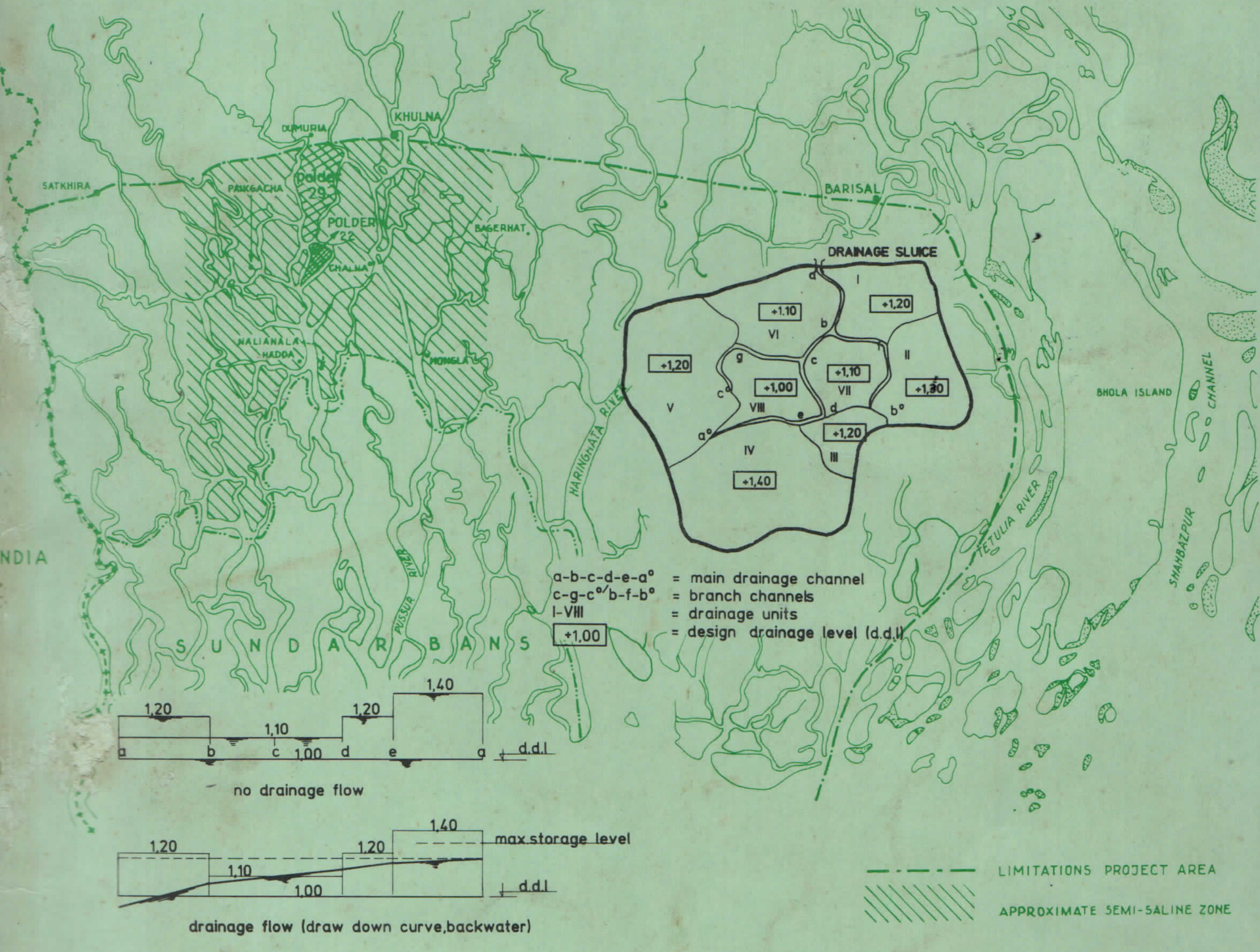
DESIGN MANUAL

FOR POLDERS IN SOUTH-WEST BANGLADESH



PART 4, VOL. IX (SAMPLE DESIGN)

