Table-28 OUTLINE OF GENERAL CONDITIONS OF UPSTREAM & DOWNSTREAM SITES FOR WEIR

Item	Upstreame Site	Downstreme Site
Location from Kaalamahato	53 km	49 km
River bed elevation	57.4 m	55.1 m
Slope of river	1:2,000	1:2,000
Catchment area	520 km^2	540 km^2
Design flood discharge		
1 in 100 year probability	620 m^3/sec	640 m^3/sec
1 in 1,000 year probability	840 m^3/sec	870 m^3/sec
Design width of weir crest	48.0 m	50.0 m
Design elevation of weir crest	61.4 m	60.6 m
Design back water hight	4.0 m	5.5 m
Design flood elevtion	65.05 m	64.1 m
Desing hight of river banks	66.55 m	65.60 m
Width of sub weir	560.0 m	510.0 m
Total submerged area in flood	295.0 ha	350.0 ha
The same in North Sumatra State only	39.4 ha	28.5 ha
Normal submerged area Total	85.0 ha	76.0 ha
The same in North Sumatra	9.0 ha	5.3 ha
Construction method	Temporary diversion or Coupure method	Coupure method
Others	Dam can be considered	

Conditions of the above comparative study were as followings.

- Design flood discharge is given by the specific discharge of downstream data.
- Design width of weir crest is based on the unit width flood discharge q = 13.0 m^3/s/m
  Plan of upstream site : B = 620.0 m^3/sec/13.0 ≠ 48.0 m
  Plan of downstream site : B = 620.0 m^3/sec/13.0 ≠ 50.0 m
- Design elevation of weir is based on the required water level of the downstream plan.
  Plan of upstream site = EL 60.60 m
  Plan of downstream site = EL60.60 + 4,400/5,500 = EL 61.40
  Where : Canal length : L = 4,400 m
  Longitudinal slope of canal I = 1/5,500
- Back water hight = EL of weir crest - EL of river bed
  Plan of upstream site = EL 61.40 - EL 57.40 = 4.00 m
  Plan of downstream site = EL 60.60 -

- EL of river banks
  = EL of weir crest + Overflow depth + Freeboard
    (Fb = 1.50 m)
  Plan of upstream site
  = EL 61.40 + 3.65 + 1.50 = 66.55 m
  Plan of downstream site
  = EL 60.60 + 3.50 + 1.50 = 65.60 m
- Calculation of overflow depth
  $Q = C \times Be \times H \cdot 3/2$

	Plan of upstream site	Plan of downstream site	Remarks
Design flood discharge	620 m^3/sec	640 m^3/sec	(1/100)
Disign width of weir	48.0 m	50.0 m	(B = Q/13.0)
Effective width of weir crest	43.0 m	45.0 m	(B × 0.9)
Coefficient of overflow	2.10	2.18	(The assumed)
Overflow depth			
H = 3.60 m	Q = 617	_	
H = 3.65 m	Q = 629	_	Adopted for upstream plan
H = 3.45 m	_	Q = 629	
H = 3.50 m	_	Q = 642	Adopted for downstream plan
Design elevation of weir crest	EL 61.40 m	EL 60.60 m	
Design EL of flood discharge	HWL 65.05 m	HWL 64.10 m	

(4) Comparative Study of Rough Estimates of the Construction Costs

Rough Estimates of the construction costs considering weir heights and canal lengths are as followings.

	Plan of upstream site	Plan of downstream site
Height of weir	H = 4.00 m	H = 5.50 m
Length of canal	4,400 m	0 m
(Rough cost estimate)		
Weir	3,640 10^6Rp.	3,860 10^6Rp.
Canal	1,716	–
Total	5,356	3,860
(Percentage)	(139)	(100)

Here, these rough cost estimations were based on the Weir Height-Cost Curve and Canal Cost-Capacity Curve of the following figures.

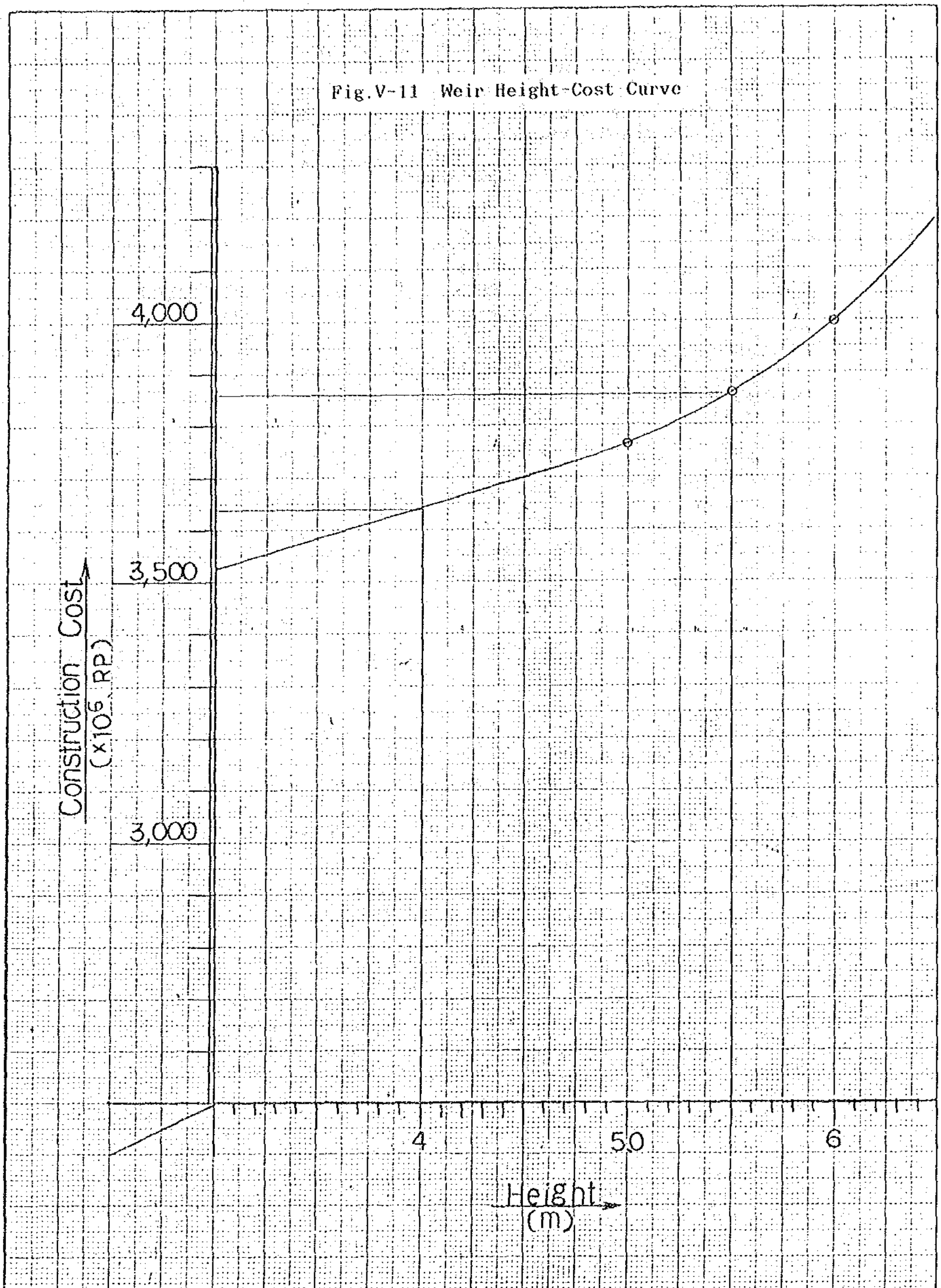


Fig.V-11 Weir Height-Cost Curve
4,000
3,500
3,000
Construction Cost
(×10⁶ RP)
4
5.0
6
Height
(m)

