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CONNECTION KAHAYAN - SEBANGAU

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CONTENTS

1 INTRODUCTION

Years ago plans were made to set up an inland navigation network in the area of Kalimantan. The canals connect the rivers flowing from the North to the South. A number of these rivers have already been executed: the Anjir Serapat, Anjir Kelampan and the Anjir Besarang. See figure 1.1 for a groundplan. The present navigation system often forms the only way of transport in this area. The canals also serve as drinage canals for the area. The primary canals of the irrigation system were connected to the navigation canals.

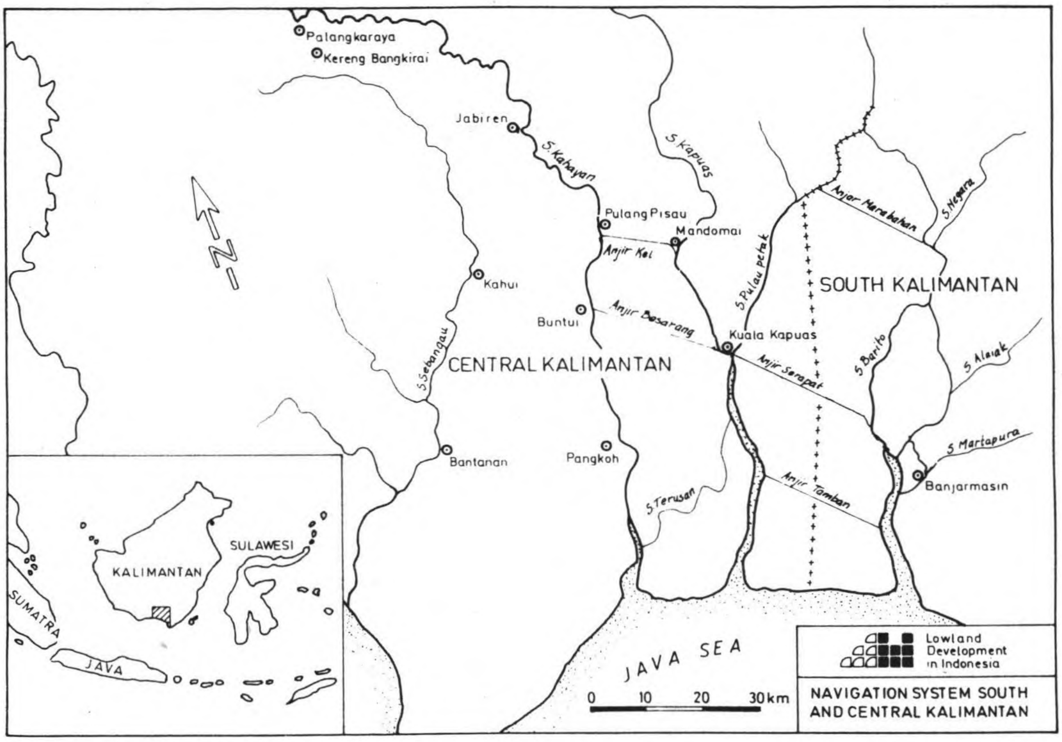


figure 1.1 Groundplan inland navigation network in Kalimantan.

This project concerns the dredging of the Anjir Mintin (see dashed line figure 1.2), the connection between the rivers Kahayan and the Sebangau. The dredging of a canal between the Kahayan and the Sebangau. The dredging of a canal between the Kahayan River and the Sebangau River is desirable because it will connect the Sebangau area with the area of the Kahayan, Kapuas, and Barito (with places as Palangkaraya, Pulang Pisau, Kuala Kapuas and Banjarmasin), and because the way along the coast from the mouth of the Sebangau to the mouth of the Kahayan is very dangerous. This connection is the more important in view of the envisaged reclamation/ development of the downstream Sebangau area.

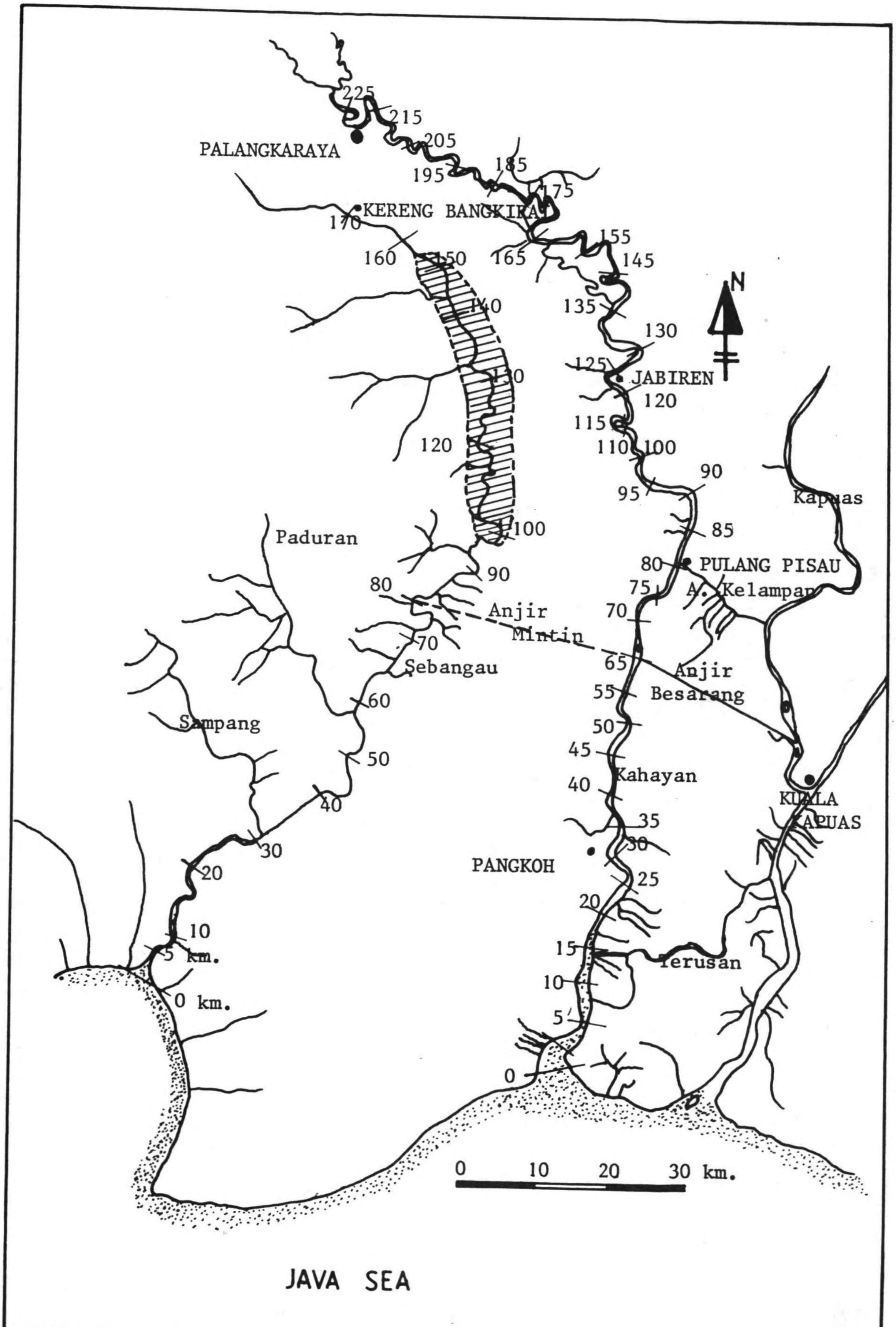


figure 1.2 Groundplan Sebangau and Kahayan.

The Sebangau is a rather small river (width approx. 30-50 m. and a depth of approx. 10 m.). The river has a length of about 180 km. During the dry season (May - September) the run off is very small. The tidal intrusion is rather strong in the dry season (up to 150 km. from the mouth of the river). In the wet season a lot of water has to be discharged by the river and than a lake arises in the Northern part of the river with a length of 60 km. and a width of 3-5 km. Along the river a kind of flood plains are flooded. The tidal propagation distance is 60 km. A very small suspended sediment transport and bed load transport was measured. The Kahayan is a wide flat river (width 200-100 m. and depth 20-40 m.) with a strong tidal intrusion (even) during the wet season (up to 200 km.). The banks are very stable. The river has a very small sediment transport.

When the plans for dredging the Anjir mintin were prepared the dredging work had been started. Unfortunately, the construction of the Anjir is not copmleted by far. Only 6 of the 25 km. has been dredged. Execution of the dredging work was stopped when the amount of dredged material exceeded considerably the amount expected on base of topographical data.

During the stagnation of the dredging work more hydraulic and topographical data became available and more questions arose about an adequate location of the Anjir Mintin. Therefore it is the intention to reconsider the designed location. Dependent on the locations certain effects can be caused. Several aspects of the waterway are playing a role and can cause problems in the area. These aspects are:
-effects on the hydraulic conditions of both rivers.
-effects on salinity intrusion, especially in the dry season. The dredging of the canal can cause a decrease of the average discharge in the direction of the sea and so causes an incrase of the salt intrusion. This is very unfavourable for the reclamation area in the downstream part of the Sebangau.
-possibilities of drainage of the upper Sebangau area in the wet season. A canal can favourite this possibility by increasing the clearance capacity of the Sebangau. This canal can drain the Sebangau Lake and the marshy banks in the downstream part of the river so that the banks can be used for all kind of purposes.

This report will contain an examination of the present location of the Anjir Mintin. It is restricted to the wet season. The aims of the study are the following:
- examination of the hydraulic effects on both rivers caused by the Anjir Mintin. The changes of the water movements in the rivers will be studied based on a simulation of water movement in the rivers connected by a canal. The confluence with the Sebangau will be varied to see whether this variation will have a large effect on the results. The question how far one canal can serve as drainage for the upper Sebangau area will be answered.
- supply a tool for further analysis. Because a lot more questions have to be examined, this study can serve as impuls for further analysis of a proper canal location.

In chapter 2 some general considerations, which apply for the whole report are given: the data used for the research, some information about the flows program which was applied to do the computations, and the problem approach for this project.

The design of the computations is described in chapter 3: the tidal propagation in the Sebangau and the Kahayan and the computation of the total canal - river system. The results of these computations will be discussed in chapter 4.

Hence follow the conclusions (chapter 5) and a number of recommendations are given in chapter 6.

2 GENERAL CONSIDERATIONS

2.1 Data

To simulate the water movements in the rivers Sebangau and Kahayan data are needed. These are sypplied by some survey reports: see reference reports [2], [3] and [4]. A short recapitulation of the results of the surveys, which are necessary for carrying out the calculations is given here. This means that only water level and discharge measurements will be discussed.

As reference level Mean Sea Level (MSL) is chosen. The tide on the Java Sea is at each mouth of the rivers nearly the same: the amplitude and phase of the tidal constants are approximately equal. During spring-tide the water level variation is diurnal, while during neap-tide semidiurnal influences dominate.

Of the Kahayan only data of the wet season are available. The water levels are measured and the slope is estimated using the "Bijker method". In figure 2.1 the measuring points can be found indicated "KH". The mean water level along the river axis is given in figure 2.2. The range of the water level variation is given in the table below (spring tide condition). The tidal intrusion stretches up to approx. 200 km.

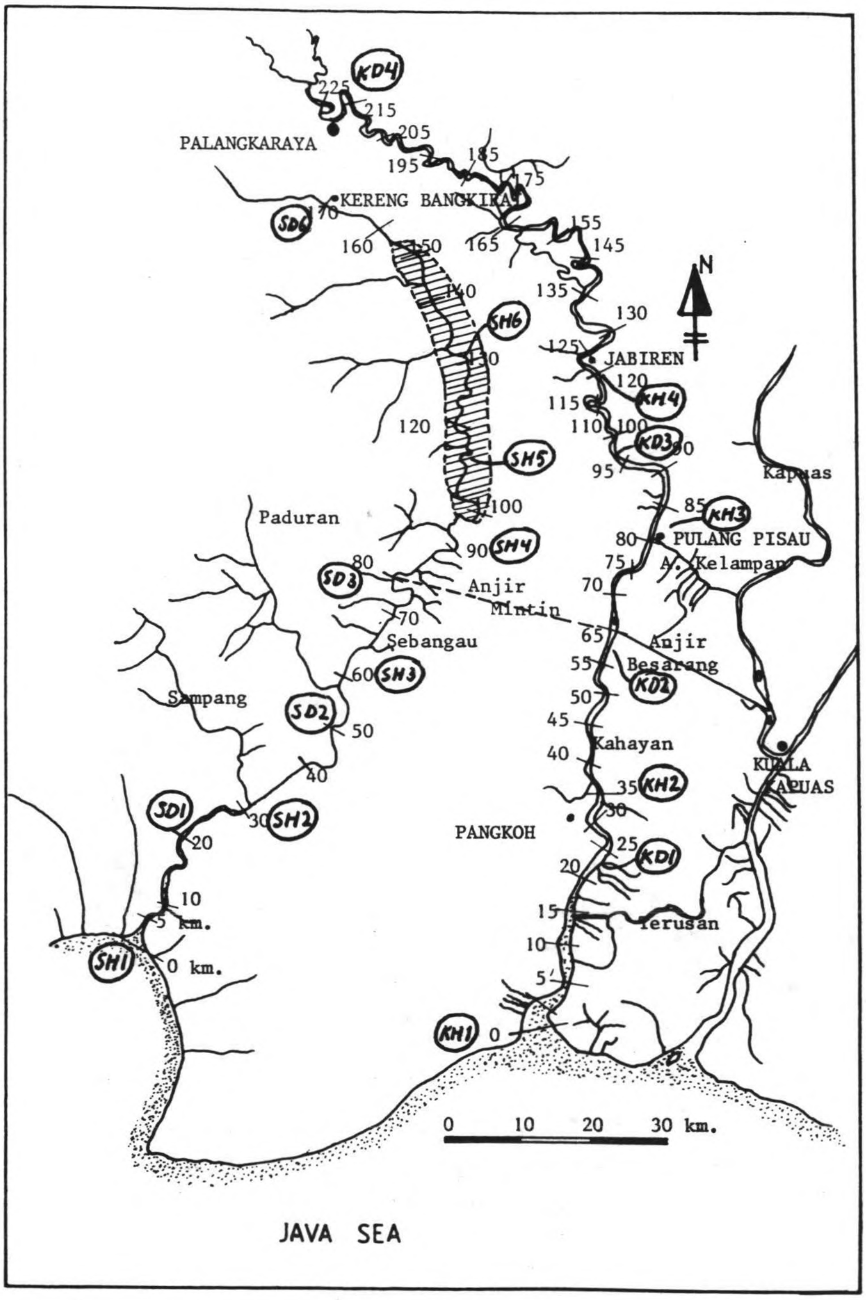


figure 2.1 measuring points Kahayan and Sebangau.

