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REPUBLIC OF INDONESIA
MINISTRY OF PUBLIC WORKS
DIRECTORATE GENERAL OF HOUSING BUILDING
PLANNING AND URBAN DEVELOPMENT (CIPTA KARYA)

MEDAN URBAN DEVELOPMENT HOUSING, WATER SUPPLY AND SANITATION PROJECT

44p

TECHNICAL MEMORANDUM NO. 36

SURFACE WATER HYDROLOGY

This a draft of Appendix B-1 of the Master Plan Report
for Water Supply and Sanitation

NOVEMBER 1979

ENGINEERING - SCIENCE, INC. • SINOTECH ENGINEERING CONSULTANTS, INC
A JOINT VENTURE
in association with
PADCO and P.T. DACREA

MEDAN URBAN DEVELOPMENT, HOUSING, WATER SUPPLY AND SANITATION PROJECT
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Our ref.: 79/1205/MUDS/313

10 November 1979

Director General Cipta Karya
Ministry of Public Works
Jalan Pattimura 20
Kebayoran Baru
Jakarta Selatan

Subject: Technical Memorandum No. 36, Surface Water Hydrology

Dear Sir:

Attached are 20 copies of the subject Technical Memorandum for your information and review. The material contained in this memorandum constitutes submission of Appendix B-1 of the draft Master Plan for Water Supply and Sanitation.

Yours faithfully,

ENGINEERING SCIENCE INC. MEDAN URBAN PROJECT INDONESIA

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Report No.	Title	Date Submitted
1.	Preliminary Site Selection Criteria for Perumnas Medan III, SSCH/LCH Project	March, 1979
2.	Work Plan for Water Supply and Sanitation Master Plans and Feasibility Studies	April, 1979
3.	Policy Issues for Project Guidance	March, 1979
4.	Drainage - Principal Rivers and Rainfall Analysis	May, 1979
5.	Preliminary Evaluation of Sunggal Water Treatment Plant	May, 1979
6.	Public Health Considerations	July, 1979
7.	The Present Drainage System	August, 1979
8.	Recommended Drilling Program	August, 1979
9.	Medan Household Income/Expenditures	August, 1979
10.	Existing Land Use in Medan	August, 1979
11.	The Regional Functions of Medan	August, 1979
12.	Existing Solid Wastes Systems and Projected Solid Wastes Characteristics	August, 1979
13.	Evaluation of Medan Master Plan	August, 1979
14.	Physical Constraints to Urbanization	August, 1979
15.	Development in Health Care in Medan	September, 1979
16.	Existing Water Supply Systems	September, 1979
17.	Developments in Education	October, 1979
18.	Existing Water Supply and Sanitation Systems	October, 1979
19.	Public Health and Environmental Aspects	October, 1979
20.	Alternative Solid Wastes Management Systems	October, 1979

LIST OF TECHNICAL MEMORANDA PREVIOUSLY SUBMITTED (CONTINUED)

Report No.	Title	Date Submitted
21	The Distributed Investment Strategy Plan (DISP)	October, 1979
22	Recommended Solid Wastes Management System	October, 1979
23	Recommended Drainage Management System	October, 1979
24	Alternative Water Supply Management Systems	November, 1979
25	Water, Wastewater, Stormwater and Solid Wastes Systems	November, 1979
26	Alternative Wastewater Management Systems	November, 1979
27	Design Criteria and Bases for Cost Estimates	November, 1979
28	Recommended Water Supply Management System	November, 1979
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30	Environmental Assessment	November, 1979
31	Finance	November, 1979
32	Groundwater Resources	November, 1979
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34	Sibolangit Springs	November, 1979
35	Distribution System Analysis	November, 1979

APPENDIX B-1

HYDROLOGY

B-1.1 RAINFALL CHARACTERISTICS

The equatorial location and low elevation of Medan(3°35' N, sea level to 50m) largely determines the tropical climate of the region. Although rainfall, temperatures and sunshine show some seasonal variation, these seasons are not as distinctly marked as in Java and many other parts of Asia. Two rainy periods occur during the fall and spring rather than during the more typical "monsoon" seasons which occurs over much of Asia. These rainy periods more closely resemble those in southern India, Sri Lanka, and Equatorial Africa.

Medan rainfall has been recorded since 1879 at three stations (different recording periods) and is summarized in several reports (US 6, 7, 8, 9, 13 and 14). These reports and monthly records for 935 months in an 83 year period have been summarized (Table B-1.1) to focus on the major storms which will affect drainage planning and on the major drought periods which govern water supply planning. During the period of record, annual rainfall has varied from 1352 to 2873 mm. The 10 and 90 percentile values are 1633 and 2388 mm, respectively. Fifty percent (25 to 75 percentile) of the annual rainfall records ranged from about 1810 to 2250 mm, and the average annual rainfall for 1901 to 1941 was about 2050 mm.

B-1.1.1 Rainy Seasons

Distribution of rainfall throughout the year shows two high rain months: October and May, although the longer rainy season extends from September to January. Of the 935 months of complete annual rainfall records, 80 percent of the months have rainfall between 60 and 300 mm, while about seven percent of the months have rainfalls from 300 to 400 mm with two percent (six months) greater than 400 mm per month (Table B-1.2). About 20 percent of the years of record had rainfalls during two consecutive months of more than 300 mm/mo or less than 60 mm/mo. Two percent of the years had rains of greater than 300 mm for three consecutive months while seven percent had less than 60 mm/mo for three or four months.

TABLE B-1.1

SUMMARY OF ANNUAL AND MONTHLY

RAINFALL RECORDS FOR MEDAN PUTRI,

1879 TO 1941 AND 1955 TO 1974

Annual Rainfall (mm)	Number of years	Percent
2800 - 2899	1	1
2700 - 2799	0	
2600 - 2699a	2	10
2500 - 2599	2	
2400	4	
2300 - 2399a	7	33
2200	11	
2100	10	
2000 - 2099	13	15
1900	6	
1800	8	31
1700	6	
1600	6	
1500	6	10
1400	0	
1300 - 1399	2	
Total	84 years	100

a- includes storm of record

Monthly Rainfall (mm)	Number of Months	Percent	
600 - 700	3	0.3	
500	3	0.3	7.9
400	0	0	
300	68	7.3	
200	760	81.3	81.3
100			
60			
20 - 60	87	9.3	10.8
0 - 20	14	1.5	
Total (Months of complete years)	935	100.0	100.0

REFERENCE - DPU - Hydrological Design Unit.

TABLE B-1.2

SEQUENTIAL MONTHS WITH HIGH OR LOW RAINFALL

	Wet (300 mm)		Dry (60 mm)		
	3 Months	2 Months	2 Months	3 Months	4 Months
Periods	IX-XI/1895 X-XII/1973	X-XI/1881 VIII-IX/1884 X-XI/1893 XI-XII/1903 XII/1916-I/1917 X-XI/1922 X-XI/1923 X-XI/1925 X-XI/1929 IX-X/1931 X-XI/1936 IX-X/1940 X-XI/1969 X-XI/1970	II-III/1884 III-IV/1901 II-III/1903 II-III/1906 II-III/1911 II-III/1919 I- II/1923 III-IV/1929 II-III/1931 VI-VII/1938 IV- V /1962 III-IV/1963 I -II/1965 II-III/1966 I- II/1968	I-III/1886 III-V/1891 II-IV/1926 I-III/1940 I-III/1976	I-IV/1885
Total Periods	2	14	15	5	1
Percent of Total Months	0.6	3.0	3.2	1.6	0.4
Percent years	2.6	19.0	19.0	6.4	1.3
Total Months	943 (78 x 12 months + 7 months)				

B-1.1.2 Storms

The three stations in Medan had three different days with 250 to 290 mm of rain in 24 hours. (Table B-1.3). Although these storms occurred in December or January, they occurred in widely different years, 1907, 1937, and 1956, and these storms coincide with high monthly rainfalls, but not with highest rainfall years. Such temporal distribution indicates that the storms were of limited areal extent and period and that rainfall quickly decreased beyond the intense centre of rain storm.

Comparisons of Medan with twelve other northern North Sumatran Stations (below 50 m elevation) show average annual rainfall varied from 1800 to 3177 mm. Monthly averages for daily maxima varied from 26 to 85 mm, while storms of record ranged from 112 to 309 mm/d during 10 to 20 year periods. Most records showed the storms of I/1931 and XI/1956 to have been the most widespread with limited local centres of very high rainfall.

The rainfall daily maxima for Sibolangit were 130 to 140 mm or similar to the secondary maxima in the more northern, lower stations. A 1931 daily maximum at Binjei and a 1956 maximum at Tanjung Pura indicate that some frontal storms could provide widespread heavy rains and locally very heavy rains.

B-1.1.3 Daily Rainfalls

Diurnal rainfall (US 14) shows a strong tendency towards afternoon and night rains and relatively dry morning periods. For a 15 year period, rainfall of more than 5 mm/hr during January to September generally occur between 1200 to 0100, while during the long rainy season rains would continue from 1200 or 1500 to 0600 the next morning (adding 50 percent to the total rain period). These records indicate that periods of 6 to 12 hours separate the rainy periods of each day and thereby allow runoff and drainage before the next days rains.

The same diurnal rain records (US 14) indicated that the higher hourly rainfalls of 16 to 30 mm most commonly occurred between 1800 and 2200 during March to September and between 2300 and 0100 during the rainy period of October to December. Maximum hourly rainfalls during January to March were below 15 mm.

TABLE B-1.3

STORMS OF RECORD

Refrence Station (US-8)	Date (Mo/yr)	24 Eours Rainfall (mm)		Long Term Rainfall (mm)	
		Highest	Second Highest	Monthly	Annual
Medan Putri	I/1931	205	104	686	2695
Medan	I/1931	262	133		
Polonia	XI/1956	285	151		2296
Medan Putri	XII/1907	253	-	684	2358

Note: Storms of Record did not occur during unusually high rainfall periods.

REFERENCE - DPU - Hydrological Design Unit.

B-1.1.4 Rainfall and Elevation

Rainfall records for 1879 to 1941 have been summarized (US 6) for 15 stations within the regional drainage basin of Medan. These records clearly indicated the increase of rainfall with elevation:

Average Annual Rain (mm)		Elevation (m)
1773-2036	Mabar	6 - 12
2065-2269	Medan	28 - 38
2298-3098	Two Rivers, Deli Tua	60 - 101
3127-3978	Petani	129 - 174
4520	Sibolangit	565
5279-6676	Bandar Baru	864 - 928

A comparison of monthly rainfall at Sibolangit and Medan (Table B-1.4) showed the same highest rainfall during October and May, but in Sibolangit, the rainy period extended from August through May with more than 250 mm of rain per month in a summer dry season.