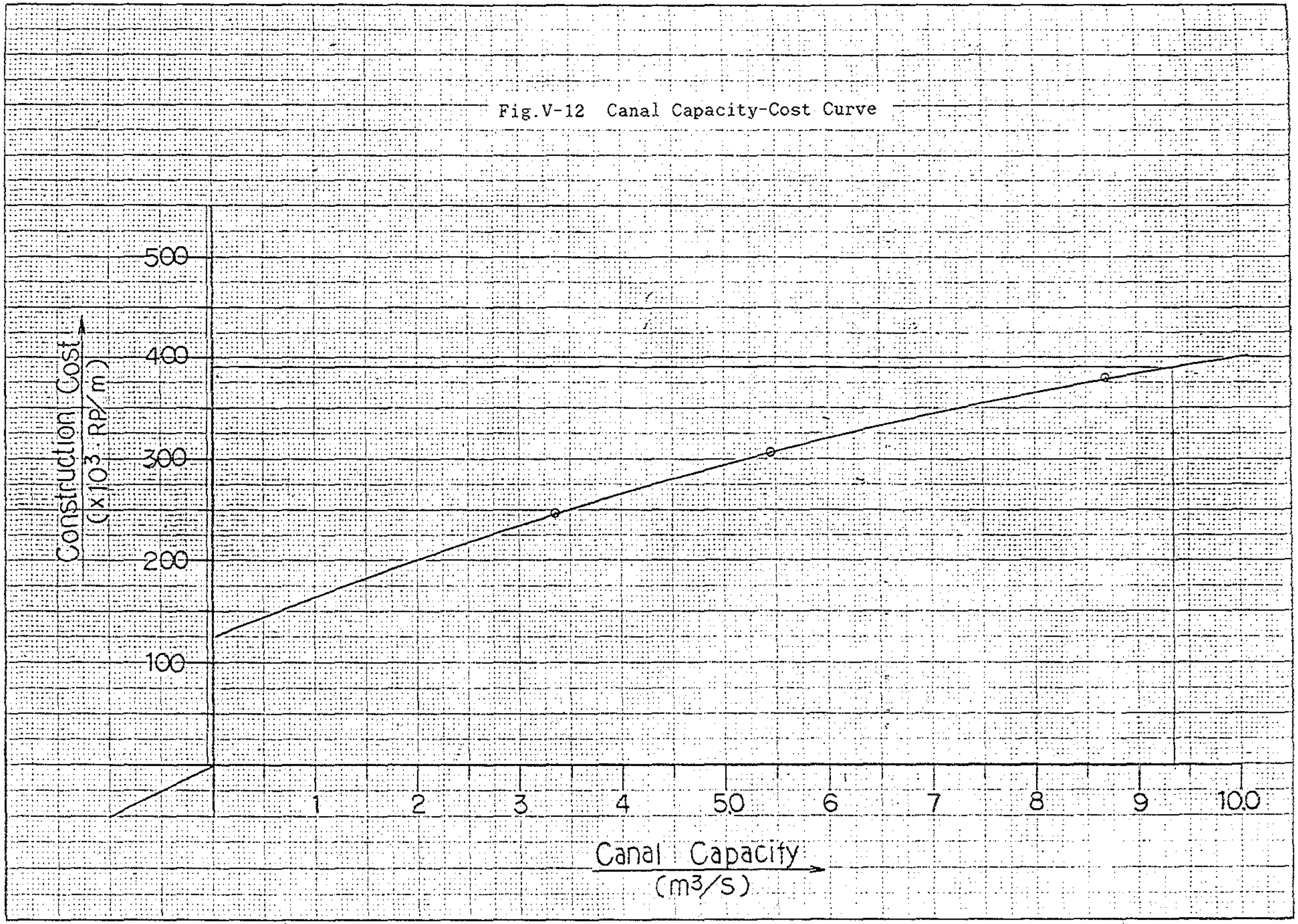


Fig.V-12 Canal Capacity-Cost Curve

- Construction cost of canal
  ($Q = 9.34\ m^3/sec$ → 390 × 1,000 RP/m)
  4.400 m × 0.390 = 1,716 × 1,000,000 RP

(5) Composite Comparison

The following matters could be mentioned by the above rough comparative study.

- The more catchment area the more flood discharge. But it is generally said the more catchment area makes the more efficiency of irrigation capacity through the increase of irrigable area.
- The upstream plan is smaller 2 m in weir width, 1.5 m in the height. Conversely, it incleases 4,400 m in canal length, 50 m in the length of sub weir. As a result, the downstream plan is favorable about 39% in the economy.
- In the upstream plan, the normal and flood submerged areas influence more in North Sumatra. It can be a problem on a view point of the irrigation purpose of Riau State.
- There are no much difference between the two in geographical conditions.
- In the upstream plan, it is also considerable to make a dam. However, it would also have the above same problem getting more influence upon the submerged areas.
- There are giographical problems in the steep area where is around G.L 85.0 m. One is immidiately upside of the downstream plan in the left bank and the other is downside of the same in the right bank. In the upstream plan, it is an economic problem to pass main canal in these area. In the downstream plan, it is free from the problem by the intake at the left bank.

Since, the site of weir of this Project is more faborable on the downstream plan than the upstream one by the all-round study.

4.1.3 Design & hydraulic calculation on size of the facility

(1) Dimension of the structure

a) Dimension of the structure

Water source	: Kumu river
Location of intake facility	: about 3.5 Km upstream from Kota Bangung
Catchment area	: 540 Km^2
Elevation of river bed	: 55.10 m
Elevation of crest	: 60.60 m
Height of weir	: 5.50 m
Height of weirbody	: 7.50 m
Width of weir	: 50.0 m
Intake water level	: NWL. 60.5 m
Flood discharge	: HWL 64.10 m (1 in 100 year probability)
Flood discharge	: HWL. 64.90 m (1 in 1000 year probability)
Elevation of river bank	: 65.60 m
Freeboard	: 1.50 m (1/100 y. prob.)
Freeboard	: 0.70 m (1/1000 y. prob.)
Inundated area	: Total 350.0 ha within North Sumatra State 28.5 ha
Type of weir	: Fixed type
Flood way	: Fixed weir (Length of span 14.0 m × 3 Nos.)
Scouring sluice	: Under sluice (2 m × 2 gates × 2 stairs)
Intake	: Sluice type gate (3.50 m × 3 gates)
Design intake discharge	: 9.34 m^3/s
Construction method	: Coupure

b) Hydrologic condition (From the hydrologic data)

1 in 5 year flood discharge probability
Q1/15 = 390.0 m^3/s

1 in 25 year flood discharge probability
Q1/25 = 510.0 m^3/s

1 in 50 year flood discharge probability
Q1/50 = 569.0 m^3/s

1 in 100 year flood discharge probability
Q1/100 = 640.0 m^3/s

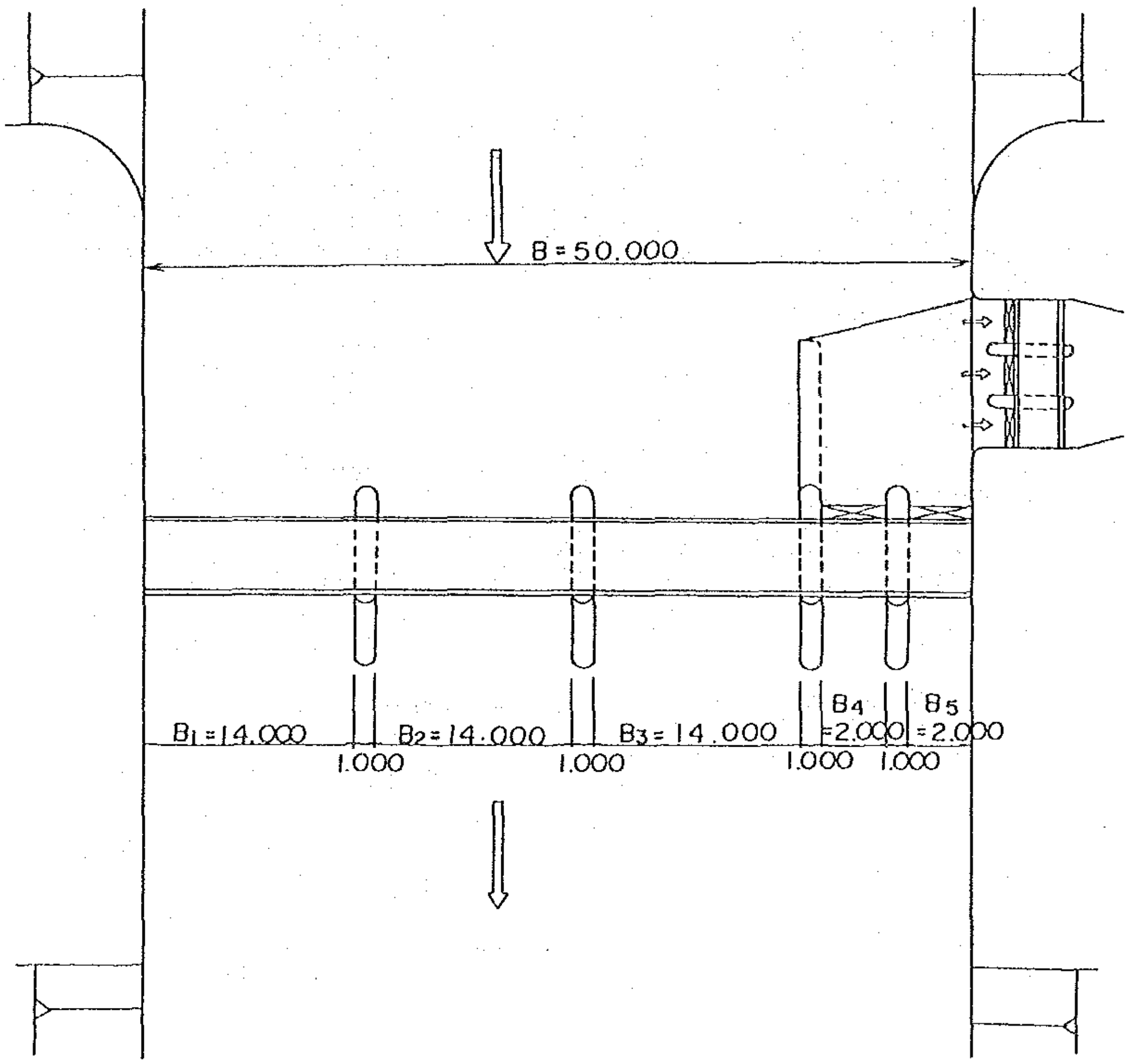
1 in 1000 year flood discharge probability
Q1/1000 = 870.0 m^3/s

(2) Study of weir width

Total width of weir is decided by unit flood quantity which is the standard, q = 12.0~14.0 $m^3/s/m$

$$B = Q1/100/q = 640\ m^3/s/13.0\ m^3/s/m$$
$$= 49.23\ m \fallingdotseq 50.0\ m$$

Concerned the spans, they are given under the condition of less than 15.00 m for the flood way, and about 2.0 m for the scouring sluice as follows.



