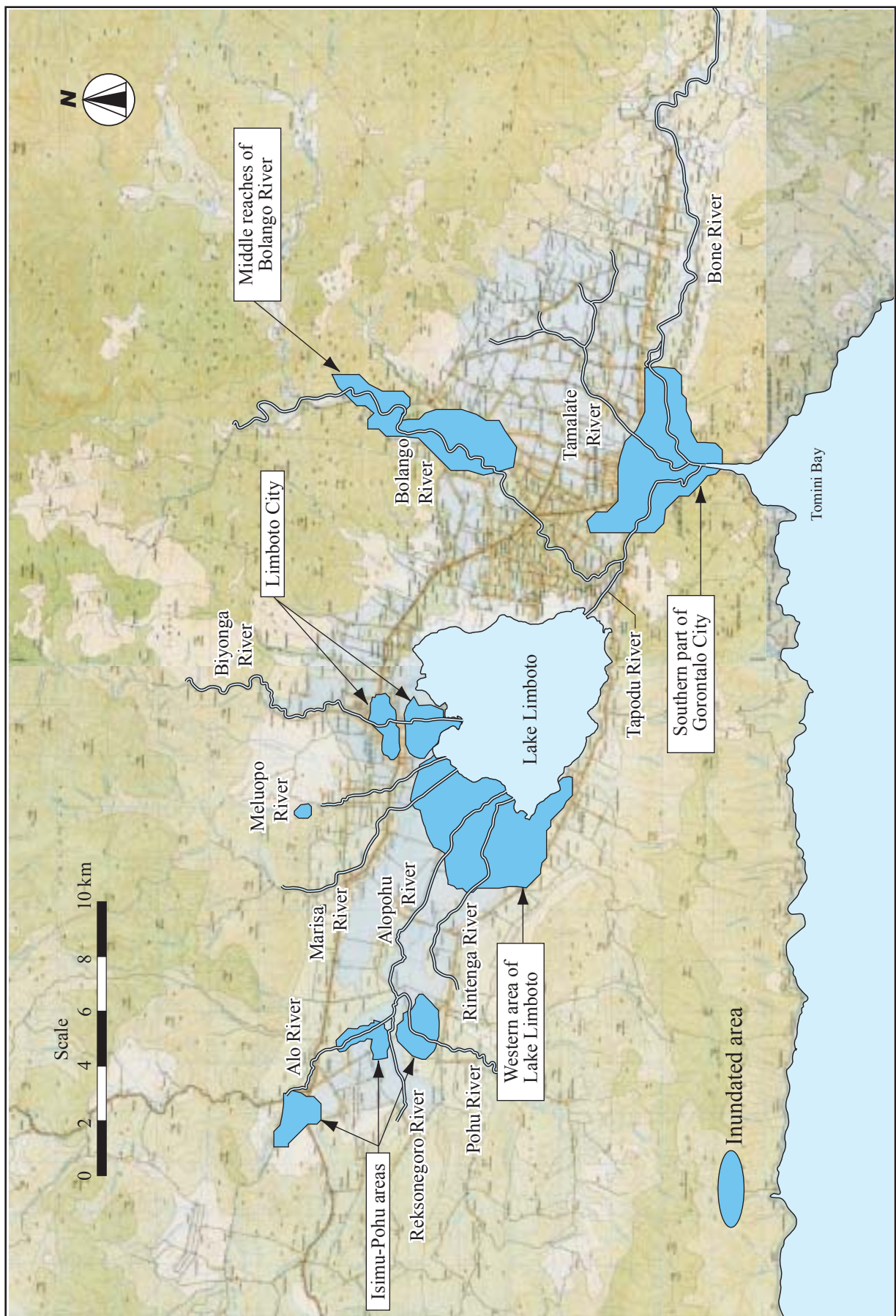
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Figure A3.2.2
CHANNEL CHARACTERISTICS
(4/5 : TAMALATE RIVER)



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Figure A3.2.2
CHANNEL CHARACTERISTICS
(5/5 : BONE RIVER)



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Figure A3.3.1
FREQUENTLY INUNDATED AREAS