TABLE B-1.4

SUMMARY OF MONTHLY RAINFALLS OF MEDAN AND OTHER STATIONS IN NORTHERN NORTH SUMATRA

Station		10 year Average Annual Rainfall (mm)	Monthly Average Daily Maxima (mm)	Daily Maxima (mm)	Date
126		2053	28-64	205	I/1931
127a		1872	28-74	262	I/1931
d		1944	26-77	173	XI/1956
e	Medan and	2237	40-74	264	IX/1960
f	Vicinity	1974	31-64	135	IX/1959
g		1960	36-76	208	XI/1956
h		1800	30-76	309	XI/1956
i		2174	38-85	285	XI/1956
Binjei		2561	29-81	177	I/1931
Tandem		2334	37-73	181	I/1931
Tanjung Pura		2097	26-64	112	XI/1956
Pangkalan Berandan		3177	38-72	184	VII/1955
Sibolangit (500m)		4078	52-87	141	III/1954

B-1.1.5 Dry Seasons

Two dry seasons occur in northern Sumatra between: (1) February and April; and (2) July and August. During these seasons, monthly rainfall decreases to less than 100 mm per month and often to about 60 mm. These two seasons of five months may produce only 20 to 30 percent of the annual rainfall. When the dry seasons monthly rains fall below 60 mm, drought conditions may be formed, and when more than one month of less than 60 mm/month rainfall occurs, the drought will intensify. Review of the monthly rainfall records for Medan (Table B-1.2) indicates the dates and relative frequency of droughts during the record of about 80 years. A total of 21 years (27%) had a period of two to four months with less than 60mm/month of rainfall, and about five percent of all months had less than 60 mm/month. The most recent drought of 1976 was reported by residents in many places in Medan who depend upon shallow groundwater wells which went dry.

B-1.2 SURFACE HYDROLOGY

B-1.2.1 Basin Form

Surface hydrology of the Medan area largely involves three major basins, the Belawan, Deli and Percut Rivers. As shown in Table B-1.5 and Figure B-1.1, the forms of these major basins are quite linear from south to north, while the smaller basins along the coast are much more triangular, as indicated by the length to area ratios. The three major rivers begin in the Barisan Range, 60-80 kilometers south of Medan. Gradients in the upper sub-basins vary from 8 to 18 percent in the hills, while gradients decrease to 2.0 to 2.2 percent between elevations of 50 to 600 metres, and then to 0.1 to 1.0 in the lower reaches of the major streams.

The Belawan River has its major channel along the eastern margin of its basin and collects runoff from a series of distinct branches rather than a more typical dendritic river basin form. The Percut basin is the narrowest of the three with small lower and middle sub-basins. However, the upper sub-basin expands and collects runoff with a more typically dendritic area in the highest rainfall zone (4,000 to 6,000 mm/yr). The Deli River has an intermediate basinal form with the main channel along

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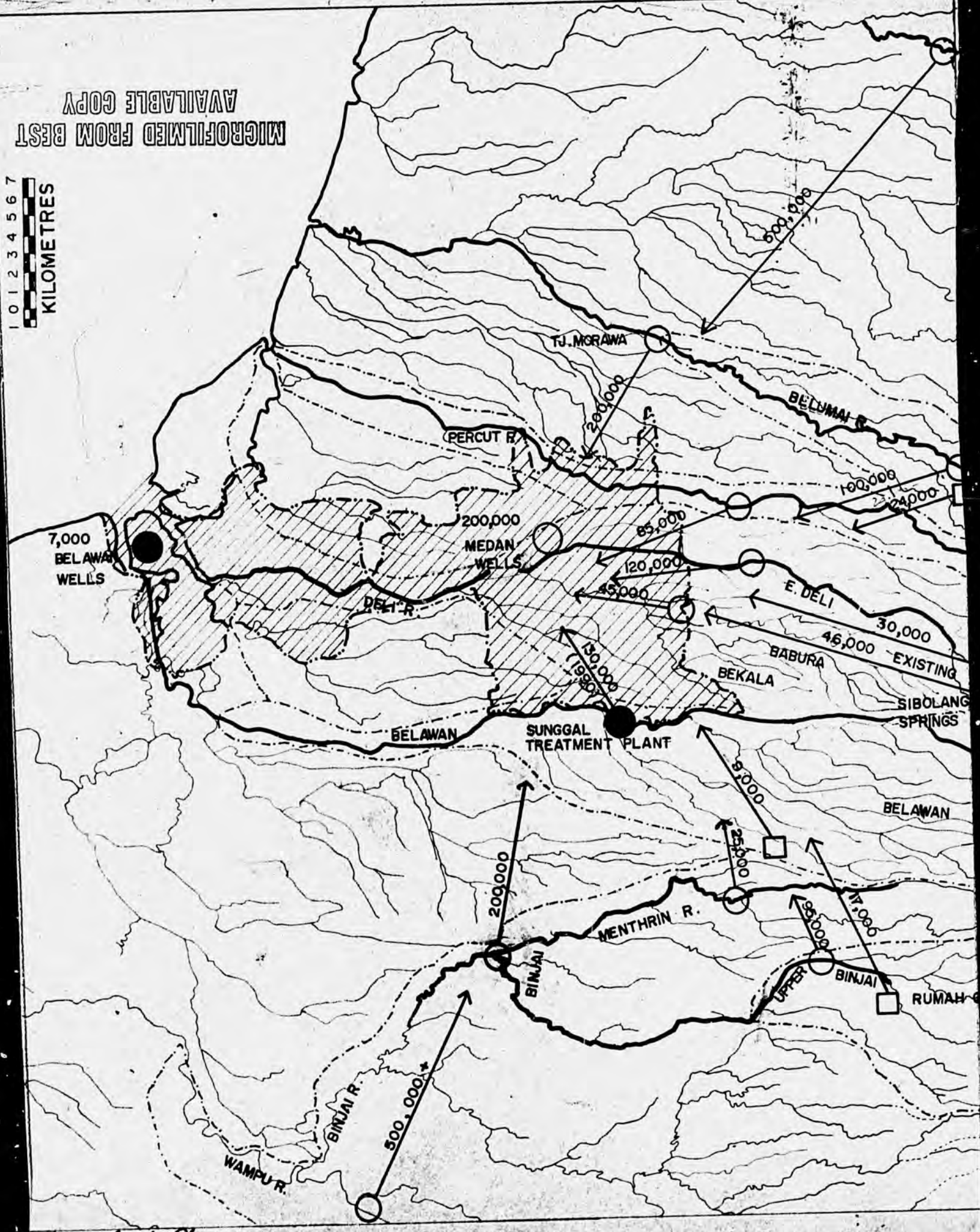

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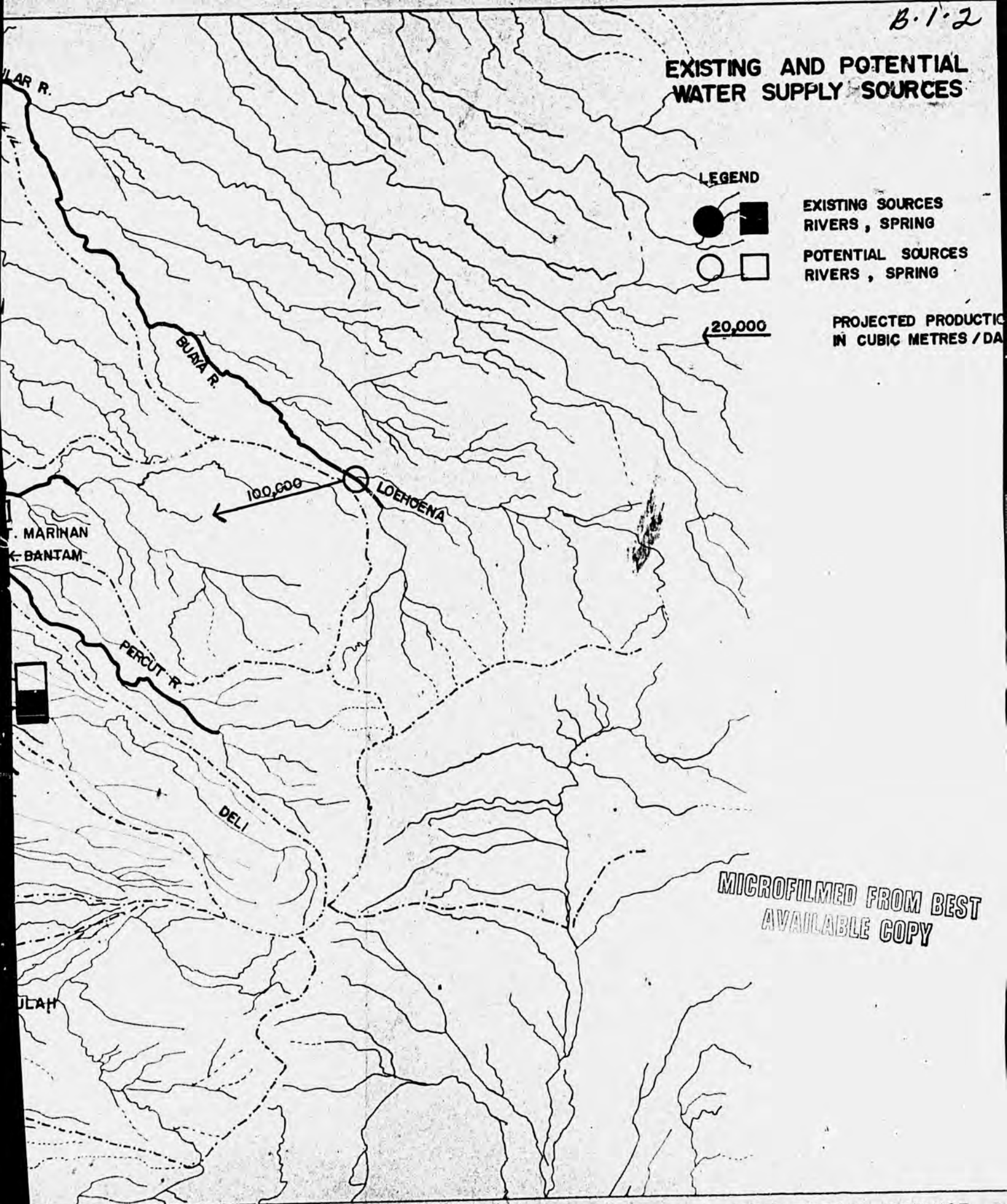
EXISTING AND POTENTIAL WATER SUPPLY SOURCES



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the eastern margin and with a major expansion in the middle and upper sub-basins. The altitudinal zonation of rainfall and the relative proportions of basins in the upper, middle, and lower segments should strongly influence both floods and low flows.

B-1.2.2 Basin Flows

Most major rivers in North Sumatra have been monitored for flows and river stages in order to plan for irrigation and flood protection. Most records, however, are for less than ten years, and many available records are for 1972-1979. River gages were located on only the Belawan and Deli rivers within the Medan study area as shown in Figure B-1.1 The Babura Branch of the Deli River and the Percut River have not been monitored for flows.

TABLE B-1.5

BASIN FORMS OF MAJOR MEDAN RIVERS

Basin	Total Area (km^2)	Length (km)	Area/ Length Ratio (km^2/km)	Gradients (percent)
Belawan	270	62	4.35	U 8.0 M 2.1 L 0.11-0.26
Deli (E and W)	395	68	5.81	U 16.0
E only	200	47	4.25	M 2.2 L 0.13-0.23
Percut	213	65	3.23	U 8.0
Upper	143	35	4.10	M 2.0 L 0.11-0.33

U : Upper segment between 600 and 1900 m

M : Middle segment between 50 and 600 m

L : Lower segment between sea level and 50 m

B-1.2.2.1 Belawan River

The Belawan River has been monitored by the Institute for Hydrological Investigation (Bandung) and DPU Medan for seven years ast Asam Kumbang. The gage was located about one kilometre above the Sunggal Water Plant and about six kilometres from the Medan city centre (Figure B-1.1.). Available flow measurements include three years of average daily flows and 52 instantaneous discharges periodically taken over seven years. An additional gage has been located downstream to near the mouth of the Belawan River, 25 km north of the old gage site and Sunggal Plant.