(3) Hydraulic calculation at the time of flood

a) Calculation of overflow depth

Q = Cd × Be × H2/3

Here Q : Quantity of overflow m^3/s

Be : Width of crest m

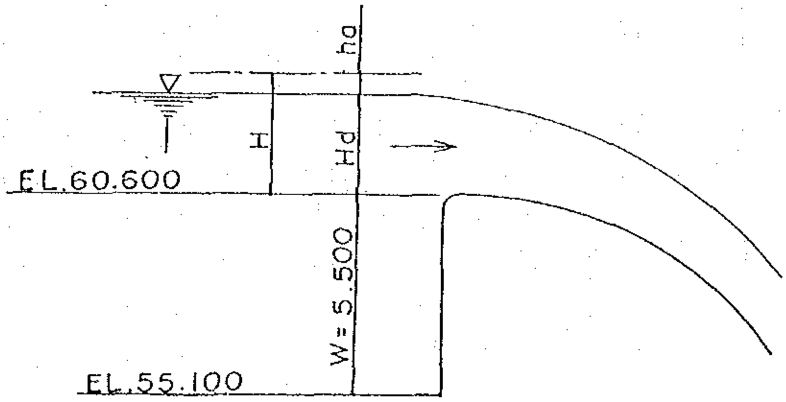
H : Overflow head

(Overflow depth, Hd + Volocity head, ha)

Cd : Coefficient of discharge

= 2.200 - 0.0416 (H/W) 0.990

W : Hight of weir



o Calculation of effective width of overflow (Be)

Be = Bn - {2(n · Kp) x H + (Bs - 0.8 x Bs)}

= (50.0-1.0 x 4)-{2(3 x 0.01)H+(4.0-0.8 x 2.0 x 2)}

= 46.0-{0.06H + (4.0-3.2)}

= 45.2-0.06H

Here Bn: Total width of overflow

Kp: Coefficient by pier (Circle = 0.01)

n : Number of piers (3 Nos.)

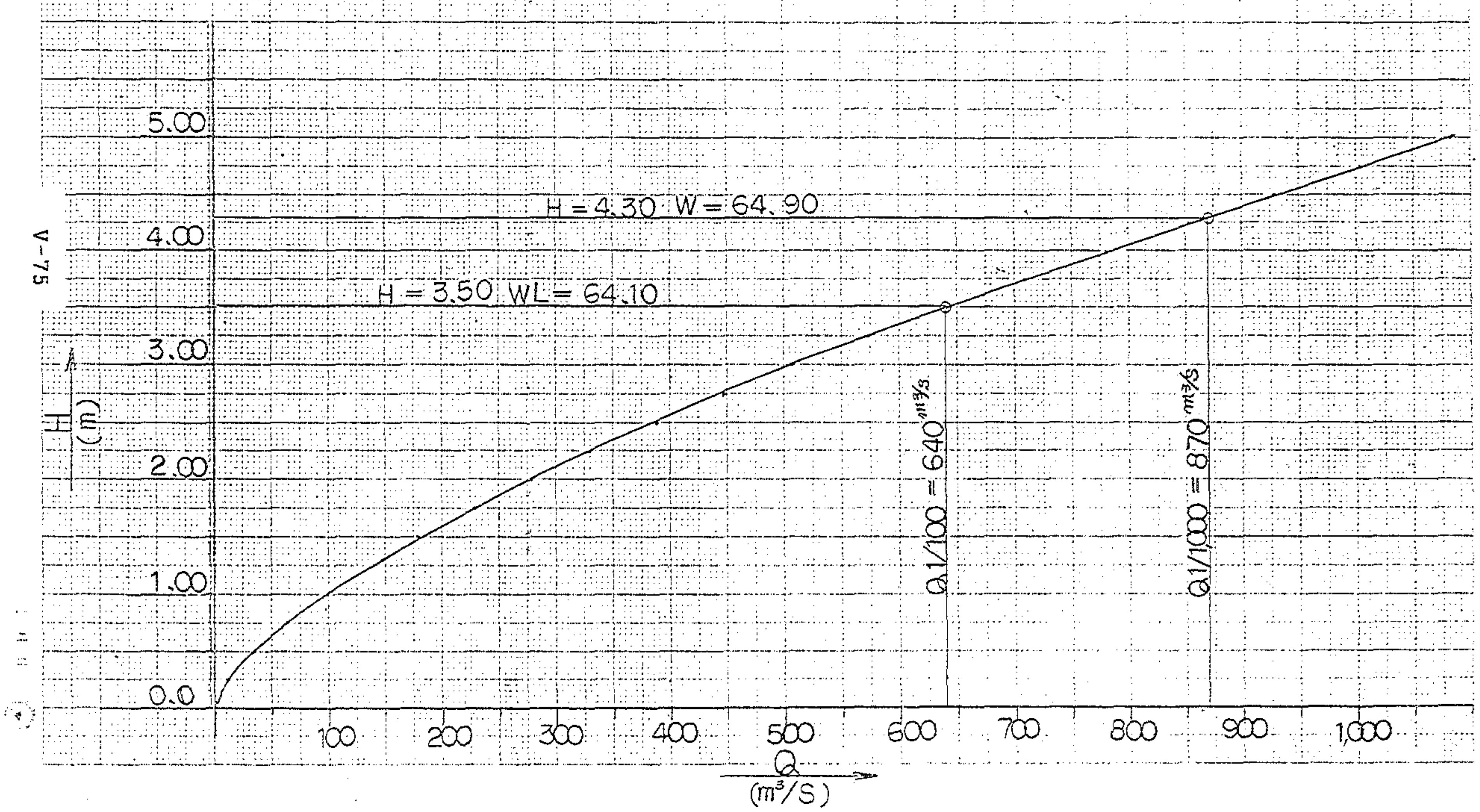
Bs: Total width of scouring sluice (m)

H : Overflow head (m)

Table V-29 CALCULATION OF THE RELATION BETWEEN OVERFLOW DEPTH AND DISCHARGE FOR WEIR

H (m)	Be (m)	0.99)((H/W)	0.0416× (〃)	Cd	3/2 H	Q (m3/s)
0.25	45.19	0.047	0.002	2.198	0.125	12.4
0.50	45.17	0.093	0.004	2.196	0.354	35.1
0.75	45.16	0.139	0.006	2.194	0.650	64.4
1.00	45.14	0.185	0.008	2.192	1.000	98.9
1.25	45.13	0.231	0.010	2.190	1.398	138.2
1.50	45.11	0.276	0.011	2.189	1.837	181.4
1.75	45.10	0.323	0.013	2.187	2.315	228.3
2.00	45.08	0.367	0.015	2.185	2.828	278.6
2.25	45.07	0.413	0.017	2.183	3.375	332.1
2.50	45.05	0.458	0.019	2.181	3.953	388.4
2.75	45.04	0.503	0.021	2.179	4.560	447.5
3.00	45.02	0.549	0.023	2.177	5.196	509.3
3.25	45.01	0.594	0.025	2.175	5.859	573.6
3.50	44.99	0.639	0.027	2.173	6.548	640.2
3.75	44.98	0.684	0.028	2.172	7.262	709.5
4.00	44.96	0.730	0.030	2.170	8.000	780.5
4.25	44.95	0.775	0.032	2.168	8.762	853.9
4.50	44.93	0.820	0.034	2.166	9.546	926.4
4.75	44.92	0.865	0.036	2.164	10.352	1,006.3
5.00	44.90	0.910	0.038	2.162	11.180	1,085.3

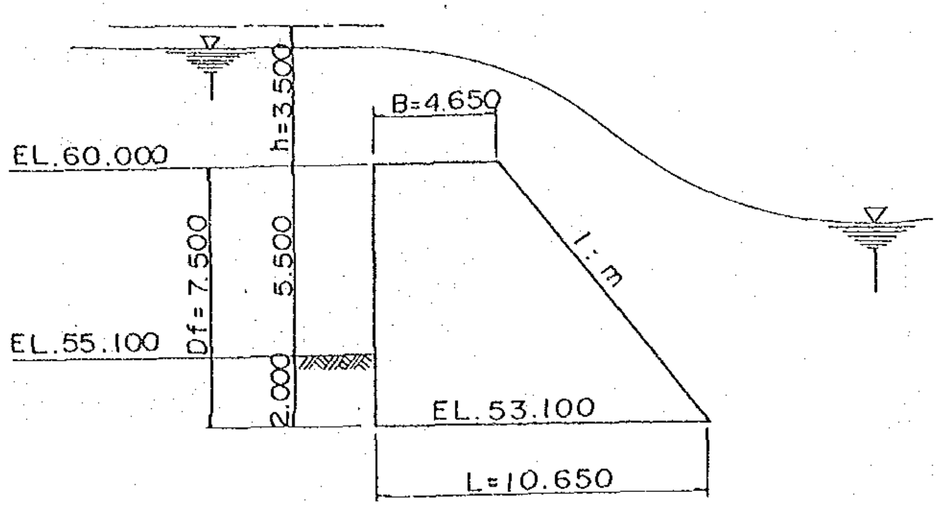
Fig.V-13 Q-H Curve of Overflow Depth at Weir