DELTA DEVELOPMENT PROJECT
BANGLADESH-NETHERLANDS JOINT PROGRAMME
UNDER BWDB

DHAKA
NOVEMBER 1985

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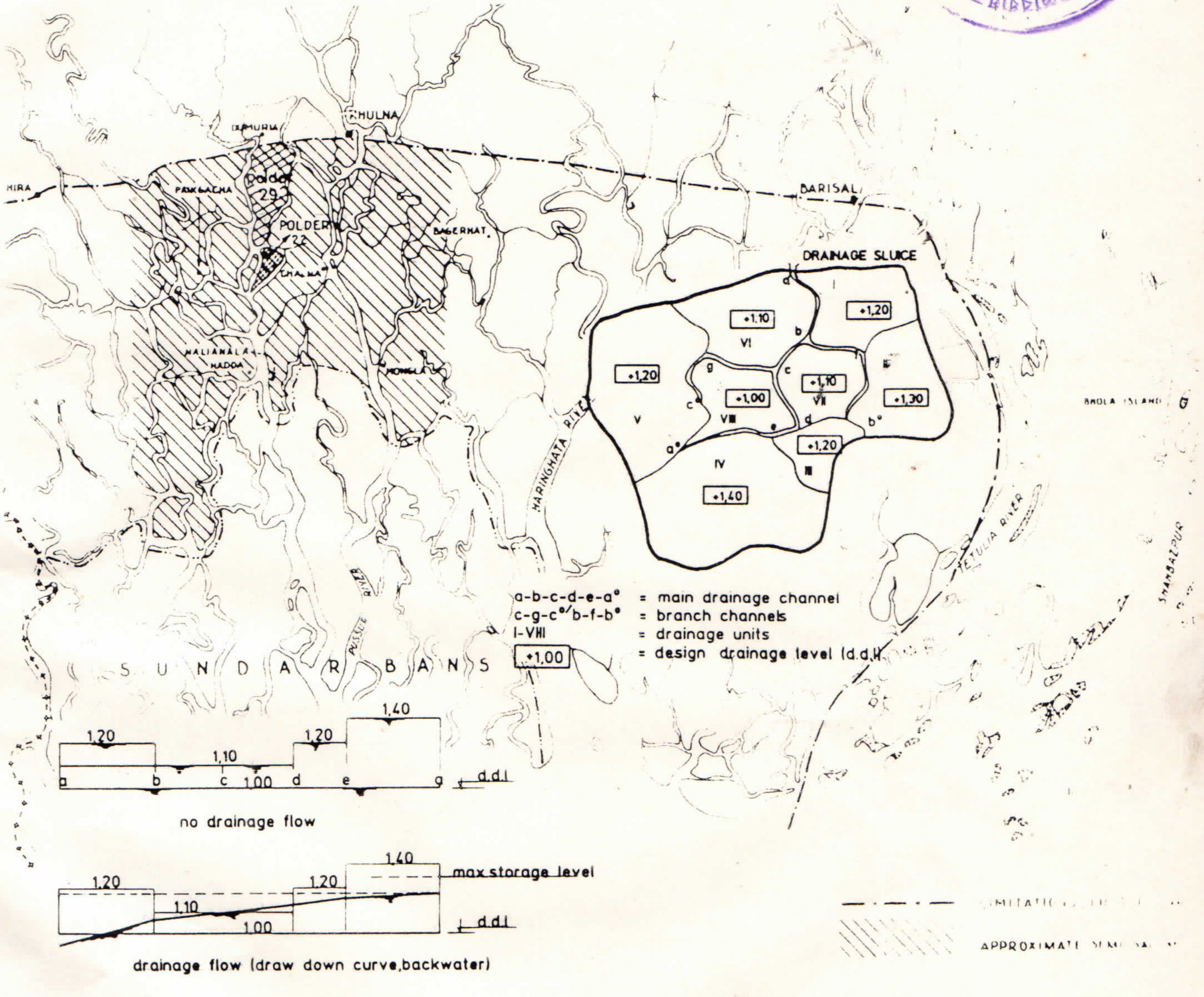