The Belawan River gage and that on the Deli River were relocated dewanstream because of unstable and highly variable cross-sections at the gage sites. Such variable sections and their influences upon the accuracy of the flow measurements are generally more important to high flood flows than to low flows. Unfortunately, no direct means are available to verify or modify the low flows recorded at the gage sites. Therefore, these previous data cannot be used for design purposes.

Similarities of yield rates (averaged low flows distributed over the total catchment area of the gage) can be seen from catchments above the Belawan, Deli, Binjei, Belumai, and Ular River gages (see individual river discussions). Yield rates for one percent recurrent flows vary from about 700 to 1,000 $m^3.d/km^2$. Such similarities support use of the low flows for this master planning study a general guide for surface water development.

Short-term records have been reviewed and generalized projections were made for low flows in the Belawan and Deli rivers (see Report Section 6.2.2.1 and Figure 6.5 and Table B-1.6). During the three years of averaged daily flows, lowest flows for each month varied from 2.5 to 14.3 m^3/s and for each year was from 2.5 to 4.7 m^3/s (Table B-1.6). Lowest periodic discharge measurements in each year (total measurements: 52, 1971-1979) varied from the 1.7 to 6.5 m^3/s (147,000 to 562,000 m^3/d). About 10 percent of all averaged daily flows in three years and the periodic discharges in eight years were less than 5.0 m^3/s or 430,000 m^3/d, while 20 percent were less than 6.0 m^3/s or 520,000 m^3/d.

TABLE B-1.6

LOWEST DAILY FLOWS FROM MONTHLY RECORDS
AND LOWEST MEASURED DISCHARGES OF ANNUAL RECORDS NEAR MEDAN

Stations		Year							
		1972	1973	1974	1975	1976	1977	1978	1979
	Monthly								
Belawan River	O.R.	3.9 - 9.4	2.5 - 14.2	4.7 - 10.7	-	-	-	-	-
	Mean	6.1	6.6	6.2	-	-	-	-	-
Periodic Discharge (Asam Kumbang)*		4.5	5.2	6.5	4.0	4.0	1.7	4.5	3.1
	Monthly								
Deli River	O.R.	2.4 - 6.8	4.8 - 9.0	-	-	-	-	-	-
	Mean	6.0	6.3	-	-	-	-	-	-
Periodic Discharge (Simeme)*		5.7	5.7	5.0	3.8	4.0	2.6	4.8	3.8
	Monthly								
Belumai River	O.R.	5.8 - 12.7	5.9 - 19.6	6.3 - 13.9	4.8 - 9.9	5.3 - 9.3	-	-	-
	Mean	7.5	8.4	8.9	7.1	7.0	-	-	-
Periodic Discharge (Tanjung Morawa)		5.9	7.1	8.3	5.2	5.5	4.0	6.4	4.3
	Monthly								
Ular River	O.R.	27 - 52	35 - 54	39 - 51	34 - 47	36 - 60	37 - 48	-	-
Periodic Discharge (Pulau Tagor)		26.8	35.0	38.6	33.5	36	36.5	33.6	32.7

* Records from 1971-1977 were taken at locations about 200 m a way from site for 1978 and 1877 recording.

Low flows at long-term recurrence intervals were projected using log-probability paper (see Report Figure 6.5) for periodically recorded discharges (see Report Section 6.2.2.1b). Low flows were plotted and projections extended to the one and five intervals. Projected low flows were about 215,000 m^3/d for the one percent recurrence and 250,000 m^3/d for the five percent recurrence. Such flows or less would be expected to occur one percent and five percent of the years over a very long period (or one year and five years out of 100 years would have such a flow). This flow or higher would be expected 99 and 95 percent of the years over a long period.

As indicated in the Report Figure 6.5, the lowest recorded flow at the Asam Kumbang gage reached a low flow of 1.7 m^3/s or 147,000 m^3/d. This flow would have been expected to have occurred only once in 200 years and its occurrence in the short monitoring period would indicate an even lower projection for low flows (i.e. about 90,000 and 140,000 m^3/d) than that projected from the other flow measurements. Differences between the projection for other values and this extreme value clearly supports the use of the existing flow measurements only as a guide to general planning and the need for immediate and long-term monitoring of the rivers which can supply Medan. Slopes of projected flow lines for all other rivers appear to be quite similar and resemble the line projected for all Belawan values.

The catchment yields for the one percent low flow would be about 885 $m^3.d/km^2$ for the sub-basins of 240 km^2 above Asam Kumbang gage and the Sunggal Plant. This includes general seepage from the surficial groundwater table, a flow of 8,600 m^3/d from the Tuntungan Springs, and runoff from minor rainfall (less than 20 $m^3.d/km^2$ and 60 mm/month). Excluding the spring flow, the net average yield would be about 850 $m^3.d/km^2$.

B-1.2.2.2 Deli River

The Deli River has been monitored by the Institute for Hydrological Investigation (Bandung) and DPU (Medan) for nine years at Simeme, about 3.0 km above Deli Tua and about 13 km south of Medan city centre. The stream gage was located on the main channel of the Deli River and did not

receive flows from the Babura River tributary branch. The gage location has been given as near the bridge across the Deli River and downstream from the confluence of the Petani and Saimaimai branches. The reported catchment area for the gage was given as 133 km^2. Such a total reported catchment area would be less than the total area of the two branches measured on 1:250,000 scale maps: 133 km^2 rather than 164 km^2. The flow measurements will remain the same, but the areal yield from the catchment would be 30 percent smaller than that of the smaller reported catchment (800 $m^3/km^2.d$ rather than 1,000 $m^3/km^2.d$).

Flow measurements included three years of average daily flows and 67 instantaneous measurements periodically taken over seven years. Discharge recordings of 1971-1979 have been considered as unreliable because of unstable and highly variable stream cross-sections, and the gage location was relocated to more stable sections and a second station has been placed near the mouth of the Deli River and the Port of Belawan. If these recordings represent the only available data for potential surface water sources on the Deli River, however, as indicated in similar discussions of the Belawan River gage, the unstable cross-section may have influecned accurate recording of high flows more than low flows. Similarities between the basinal yield of several river basins in northern North Sumatra support the use of these recordings for general water resources planning, although design of final plant production and facilities must be based upon more accurate and long-term monitoring of the Deli River near Deli Tua.

Periodic flow discharge measurements were analysed for low flow projections. As indicated in Table B-1.6 and Report Section 6.2.2.1, lowest measured annual discharges varied from 2.6 to 5.7 m^3 (225,000 to 490,000 m^3/d), while the lowest averaged daily flows of each month for 1972 and 1973 varied from 2.4 to 9.0 m^3/s (210,000 to 780,000 m^3/d). Projected low flow of 175,000 and 215,000 m^3/d for the catchment above the Simeme gage are presented in Report Figure 6.5. One and five percent recurrent flows are similar to but less than those of the Belawan River gage. Projected one and five percent low flows are less than those recorded during the seven year period, and thereby the projections are consistent with available recordings.

Gross areal yields for the Deli gage catchment would be about 1,070 $m^3/km^2.d$ for a one percent recurrence. The Sibolangit Springs have a total flow of about 76,000 m^3/d of which about 45,000 m^3/d is collected by Tirtanadi. The remaining 31,000 m^3/d flows into the upper Deli River and is included in the downstream flow near Deli Tua. Excluding the spring flow, the net yield from the 164 km^2 catchment would be about 880 $m^3/km^2.d$. The yield rate is similar to those of the Belawan and Belumai catchments, which also have similar forms and elevational distributions.

B-1.2.2.3 Babura Branch - Deli

The Babura Branch forms a major sub-basin of the Deli River which joins the Deli River in Medan. This tributary sub-basin has not been gaged for stream flows and therefore no accurate projections of water supply potential can be made. Visual inspection of the stream indicate that it may prove to be a modest source of water supply, and estimates of possible flows are made by extrapolations from adjoining basins. Such estimates cannot be taken as adequate for design studies and must be verified or modified based upon accurate gaging of flows in relatable locations.

Estimated low flows for the Deli and Belawan gages were 175,000 to 215,000 m^3/d with an estimated net yield from their catchments of between 800 and 900 $m^3/km^2.d$. As indicated in Table B-1.7, a conservative yield of 700 $m^3/km^2.d$ would produce a flow of 75,000 m^3/d or less once in 100 years (one-percent recurrence) and about 130,000 m^3/d in five year out of every 100 years at the confluence of the Babura and main Deli River. Other sub-basins and reaches of the main Deli River are expected to have smaller yields and would add little to the overall low flow of the Deli River. The estimated flows of the Babura indicate that it is the only important water source downstream of Deli Tua, although it should be considered as a supplemental source rather than an independent source.

TABLE B-1,7

ESTIMATED LOW FLOWS AND YIELDS FOR THE DELI AND PERCUT BASINS

	Area (km^2)	Estimated 1% Areal Yield Rate ($m^3/km^2.d$)	Sub Basinal 1% Low Flow (x 1,000 m^3/d)	Accumulative Basinal Low Flow (x 1,000 m^3/d)
DELI				
Petani	133	1110	149	149
Saimaimai	31	805	26	175
Deli Tua-Medan	19	700	13	188
Batuan	24	700	17	205
Babura	106	700	75	280
Sikambing	36	500	18	298
Medan-Belawan	45	500	23	321
Total	394	905 (Averaged)	317	321
PERCUT				
F	37	1,000	37,000	37,000
E	24	1,000	24,000	61,000
D	17	1,000	17,000	78,000
C	25	1,000	25,000	103,000
B	21	700	15,000	118,000
A2	49	700	34,000	152,000
A1	41	700	29,000	181,000
Total	214	850 (Averaged)	181,000	181,000

1 Includes spring flows from Sibolangit.

B-1.2.2.4 Percut River

Flows of the Percut River have not been measured and only general estimates can be made from the calculated flows and yields from the nearby Belawan, Deli, and Belumai basins. The basinal yields vary from a low of about 700 to a high of 1,000 $m^3/km^2.d$. As indicated in Table B-1.7, the long, north-south basin is divided into two groups with different yield rates: 700 $m^3/km^2.d$ for the lower sub-basins and 1,000 $m^3/km^2.d$. The yields from the Ular, Binjei, and Wampu are higher than 1,000 $m^3/km^2.d$, while those of the Deli, Belawan, and Belumai are less than 1,000 $m^3/km^2.d$ after excluding known springs. No significant spring has been recorded from the Percut River basin.

The total basinal flow for the Percut River would be 181,000 m^3/d for a one-percent recurrent flow and about 265,000 m^3/d for a five-percent recurrent flow (assuming the same ratio as in the Deli flows: 1.47). Sub-basins of the Percut River above Deli Tua - have an area of about 173 km^2 and would produce about 150,000 m^3/d and 220,000 m^3/d at one and five percent recurrent flows, respectively (see Report Table 6.4).

Units of the Deli and Percut basins are sub-basins and major segments of the main channel of the Deli and Percut rivers from the basin divide down to the Straits of Malaka. No standard terms are available for the Percut sub-basins and they are given letter designations. These sub-basins are also discussed in Report Section 3.1.