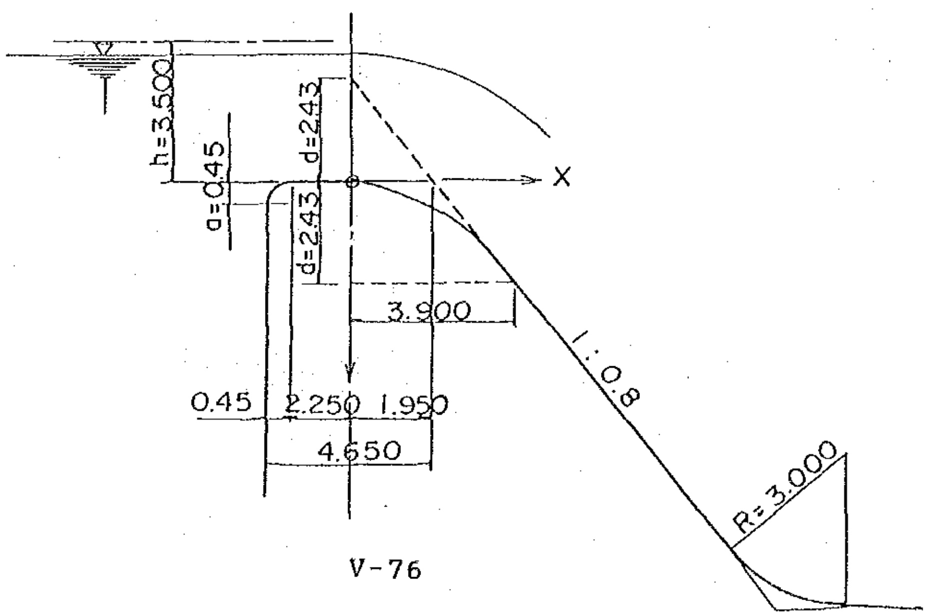
b) Basic cross section of weir

o Assumption of the cross section

When m = 0.8 is applied safe and economic section modulus (α) is considered as α = 0.62
B = α x Df = 0.62 x 7.50 = 4.650m
L = (α + m) Df = (0.62 + 0.8) x 7.50 = 10.65m



o Modification of the trapezoid section.



There are several modified sections for the modification of trapizoid section which is the basic section of weir. However it is always required to apply a curve formula considered that the vein of overflow must fit to the body, satisfy the hydraulic conditions, and be easy for the construction works.

$X2 = 4 \cdot m^2 \cdot d \cdot Y \quad d \geqq 1.78h/4m^2$

$d = 1.78 \times 3.50/4x0.802 \fallingdotseq 2.43$

$= 4 \times m^2 \times d \times Y = 4 \times 0.80^2 \times 2.43 \times Y$

$= 6.221 \cdot Y$

Y	0.0	0.05	0.10	0.20	0.40	0.80	1.60	2.43
X	0.0	0.56	0.79	1.12	1.58	2.23	3.15	3.90

o Upstream top side of weir is a quarter circle
  $a = 0.125h = 0.12 \times 3.50 = 0.45m$

o Bucket curve is set at the water cushion to change the direction of the falling vein into the holizontal one.
  $R = Df \times (1/2 \sim 1/3)$
  $= 7.50 \times (1/2 \sim 1.3) = 3.50 \sim 2,33 = 3.00m$

$\tan \alpha = 1/0.8=1,259$

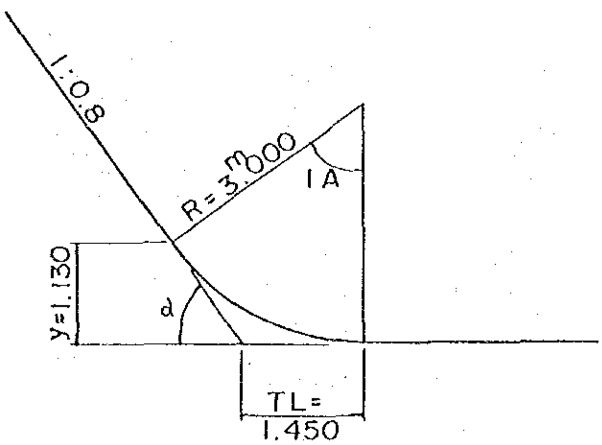
$\alpha = IA = 51°20'25"$

$TL = R \tan IA/2$

$= 1.442 \fallingdotseq 1.450m$

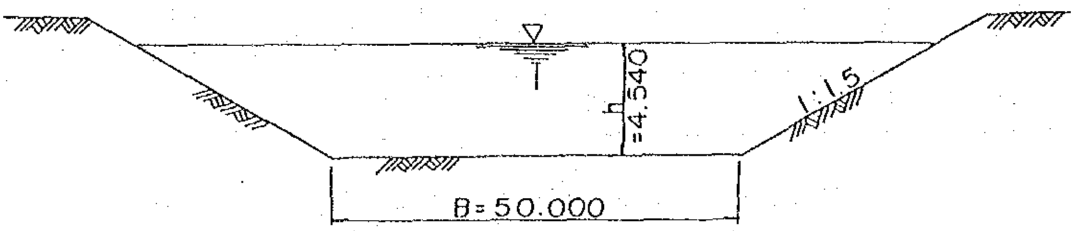
$y = \sin \alpha \cdot TL$

$= 1.126 \fallingdotseq 1.130m$



c) Calculation of canal sections by Coupure method

Quantity	$Q = 640m^3/s$
Longitudinal slope of canal	I = 1/2000
Slope	Z = 1:1.5
Width of canal	B = 50.0m
Coefficient of roughness	n = 1/45 = 0.022



$A = Bh + Zh2$

$R = A/P$

$Q = A \times V \quad (m^3/2)$

$P = B + 2h\sqrt{1+Z2}$

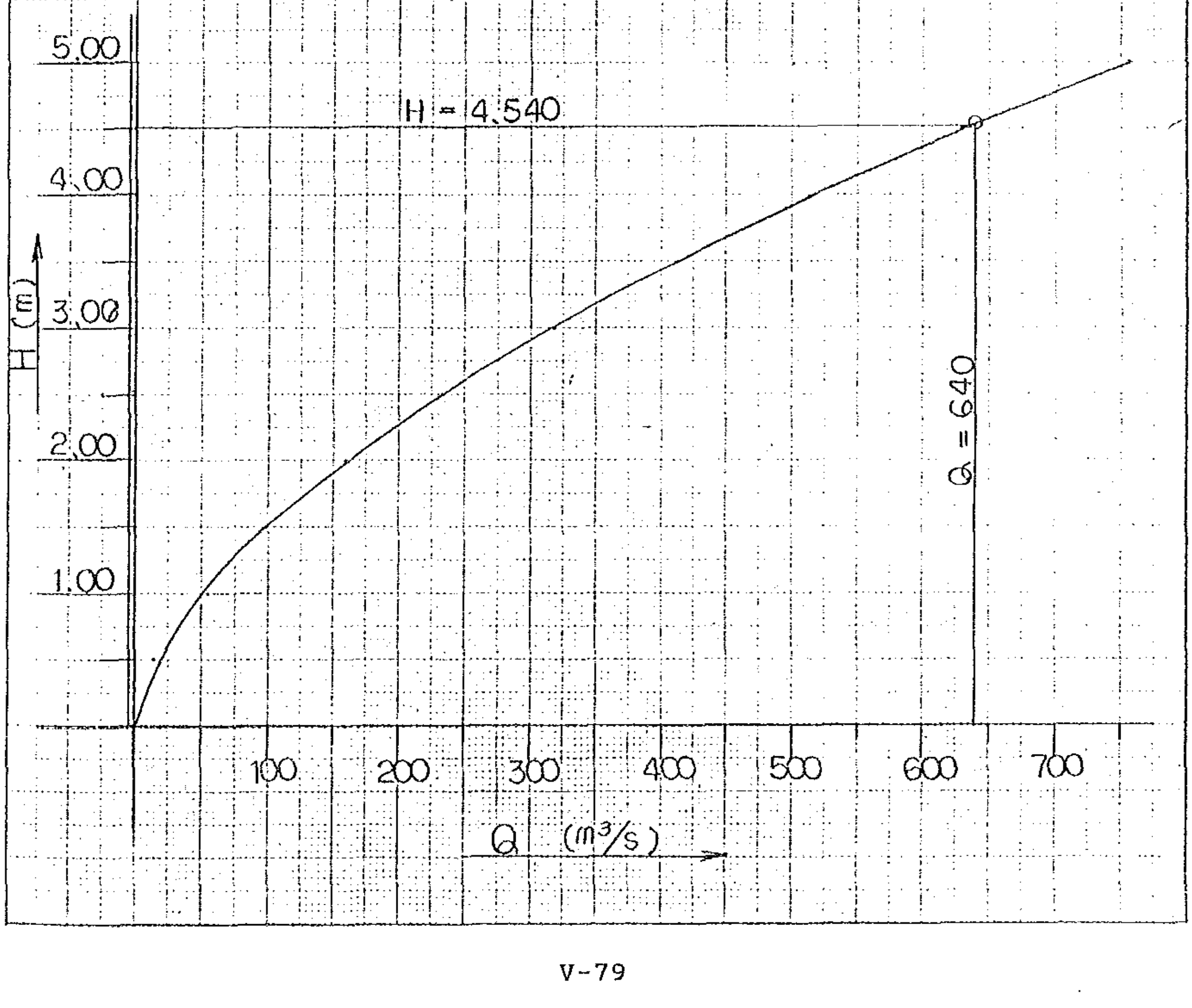
$V = 1/n \cdot R2/3 \cdot \sqrt{I}$

$= 45 \times R2/3 \times \sqrt{0.0005}$

$= 1.006 \cdot R2/3$

h (m)	A (m^2)	P (m)	R (m)	R2/3	V (m/s)	Q (m^3/s)
0.50	25.375	51.80	0.490	0.621	0.624	15.8
1.00	51.500	53.61	0.961	0.974	0.980	50.5
1.50	78.375	55.41	1.414	1.260	1.268	99.4
2.00	106.000	57.21	1.852	1.509	1.518	160.9
2.50	134.375	59.01	2.277	1.731	1.741	233.9
3.00	163.500	60.82	2.688	1.933	1.945	318.0
3.50	193.375	62.62	3.088	2.120	2.133	412.5
4.00	224.000	64.42	3.477	2.295	2.309	517.2
4.50	255.375	66.22	3.856	2.459	2.474	631.8
4.54	257.917	66.37	3.886	2.472	2.487	641.4
5.00	287.500	68.03	4.226	2.614	2.630	756.0