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THIS DESIGN MANUAL CONSISTS OF THE FOLLOWING PARTS AND VOLUMES :

PART 1

VOLUME I	INTRODUCTION AND SUMMARY OF DESIGN PROCEDURES
VOLUME II	SURVEY AND MEASUREMENTS
VOLUME III	DESIGN OF EMBANKMENTS, CLOSURE DAMS
VOLUME IV	IRRIGATION AND DRAINAGE REQUIREMENTS - DESIGN CRITERIA
ANNEX PART 1	COMMENTS ON AND REMARKS OF DESIGN CIRCLE-I

PART 2

VOLUME V	HYDRAULIC COMPUTATIONS
VOLUME VI	FOUNDATION DESIGN
VOLUME VII	GENERAL AND STRUCTURAL DESIGN ASPECTS

PART 3

VOLUME VIII	BASIC DESIGN DRAWINGS

PART 4

VOLUME IX	WORKED-OUT EXAMPLE.

VOLUME IX WORKED - OUT EXAMPLE

Table of Contents

VOLUME IX WORKED - OUT EXAMPLE

Introduction

In this Volume a complete worked-out example is presented, as far as the basic data provided permitted, of the design of drainage and irrigation structures for a polder in the delta area.

The worked out example is based on the design work carried out by the BWDB Design Department III, who prepared the design of two tidal drainage sluices for Polder - 43/2c,Patuakhali District, a scheme taken up by E.I.P. in 1984-85. For the design of the two sluices, the BWDB - design engineers used the draft manual as the basis.

In the following worked out example it should be noted that a different design drainage level has been assumed than in the BWDB design. The example furthermore only considers the southern part of the scheme, i.e. sluice S-2 in Munchir Khal.

The foundation and structural part of the try-out design of the BWDB design engineer was found to be in good order and procedures were followed very well. Therefore there was no need to elaborate further on this subject in the worked-out example.

2.4.1 Data Collection

a) Information on the area:

from Project Report no. 11: (see ANNEX IX-1)

crops grown : rabi, aus, T-aman.

T-aman grown in nearly entire area.
Damages due to saline water intrusion during spring tides January-May and drainage congestion/fresh water flooding in monsoon period.

project area : 5800 acres = 2347 ha

90% is medium level
low level is 0.30 m below medium
high level is 0.30-0.60 m above medium.

highland : 500 acres = 202 ha: T-aman+rabi

medium land: 5200 acres = 2104 ha:

41% = 863 ha is single crop, T-aman.
36% = 757 ha is double crop, T-aman + aus or rabi.
23% = 484 ha is triple crop, T-aman + aus + rabi.

low land: 100 acres = 41 ha: Boro (12 ha) or T-aman + rabi (29 ha).

The boro area (12 ha) is submerged during most of the year. Aus seedlings are prepared in April-May, suffer from saline flooding during spring tides.

HYV were for some years grown in 50% of the area, but this practice was abandoned after a few years due to saline constraints (flooding).