B-1.2.2.5 Western Region - Binjei River

The Binjei River is the eastern most tributary or sub-basin of the Wampu River on the north side of the Barisan Range, and its upper sub-basins are adjacent to the Belawan and Deli sub-basins. The Diski basin separates the middle and lower sub-basins of the Binjei and Belawan rivers. Stream flows on two branches of the upper Binjei River were monitored in 1977, 1978, and 1979 at Namu Ukur and Namu Sira Sira, 30 km upstream of Binjei (Figure B-1.1). The recorded low discharges at Namu Ukur range from 10.2 - 14.3 m^3/s *880,000 to 1.2 million m^3/d), while the projected one percent low flow would be about 6.5 m^3/s (562,000 m^3/d) and

the five percent low flow would be about 8.0 m^3/s (690,000 m^3/d) (See Figure B-1.2 and Table B-1.8). Low flow of Namu Ukur catchment would require yields of 2,130 to 2,610 $m^3/km^2.d$, respectively. Such high yields are more twice those of the Wampu, Belawan, Deli, and Belumei rivers but are similar to those of the Ular River. Extrapolation of the yield of 2,100 $m^3/km^2.d$ over the entire Binjei basin above Binjei would indicate a one percent low flow of about 817,000 m^3/d at Binjei.

B-1.2.2.6 Western Region - Wampu River

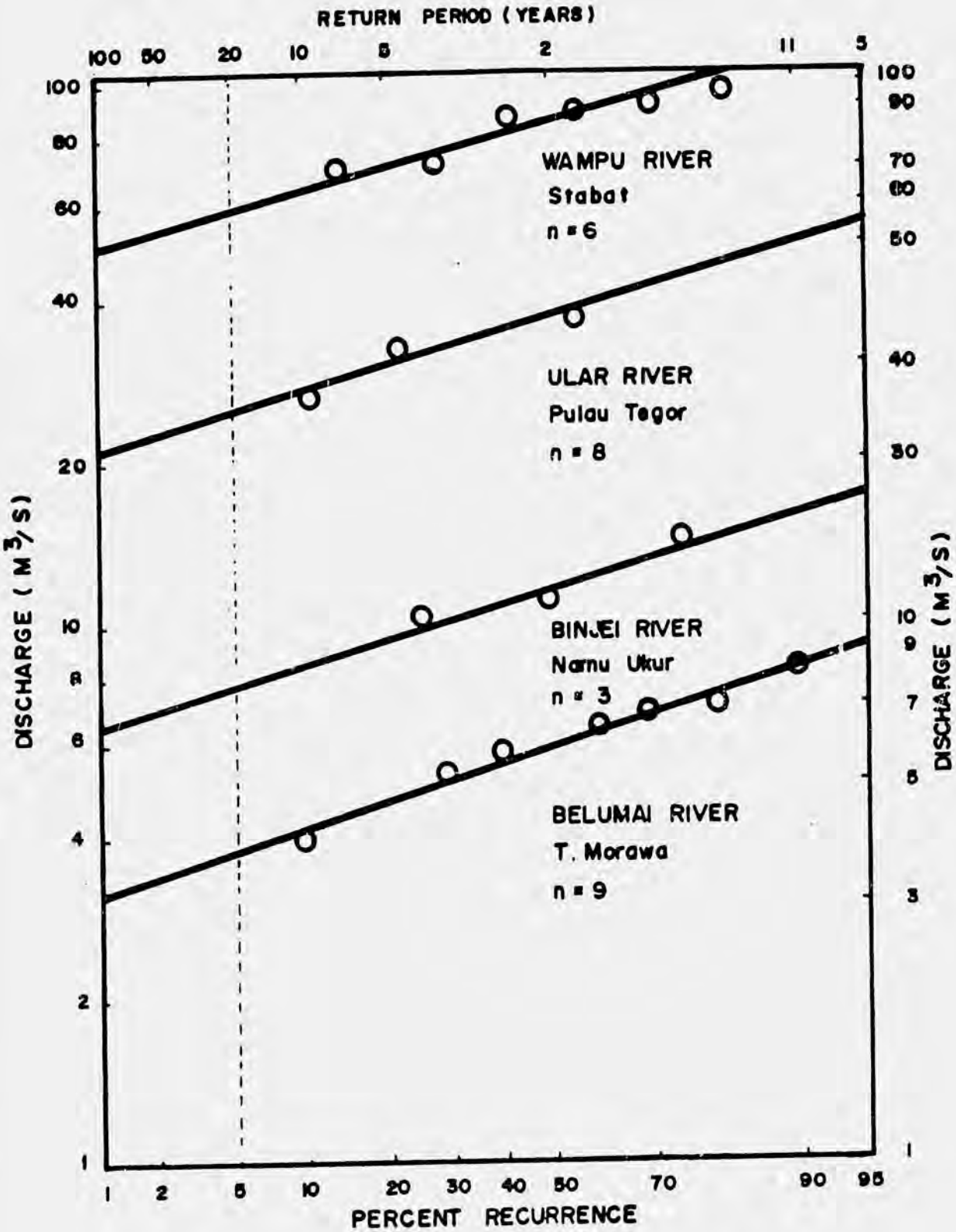
The largest and longest river in northern North Sumatra is the Wampu River which lies about 30 km west of Medan. The river begins on the west side of the Barisan Range, passes through the range, and flows north between Binjei and Tanjung Pura, where it flows into the Straits of Malaka (See Figure B-1.1 and Report Figure 1.1). The river has been gaged at Stabat about 25 km northwest of Binjei. As indicated in Table B-1.8 and Figure B-1.2, the Wampu River has had very large low flows of 70 to 100 m^3/s, or daily flows of six to nine million cubic metres. This is more than 10 times the projected low flows of the Deli and Belawan rivers. Projected low flows of Wampu River would be about 50 m^3/s or 4.3 million m^3/d for one percent recurrent flows and about 6.2 million m^3/d for five percent recurrent flows.

The reported area of the gage catchment is 1,621 km^2, although measured areas for maps of 1:250,000 scale indicates a total catchment of about 4,000 km^2. The basinal yield for a one percent recurrent flow from the smaller basin would be about 2,700 $m^3/km^2.d$, twice that of the Deli and four times that of the Belawan. Using the larger basinal area, the yield falls to about 1,100 $m^3.d/km^2$. More than 20 springs lie within the upper Wampu basin but contribute less than 125,000 m^3/d to the river flow (less than five percent of the estimated low flows). A net yield with the larger basin would be about 1,030 $m^3.d/km^2$.

B-1.2.2.7 Eastern Region - Belumai River

Flows in the Belumai River have been measured during 1971 to 1979 near Tanjung Morawa at the Morawa - Medan Road Bridge. The lowest recorded

FIGURE B-1.2



FREQUENCY–DISCHARGE FOR LOW FLOWS
ON NORTH SUMATRAN RIVERS

TABLE B-1.8

LOW FLOWS RECORDED IN NORTH SUMATRAN RIVERS

WESTERN REGION

Binjei River : Gage-Namu Ukur, Catchment Area - 264 km^2

Lowest Recorded Flows-1977: 14.3 m^3/s
1978: 10.2 m^3/s
1979: 11.3 m^3/s

Projected One Percent Low Flow : 6.5 m^3/s; 562,000 m^3/d

Projected One Percent Yield Rate : 2,130 $m^3/km^2.d$

Wampu River : Gage-Stabat, Catchment Area-1,621 km^2 (actual 4005 km^2)

Lowest Recorded Flows - 1973, 95 m^3/s
1974,100 m^3/s
1975, 90 m^3/s
1976, 87 m^3/s
1977, 72 m^3/s
1978, 70 m^3/s

Projected One Percent Low Flow: 50 m^3/s;4.3 million m^3/d

Projected One Percent Yield Rate* : 2,665 $m^3/km^2.d$
(1080 $m^3/km^2.d$)

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* All projected yield rate are gross and include flows from springs

TABLE B-1.8 (CONTINUED)

EASTERN REGION

Belumai River : Gage-Tanjung Morawa, Catchment Area - 250 km

Lowest Recorded Flows-1971, 5.8 m^3/s
1972, 6.9 m^3/s
1973, 7.1 m^3/s
1974, 8.3 m^3/s
1975, 5.2 m^3/s
1976, 5.5 m^3/s
1977, 4.0 m^3/s
1978, 6.4 m^3/s
1979, 4.3 m^3/s

Projected One Percent Low Flows: 3.2 m^3/s; 276,000 m^3/d

Projected One Percent Yield Rate: 1,100 $m^3/km^2.d$

Ular River : Gage-Pulau Tagor, Catchment Area - 1,031 km^2

Lowest Recorded Flows-1972, 26.8 m^3/s
1973, 35.0 m^3/s
1974, 38.6 m^3/s
1975, 33.5 m^3/s
1976, 36.0 m^3/s
1977, 36.5 m^3/s
1978, 33.6 m^3/s
1979, 32.7 m^3/s

Projected One Percent Low Flow: 2.3 m^3/s; 2.0 million m^3/d

Projected One Percent Yield Rate: 1,930 $m^3/km^2.d$

flows of periodical discharges for 1971 to 1979 varied from 4.8 - 6.3 m^3/s (415-544,000 m3/d; (Table B-1.8,Figure B-1.2). The projected one percent recurrence would have a flow of about 3.2 m^3/s or 276,000 m^3/d (about 320,000 m^3/d for a five percent flow) or about 50 percent greater than those flows projected at the Deli and Belawan rivers gages.

The catchment area for the Belumai gage (250 km^2) is only slightly greater than that of the Belawan gage and about twice that of the Deli gage,the gross yield of the middle and upper sub-basins of the Belumai River is about 1.100 $m^3/km^2.d$ and is similar to or higher than the net yields of the Petani-Deli subbasin and the Belawan catchment above the Sunggal Water Plant. The springs at Tanjung Marihan and Kampung Bantan have combined flows of about 24,000 m3/d or about 13 percent of the projected one percent low flow at Morawa. Excluding this spring flow, the net yield rate would be about 660 m3.d/km2, 10 percent less than those for the catchments of the Deli and Belawan river gages.

Eastern Region-Ular River. Flows have been measured for more than five years in the Ular River at Pulau Tagor, about 25 km east of Medan and 18 km east of Morawa. This gage has a catchment of about 1,000 km2, about four to five times greater those of the Belawan, Deli, Binjei,and Belumai gages and one-quarter of that of the Wampu gage (Table B-1.8, Figure B-1.1). The lowest recorded discharge in six years was about 2.3 million m3/d, about 5 to 10 times those of the Belumai gages but one -third of the low flows at the Wampu gages. Projected flows at one and five percent reccurrence intervals (Figure B-1.2) would be about 2.0 and 2.25 million m3/d,respectively. The yield rates for the catchment are about 1,900 and 2,200 m3.d/km2 for one and five percent recurrent events. The one percent yield rate is quite similar to the grosss rate above the Binjei gage and two to three times greater than the net rates above the Belawan, Deli, Wampu and Belumai gages. Some springs may contribute to the higher yields for the Ular catchment above Pulau Tagor.

B-1.3 POTENTIAL SUPPLY SYSTEMS

Within 30 km of Medan, seven major rivers can supply Medan with water. Analyses of the available flow measurements indicate that these

rivers in various combinations or even as separate sources can supply the projected average daily demand of 450,000 m^3/d in the year 2000 (maximum day demand: 530,000 m3/d). Using the estimated flows of the various rivers, topographic data,and structure of the basins,potential treatment plant sites and development strategies have been formed. These strategies also reflect the poor data base for planning.

Surface water development strategies are divided into local and regional systems,although regional strategies could supplement or dominate the development of local sources. Both regional and local strategies depend upon single new treatment plants with some later diversions and inter-basinal transfers. Development of each plant would coordinate increases of plant capacity with a thorough and rigorous monitoring program. As local basin flows constrain further plant development, previous monitoring of adjacent, supplemental basins will have been conducted over the longest period of time. Since direct withdrawals will be used first, longer term monitoring will also allow rigorous evaluation of surface reservoirs.