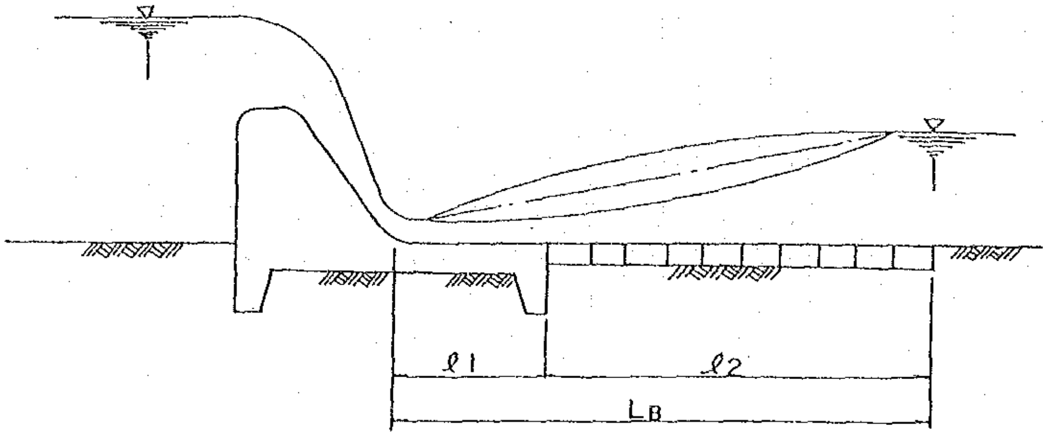
Fig.V-14 Q-H Curve of Coupure Section



(4) Study of energy dissipator

a) Study of fore apron and the protection works of river bed

The lengths of fore apron and downstream protection works of river bed are calculated against scouring the downstream bed by overflow water.



o Length of fore apron

$L1 = 0.6 \cdot C\sqrt{D1}$

Where C: Bligh's coefficient (Middle class sand 13)

D1: Height between the crest and apron

$= 0.6 \times 13\sqrt{5.50} = 18.29 \fallingdotseq 18.50m$

o Length of the protection works of river bed

$LB = 0.67 \cdot C\sqrt{Hd \cdot q}$

Here C: Bligh's coefficient (Middle class sand 13)

Hd: Difference of water elevation between flood stage & draughty water level (D_1 = Hd = 5.50m)

q: Unit quantity of flood discharge $640m^3/s/50m = 12.8m^3/s/m$

$= 0.67 \times 13\sqrt{5.50 \times 12.8}$

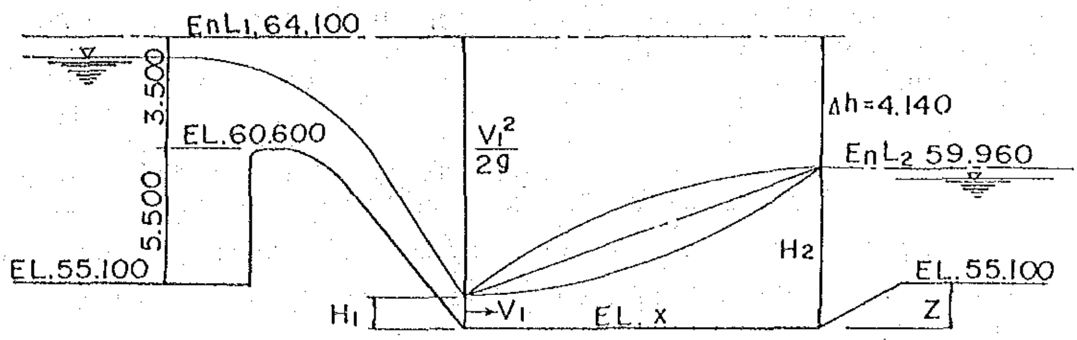
$= 73.08 \fallingdotseq 73.5m$

$L2 = LB - L1 = 73.5 - 18.5 = 55.0m$

As a result of the above calculation, the structure of downstream side of weir is decided as the type of energy dissipator.

- The river bed protection works is uneconomic by increasing the length of the protection works because the back water height is high.
- Most of the results of Indonesian construction are also in the type of energy dissipator.

b) Hydraulic calculation of energy dissipator



Height of hydraulic jump $H_2/H_1 = 1/2(\sqrt{1+8F2} - 1)$

$V = q/H1$

$H_2 = H_1(\sqrt{1+8F2} - 1) \times 1/2$

$q = 12.8m^3/s$

Froude number $F1 = V1/\sqrt{g \cdot H1}$

$EL \times 1 = 64.10 - (H1 + V1^2/2g)$

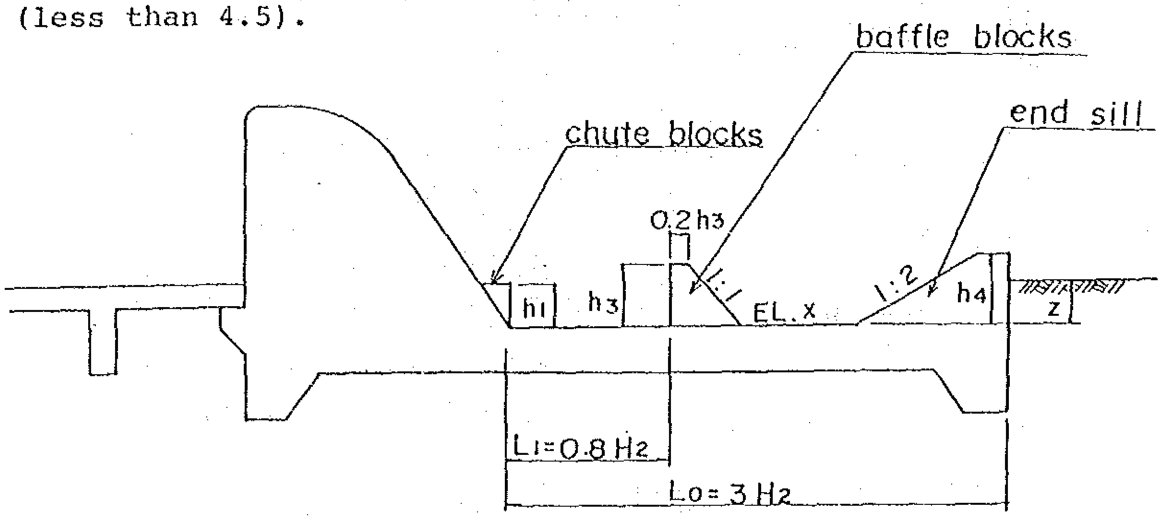
$EL \times 2 = 59.96 - H2$

H1 (m)	V 1 (m/s)	V1/2g (m)	ELx1 (m)	F	H2 (m)	ELx2 (m)	ELx1 - ELx2
4.50	2.84	0.41	59.14	0.43	1.29	58.67	0.47
4.00	3.20	0.52	59.58	0.51	1.51	58.45	1.13
3.50	3.66	0.68	59.92	0.62	1.78	58.18	1.74
3.00	4.27	0.93	60.17	0.79	2.17	57.79	2.38
2.80	4.57	1.07	60.23	0.87	2.32	57.64	2.59
2.60	4.92	1.24	60.26	0.97	2.50	57.46	2.80
2.40	5.33	1.45	60.25	1.10	2.72	57.24	3.01
2.20	5.82	1.73	60.17	1.25	2.94	57.02	3.15
1.80	7.11	2.58	59.72	1.69	3.50	56.46	3.26
1.60	8.00	3.27	59.23	2.02	3.84	56.12	3.11
1.40	9.14	4.26	58.44	2.47	4.24	55.72	2.72
1.20	10.67	5.81	57.09	3.11	4.71	55.25	1.84
1.00	12.80	8.36	54.74	4.09	5.31	54.65	0.09
0.80	16.00	13.06	50.24	5.71	6.07	53.89	-3.65
0.60	21.33	23.21	40.29	8.80	7.17	52.79	-12.50

c) Type of energy dissipator

As a result of the above hydraugh calculation, height of the jump (H_2) is H_2 = 5.31mt with a condition of the vein of inflow H_1 = 1.0 m^2, F = 8.36, V_1 = 12.80 m^3/s and it can be connected smoothly with the downstream water surface.

As a type of energy dissipator, the forced jump USBR type III can be applied based on the condition of unit quantity of flow (less than 18.5 $m^3/s/m$), Velocity of inflow (less than 18.0 $m^3/s/m$), Froude number of inflow vein (less than 4.5).