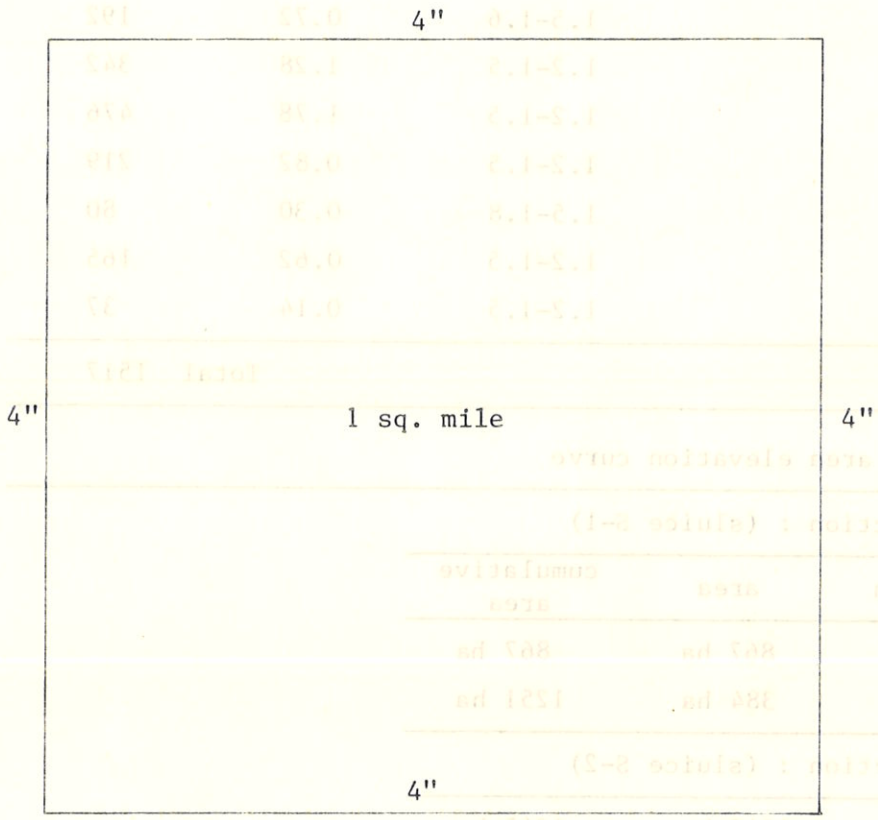
Irrigation is practiced with five low lift pumps and donga over 225 acres = 91 ha.

There exists a large number of internal khals of which 37 running miles (= 59.5 km) have been surveyed.

b) Topographic information

Planimetering of the available topographic maps yields the following information:

- calculation of planimeter constant: scale : 4" = 1 mile.



0.97 revolutions = 1 sq. mile

1 rev. $= \frac{1}{0.97}$ sq. mile $= \frac{1}{0.97}$ x 259 ha = 267 ha.

- planimetering of map: (see ANNEX IV - 2).

Upper section of the map : (sluice S-1)

Symbol no.	planimeter constant	contour in between (m)	revolution no.	required calculated area (ha)
1	267	1.2-1.5	1.23	328
2		1.2-1.5	2.02	539
3		1.5-1.8	0.72	192
4		1.5-1.8	0.72	192
			Total	1251

lower section of the map: (sluice S-2)

1	267	1.5	0.02	5
2		1.5-1.6	0.72	192
3		1.2-1.5	1.28	342
4		1.2-1.5	1.78	476
5		1.2-1.5	0.82	219
6		1.5-1.8	0.30	80
7		1.2-1.5	0.62	165
8		1.2-1.5	0.14	37
			Total	1517

- data for area elevation curve

upper section : (sluice S-1)

elevation	area	cumulative area
1.5 m	867 ha	867 ha
1.8 m	384 ha	1251 ha

lower section : (sluice S-2)

1.5 m	1245 ha	1245 ha
1.8 m	272 ha	1517 ha

From the contour map it is seen that the total area is within + 1.8 m elevation.

total drainage area for sluice S-1 = 1251 ha

total drainage area for sluice S-2 = 1517 ha.

For area elevation curve (sluice S-2) :

area below 1.8 m:1517 ha.

area below 1.5 m:1245 ha. (rather high!) check maps.

area below 1.35m: 200 ha. (estimated roughly).

area below 1.2 m : 12 ha

lowest point + 1.08 m

highest point + 2.13 m.

c) aerial photos not included in design material

d) detailed topographic survey is available for the proposed sluice construction site.

e) Rainfall and evaporation information from Patuakhali may be used. Duration curves available in the Design Manual.

f) Water levels of station Golachipa (185), River Lohalia of the years 1968-1980 were included in the design material. For the year 1968/1969 the water levels have been analysed and processed to determine the fortnightly mean level. (see ANNEX IX-3 and -4).