All surface water development has assumed similar water quality in the raw water taken from the river above urban centers. No treatment plant has been considered below an urban center, because of the assumed drainage of hoghly polluted water from Medan, Deli Tua, Binjai, and Tanjung Morawa. Such pollutants would be even more severe degradation of raw water during the low flow conditions in the rivers.

B-1.3.1 Belawan River

The Sunggal Water Plant was assumed to be the only possible surface water source on the Belawan River. The only other potential site would be at Lalang on the Binjai Road, about 3.0 km downstream of the existing plant. The Lalang site receives flow from an additional 30 km^2 and would add about 21,000 m^3/d to the projected low flow of 215,000 m^3/d at the Sunggal Plant. This more northerly site would receive more drainage from the urban corridor along the Binjei Road and intensive irrigation projects (e.g. Medan Karo) between the Sunggal Plant and the Lalang site.

The planned Sunggal production of 130,000 will require about 60 percent of the projected one percent recurrent low flows. The other local

rivers, Babura, Deli, and Percut cannot provide significant inter-basinal transfers to increase the low flows and reduce the percentage of raw water/low flow intake at the Sunggal Plant. In general, most of the Deli and Percut sub-basins lie below the closest points on the Belawan River. High ridges separate the uppermost Belawan basin from the Sibolangit reaches of the Deli River and could not be penetrated or spanned in any reasonable manner.

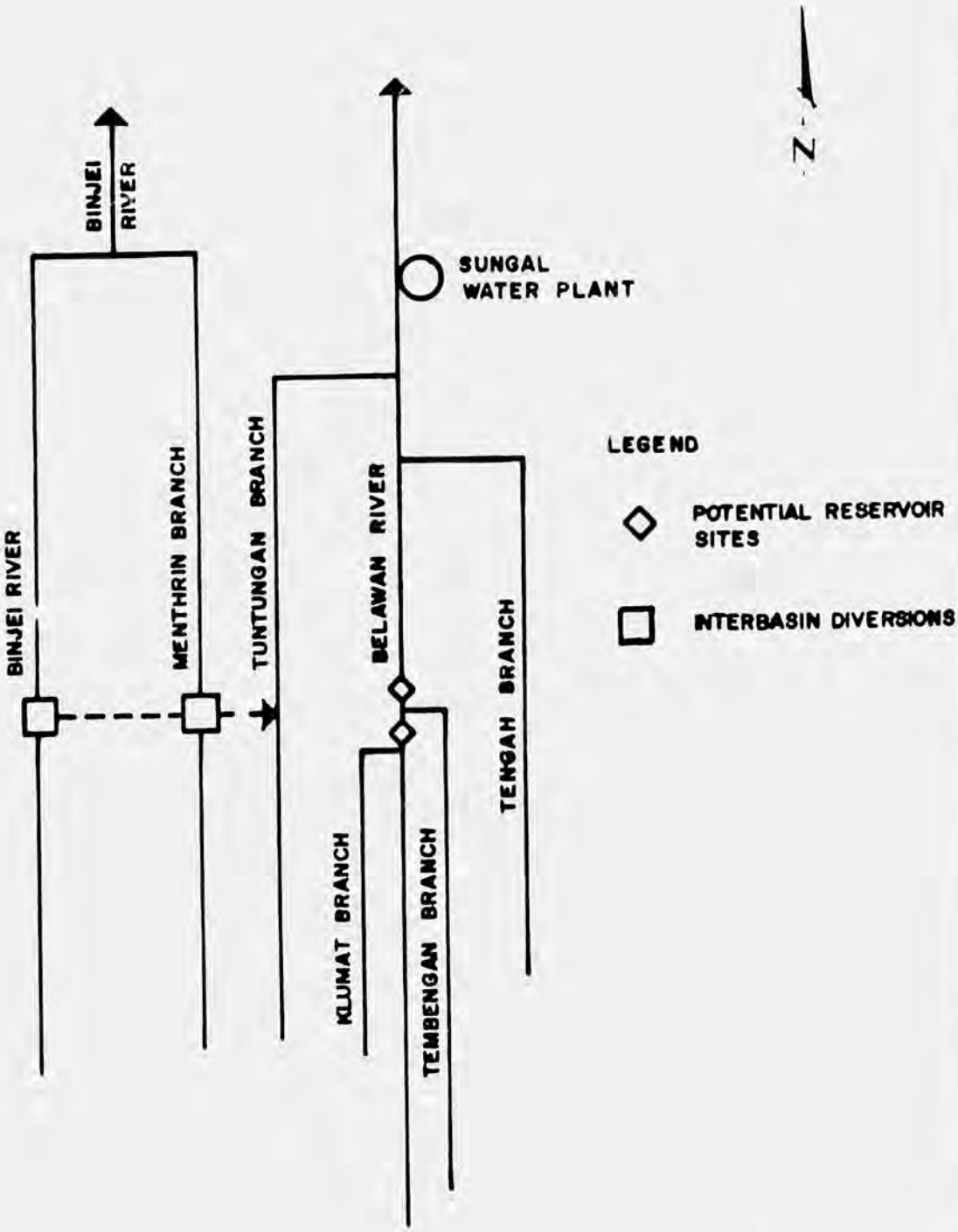
Available topographical maps are insufficient to locate potential surface reservoir sutes. Some general considerations indicate that relatively small reservoirs could be practical means to increase the production of the Sunggal Plant or reduce the percentage of low flows taken from the river by the plant. Potential sites (Figure B-1.3) may be located along the main channel of the Belawan River about 20 km above the Sunggal Plant but downstream of the Klumat or Tembengan branches.

As indicated in the discussions of regionak strategies, the upper sub-basins of the Binjei River could be diverted from the Menthrin branch (Binjei) and the main Binjei River into the Tuntungan branch of the Belawan River. Estimates of yields of 1,800 $m^3.d/km^2$ could allow 100,000 to 200,000 m^3/d production to be transferred from the Binjei subbasins to the Belawan River. More detailed topographical maps and aerial photos must be made in order to accurately locate, evaluate, and compare reservoirs or gravity flow inter-basinal transfers. While the need for such supplements to the planned production capasity of the Sunggal Plant depend upon evaluation of long-term monitoring of river flows at the Sunggal Plant.

B-1.3.2 Deli and Percut Rivers.

Costs of two separate water plants on the Deli and Percut rivers may be higher than a single plant with inter-basinal transfers. A single plant has been assumed to be located above the confluence on the Babura and Deli River and below the confluence of the Petani and Saimaimai branches. Raw water intakes would be located on the Babura and Percut rivers, and pump stations, pipelines, and canals could transfer water to the Deli subbasins or directly to the treatment plant on the Deli River. An integrated system between the Deli and the Percut subbasins

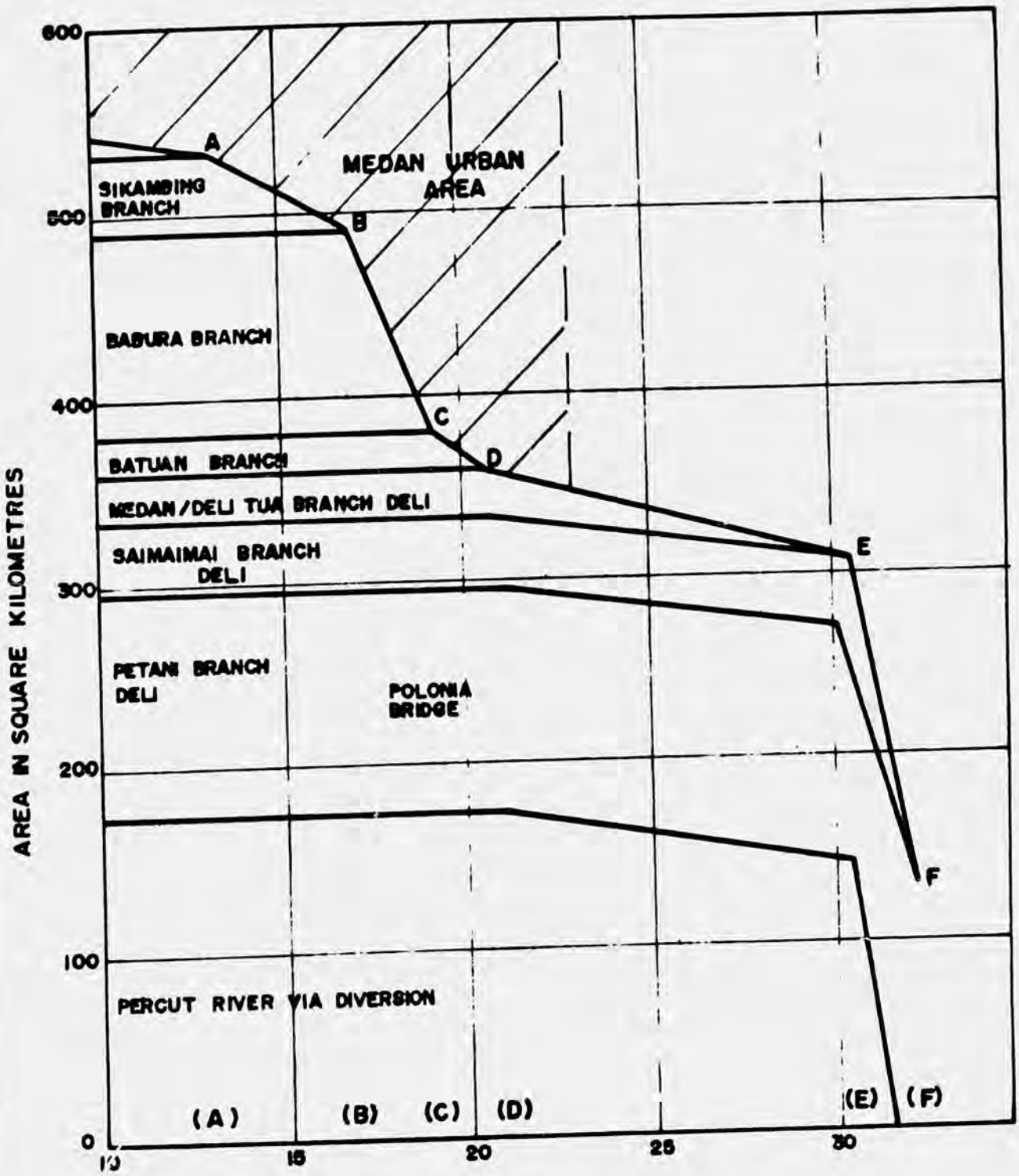
SCHEMATIC DIAGRAM OF THE BELAWAN BASIN FACILITIES AND POTENTIAL RESERVOIRS AND INTER BASINAL DIVERSIONS



allows the greatest flexibility in the use of these water sources in the light of the poor data on the Deli River and the absence of direct data on the Babura and the Percut rivers. As monitoring continues, the diversion of adjacent basins could be advanced or delayed depending upon monitoring results. Because of the physical capability of even more distance transfers,any planned plant production up to 400,000 m^3/d may be met but at higher costs. In addition to inter-basinal transfers, storage reservoirs may be able to store and supplement low flows both in the Deli and Percut subbasins and further expand the Deli Tua Plant pruduction.

Figure B-1.4 and Table B-1.9 indicate the potential catchment areas and estimated flows for various plant sites along the Deli River; the graph clearly shows the importance of the Babura River branch to the total catchment and flows for water plant on the Deli River. The urban area of southern Medan will expand in the lower portion of the Babura and Batuan subbasins, and urban drainage will degrade the raw water quality for any treatment plant. In addition, the expanding and intensifying urban uses in the Babura and Titi Kuning - Deli Tua areas will also restrict or eliminate potential plant sites along the Babura or Deli rivers. Because of the relatively minor of urban pollutants during low flows, and the restrictions on available plant sites, several sites near Deli Tua in river segment "D" and "E" were finally considered as feasible, and the flows and their productions at these sites are presented in Table B-1.10.