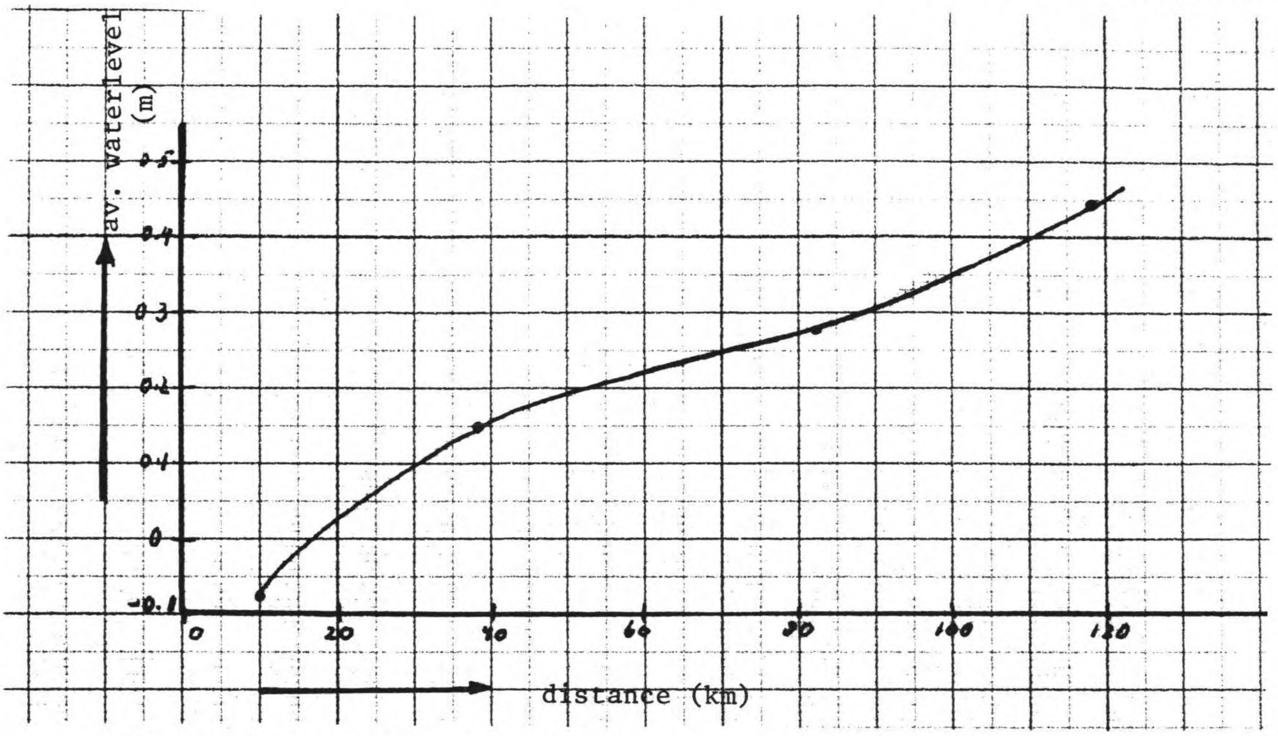


figure 2.2 mean water level Kahayan.

point fig. 2.1	distance from mouth	range	time-lag
KH1	0 km.	2.2 m.	
KH2	35	2.2	1-2 hrs
KH3	80	2.3	1-2
KH4	120	2.0	1-2

Discharges were measured at points indicated in figure 2.1 ("KD"). The average values are given in the next table.

point fig. 2.1	distance from mouth	average disch.
KD1	23 km.	965 m3
KD2	60	1065
KD3	97	910
KD4	225	680

The cross-sections were measured each 5 km. and each 10 km. more upstream. The levels are related to MSL. The banks are very stable and dry.

Of the Sebangau two survey reports are of importance: one contains a survey during the dry season, the other during the wet season.

In the dry season the tidal propagation reaches up to approx. 140 km. from the mouth of the river. The tidal range is 2.40 m. at the mouth and 0.25 m. at 132.3 km. The aim of the measurements which were done in the dry season was to do a slope analysis using the Bijker method. With the help of this analysis the water level measurements are related to one datum, in this case Mean Sea Level (MSL). Also the levels of the cross-sections were topographically related to MSL. In figure 2.1 the points are indicated where water levels and velocities/discharges were measured. Simultaneous water level and discharge measurements are available at 5 parts of the river. At each side of such a part the water level is measured and in the middle the velocity and discharge. The duration of the measurements is approx. 24 hours at each location. The average discharge in the Padunan and the Sampang, the main tributaries were measured: they are respectively 4 and 6 m3/s. In the next table the average discharges are given.

point fig. 2.1	distance from mouth	average disch.
SD1	20 km.	31 m3
SD2	50	25
SD3	76	24
SD4	103	14
SD5	122	14
SD6	170	8

In the wet season the tidal propagation reaches 60 km. The water level measurements are given in the next table:

distance from mouth	tidal range spring	neap	time-lag
0 km	2.7 m	1.4 m	
28	1.6	0.7	1.25 h.
43	0.9	0.3	1.25 h.
60	0.1	0	

The mean water levels were estimated up to 60 km. See figure 2.3.

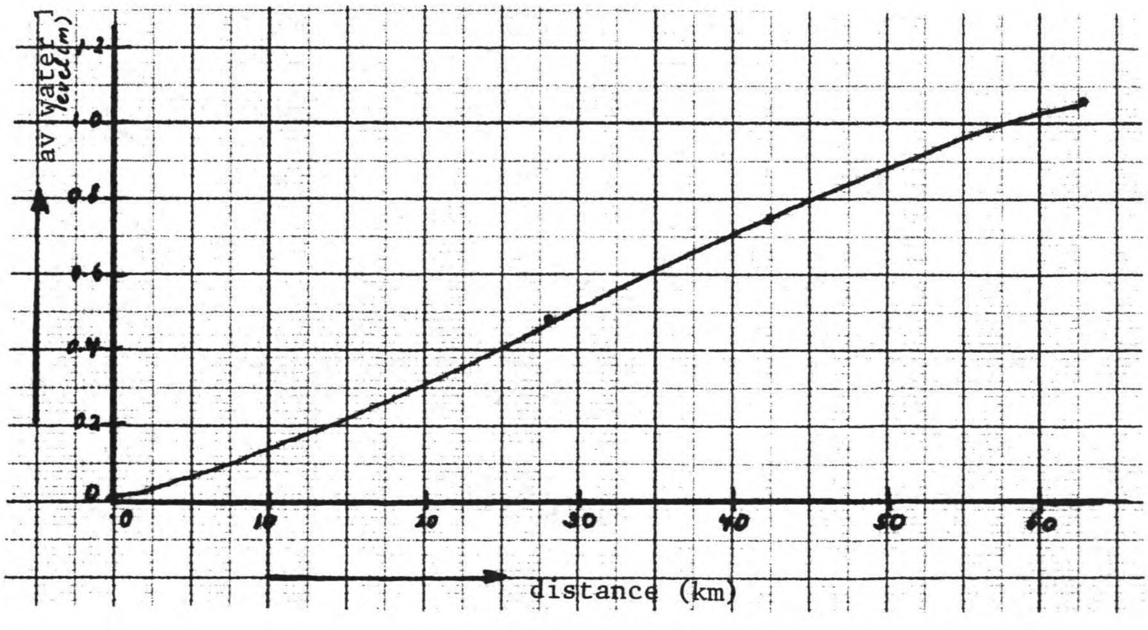


figure 2.3 Mean water levels Sebangau (wet).

As can be seen the damping of the tide is very strong. The banks are often inundated. Important lateral storages may be expected.

The discharges in the river mouth were measured during spring_tide: an ebb flow of 1000 m3/s and an flood flow of 550 m3/s. It appears from the discharge measurements that the damping of the horizontal tide is very strong (at 40 km the discharge is nearly constant). The measurements of the average discharge is given in figure 2.4. The figures in 2.4 show a strong water supply from the banks.

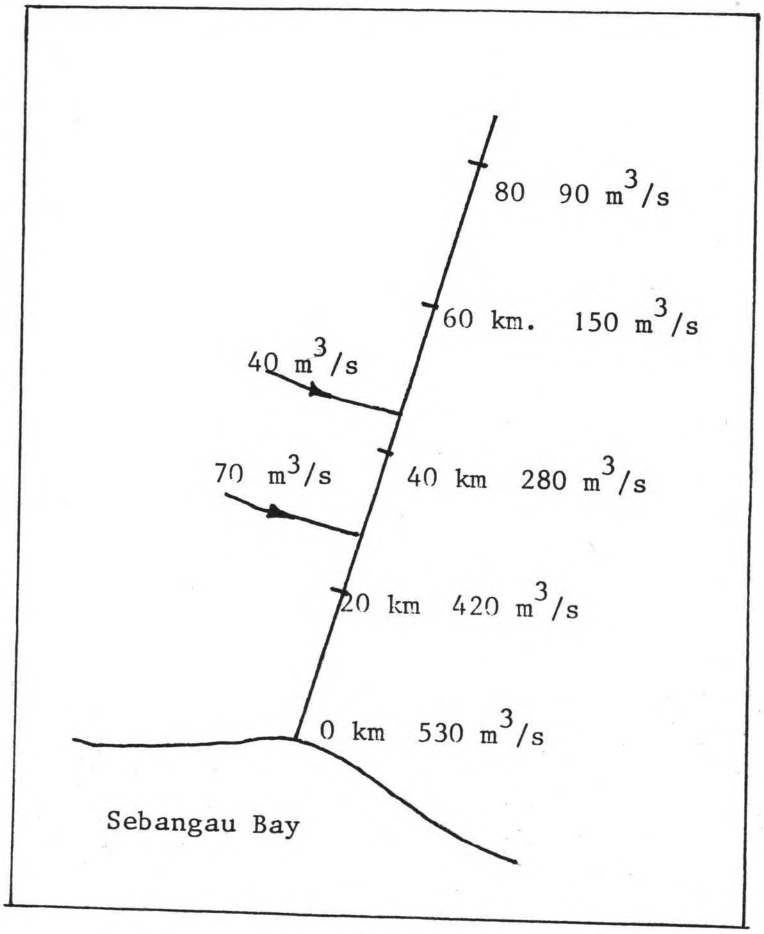


figure 2.4 Discharge measurements Sebangau (wet).

2.2 Flows program

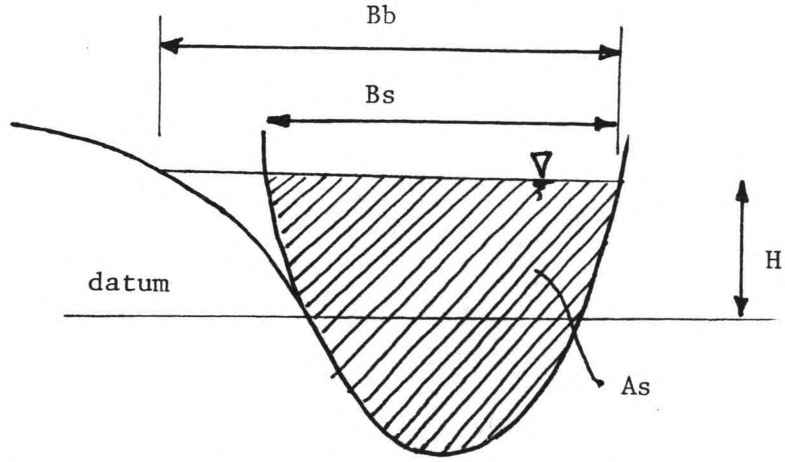
Flows is a computer program developed at the Delft University of Technology and is meant for amongst others tidal computations in networks of waterways. The tidal flows are computed by means of implicit numerical schemes. The implicit scheme has the advantage that for stability of the calculation process no limit is imposed on the time-step. The scheme is of the type, where the values of discharge and water level are taken at the same points in the scheme.

The numerical model for water flow in one-dimensional canals and rivers uses 2 equations: the momentum equation and the continuity

equation.
They are respectively:

$$\frac{\partial h}{\partial x} = -\frac{1}{gA_s}\frac{\partial Q}{\partial t} - \frac{|Q_g|Q_g}{C^2A_s^2R} + \frac{\partial}{\partial x}(Q\,u)$$

$$\frac{\partial Q}{\partial x} + B\frac{\partial h}{\partial t} = 0$$



in which:
h = water level
x = axis along river
As= stream area
Q = discharge
t = time
C = Chezy coefficient
R = hydraulic radius
B = width
u = average velocity

The network is divided in branches: these are considered as one elementary step in the numerical analysis. The discharge and water level in each branch are characterized by their values at both ends of the branch. The water levels in branch m are identical to the levels m-1 and m. In case of unsteady flow one further distinction has to be made, namely between different time levels. Therefore a superscript + is introduced to indicate time t+ (is time-step) and a superscript - indicating time t. See figure 2.5 for the numerical scheme. As point of reference a point near the centre of the rectangle in fig. 2.5 is chosen. With help of this scheme partial derivates and functions of the variables at the corners of the rectangle (in this case the water level h and discharge Q) can be calculated. In this way the equation of motion can be solved. See for details reference [1].