On ANNEX IX-5, the fortnightly mean water levels (F.M.L.) for the years of record have been summarized and the mean value (50%) was determined.

On ANNEX IX-6, the same was done for the mean high meters (M.H.W.) and mean low waters (M.L.W.).

On ANNEX IX-7, the highest high water spring tide (H.H.W.) and the lowest low water springtide (L.L.W.) are summarized for the years of records and the critical period for drainage, as determined later on. (second half of June , first half of July).

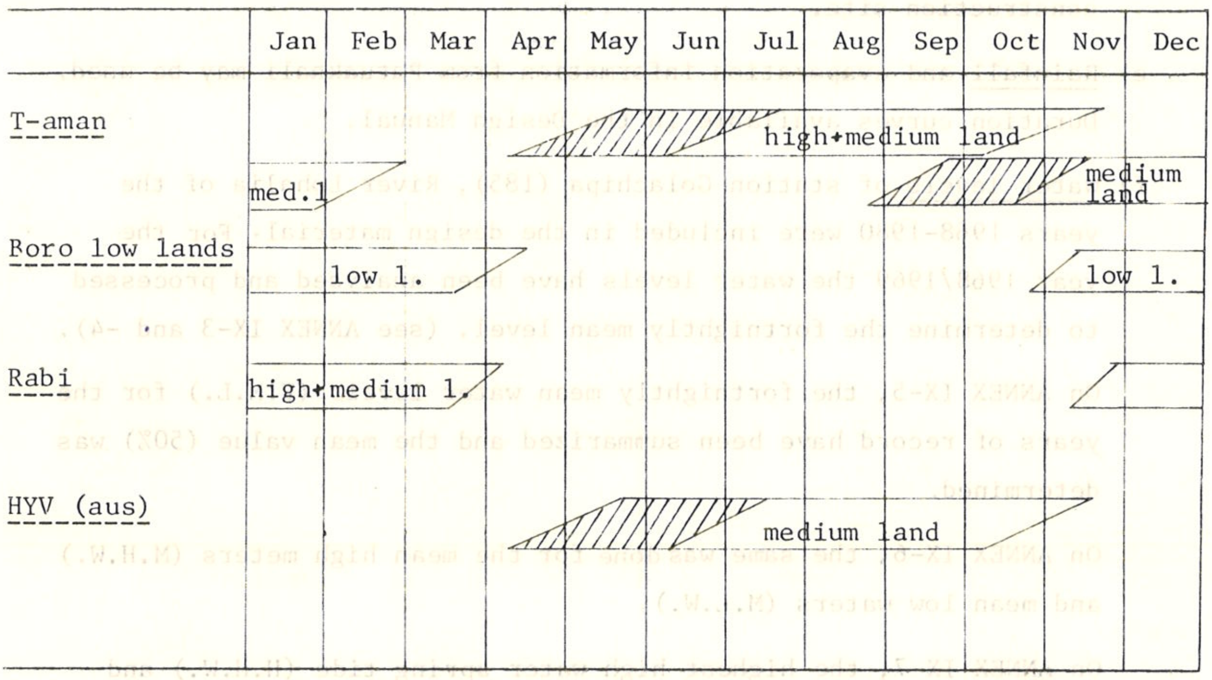
Since the Golachipa gauge is very near to the project area, readings from this gauge can be maintained for the tide at the drainage sluices. This was confirmed by the readings of two temporary gauges installed at the proposed sluice sites which were taken during two months and were correlated to the Golachipa gauge reading. (see Project Report no. 11).

g) Salinity

The project report mentions saline river waters from January-May.

2.4.2 Data Evaluation

a) Based on the available information on present agricultural use, the following cropping calendre for the area has been assumed:



From the information of the topographic maps, an area - elevation curve for the S-2 area is prepared and presented in ANNEX IX-8.