Several representative sites, D1 - D4 and E (Figure B-1.5,B-1.6), were chosen to demonstrate differences in flows, production, and the diversion and transmission pipelines. Using a preliminary estimate of 50 percent of the one percent flows, tentative production targets varied from 169,000 upto 209,000 m^3/d for a plant on the Deli River (Table B-1.9). As indicated before, concerns over pollutants in urban runoff from Titi Kuning (south Medan) and Deli Tua restricted potential sites to D3, D4, and E (Figure B-1.5 and B-1.6). In order to improve the production from these sites, the Babura flows would be collected from near the confluence of the Babura branches and then pumped upto the Deli Tua plant site. Production would also be increased to about 60 percent of the one percent low flows or to about 50 percent of a two to three percent low flow recurrence.



DISTANCE (Km) AND SITE LOCATIONS
FROM BELAWAN DELI BRIDGE

A - F PLANT SITE LOCATIONS IN FIGURE B-1.9 AND TABLE B-1.7

COMPARISON OF POTENTIAL SOURCES ON THE DELI AND PERCUT RIVERS AND THEIR CATCHMENT

TABLE B-1.9

COMPARISONS OF PETENTIAL SOURCE

LOCATIONS ON THE DELI RIVER AND PERCUT RIVER

Location and Distance from Belawan (Site)	(km)	Deli Basin Area (km^2)	Percut Basin Area (km^2)	Total Source Area (km^2)	Total Projected One Percent Low Flows (x 1,000 m^3/d)
O	O	397	173[5]	567	317 + 152 = 469
A	13.0	349	173[5]	522	294 + 152 = 446
B	17.0[1]	313	173[5]	486	276 + 152 = 428
C	19.3[2]	307	173[5]	380	202 + 152 = 354
D	20.7	183	173	356	185 + 152 = 337
E	30.5[3]	164	148	337	170 + 135 = 305
F	31.5[4]	133	O[5]	133	147 + O = 147

1 - 4 : 1, B is the confluence of the Babura and Deli River,
2, C is the Polonia - Suprapto St. Bridge on the Deli River,
3, E is the confluence of the Petani and Saimaimai branches,
and 4, F is the Petani branch above the confluence.

5 : The Percut River could not be practically diverted to the Petani branch or to Deli below D (Deli Tua - Titi Kuning).

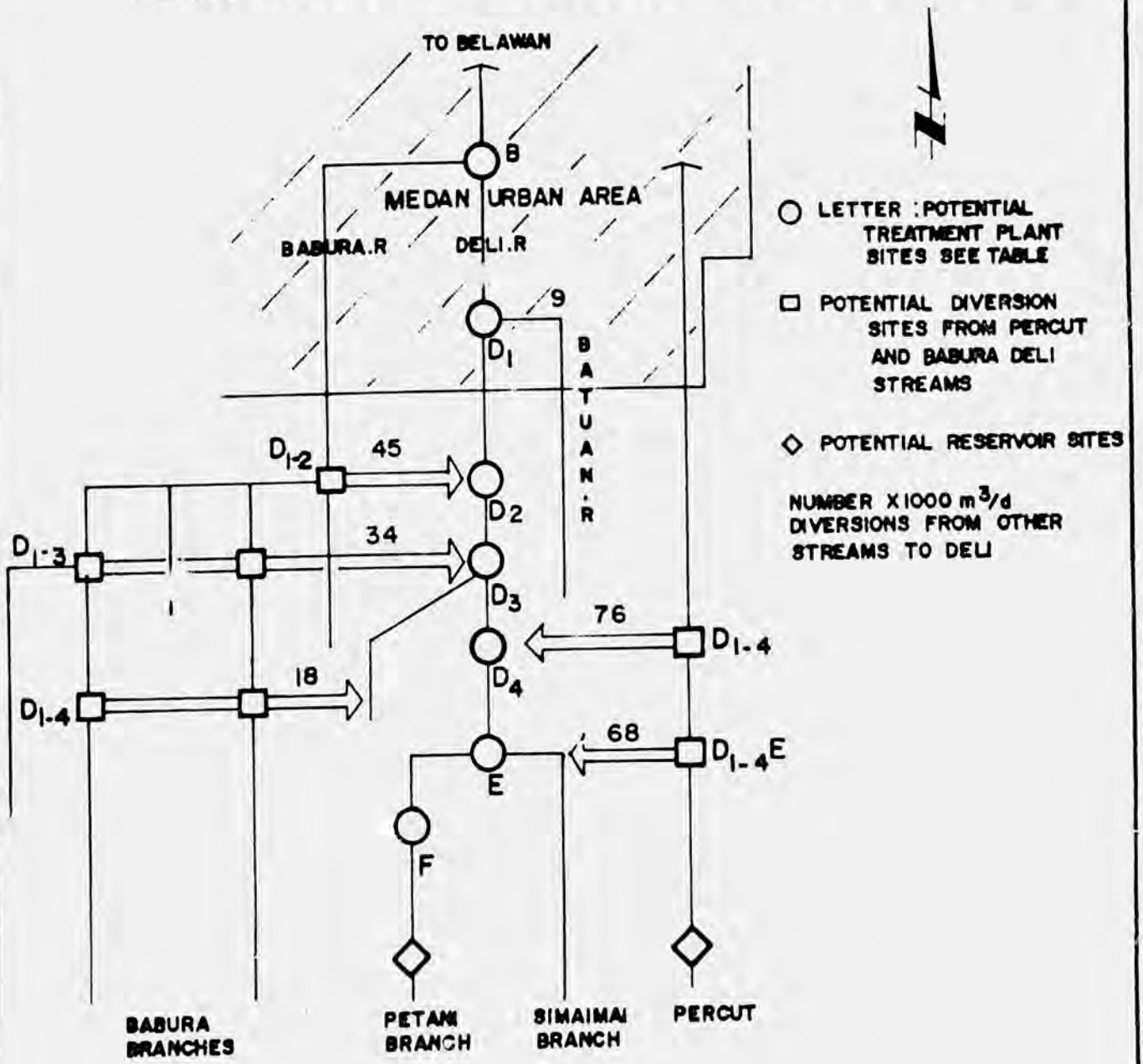
TABLE B-1.10

PROJECTED STREAM FLOWS AND PRODUCTION LEVELS

Basin	Stream Flows and Production (x 1,000 m^3/d)				
	Site D1	Site D2	Site D3	Site D4	Site E
Babura	64(32)1	64(32)	56(28)	36(18)	30(15)
Deli	202(101)	185(93)	182(91)	178(89)	172(86)
Percut	152(76)	152(76)	152(176)	152(76)	135(68)
T o t a l	418(209)	401(201)	390(195)	366(183)	337(169)

1 ( ) - Production given as 50 percent of the one percent recurrent flows,e.g. 64 x 0.50 = (32)

SCHEMATIC DIAGRAM OF POTENTIAL DIVERSIONS AND PLANT SITES WITHIN THE DELI AND PERCUT BASINS



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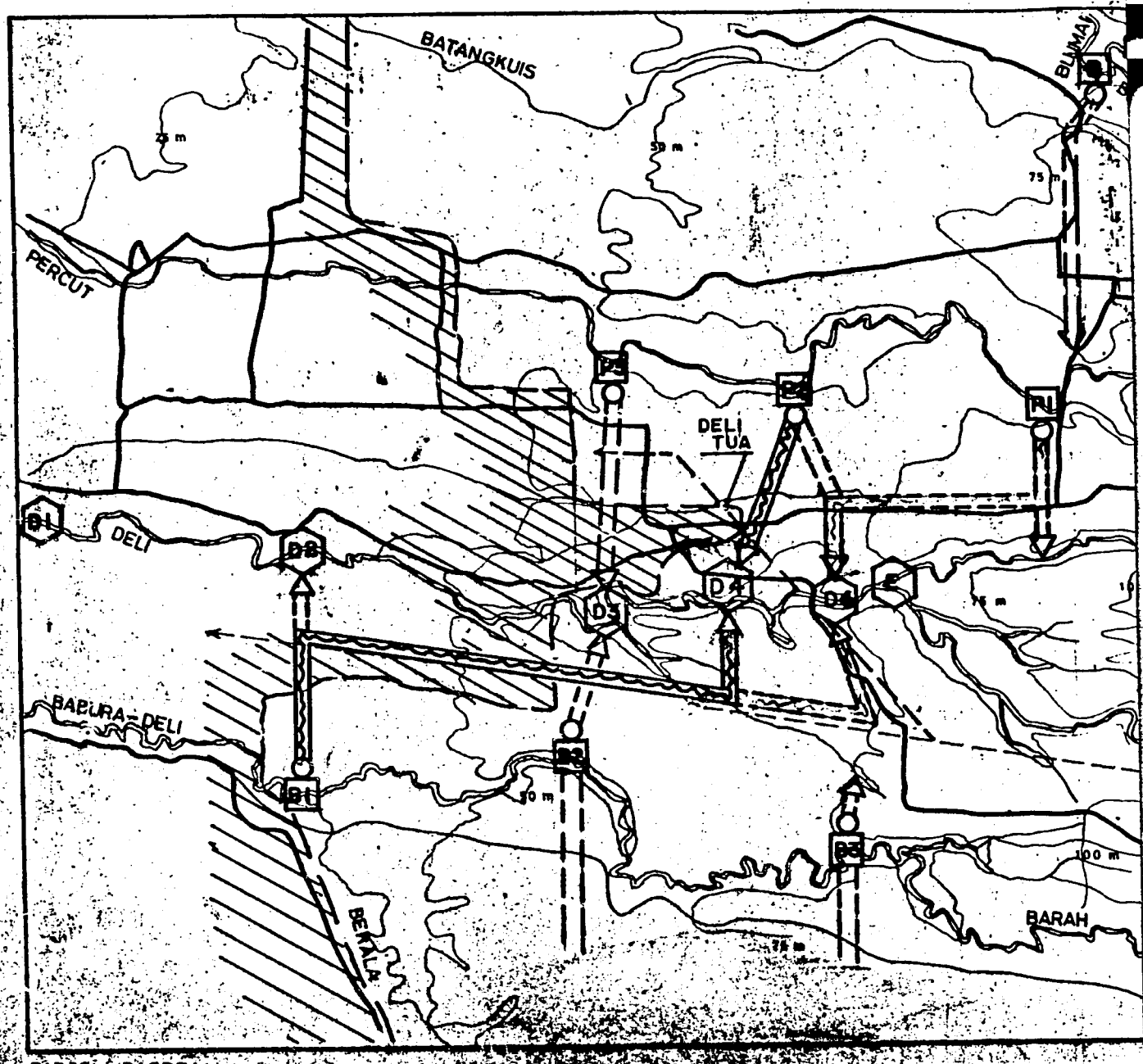