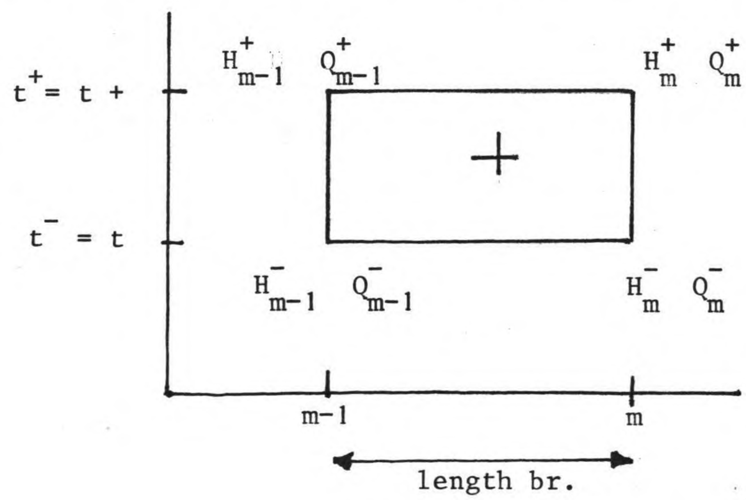


figure 2.5 Numerical scheme FLOWS.

In all the computions which follow in this report the time-step is equal to 300 sec. This follows from the equation $\Delta t < \Delta x/c$. It says that the time-step has to be less than the length of the branch divided by the celerity. In spite of the fact that no instability problems occur this equation is used for accuracy of the computation. The most unfavourable value of Δt follows from the smallest branch (

Δx) and the deepest branch ($c=\sqrt{ga}$).

As friction law the friction coefficient $f'=g/C^2$ is used, where C is the usual Chezy coefficient, determined by a certain friction law.

The branches are schematized by a certain length, friction and profile. The profile is given by a number of levels (related to the datum MSL and the stream width Bs and the storage width B at that level.

2.3 Problem approach

To examine the location of the Anjir Mintin in the wet season the steps described below will be taken. The analysis consists of a number of computations with the flows program. For these computations the boundary condition at the mouth of the rivers is the water level variation of the sea, schematized by a sine function with an amplitude of 2.4 m. and a period of 24 hours. This corresponds reasonable with the spring-tide condition. This is done to make the results better interpretable.

First the tidal propagation in the rivers separate will be computed:
a) computation of the tidal propagation on the Kahayan for the wet season.
b) computation of the flows of the Sebangau in the dry season.
c) computation of the waterlevels and discharges in the Sebangau - wet season.

After each computation the results will be examined and where data are available the computations will be adjusted as good as possible.

The final step in the problem approach is to make a computation of the canal - river system for the wet saeason. It should be mentioned that as starting point the canal part with a length of 6 km., which already has been dredged, will be taken. So the confluence with the Kahayan lies firm. The confluence with the Sebangau of the Anjir Mintin will be varied to determine the best solution. Three calculations will be made:

- a computation with the Anjir at its original location (see dashed line 2.1).
- a computation with a Northern confluence with the Sebangau.
- a computation with a more Southern confluence with the Sebangau.

3 COMPUTATIONS

3.1 Tidal propagation

3.1.1 Kahayan

The Kahayan has been divided in 23 branches and they were numbered 2 to 24. The nodes were numbered 1 to 25. See figure 3.1 for the division of the Kahayan in branches and their lengths. At node 9 (65 km from the mouth) the Anjir Mintin origins. Branch 26 has been connected to node 25 and in this branch a fixed discharge was given. This is the upstream boundary condition: the run off of the river. It is equal to approx. 700 m3/s. At node 1 the water level variation of the sea is given. The profiles of the branches are shown in annex 1. The Chezy coefficient in branches 2 to 5 is equal to $80\sqrt{m}/s$, in branches 6 to 13 $C=60\sqrt{m}/s$ and in the rest of the branches $C=50\sqrt{m}/s$. These are the values which were applied for the slope analysis (see reference [4]).

3.1.2 Sebangau

The Sebangau has been divided in 17 branches numbered 27 to 43. They connect the nodes 26 to 43. Each branch is 10 km. long. See figure 3.2 for the schematization. A number of branches with a fixed discharge were connected to the Sebangau at nodes 43, 38, 32, 31, 29 and 28. They were numbered 44 to 49. Two of them, branch 45 and 47 represent the main tributaries of the Sebangau, the rivers Sampang and Paduran. The other so called "discharge"-branches take care of the flow from the banks and the run off in the North, especially in the wet season, when a large flood supply from the banks occurs. The next table shows the values of the discharges in the dry and wet season.

branch number	dry	wet
44	0	100
45	4	40
46	0	130
47	6	70
48	0	100
49	8	100

in m 3/s

At node 26 the water level variation is given as boundary condition. the Chezy coefficient in branches 27 to 29 is equal to $50\sqrt{m}/s$, in branches 30 to 32 $40\sqrt{m}/s$, and in the rest of the branches 30 m/s. These values wer applied for the slope analysis in the dry season (report [3]). The cross-sections of the branches are shown in annex 1. They are supplied by the survey report of the dry season. The storage widths at certain levels were chosen based on first calculation results. The storage widths/ areas were not estimated during the surveys.

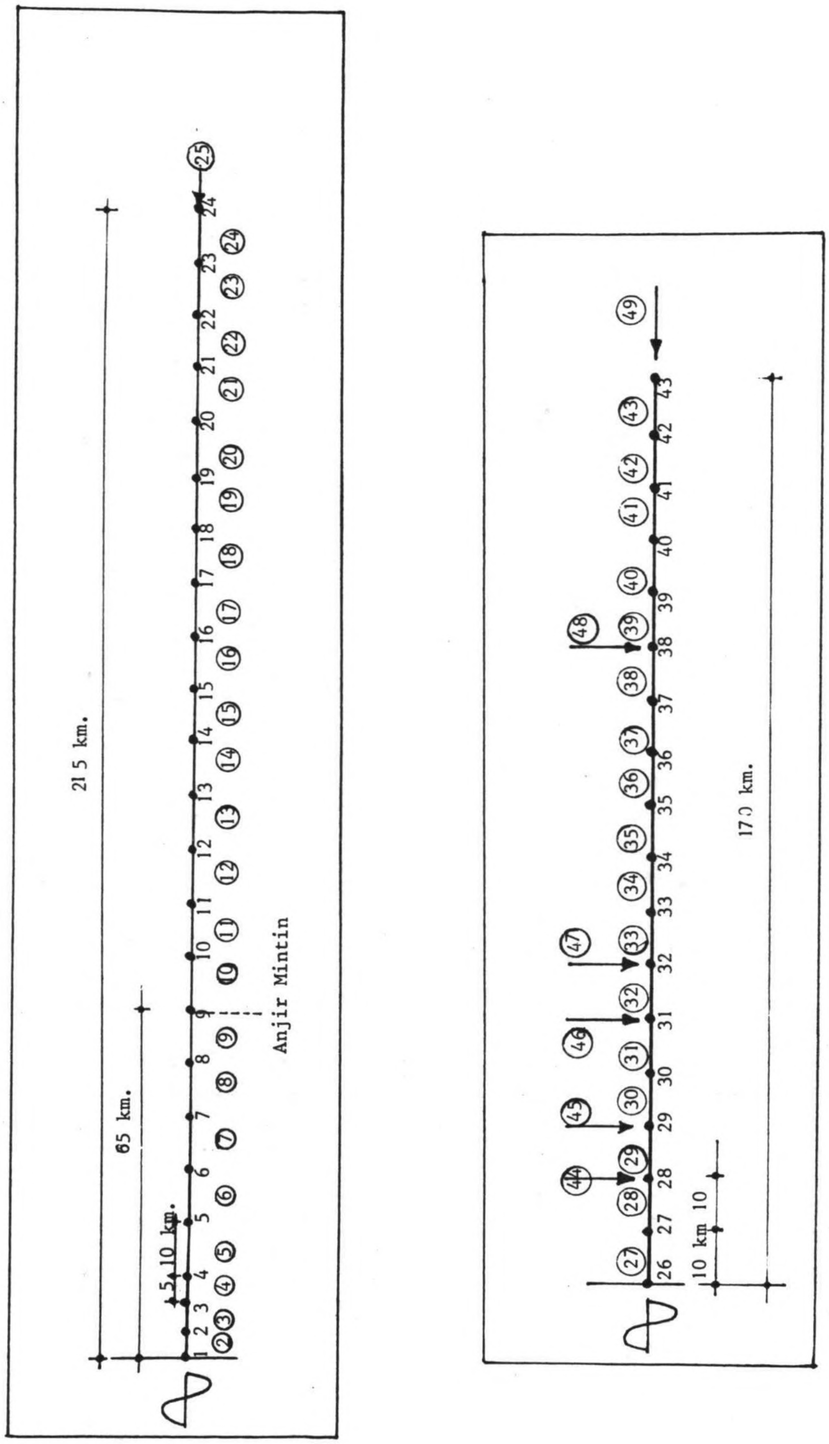


figure 3.1 Schematization Kahayan and Sebangau.

3.2 River - canal system

As mentioned in the problem approach 3 computations were carried out of the total river - canal system: the confluence with the Sebangau was varied. Figure 3.3 shows these 3 alternatives. the first part of the canal was fixed: it is branch 47 and has a length of 6 km and has already been dredged.

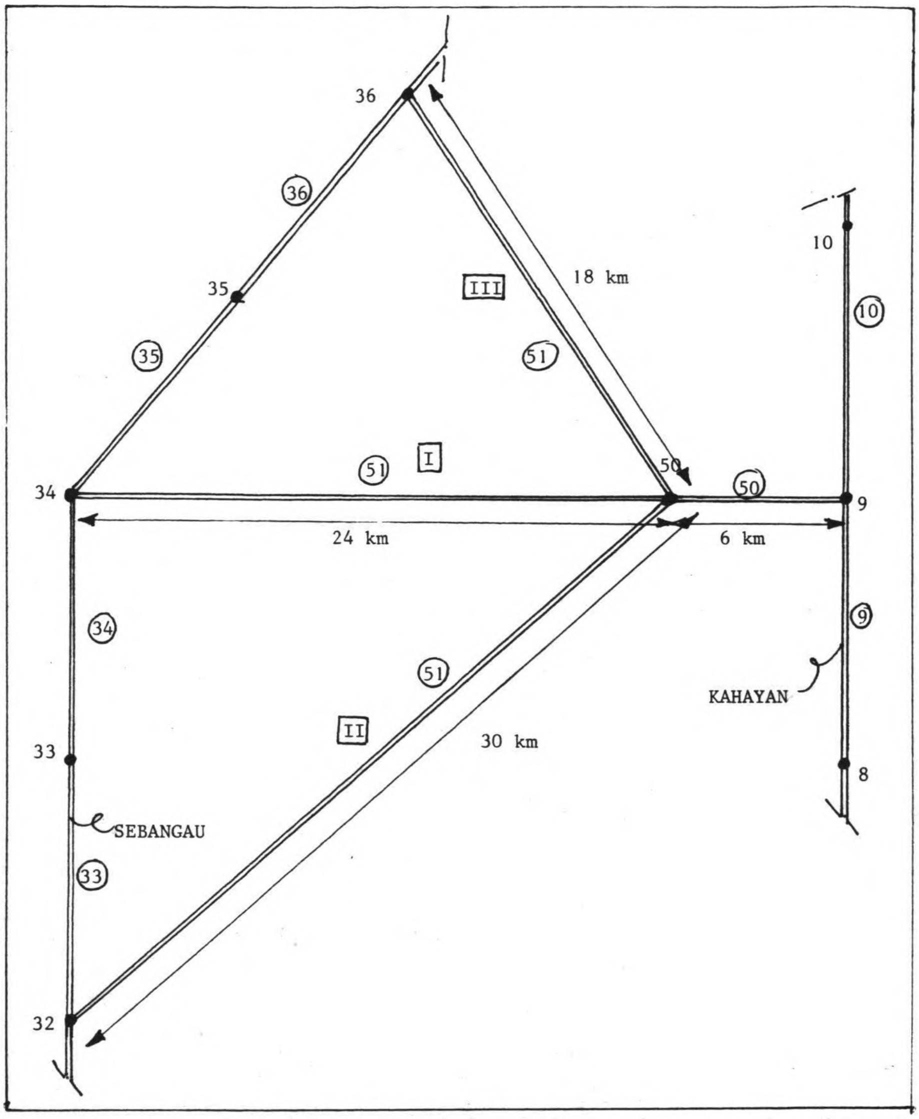


figure 3.3 Computations canal system

The second part of the canal is branch 48 and reaches the Sebangau at 3 nodes:

I - This is the original plan for the location of the Anjir. It connects the Sebangau at node 34, 80 km. from the mouth of the river.

II - This is the more Southern location and leads to node 32, 60 km from the mouth of the Sebangau.

III - This is the more Norther location and leads to node 36, 100 km from the river mouth.

See figure 3.4 for the location of these alternatives. The canal has the following characteristics: a width of 40 m, a depth of 3 m (related to MSL) and a friction coefficient $C=50\sqrt{m}/s$.