Length of energy dissipator

L0 = 3 · H2 = 3 x 5.31 = 15.93 ≒ 18.5m

Location of baffle pier

L1 = 0.8 · H2 = 0.8 x 5.31 = 4.248 ≒ 4.50m

Height of chute block

	Height	h 1=H 1=1.00m
	Width	W1 = H1=1.00m
	Distance	S1 = H1=1.00m
Baffle pier	Height	h3/H1 = 2, h3 = 2 x 1.00 m = 2.00 m
	Width	W3 = 0.75 · h3 = 0.75 x 2.00 = 1.50m
	Distance	S3 = 0.75 · h3 = 0.75 x 2.00 = 1.50m
	Crest width of weir	= 0.20 · h3 = 0.20 x 2.00 = 0.40m
End sill	h4/H1 = 1.5	h4 = 1.5 x 1.00 = 1.50m

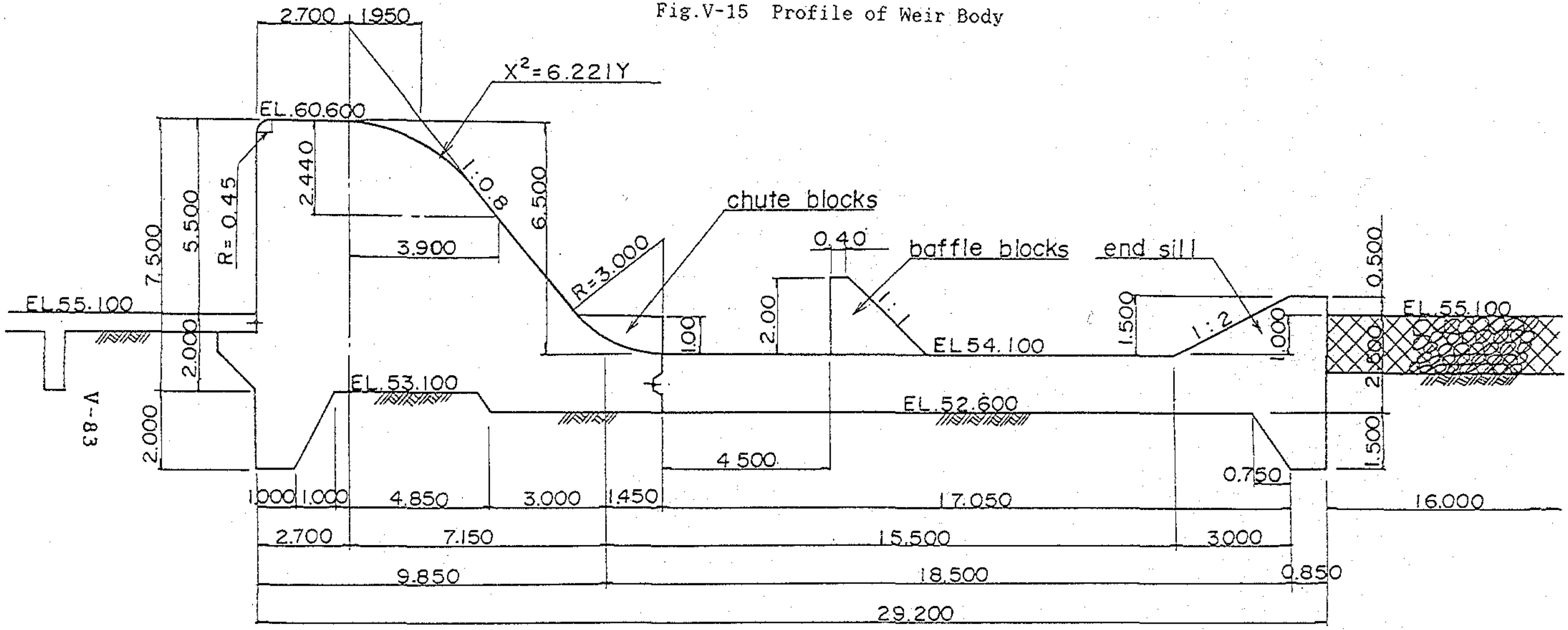
Elevation of energy dissipator

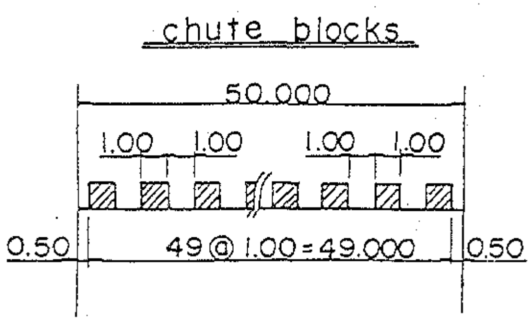
Z = EL55.10-ELX1 54.65 = 0.45

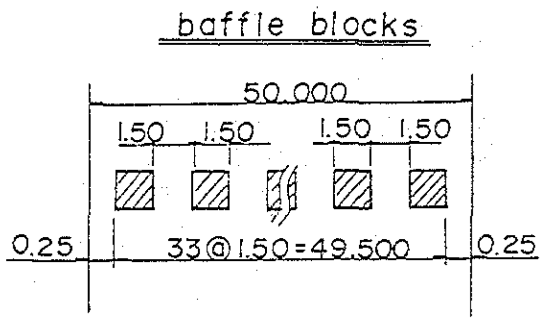
Giving a surplus : 1.0m

ELx = EL55.10 - 1.00 = EL54.100m

Fig.V-15 Profile of Weir Body







(5) Study of creep length

o Bligh's method

$L \geqq C \cdot \Delta h$

Here C: Bligh's coefficient (Middle class sand 13)

Δh: Maximum head between the upstream and the downstream (5.50m)

$C \cdot \Delta h = 13 \times 5.50 = 71.50$ m

Actual length of weir body (See the above figure)

$L = 4.0 + 29.2 + 4.0 + (2.0 + 0.5 + 1.5) \times 1.118$

$\fallingdotseq 41.70$m

* 71.50m ≧ 41.70m ..... No (Short length = 29.8m)

o Lane's method

$L' \geqq C' \cdot \Delta h$

Here C': Lene's creep ratio (Middle class sand 6)

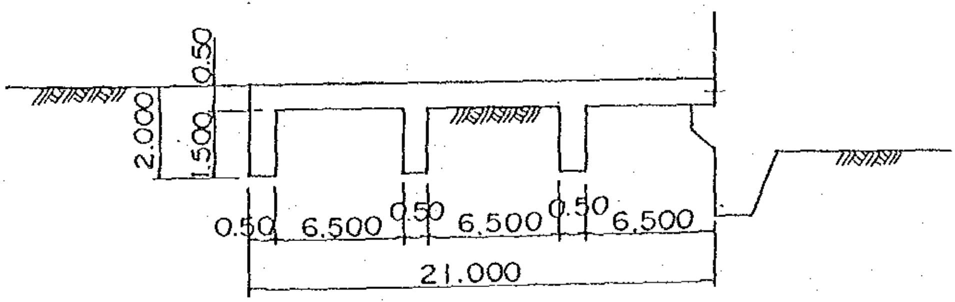
$C' \Delta h = 6 \times 5.50 = 33.00$m

Actual length of weir body (See the above figure)

$L' = (4.0+2.0+0.5+1.5+4.0)+(29.3 \times 1/3) \fallingdotseq$ 21.70m

33.00m ≧21.70m ...... No (Short length = 11.3m)

According to the above calculation, it is found that the creep length is not enough against the length of weir body. Generally, it is secured by water stop board, fore apron etc. but geologically it is very hard to apply water stop board because of construction difficulty. Thus, rear apron is provided to prevent piping by securing creep length as there were many construction examples in Indonesia, too.



When rear apron is provided like the above figure, creep length can be as follows.

o Bligh's method

$\Sigma L = 41.70+(21.00+1.50 \times 5+2.00) = 72.20m$

* $\Sigma L \geq C \cdot \Delta h = 72.20 \geq 71.50m$ ...... OK

o Lane's method

$\Sigma L' = 21.70+(2.00+1.50 \times 5+21.00 \times 1/3) = 38.20m$

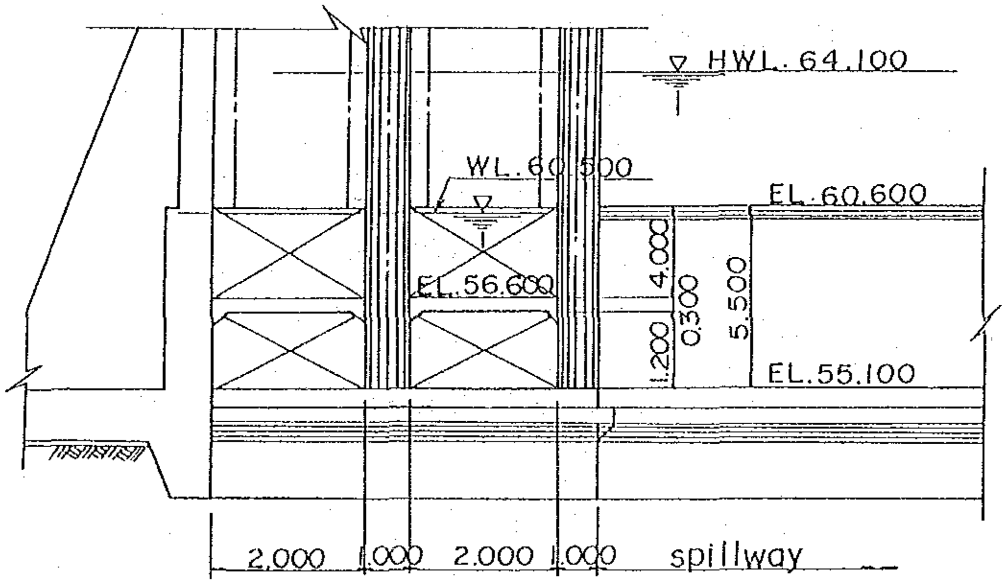
* $\Sigma L' \geq C' \cdot \Delta h = 38.20 \geq 33.00m$ ...... OK