Because the area is to be considered as extremely flat, vast areas could be cultivated with HYV. If a d.d.l. of + 1.30 m is assumed, then almost the entire area, except 100 ha could be under HYV.

The m.a.st.l. which should be adopted is then + 1.50 m.

However, the HYV require a very high drainage modulus in order to cope with the restricted capacity of storage of water in the paddy fields. This drainage modulus will result in a high required sluice discharge, which in it self requires a vast storage area because otherwise the water levels in the drainage channel would drop too much during the sluice period T.

The storage area is highly dependent on the features of the agricultural use, and will be influenced by the fact if the lands are bunded and if the drainage channel is bunded.

Since the polder is very flat with little relief, their is definite scope to use the drainage channels also as irrigation supply channels, but this requires all the main channels to be bunded so that the irrigation water can reach all parts of the polder. The bunding of all main channels will however reduce the storage capacity.

On optimum has to be found based on the above considerations.

In the following, it has been assumed arbitrarily that the design drainage level will be at + 1.30 m and the maximum allowable storage level will be at + 1.60 m and that the drainage modulus is determined for long straw varieties which will be grown in the polder.

From ANNEX IV-5 the F.M.L. is plotted on ANNEX IX-9, together with the MHW and MLW levels.

For every fortnightly period, the drainage time T of the average tide curve is determined on ANNEX IX-10. Since no additional information is available on the shape of the tide curve, the best fitting sinus shape for the tide curves is estimated from the information on M.H.W., M.L.W. and F.M.L.

Drainage time T is determined according to point 2.4.4.-d) of Volume I.

2.4.4. Drainage Design of the Polder

a) Determine the drainage modules for each month, May to August for the assumed m.a.st.l. of + 1.60 m. The rainfall duration curves for once in 10 years rainfall and the drainage modulus are plotted on ANNEX IX-11.

The criteria for the determination of the drainage modulus as :

1. The maximum depth of flooding on top of the ground surface should not exceed 200 mm for short straw varieties and 400 mm for long straw varieties. The fieldstorage that can be provided by the rice fields is resp. 100 mm and 300 mm if we consider an initial water level in the rice fields of 100 mm.

2. Starting from the initial water level of 100 mm in the rice fields, the maximum duration of the flooding above this level may not exceed 8 days.

The drainage modulus is now determined for each month and each variety (area cropped with the variety).

b) To yield the sluice discharge the drainage modulus, and area is multiplied with the sluice coefficient $\frac{T_o}{T}$

$$Q_{av} = \text{drainage mod. (mm/day)} \times \text{area (ha)} \times 1.16 \times 10^{-4} \times \frac{T_o}{T} = m^3/s$$

For the sluice S-2 area and the assumptions made for the cropping pattern, the results are :

	May		June		July		August	
	2-16	17-31	1-15	16-30	1-15	16-30	31-14	15-29
drainage modulus:								
- short straw var.	33.4		98.75		71.50		116.67	
- long straw var.	29.9*)		65.5*)		52.13*)		53.5*)	
Sluice period T(hrs)	7.0	6.7	6.5	6.15	6.15	6.05	5.85	5.7
average drainage discharge (m^3/s)								
50% long str. var. / 50% short str. var.	9.87	10.31	17.57	29.14	21.93	22.29	31.74	32.57
100% long str.var.	9.32	9.73	21.99	23.24	18.49	18.80	19.96	20.48

*) 8-day criteria critical.

It appears that the second half of June is the most critical period with a Q_{av} = 23.24 m^3/s in case the whole polder is considered under long straw varieties.

If we consider 50% of the area under short straw varieties then the total drainage requirement would be 32.57 m^3/s in the second half of August.

In order to be on the conservative side, since only scarse information on the capacity of the drainage channel is available, the design will continue using the design discharge for the case with long straw varieties.