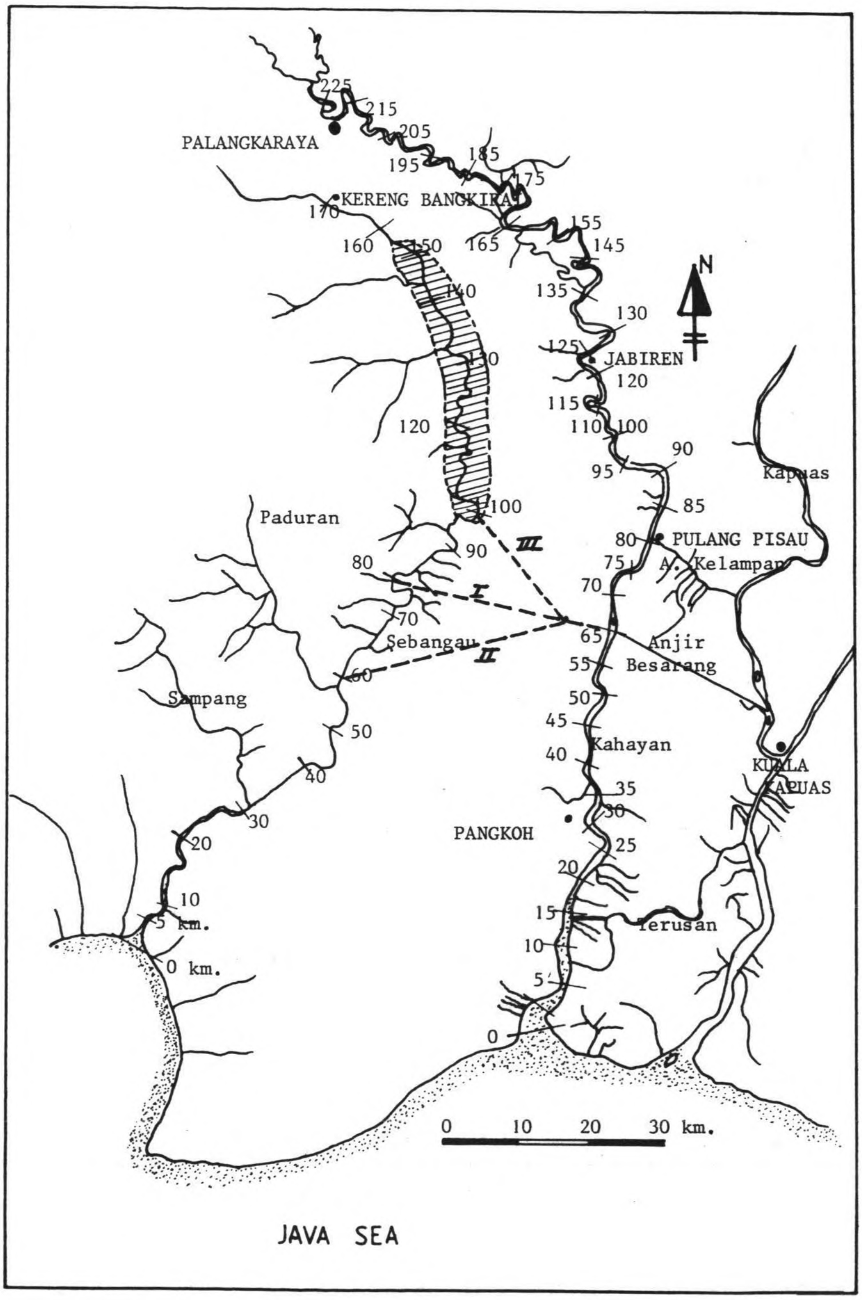


figure 3.4 Location canal alternatives.

See for the list of FLOWS-commands and some comments annex 2.

4 RESULTS

4.1 Rivers separate

4.1.1 Kahayan - wet season

The tidal propagation in the Kahayan is very strong. This appears from the computation. The strong intrusion is caused by the little roughness and the very deep branches. The run off is very small compared to the ebb and flood discharges. The tidal range and the average water levels at some points along the river axis are given in the next table.

distance from mouth	range (m.)	time-lag	average water-l.
0 km.	2.40		0 m
35	2.41	1.5 hr	0.11
85	2.48	1	0.23
125	1.90	1.5	0.60
175	1.35		1.27
215	1.30		-

The "time-lag" between two water level curves at two points along the river is equal to the time difference between the points of time at which the curves cross the average water level. The average water level along the longitudinal river axis was plotted in figure 4.1.

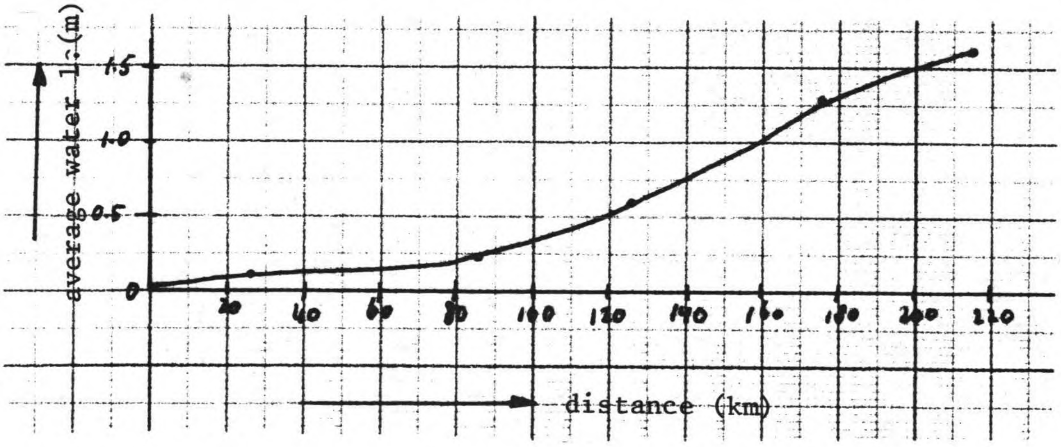


figure 4.1 Average water levels Kahayan.

The discharge variation at some points are given in the next table. The maximum and minimum discharge is given knowing that the downstream direction (ebb direction) is positive. All figures in m3/s. The ranges of the discharge correspond reasonable with the measured ones.

location (distance fr. mouth)	discharge minimum	maximum	average
0 km.	6467	-6341	700
25	3962	-3643	700
55	3054	-2428	700
95	1785	-903	700

See for the detailed variation graphs of the water levels and discharges in the Kahayan, annex 3, figure 1 and 2. A control calculation was carried out for the section 55 - 85 km in annex 4.

4.1.2 Sebangau - dry season

In the dry season nearly no fun off was masured and a tide which propagates until a distance of approx. 150 km. from the mouth. At a distance of 30 km. from the mouth the dampening of the tide increases considerably. This is caused by smaller branches and the extra storage area of the branches. This storage width has been added, because it appeared that the discharge variation was too small using the measurements of the cross-section in the survey report. A larger storage area in a certain river part causes larger discharges in the downstream part, so that the friction term in the equation of motion increases and the dampening increases.

In the table below the ranges of the water levels and discharges are given.

water levels		discharges		
location	range	location	minimum	maximum
0 km.	2.4 m	0 km.	-697 m/s	649 m/s
30	2.15	20	-453	393
60	1.58	50	-216	178
90	0.58	80	-85	43
110	0.30	100	-36	51
130	0.25	120		

See annex 3 figures 3 and 4 for the curves of the water levels and discharges. For the section between 30 and 60 km. a control calculation was carried out: see annex 4.

4.1.3 Sebangau - wet season

From the results of the wet season a few things attract attention:
- the average water level has increased considerably.
- the vertical and horizontal tide propagates until a distance of 60 km. More upstream the discharge and water level have a constant value.
- The discharges have only one direction: to the sea (downstream).

These results are caused by a large storage area above a certain level (the so called "flood plains"), and a lot of lateral discharge from the banks. The level of the flood plains was chosen avove the maximum water levels of the dry season, because otherwise these storage area would have an effect on the water levels and discharges, which is impossible.

In the next tables the tidal ranges and discharge figures are given. The average water level is shown in figure 4.2. It is interesting to see that the average water level slope is steeper on the first 60 km than on the upstream part where the lake arises.

water levels		discharges			
location	range	location	minimum	maximum	average
0 km	2.4 m	0 km	68 m/s	901 m/s	540 m/s
30	1.21	20	89	620	440
60	0.11	50	122	322	270
90	0.01	80	174	207	200
		170	100	100	100

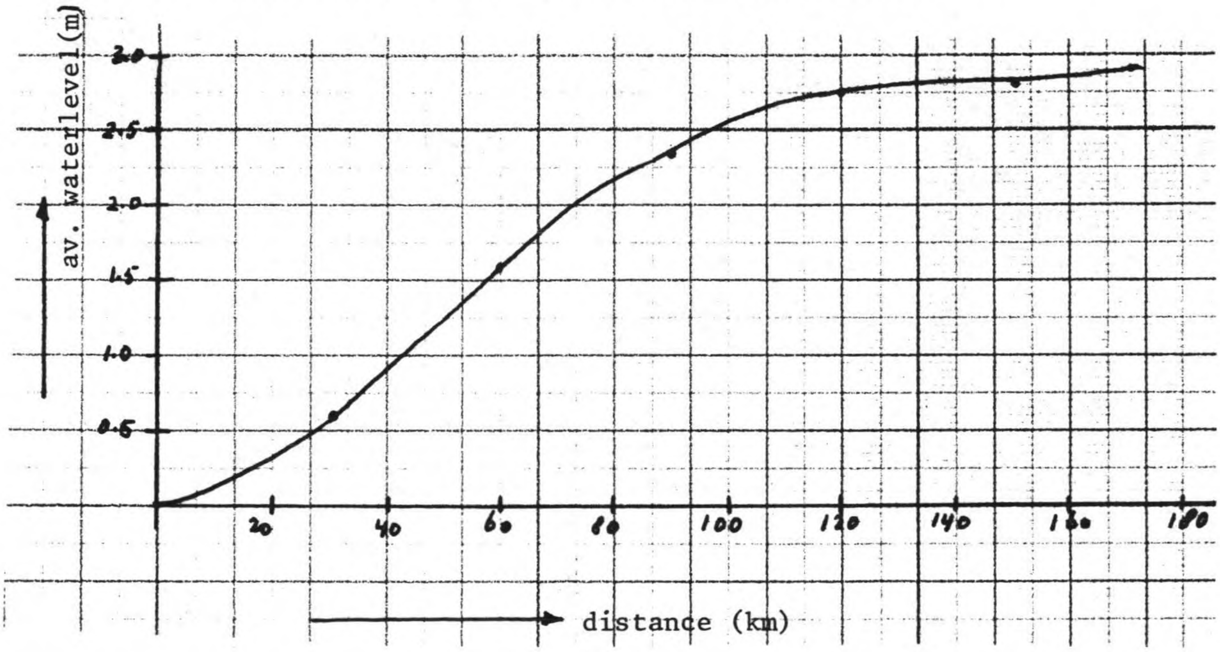


figure 4.2 Average water level Sebangau (wet).

See annex 4 for a calculation between 0 and 30 km.

4.2 Connection of the rivers

For each canal alternative mentioned in chapter 3.3, named I, II, III, the results are presented here. In general it can be said that for each alternative a net discharge from the Sebangau to the Kahayan was calculated. The next tables show the range of the water levels and discharges at the same points as presented for the rivers separate. The figures for the Kahayan are only given of alternative I, because for all alternatives the tidal propagation in the Kahayan is nearly the same.

Kahayan - alternative I.

water levels		discharges			
location	range	location	minimum	maximum	average
0 km	2.4 m	0 km	-6245 m^3/s	6488 m^3/s	800 m^3/s
35	2.38	25	-3586	4076	800
85	2.45	55	-2403	3143	800
125	1.89	95	-904	1773	700
175	1.35				
215	1.3				

Net flow through canal: 100 m3/s.

Sebangau - alternative I (canal at 80 km from mouth Sebangau).

water levels		discharges			
location	range	location	minimum	maximum	average
0 km	2.4 m	0 km	-146 m^3/s	832 m^3/s	440 m^3/s
30	1.43	20	-137	510	340
60	0.14	50	-84	300	170
90	0.05	80			100

Net flow through canal: 100 m3/s.

Sebangau - alternative II (canal at 60 km from mouth Sebangau).

water levels		discharges			
location	range	location	minimum	maximum	average
0	2.40	0	-99	838	460
30	1.29	20	-102	560	260
60	0.16	50	-86	317	190
90	0.02	80			200

Net flow through canal: 80 m3/s.

Sebangau - alternative III (canal at 100 km from mouth Sebangau).

water levels		discharges			
location	range	location	minimum	maximum	average
0	2.40	0	-217	826	420
30	1.49	20	-159	538	320
60	0.26	50	-128	288	150
90	0.03	80			80

Net flow through canal: 120 m3/s.

The influence on the Khayan is as could be expected, not very great. The influence on the Sebangau is more interesting: the tidal propagation has changed. Also the average water level along the river axis is different for the three alternatives: see figure 4.3.

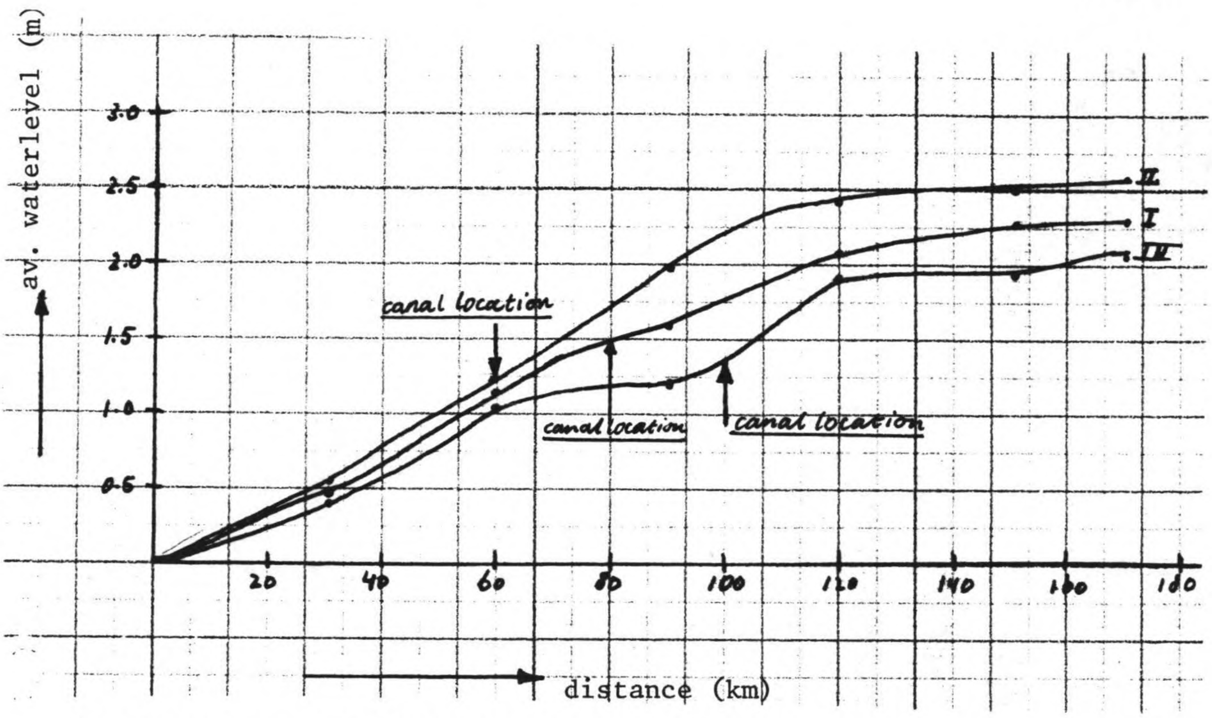


figure 4.3 Average water levels Sebangau with canal.