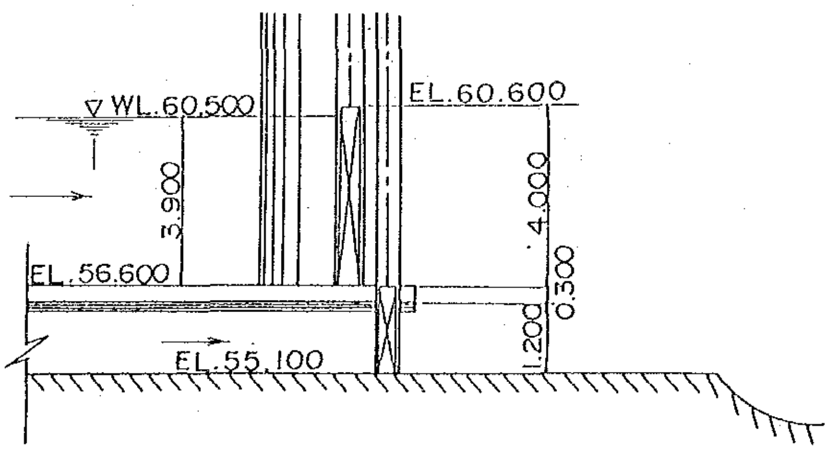
Thus, creep length can be secured by rear apron.

(6) Scouring sluice

Under sluice type is selected because it has many construction example of the same type for scouring sluice in Indonesia Numbers and each length of the spans are decided refering to similar scale of Indonesian ones.

Number of span N = 2 gates
Length of span B = 2.00m (Scale of gate should be be possible to be controlled by hand.)
Width of scouring sluice
(Width of the inflow mouth x about 0.6)
= (7.50~9.10) x 0.6
= 4.50~5.46 ≒ 5.00m





(7) Study of intake

o Maximum regulated intake quantity

$Q = 9.34\ m^3/s$

o Design velocity of standard intake flow

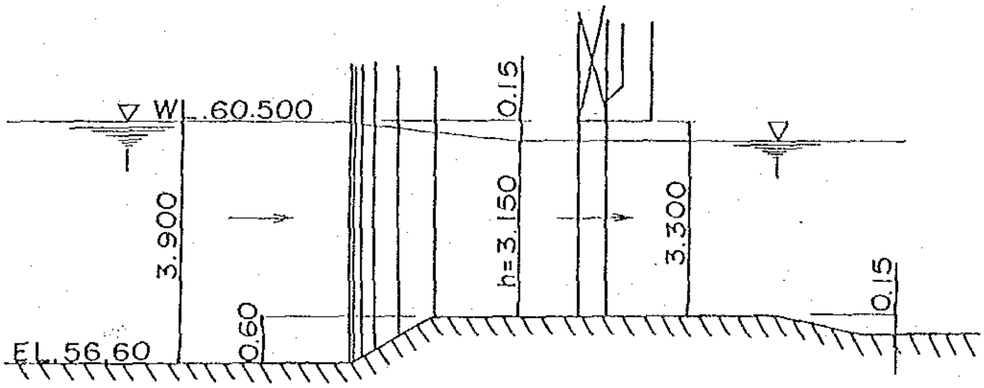
V = 10 · d0.5

Where d = Grain size of river bed material according to the study of the grain size of river bed material at the proposed point of weir in the present condition, they are around 0.6mm, 2.4mm, 5.5mm by the sieving study of 50% grain size.
In this Design, intake velocity is applied to stop grain size of (0.6+2.4) x 1/2 = 1.5mm

* V = 10 x 0.00150.5
= 0.387 ≒ 0.40 m/s

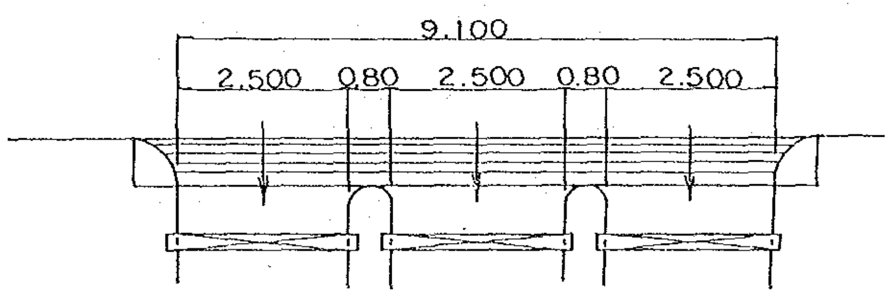
o Design intake depth

When the intake loss head is 0.15m and intake sill is about 0.60m, water depth of immediate downstream of intake is h = 3.150m.
h = 3.900 - (0.15 + 0.60) = 3.150 m



o Design width of inflow

Design width of inflow = $9.34m^3/s/3.15m$ x 0.40m/s
= 7.410 ≒ 7.50m
Width of each gate = 7.500 m/3 gates = 2.500m



(8) Study of sub-dike

Section of sub-weir is assumed as follows and upstream slope is protected by stone.

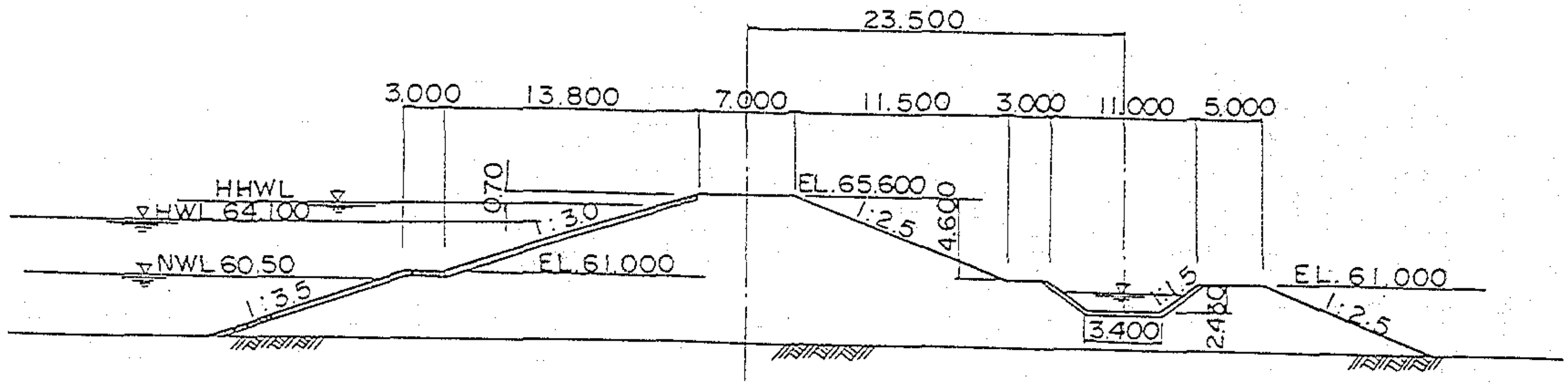


Fig.V-16 Profile of Sub-dike

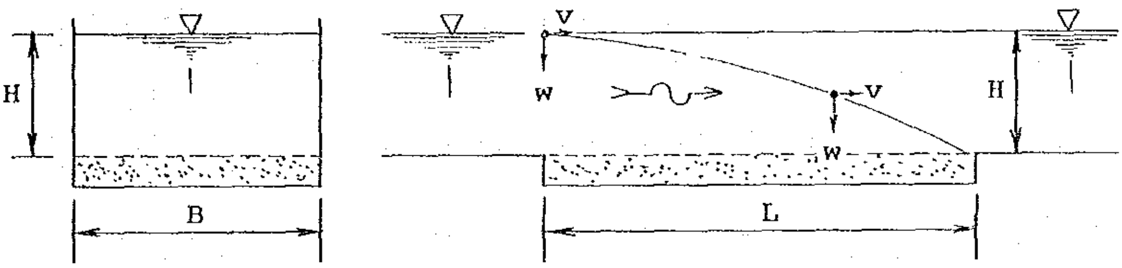
(9) Study of Sand Trap

a) Relation between Velocity and Grain Diameter

$$Vd = 10 \times d^{0.5}$$

where Vd : Average Velocity (m/s)
d : Grain Diameter (m)

b) Dimension of Sand Trap (Length and Width)