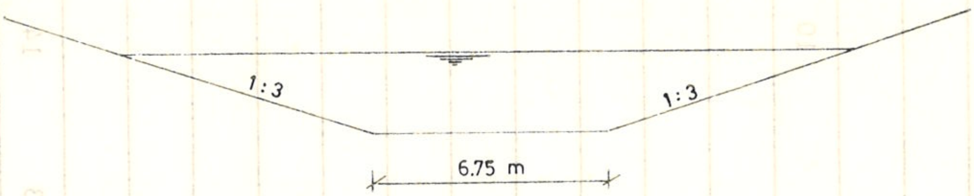
c) Determine the design drainage discharge for each section of the main drainage channel.

Sub-divide therefore the polder area in parts which drain to a certain channel section.

This is done on ANNEX IX-12, and with the table of page 10.

A longsection of the main drainage channel is plotted on ANNEX IX-13 in which the discharge points a .... a* are plotted. For every channel section the mean discharge is now determined.

Total length of main drainage channel as measured from the map is 7880 m for stretch a - a* and 1660 m for stretch e - e*. Only of the first 2000 m (6400 ft) information on the bottom slope is available and of the first 800 m (2600 ft) cross-sections are available which are plotted on ANNEX IX-14 to determine the schematised cross-section for the drainage channel, which is as shown below for the downstream end of the drainage channel.



The schematisation of the whole drainage channel therefore has to be assumed which is done in the following table.

section	a - e	e - i	i - l	l - m	n - o	o - a*
length (m)	1610	1040	1000	590	1740	1900
average bottom slope x 10^{-4}	3	3	3	3	3	3
average bottom width (m)	6.75	6.25	5.25	4.50	3.50	2.00
roughness coefficient (n)	0.045	0.045	0.045	0.045	0.045	0.045
Q_{av} = 23.24 m^3/s	22.76	14.22	11.56	8.34	5.48	3.22

area part	area (ha)	discharge point a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s
I	264																264			
II	105																			105
III	82																		82	
IV	48															48				
V	19						10											9		
VI	80												24		56					
VII	70										70									
VIII	136																		136	
IX	189			57														113	19	
X	24		24																	
XI	76													76						
XII	177												177							
XIII	40											40								
XIV	53										53									
XV	53									53										
XVI	60								60											
XVII	41				13		14	14												
Total	1517	1517	24	57	13	464	24	14	60	53	123	40	201	76	56	48	264	122	237	105
Cummulative		1517	1517	1493	1436	1423	959	935	921	861	808	685	645	444	368	312	264	464	342	105
Q_{av} = (m^3/s)		23.24	23.24	22.87	22.00	21.80	14.69	14.32	14.11	13.19	12.38	10.49	9.88	6.80	5.64	4.78	4.04	7.11	5.24	1.61

The normal waterdepth for each section is now calculated using Manning's formula and the above information.

normal water-depth (m)	2.75	2.25	2.14	1.90	1.67	1.47

In order to plot the delivery curves for the drainage channel, the normal waterdepths for a range of discharges is furthermore calculated according to the same procedure.

	Q in section *)					
Q sluice	a - e	e - i	i - l	l - m	n - o	o - a*
30 m^3/s	h_n=3.11 m	2.54	2.41	2.15	1.87	1.65
28	3.01	2.46	2.33	2.08	1.82	1.60
26	2.90	2.37	2.25	2.01	1.75	1.55
24	2.80	2.28	2.17	1.93	1.69	1.49
22	2.68	2.19	2.08	1.86	1.62	1.44
20	2.56	2.09	1.99	1.77	1.55	1.38
18	2.44	1.98	1.89	1.69	1.48	1.31
16	2.30	1.87	1.78	1.59	1.40	1.25
14	2.15	1.75	1.67	1.49	1.30	1.17
12	2.00	1.62	1.55	1.38	1.22	1.09
10	1.82	1.48	1.41	1.26	1.11	1.01
8	1.63	1.32	1.26	1.13	1.00	0.91

*) The discharges of other stretches are adapted proportionally to the surface drained.