For all three locations a nearly steady flow through the canal exists. No deadlock in the canal occurs. The change of location is the most noticable in the river part from 60 - 120 km. The effect of a canal connected at 100 km is the most significant. This alternative is considered more extensive here. Just north of the canal location the slope is very steep. From 120 - 180 km the nearly horizontal slope of the lake still exists. This is caused by the large resistance of Sebangau river in the north: small cross section and a large friction. For the large fall (approx 0.55 m.) at the section 100 - 120 km a steady flow computation is shown in annex 4.

See annex 3 figures 7 and 8 for the water levels and discharges in the Sebangau, alternative III.

5 CONCLUSIONS

Based on the calculations a number of conclusions can be drawn for the present location of the Anjir Mintin in the wet season.

- HYDRAULIC EFFECTS ON RIVERS

* Kahayan
The dredging of the canal will not change the tidal propagation in the Kahayan. The net flow to the Kahayan of 80 - 120 m3/s is low compared to the run off of 700 m3/s and to the tidal discharges (amplitude of 6500 in the mouth).

* Sebangau
The effects on the Sebangau are larger: the tidal intrusion length increases for all three locations, especially for the Northern alternative. A decrease of the average water level of 10% (southern location) to 30% (northern location) can be expected. Also discharges in the upstream direction occur.

* Possibility of draining the upper Sebangau area
The Sebangau area can not be drained by one canal. The capacity of a canal of 50 m width (an incrase of 50 % of the stream area) is too low. The canal causes a net flow of 80 - 120 m3/s from the Sebangau to the Kahayan. Compared to the total run off of approx. 500 m3/s which has to be cleared in the wet season it can be expected that more clearance capacity of the Sebangau will be needed. The maximum effect is reached for the most Northern location. The main cause of the lake is the resistance of the Sebangau itself.

6 RECOMMENDATIONS

The computation modelling described here can serve as tool for further analysis of the connection between the Kahayan and the Sebangau. It forms an impulse to the modelling of the river - canal system. However, for more detailed information a more thorough calibration of the rivers has to be carried out. For this purpose, especially of the Sebangau more hydraulic data will be needed:
- for the dry and wet season simultaneous discharge / water level measurements along the whole river.
- more information about the storage area, as well in the dry season (marshy banks) as in the wet season (the Sebangau Lake).

Further a follow up of the research for a good canal location in the dry season is recommended. The impact on the salt intrusion is not known and for the present location, which was considered here, it is nice to answer whether one canal has sufficient clearance capacity to drain the marshy banks in the dry season. For both seasons also other locations than the present location can be examined.

Finally it is recommended to attack the problem the way which was applied here: first a calculation of the rivers separate and then the extension of the network with a connection.

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Report no. PS 678, DPMA - P4S - BTA60 Bandung.

[3] DPMA. 1981.
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[4] DPMA. 1980.
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[5] DPMA. 1980.
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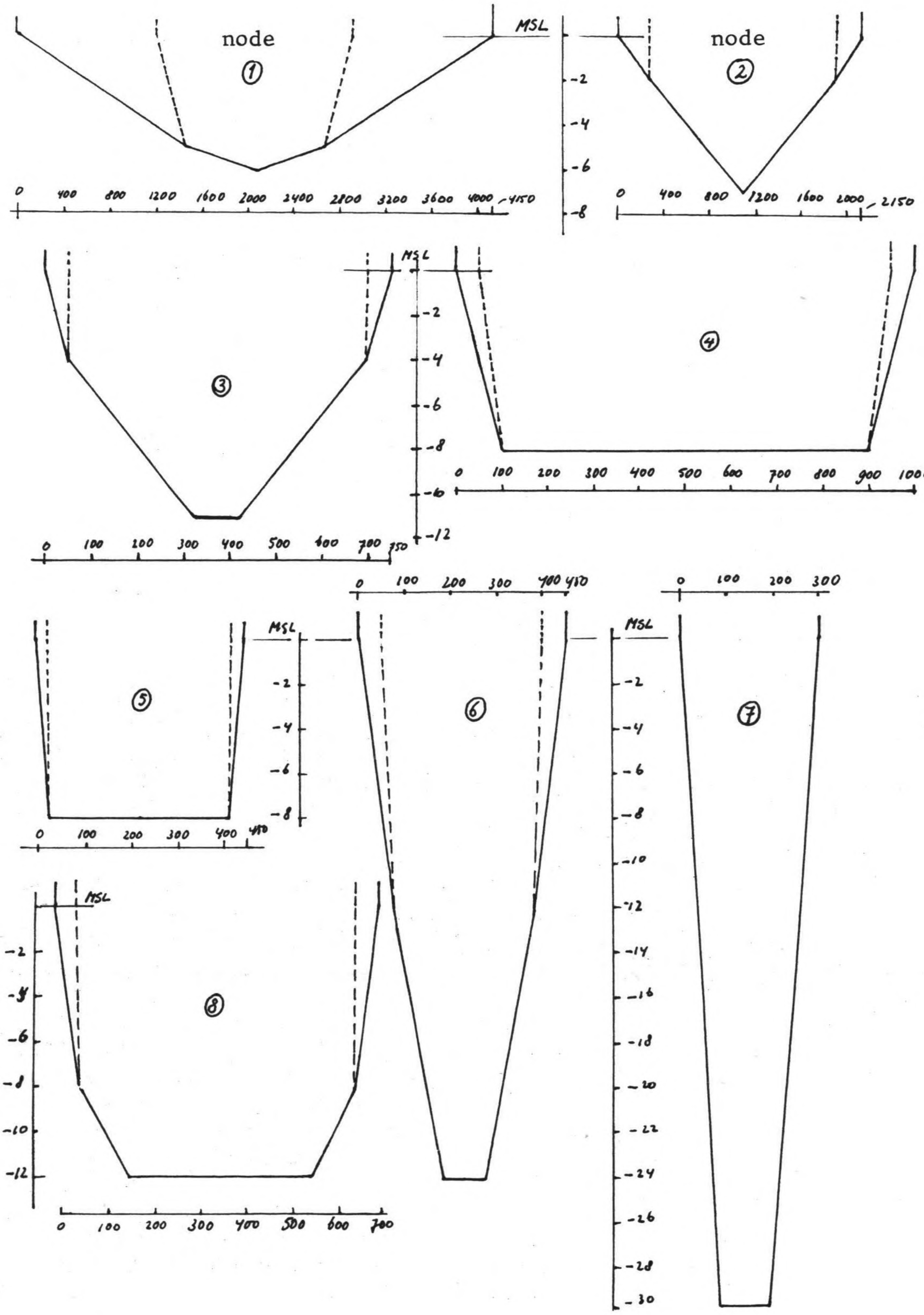
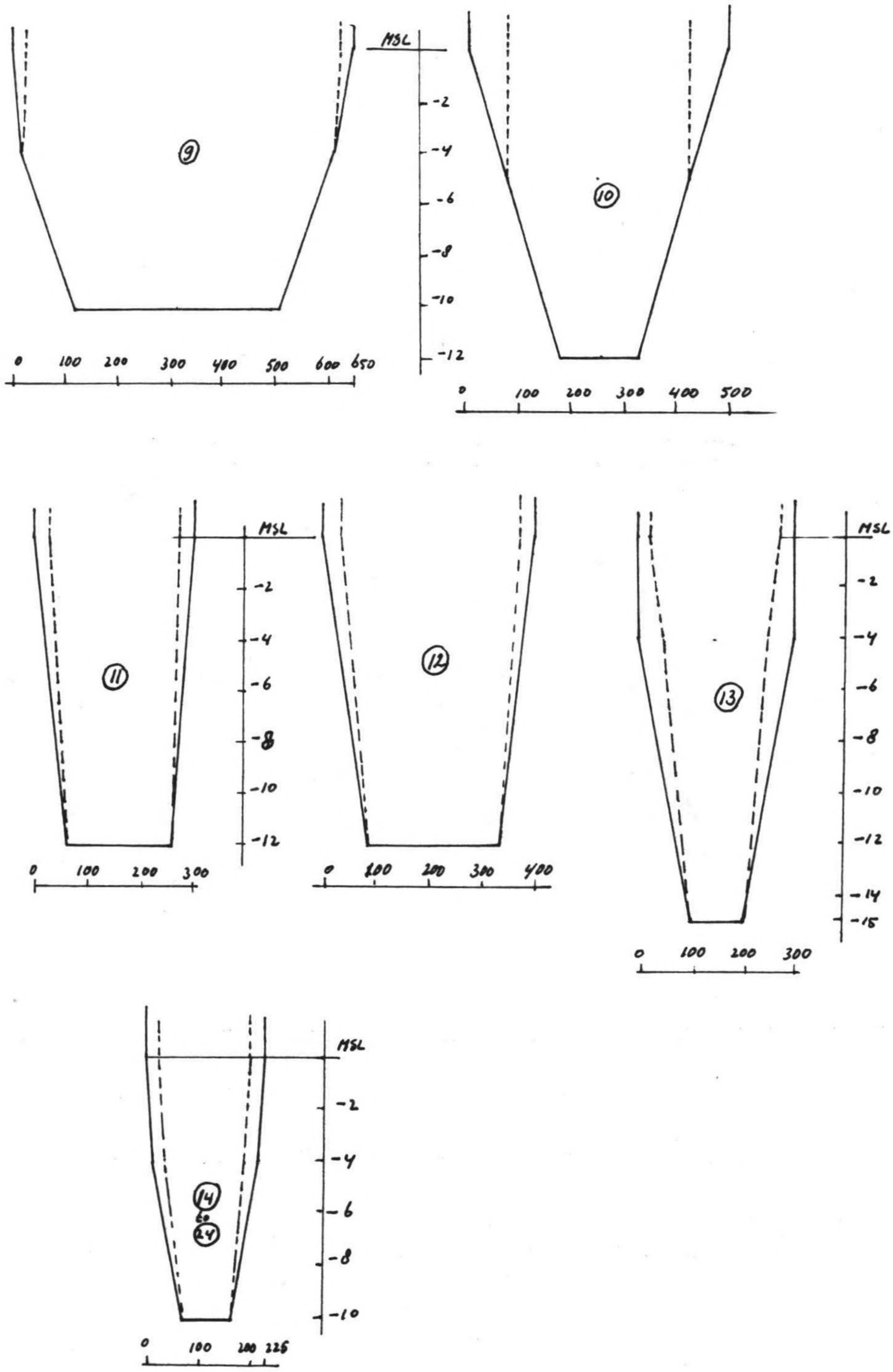
Report no. PS 658, DPMA - P4S - BTA60 Bandung.

[6] Verspuy, C. 1985.
Lange Golven, collegehandleiding.
Technische Universiteit Delft.

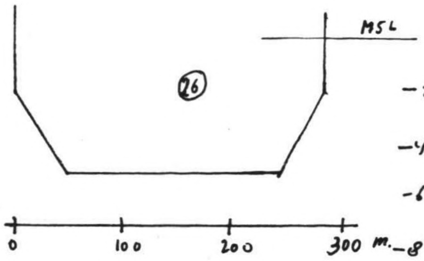
ANNEX 1   CROSS SECTIONS KAHAYAN AND SEBANGAU

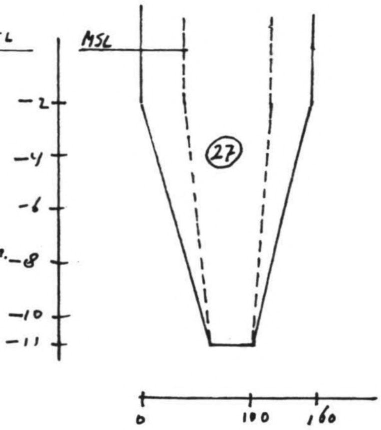
all measures in meters

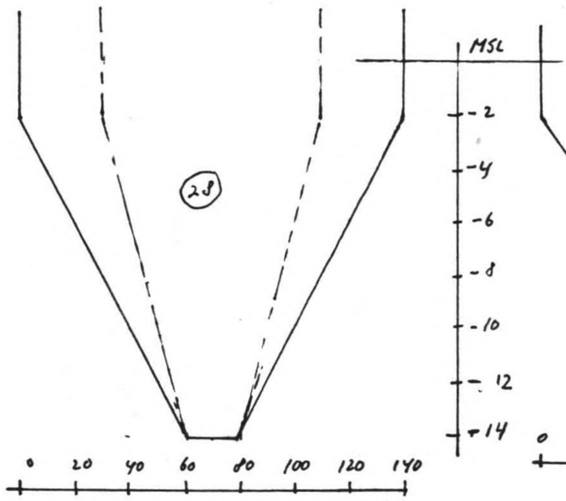


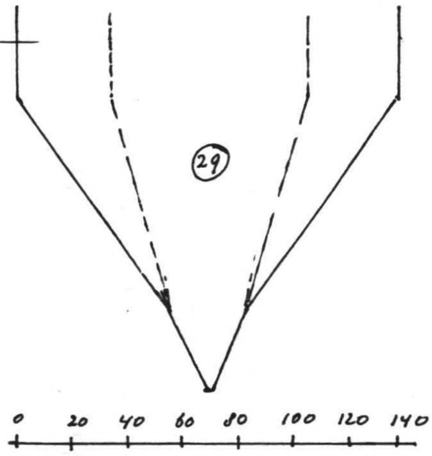


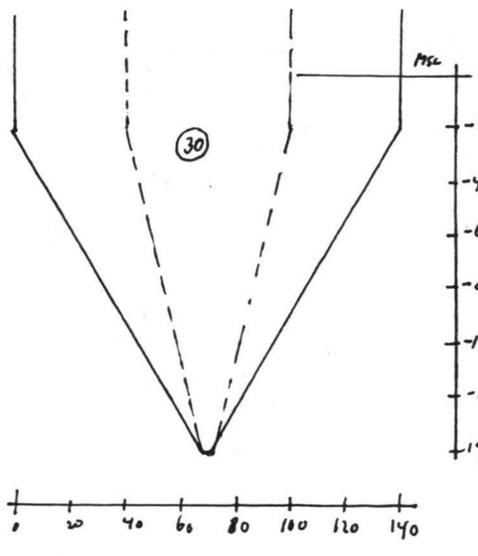
9
10
11
12
13
14
24
MSL
-2
-4
-6
-8
-10
-12
-14
-15
0 100 200 300 400 500 600 650
0 100 200 300 400 500
0 100 200 300
0 100 200 300 400
0 100 200 300
0 100 200 225

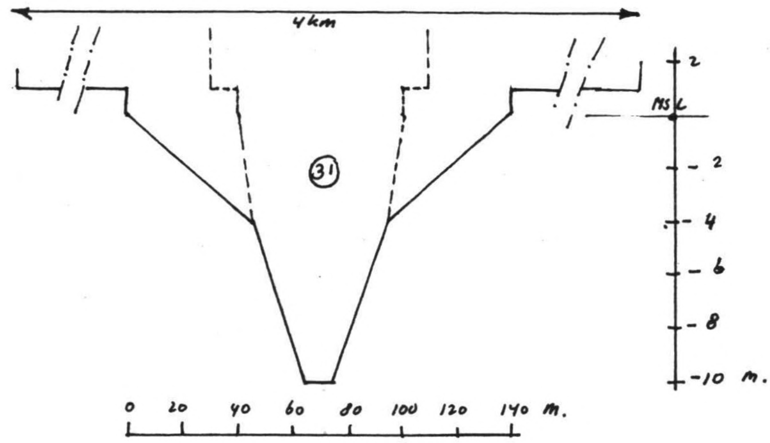

MSL
26
0
100
200
300 m.