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B1.6 b

FIGURE B-1.6

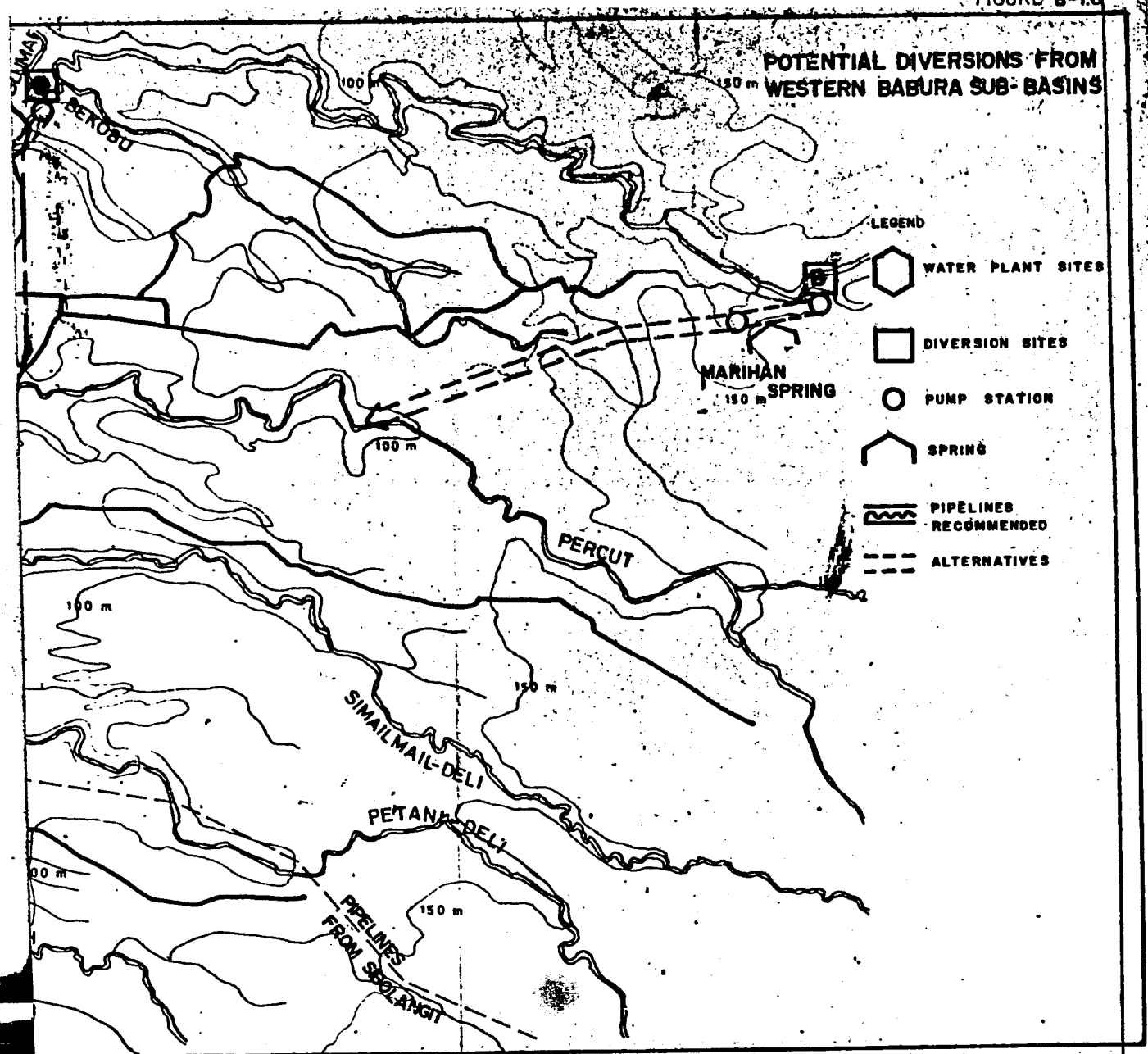

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TABLE B-1.11

COMPARISON OF DELI TUA WATER PLANT SITES, FLOWS, PRODUCTION, AND PIPELINE OR CANAL TRANSMISSION SYSTEMS

(See figures B-1.5 and B-1.6)

Site	Elevation (m)	Distance above Polonia Bridge (km)	Production Targets 1 (x 1,000 m^3/d)	Pipeline and Canal Length (km) Babura[2]	Percut[3]	Medan	Total
D1	25	2.0	289(20)	3.0	2.5	0	5.5
D2	35	5.5	201(250)	3.0	2.5	2.5	8.0
D3	50	7.5	195(250)	6.0(8.0)[2]	5.0	5.5	16.5(19
D4	60	8.8	183(250)	4.0(9.0)[2]	4.0(9.0)	6.8	14.8(25
E	80	11.3	169	4.0	2.5	8.0	14.5

1 Production target include both the 50 percent of one percent recurrent flows and a proposed plant production of 250,000 m3/d.

2 Pipeline lengths in ( ) indicate longer distance transmission from same diversion site as in D2. Percut diversion in D1, D2 and E would discharge to river while others would enter the Deli Tua Plant at D3 and D4.

Figure B-1.6 provides a more detailed layout and organization of the D and E sites along the Deli River and the diversions to the Deli. All sites could receive water diverted from the Percut and Belumai rivers on the east. The more southerly sites, D3, D4, and E would normally receive decreasing quantities of water diverted from the Babura subbasins. This general trend, however, would be reversed by pumping water collected at the main confluence of the Babura subbasins, X , either directly to D2 or by a longer pipeline to D3, D4, and E (Table B-1.11). Conversely, Deli and Percut raw water could be collected at the sites of D3, D4, and E and then conveyed to sites D1 and D2 by pipelines in other to maintain higher raw water quality. The differences of these alternatives routings of Babura and Deli-Percut raw waters

can only be clarified by thorough analyses of slopes, elevations, and soil conditions which exceeds the resulution of the available data.

The phasing of plant construction of the Deli Tua Plant would generally reflect the three basic elements of this treatment system: Deli, Percut, and Babura elements. The first phase would concentrate on raw water the Deli River. As the low flow capacity of the Deli River was approached, a decision would be made to construct either the Babura diversion or the Percut diversion and this would begin the second phase. The third phase would involve the construction and operation of the second remaining diversion. Each phase would extract about 60 percent of the one percent recurrent low flow or about 50 percent of the two percent recurrent low flows. The overall planned system capacity would be 250,000 m^3/d. The phasing within each of the three elements would be based on production increments of about 25,000 m^3/d (0.3 m^3/s). The Deli Plant would have six annual phases with three using raw water from the Deli River, four increments using water from the Percut River, and two increments using water from the Babura River. Each unit would be equivalent to about one years growth of water demand in Medan.

In summary, a relatively conservation estimate of low-flow safe yields in the Deli, Percut, and Babura rivers could support a treatment plant of 250,000 m^3/d at a site along the Deli River. Numerous potential sites exist between the Simeme Bridge above Deli Tua and the Johor Bridge in Titi Kuning. Site selection would involve a thorough comparison of the costs for site acquisition and development, of capital costs for pipelines and pump stations and of the costs and reliability of large volume pumping either of the raw water or the treated water. As an alternative to diversions and pumping through pipelines, a modest-sized water supply reservoir could be located in the upper Deli River subbasins and could augment the low flows of the Deli River to the same extent as the diversions or could increase the potential plant capacity by about 50 percent (e.g. from 250,000 upto 370,000 m^3/d).

B-1.3.3 Western Basins - Binjei Water Plant

The western basins include the Binjei River and the main channel of the Wampu River. The Binjei River is the major eastern tributary

of the Wampu River and its upper sub-basins lie next to the Belawan Basin. The two main sub-basins of the Binjei River: the eastern Menthrin River and the western, main channel of the Binjei River. These sub-basins join in the town of Binjei. The estimated one percent recurrent flows for the two basins is 700,000 m^3/d. Such flows could provide about 350,000 m^3/d using only 50 percent of the combined flows, if a plant was located only on the main channel of the Binjei River.

A single treatment plant could be located on the Binjei River (Figure B-1.7). This plant could collect raw water from Binjei River or from both rivers. Raw water intakes would be located above the urban area in onder to reduce pollutants from urban runoff.

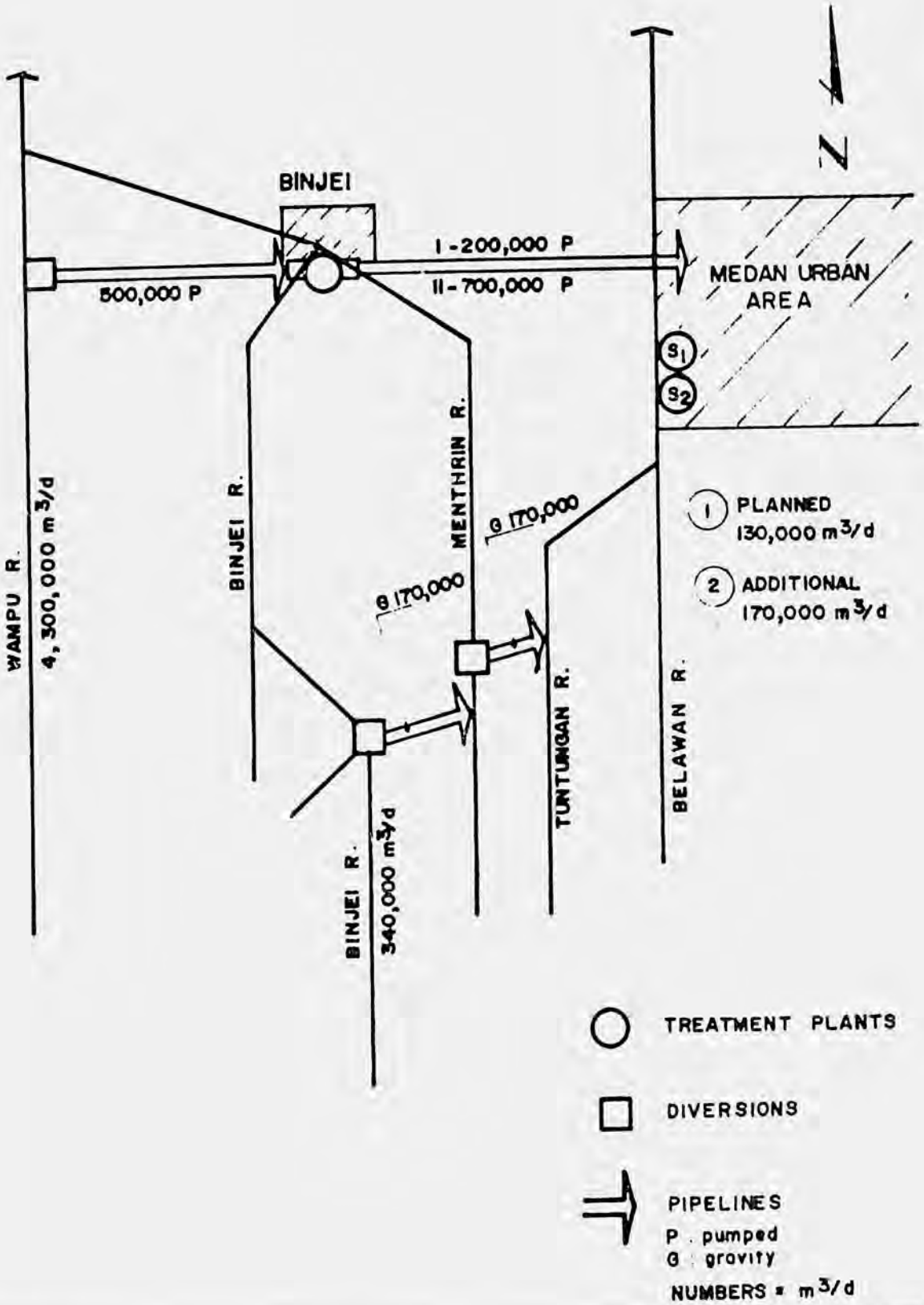
The Binjei Plant would require a 13 km transmission pipeline and pump station (200,000 m^3/d, capacity) in order to each the western edge of the Medan network system. The pipeline could connect with the Medan system in Lalang on the Binjei Road or in Sunggal at the water plant. Delivery of 200,000 m^3/d at the western perimeter would require ten new 400 to 600 mm diameter pipeline to distribute such volumes from the western periweter to central Medan.