d) From the schematisation of the drainage channel the surface area of the drainage channels is determined at the level of + 1.50 and + 1.30 and at the end of the drainage period T.

section	a - e	e - i	i - 1	1 - m	n - o	o - a*
length	1610	1040	1000	590	1740	1900
side slope	1 : 3	1 : 3	1 : 3	1 : 3	1 : 3	1 : 3
average bottom lev.	-2.76	-2.37	-2.06	-1.82	-1.47	-0.93
average bottomwidth	6.75	6.25	5.25	4.50	3.50	2.00
surfacewidth at + 1.50 m	32.3	29.5	26.6	24.4	21.3	16.6
area at +1.50	52,003	30,680	26,600	14,396	37,062	31,540
surfacewidth at + 1.30 m	31.1	28.3	25.4	23.2	20.1	15.4
area + 1.30 m	50,071	29,432	25,400	13,688	34,974	29,260

Branch channel e - e*, length 1660 m, estimated surface width at + 1.50 is 24 m, at + 1.30, 22.5 m.

From the Project Report it is known that total length of internal khals in the area is 37 miles (= 59.500 m) for the whole area.

Estimate for the S - 2 area: $\frac{1517}{1517+1251}$ x 59,500 = 32,600 m.

Branch a - a* = 7880 m
Branch e - e* = 1660 m
remaining channels= 23060 m
total 32600 m

Estimate the average surface width of the remaining channels to be 8 m at + 1.50 m level and 7.5 m at + 1.30 m level.

Estimate area of low pockets, which are in open connection with the drainage channels from the topographic map : 41 ha = 410000 m^2 to be submerged at the level of

+ 1.30 and 152 ha (10% of the area is low land) to be submerged and in open connection with the drainage channels at the level of + 1.50 m.

With the above information the storage capacity curve of the drainage channel and connected low lands can be constructed.

at the level of	+ 1.50	+ 1.30	+ 1.00
area of main dr. channel	192,281 m^2	182,825	168,600
branch channel	39,840	37,350	33,600
remaining channels and creeks	184,480	172,950	155,600
low lying areas	1,520,000	410,000	-
total	1,936,600 m^2	803,125 m^2	357,800m^2

It is further estimated that when the drainage level would be reduced to + 1.00 m (below the lowest polder ground level elevation) only the channels will draw water. The surface area at this stage is established by lineairy interpolating the data from the + 1.50 and + 1.30 level. The results are plotted in ANNEX IX-15.

The water level in the polder at the end of the drainage period T is estimated as follows.

area : 1517 ha.
drainage modulus 65½ mm/day
area drainage requirement: $1517 \times 10^4 \times 0.0655 = 993.635\ m^3/day$
$= 11.50\ m^3/s$

sluice drainage requirement: 23,24 m^3/s

Storage decrease in drainage channel system:
during one drainage period.
(23,24 - 11.50) x T = 11,74 x 6,15 hrs = 259.924 m^3/tide.

Iterate with the help of ANNEX IX - 15 to the water level H_i at which 259.924 has been evacuated:
Starting from the level of ½ (m.a.st.l. + d.d.l.)

H_i	A	$\bar{A}$	ΔH_i	$\Delta S = \Delta H_i x \bar{A}$	$\lessgtr \Delta S$
1.45	1,490,000	-	-	-	-
1.40	1,154,000	1,322,000	0.05	66,100	66,100
1.35	950,000	1,052,000	0.05	52,600	118,700
1.30	803,000	876,500	0.05	43,825	162,525
1.25	680,000	741,500	0.05	37,075	199,600
1.20	584,000	632,000	0.05	31,600	231,200
1.15	507,000	545,500	0.05	27,250	258,450

f)+g) With the previous information, backwater curves for various Q and various stages of H_i are calculated using the schematised information of the drainage channel.

The calculation is demonstrated in ANNEX IX-13.

h) The results of the backwater calculations are presented on ANNEX IX-16, as the delivery curves for the drainage channel.