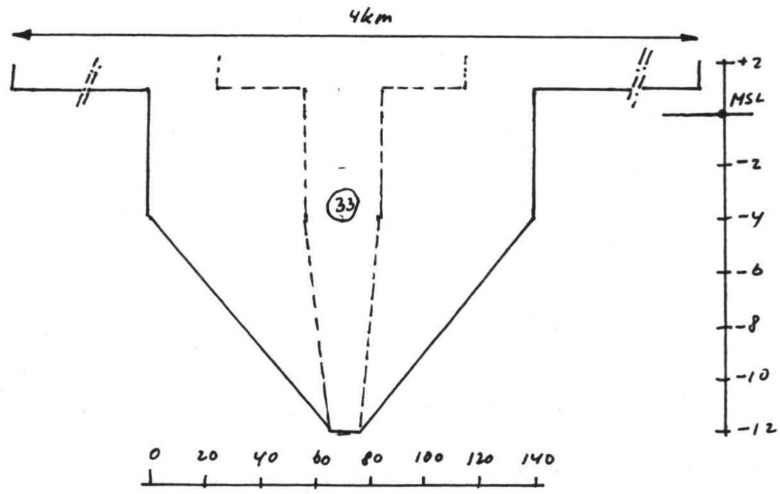

MSL
27
-2
-4
-6
-8
-10
-11
0
100
160

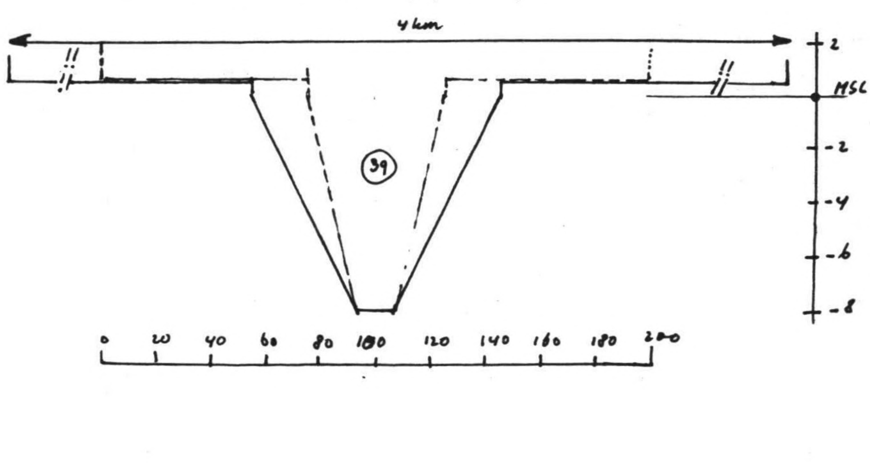

MSL
28
-2
-4
-6
-8
-10
-12
-14
0
20
40
60
80
100
120
140


29
0
20
40
60
80
100
120
140


MSL
30
-2
-4
-6
-8
-10
-12
-14
0
20
40
60
80
100
120
140


4km
31
2
MSL
2
4
6
8
-10 m.
0 20 40 60 80 100 120 140 m.


4km
33
+2
MSL
-2
-4
-6
-8
-10
-12
0 20 40 60 80 100 120 140


4km
39
2
MSL
-2
-4
-6
-8
0 20 40 60 80 100 120 140 160 180 200

ANNEX 2

COMPUTER PROGRAM FOR THE RIVER - CANAL SYSTEM

```
//WWWKCATR  JOB    (3345,),'PW VAN DE KREEKE',TIME=(,40),
//     REGION=1024K
//*LOKAAL.HDETUD2  DAG
/*JOBPARM LINES=30
//     EXEC     FLOWS
//INPUT      DD  *
FLOWS
SET NAME 'TIDAL FLOWS CANALSYSTEM'
FRICTION CHEZY 0
SET STEP 300 $ UNIT OF TIME:  1 SECOND
$ UNIT OF LENGTH 1M, DEPTH 1M, WIDTH: 1M
SET PERIOD 288

$ KAHAYAN RIVER
NODE 1 PERIOD 86400 COEF 0,0
RIVER 2 FROM 1 TO 24 LEV STOR
LEN  5000 FRICTION 0.0015 PROFILE -6,1,1, -5,1200,1200, 0,2100,4150
LEN  5000 FRICTION 0.0015 PROFILE -7,1,1, -2,1600,1600, 0,1600,2150
LEN  5000 FRICTION 0.0015 PROFILE -11,100,100, -4,650,650, 0,650,755
LEN 10000 FRICTION 0.0015 PROFILE -8,800,800, 0,900,1000
LEN 10000 FRICTION 0.0027 PROFILE -12,200,200, -8,400,400, 0,400,450
LEN 10000 FRICTION 0.0027 PROFILE -24,100,100, -12,300,300, 0,350,450
LEN 10000 FRICTION 0.0027 PROFILE -30,100,100, 0,300,300
LEN 10000 FRICTION 0.0027 PROFILE -12,200,200, -8,600,600, 0,600,700
LEN 10000 FRICTION 0.0027 PROFILE -10,400,400, -4,600,600, 0,600,650
LEN 10000 FRICTION 0.0027 PROFILE -12,150,150, -5,350,350, 0,350,500
LEN 10000 FRICTION 0.0027 PROFILE -12,200,200, 0,250,300
LEN 10000 FRICTION 0.0027 PROFILE -12,250,250, 0,350,400
LEN 10000 FRICTION 0.0039 PROFILE -15,100,100, -4,200,300, 0,250,300
LEN 10000 FRICTION 0.0039 PROFILE -10,100,100, -4,150,200, 0,175,225
LEN 10000 FRICTION 0.0039 PROFILE -10,100,100, -4,150,200, 0,175,225
LEN 10000 FRICTION 0.0039 PROFILE -10,100,100, -4,150,200, 0,175,225
LEN 10000 FRICTION 0.0039 PROFILE -10,100,100, -4,150,200, 0,175,225
LEN 10000 FRICTION 0.0039 PROFILE -10,100,100, -4,150,200, 0,175,225
LEN 10000 FRICTION 0.0039 PROFILE -10,100,100, -4,150,200, 0,175,225
LEN 10000 FRICTION 0.0039 PROFILE -10,100,100, -4,150,200, 0,175,225
LEN 10000 FRICTION 0.0039 PROFILE -10,100,100, -4,150,200, 0,175,225
LEN 10000 FRICTION 0.0039 PROFILE -10,100,100, -4,150,200, 0,175,225
LEN 10000 FRICTION 0.0039 PROFILE -10,100,100, -4,150,200, 0,175,225
LAST PROFILE -10,100,100, -4,150,200, 0,175,225
BRANCH 25 TO 24 FLOW FIX 700
INIT Q ID 700
```

```
$ SEBANGAU RIVER
NODE 26 PERIOD 86400 COEF 0,0
RIVER 27 FROM 26 TO 43 LEV STOR
LEN 10000 FRICTION 0.0039 PROFILE -5,200,200, -2,285,285
LEN 10000 FRICTION 0.0039 PROFILE -11,40,40, -2,80,160
LEN 10000 FRICTION 0.0039 PROFILE -14,20,20, -2,80,140
LEN 10000 FRICTION 0.0061 PROFILE -13,1,1, -10,30,30, -2,70,140
LEN 10000 FRICTION 0.0061 PROFILE -14,1,1, -2,60,140
LEN 10000 FRICTION 0.0109 PROFILE -10,10,10, -4,50,50, 0,55,140,-
                                  1.0,55,140,1.05,80,4000
LEN 10000 FRICTION 0.0109 PROFILE -11,15,15, -4,35,140, 1.0,35,140,1.05,90,4000
LEN 10000 FRICTION 0.0109 PROFILE -12,10,10, -4,25,140, 0.8,25,140,0.85,90,4000
LEN 10000 FRICTION 0.0109 PROFILE -9,2,2, -6,20,140, 0.6,20,140,0.65,200,4000
LEN 10000 FRICTION 0.0109 PROFILE -8,10,10, 0,35,140, 0.5,35,140,0.55,200,4000
LEN 10000 FRICTION 0.0109 PROFILE -8,1,1, -6,27,120, 0.5,27,120,0.55,200,4000
LEN 10000 FRICTION 0.0109 PROFILE -8,10,10, 0,50,90, 0.5,50,90,0.55,200,4000
LEN 10000 FRICTION 0.0109 PROFILE -7,25,25, 0,50,90, 0.5,50,90,0.55,200,4000
LEN 10000 FRICTION 0.0109 PROFILE -8,15,15, 0,50,90, 0.5,50,90,0.55,200,4000
LEN 10000 FRICTION 0.0109 PROFILE -8,20,20, 0,50,90, 0.5,50,90,0.55,200,4000
LEN 10000 FRICTION 0.0109 PROFILE -8,15,15, 0,55,90, 0.5,55,90,0.55,200,4000
LEN 10000 FRICTION 0.0109 PROFILE -8,20,20, -2,40,90, 0.5,40,90,0.55,200,4000
LAST PROFILE -4,20,20, 0,30,80, 0.5,30,80, 0.55,200,4000
BRANCH 44 TO 28 FLOW FIX 100
BRANCH 45 TO 29 FLOW FIX 40
BRANCH 46 TO 31 FLOW FIX 130
BRANCH 47 TO 32 FLOW FIX 70
BRANCH 48 TO 38 FLOW FIX 100
BRANCH 49 TO 43 FLOW FIX 100
INIT H 43 2.83
INIT H 42 2.79
INIT H 41 2.77
INIT H 40 2.75
INIT H 39 2.73
INIT H 38 2.71
INIT H 37 2.6
INIT H 36 2.48
INIT H 35 2.33
INIT H 34 2.14
INIT H 33 1.89
INIT H 32 1.63
INIT H 31 1.18
INIT H 30 0.77
INIT H 29 0.49
INIT H 28 0.35
INIT H 27 0.16
INIT Q ID 100

$ CANAL
CANAL 50 FROM 9 TO 51 LEN 6000 WIDTH 50 DEPTH 3 FRICTION 0.0039
CANAL 51 FROM 51 TO 36 LEN 18000 WIDTH 50 DEPTH 3 FRICTION 0.0039

$ COMPUTATION COMMANDS
COMPUTE STEADY FLOWS ACCURACY 0.01 ITER 50
NODE 1  PERIOD 86400 COEF 0,1.2
NODE 26 PERIOD 86400 COEF 0,1.2
SET PRINT 72
COMPUTE UNSTEADY FLOWS OVER 864
SET PRINT 12
COMPUTE UNSTEADY FLOWS OVER 288
FINISH
/*
//
```

ANNEX 3

FIGURES WATER LEVELS AND DISCHARGES

Remark: all water levels in meters
all discharges in m^3/s.
horizontal schale: time in hours