B-1.3.4 Western Basins - Binjei River Diversion

Diversions of flows from the upper basins of the Binjei River would involve using raw water transmission systems to the west branch to the Menthrin branch of the Binjei River and from the Menthrin branch of Binjei to the Tuntungan branch of the Belawan River (Figures B-1.1 and B-1.7). Such transfers would require about 8.0 km of gravity pipelines/canals upto the Belawan Basin. Once in the Belawan Basin, the transfer would add 70,000 to 200,000 m^3/d to the low flow capacity of the Belawan River at the Sunggal Plant. This addition would be available for the plant and would increase plant production from about 130,000 m^3/d (1.5 m^3/d) upto about 300,000 m^3/d (3.5 m^3/s).

Western Basins-Wampu River. The Wampu River is the largest surface water in northern North Sumatra and even 15 percent of the one percent low flow (4.3 million m^3/d) could supply more than the total year 2000 demand for Medan. However, this source lies 26 km from the edge of the Medan network, and transmission of the large volume is very costly.

SCHEMATIC DIAGRAM OF DIVERSIONS PIPELINES AND TREATMENT FACILITIES IN THE WESTERN RIVERS



In order to maintain a reasonable unit cost for this alternative system, the production must be very high. Production of less than 200,000 m^3/d from the regional basins can be more effectively provide by the Morawa plant alternative on the Belumai or the Binjei plant on the Binjei River.

A raw water intake could be locate on the east (right) bank of the Wampu River near the town of Selesch. Because of the isolated location, raw water would be pumped by diesel-driven pumps. The raw water would be conveyed to the Binjei Water Plant along 13 km long pipelines and it would be treated in incremental expansion of the Binjei Plant. From the Binjei Plant the treated Wampu water would be pumped through additional 13 km long pipelines to the edge of the Medan network. Water user in Binjei and along the treated water pipeline corridor,the Medan-Binjei corridor,could also be supplied by this system.

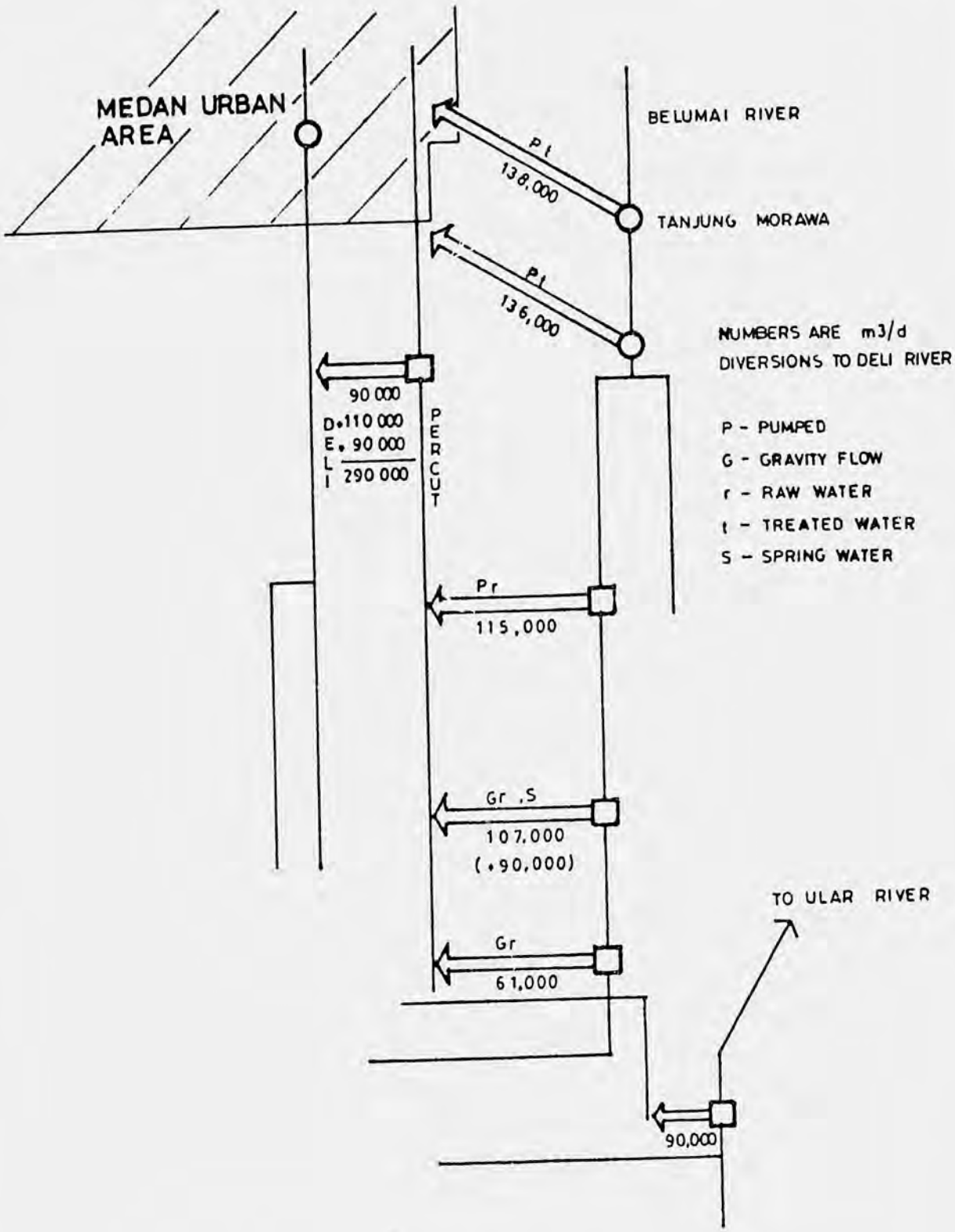
Water quality of the Wampu River is expected to be similar to that of the Belawan River and the treatment processes and effectiveness would be similar to those at the Sunggal Plant. The quality of the Wampu raw water reaching the Binjei Plant could be improved by pumping from settling basins along the Wampu or from horizontal collector wells located along the river bank. Such systems may reduce the expansion requirements for the Binjei Plant.

B-1.3.5 Eastern Basins - Belumai River

The Belumai and Ular basins have been assessed as possible sources of Medan. Yields and production from the Belumai basin would only supplement Medan's local sources and would require a new treatment plant near Tanjung Morawa or a diversion from the Belumai into the Percut and then to the Deli-Percut treatment plant. The Ular River could provide the total of the Deli-Percut plant.

Belumai River flows have been measured at Tanjung Morawa and have varied from 346,000 to 13.8 million m^3/d. An estimated one percent low flow would be about 276,000 m^3/d,while a five percent flow would be about 320,000 m^3/d.

Figure B-1.1, B 1.2 and Figure B-1.8 show locations and the



SCHEMATIC DIAGRAM OF POTENTIAL DIVERSION AND PLANT SITES BETWEEN THE DELI-PERCUT BASIN AND THE BELUMAI AND UPPER ULAR BASINS.

estimated low flow yields along the Belumai River at and above Tanjung Morawa. Diversions or separate treatment facilities at Tanjung Morawa would production about 30,000 m^3/d (using 50 percent of one percent flow more than a site above 100m elevation would produce but the Morawa site would require extra pumping for a 7.5 km transmissio system into Medan. More remote plant sites also may have smaller land costs, but they would have higher power, transportation, and housing costs compared to a site very close to the urban area. The alternative Tanjun Morawa Plant has a planned capacity of 200,000 m^3/d, so as to be comparable to the other alternatives. Such production would require with drawing 70 percent of the total one oercent low flows or about 60 perce of the five percent flow.

Projections of urban growth and water demand has indicated some urban expansion in southeastern Medan and along the Siantar-Morawa Road. Production of treated water at Tanjung Morawa would have little service value. until it reaches the expanding Medan urban area. Therefor a treatment plant at Tanjung Morawa would have no operational value over expansion of the Deli-Percut plant. Diversions of the Belumai River and collection of springs at Tanjung Marihan may allow gravity flow of about 100,000 m^3/d through pipelines/canals directly to the Deli - Percut plant or indectly into the Percut River for withdrawal at the diversion.

Water quality of the Belumai is expected to be similar to that of the Percut, Deli, or Belawan rivers and would require identical clarification and filteration treatment. Spring water from Tanjung Marihan/Kampung Bantan is expected to be similar to that of Sibolangit and will require little or no treatment, other than disinfection and aeration.

Other benefical uses of the Belumai River involve extraction at Tanjung Morawa and small historic allocations for irrigation and domesti use. The 40 to 50 percent production from the low flow capacity has been assumed to provide adequate supply for other users. Substantial use of the Marihan and Bantan springs would require adequate negotiation with local users in order to ensure reasonable allocation.

Eastern Basins - Ular River

As in the Belumai River basin, a separate diversion to the Tanjung

Morawa Plant or indirectly to the Deli-Percut system could be developed on the Ular River (Figure B-1.1). The one percent low flow is more than 2.0 million m^3/d at Pulau Tagor. The total demand from 1981 to 2000 and beyond could be drawn from the Ular River between Sennan and Baungar. A raw water intake would be on the west bank (left) of Ular River would have to have large diameter,pumped pipelines between the Ular and Medan. This pipeline system would be about 26 km long de ending on the connection with the Medan distribution system (17.5 km to Morawa and 7.5 km to Medan). The high cost for such a pipeline and operation would require a very large production from the river (at least 500,000 m^3/d) for favorable costs and virtual dependence upon this source for all new supply between 1985 and 2000 and beyond. Surface water quality would be similar to those of local sources, and raw water would be treated with similar methods.

The Ular River source would provide an eastern supply for Medan and balance the eastern and western demands/supply. Since the Ular source would be implemented between 1985 and 1995, the eastern distribution system would have to be greatly expanded with both secondary transmission and local distribution pipelines in order to adequately use the Ular production. In order to spread the Ular water after 1990, cross-city transmission pipelines would add 10 - 15 km to the effective length of the Ular transmission system and add indirect distribution costs to the Ular sources,withdrawal of the Ular raw water and pumping could be phased for best cost relationships,but little or no phasing could be made for the long,large pipelines. This eliminates much of the long.large pipelines. This eliminates much of the flexibility and adaptability of this alternative source with ut substantial additional cost.

Diversion of flow from the upper Ular River (Figure B-1.1) would depend on a gravity and low pressure pumped flow through pipelines/ canals in the upper ba in. The shortest diversion of 3.0 km would be located across the divide of the Loehoena and Balumai basins (Figure A.1). Such diversion could supplement the Deli-Percut or Belumai sources with 85,000 to 100,000 m^3/d (1.0 to 1.2 m^3/s). The water quality in the upper Ular basin may be better than that below 100m elevation,but the

surface water treatment at the Deli Tua Plant would be identical with other surface water sources.

As in the Belumai diversion source, the Ular diversion may be operated only during low flows or continuously if this source in conjunction with the Belumai and Deli-Percut would prove cost effective. Since this diverted water would provide about 100,000 m^3/d during low flows, the diversion would form only four to five annual increments to a multiple stage development of the Deli-Percut-Belumai or Belumai-Ular sources. The production would equal about three to six years of water demand and would be added only after the Belumai source was added.