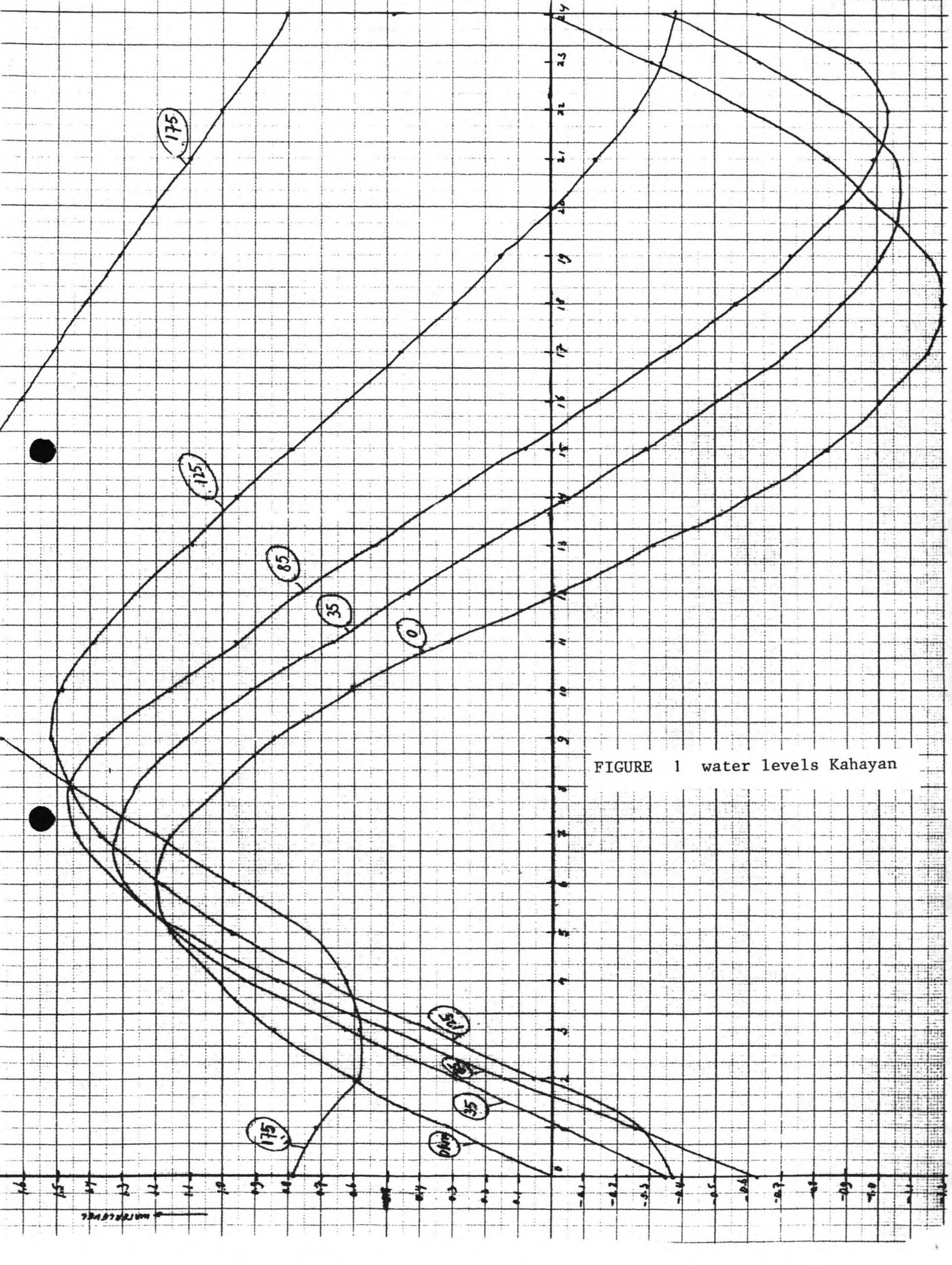


FIGURE 1 water levels Kahayan

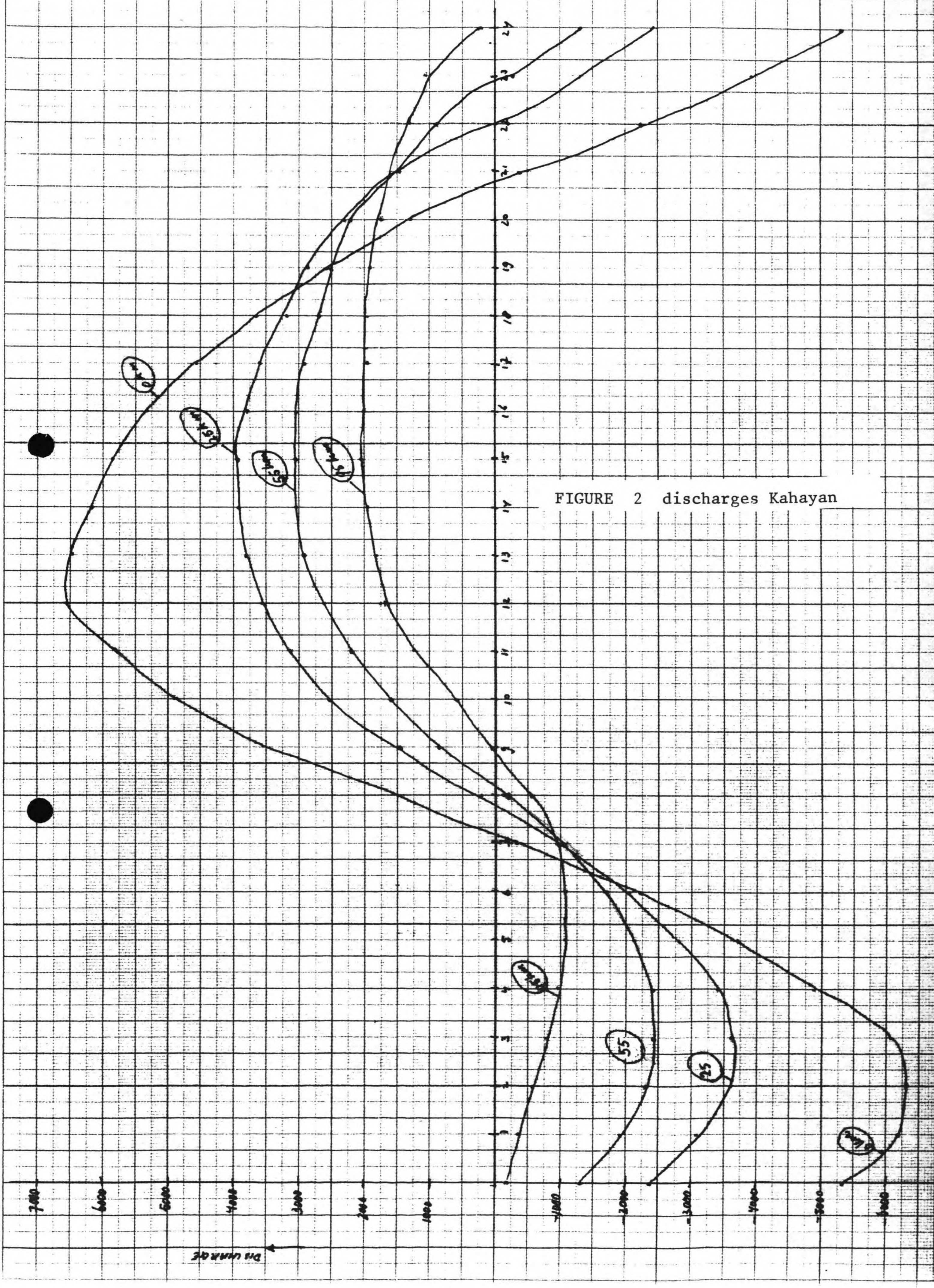


FIGURE 2 discharges Kahayan

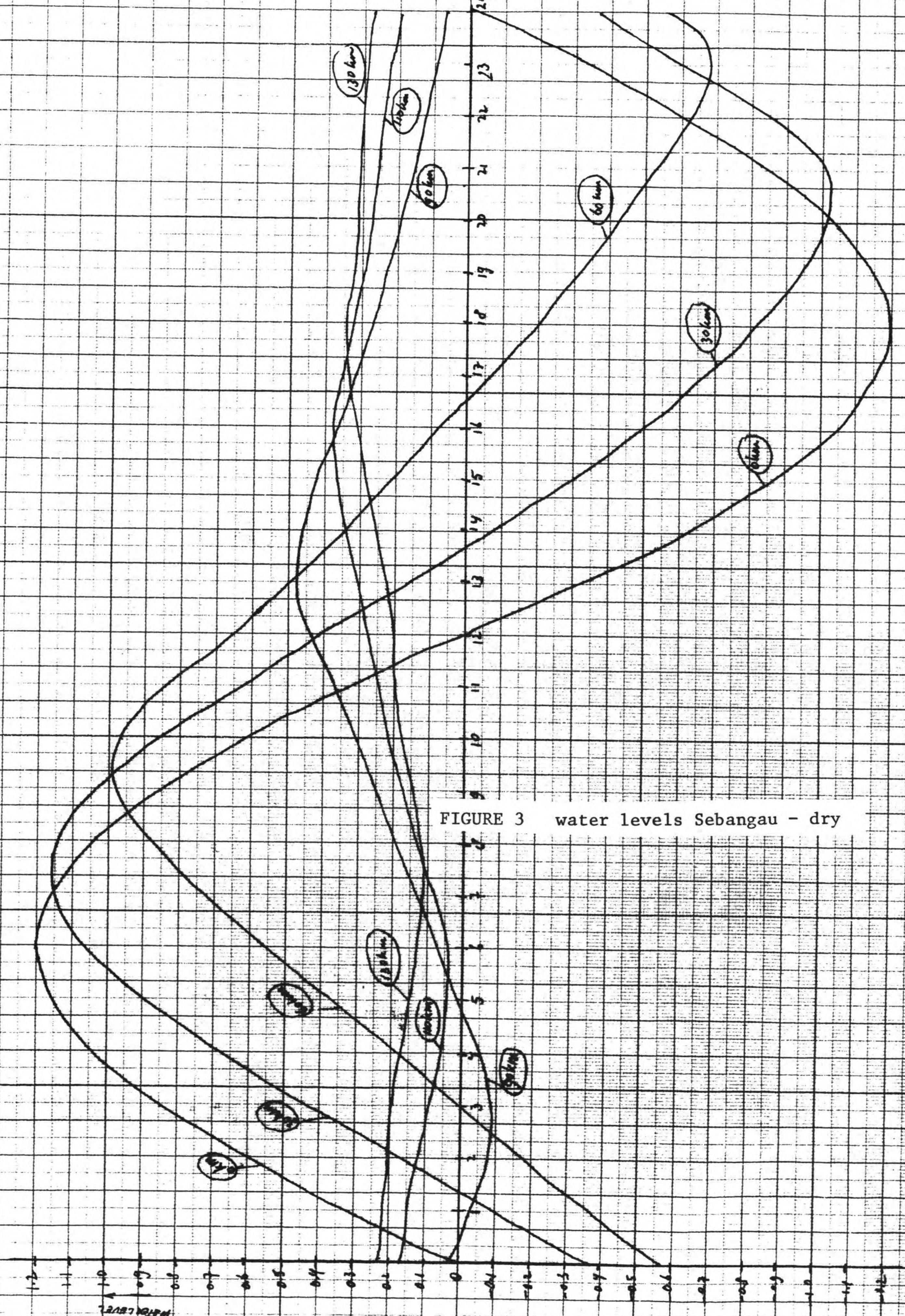


FIGURE 3 water levels Sebangau - dry

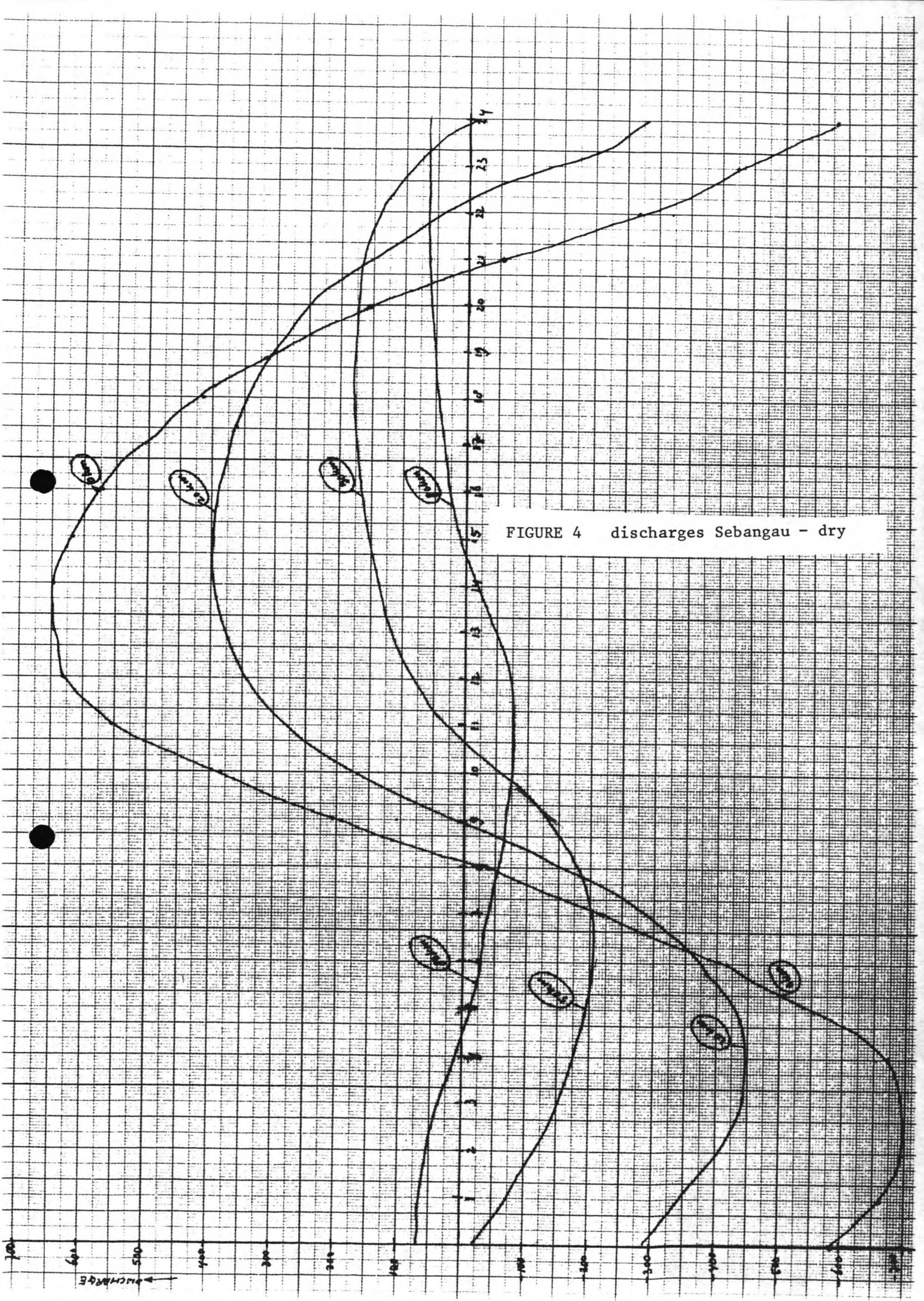


FIGURE 4 discharges Sebangau - dry

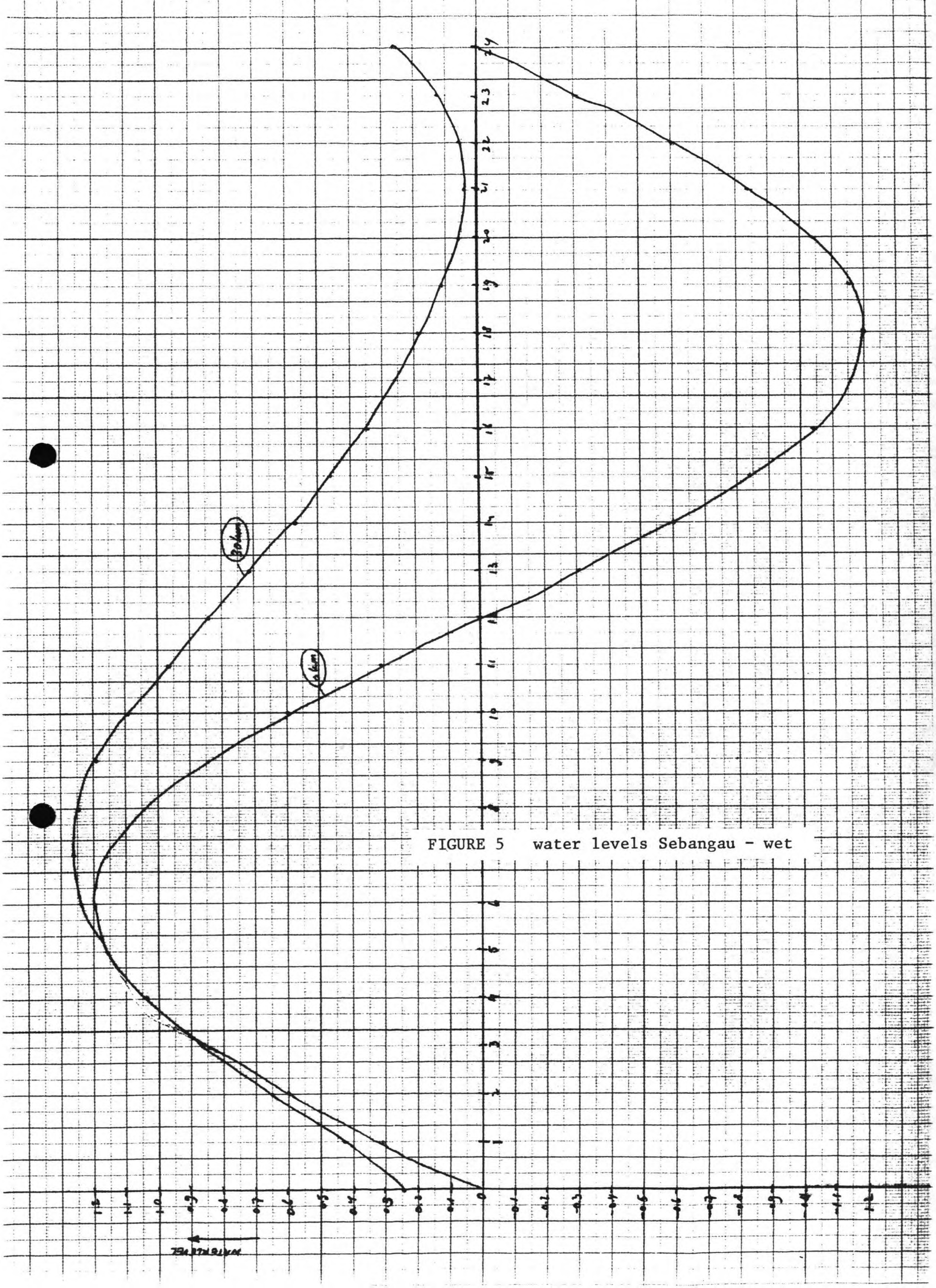


FIGURE 5 water levels Sebangau - wet

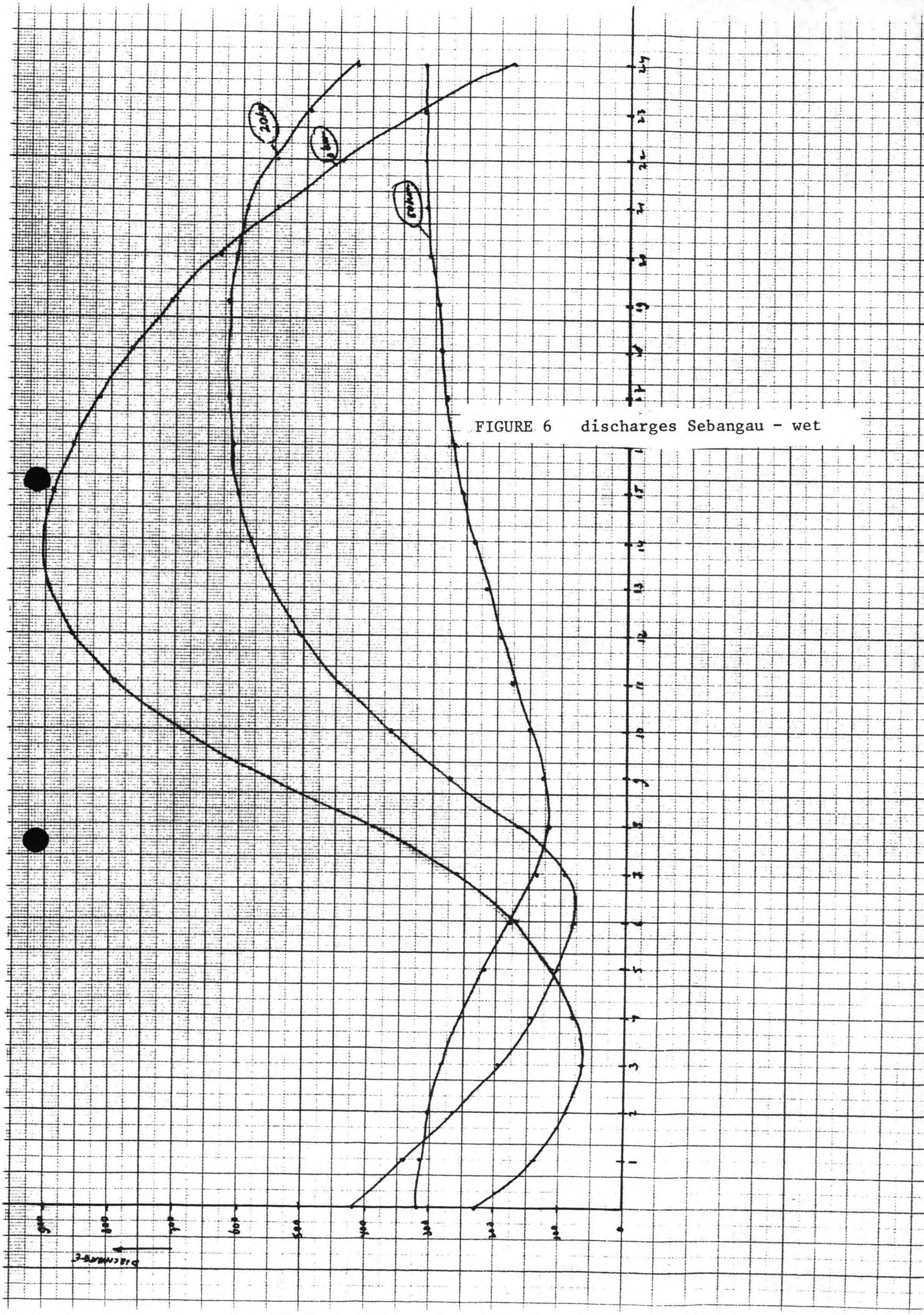


FIGURE 6 discharges Sebangau - wet

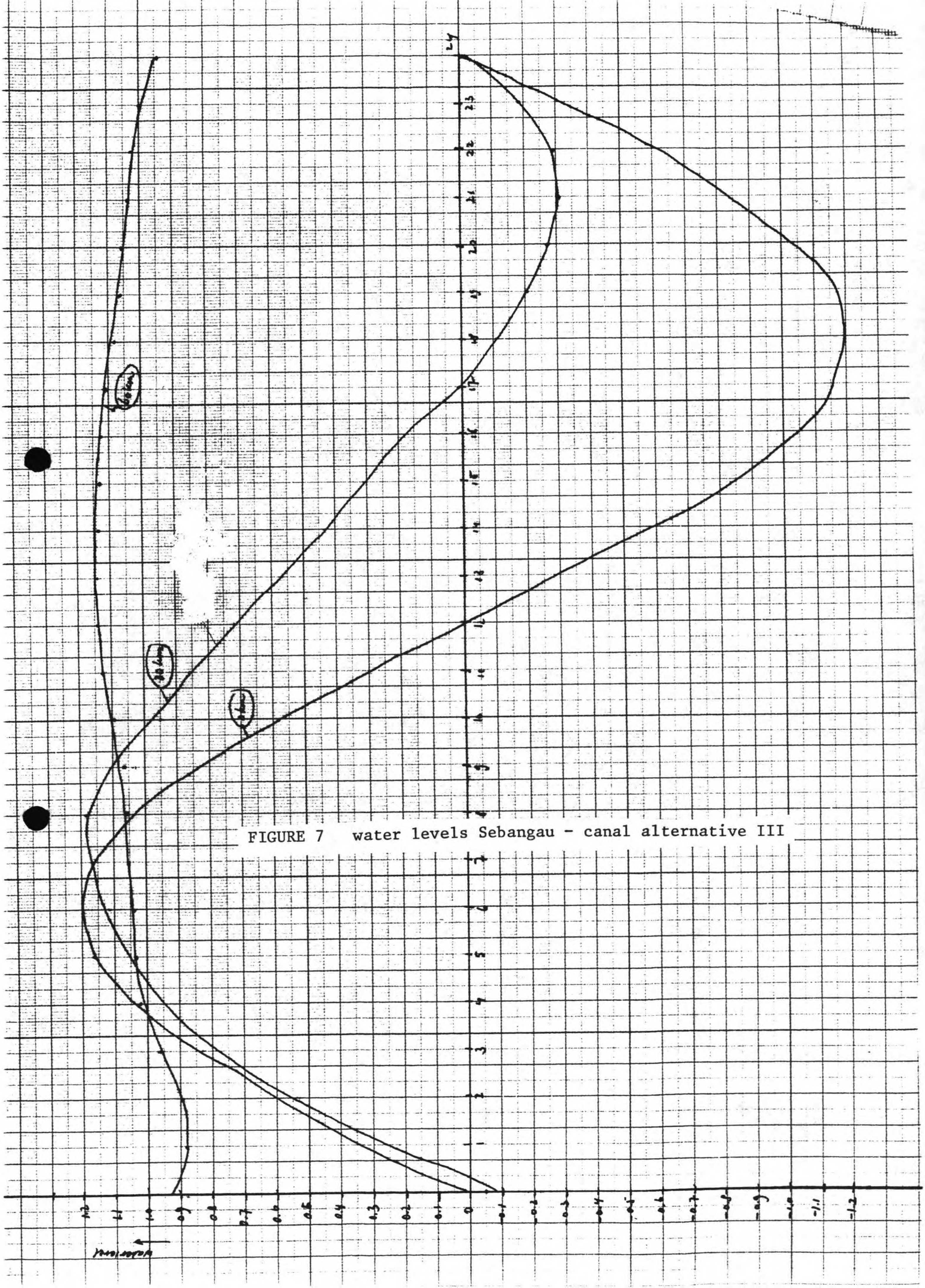


FIGURE 7 water levels Sebangau - canal alternative III

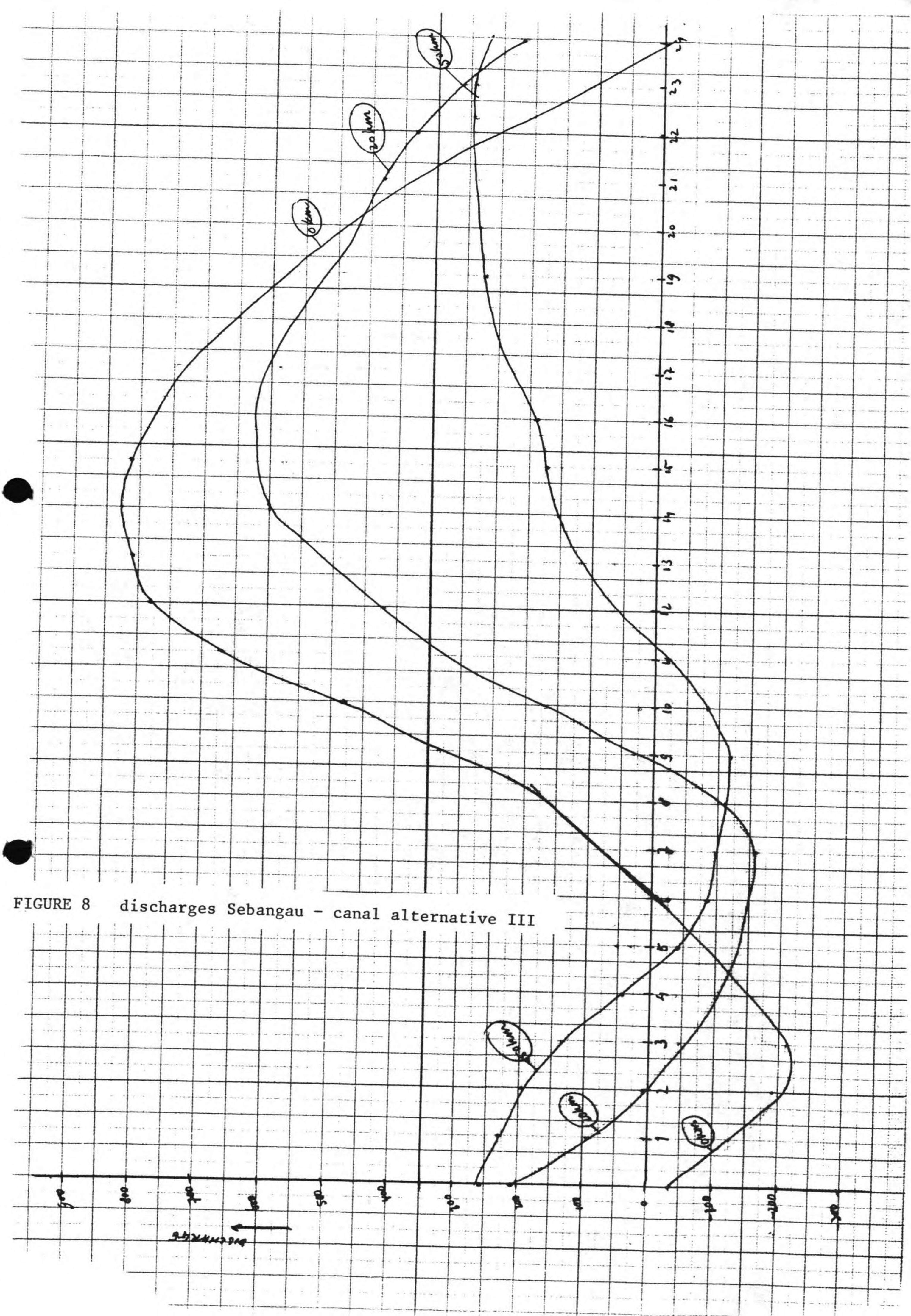


FIGURE 8 discharges Sebangau - canal alternative III