Therefore : $H/W = L/V$ with $V = Q/H \cdot B$

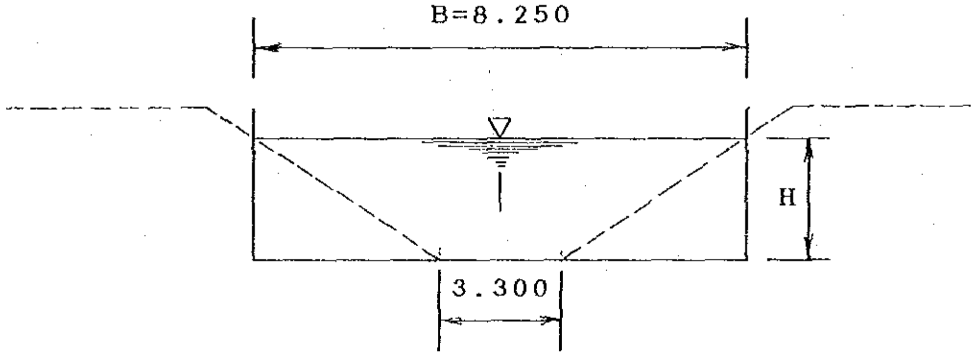
$$L = (H \cdot V/W)\ F$$

where H : Depth of Canal Flow(m)
W : Falling Velocity of Sediment Particle(m/s)
L : Length of Sediment Trap(m)
V : Flowing Velocity of Water(m/s)
Q : Canal Discharge(m /s)
B : Width of Sediment Trap(m)
F : Safty Rate (1.5~2.0)

$Qmax = 9.34\ m^3/s$ $B = 8.250m$

$V = Q/H \cdot B$ $Vd = V$

$H = Q/Vd \cdot B$



c) Relation between Length of Sediment Trap and Grain Diameter under the condition of Maximum Canal Discharge

d (m)	Vd(m/s)	W(m/s)	H (m)	L (m)	
0.0016	0.400	0.140	2.85	15.0	(*1)
0.0009	0.300	0.095	3.80	21.0	(*2)
0.0003	0.173	0.030	6.55	67.0	(*3)
0.00007	0.084	0.004	13.50	496.0	(*4)

From the above table,the following matters can be pointed out:

1) The maximum grain size flowing from the Intake is 1.6mm.(*1)

2) The maximum grain size of bed load following under the condition of minimum water volocity is 0.9mm.(*2)

3) In the case of the application of grain material (0.3mm)produced in Japan,the required length of Sediment Trap gets 67.0m.(*3)

4) In the case of the application of grain material (0.07mm)produced in Indonesia,the required length of Sediment Trap gets 496.0m.(*4)

5) The grain sizes of bed load in the vicinity of the Head Works were resulted within the range between 0.08mm and 6.5mm as shown in the following table:

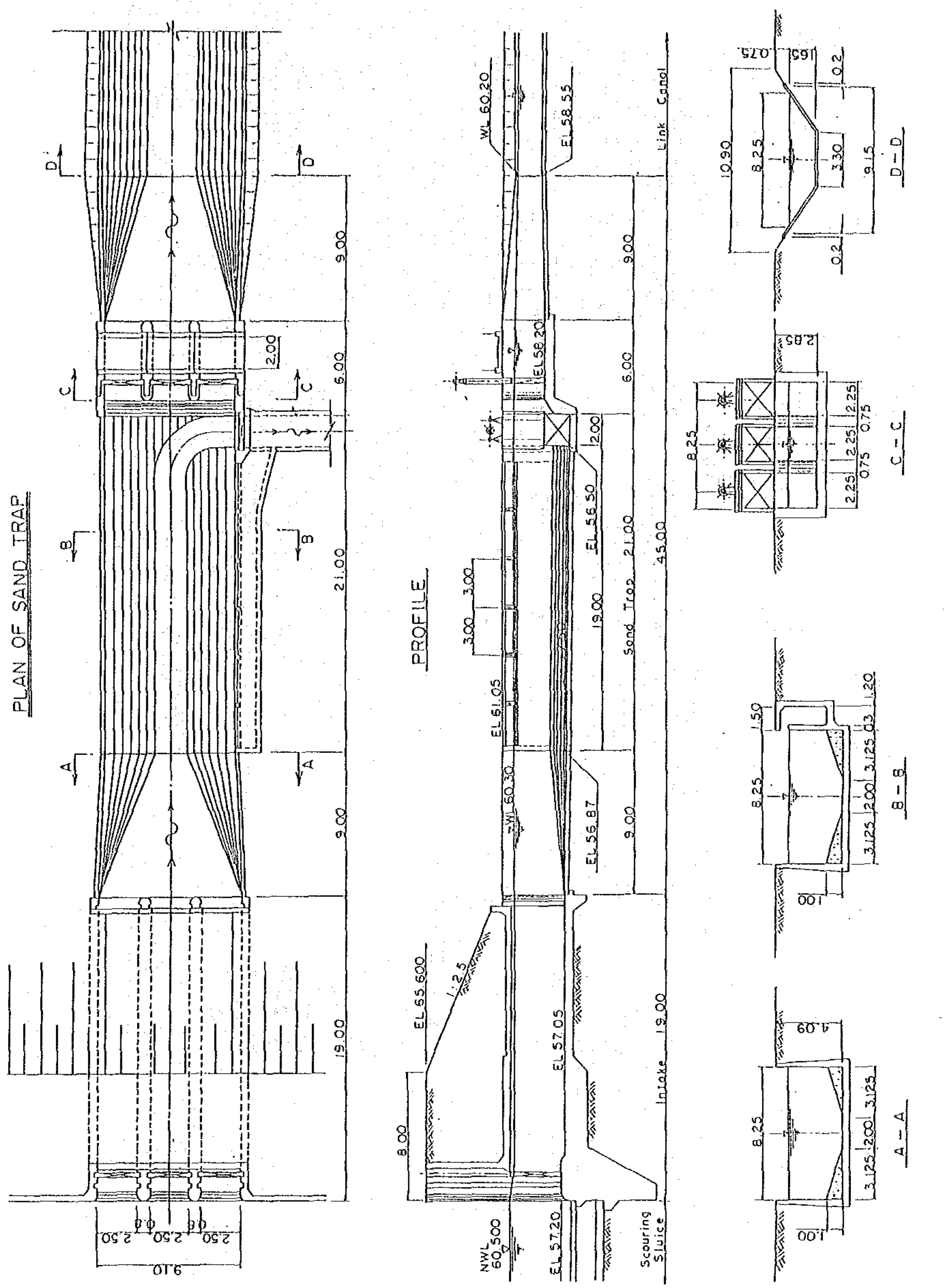
Judging from the above study,the following points are concluded:

1) The actual length of Sediment Trap is limitted by the conditions such as geological condition,necessity of drainage canal for blow off.

2) The function as a sand trap shall be employed instead of the one as a sediment trap.

3) The available grain size to be applied shall be within the range of 0.9mm to 1.6mm.

4) Taking into account the above point,the length of Sand Trap shall be 21.0m.

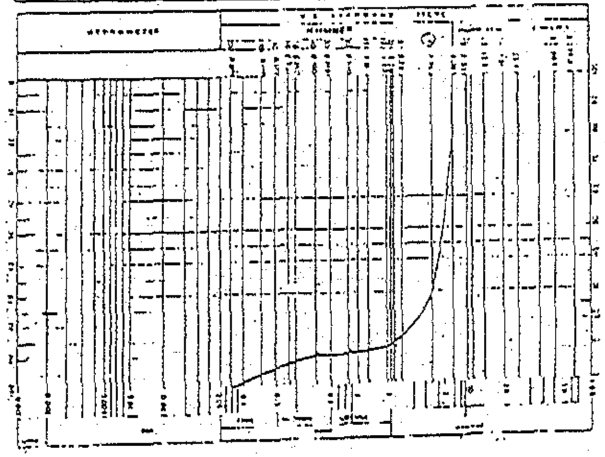

PLAN OF SAND TRAP
PROFILE
WL 60.20
EL 58.55
Link Canal
EL 58.20
EL 56.50
Sand Trap 21.00
45.00
EL 61.05
WL 60.30
EL 56.87
EL 65.600
1:2.5
EL 57.05
Intake 19.00
NWL 60.500
EL 57.20
Scouring Sluice
D – D
C – C
B – B
A – A
9.10

HYDROMETER TEST SIEVE ANALYSIS

GRAIN SIZE DISTRIBUTION

SEIVE NO	WT. RETAINED	WT. SOIL RETAINED	PERCENT RETAINED	PERCENT CUMULATIVE	PERCENT FINER
4	91.34	91.34	68.65		31.37
10	25.25	116.59	87.63		12.37
20	1.00	117.59	88.38		11.62
40	0.64	118.23	88.85		11.15
80	5.24	123.47	92.80		7.20
100	7.05	130.52	98.10		1.90
200	1.61	132.13	99.32		0.68

WT OF DRY SOIL : 133.05
SPECIFIC GRAVITY : 2.636
LOCATION : 500 m in the upstream of proposed weir site

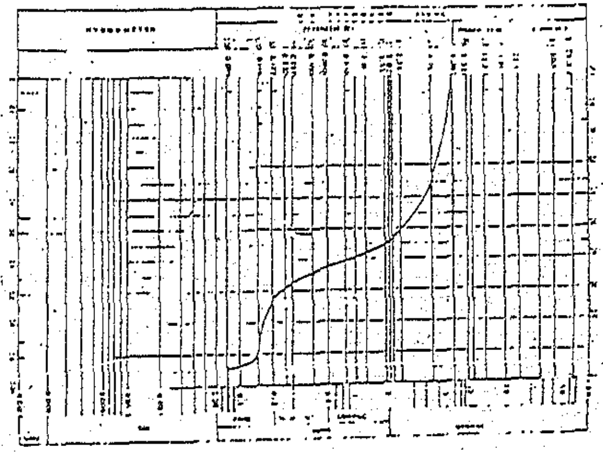


HYDROMETER TEST SIEVE ANALYSIS

GRAIN SIZE DISTRIBUTION

SEIVE NO	WT. RETAINED	WT. SOIL RETAINED	PERCENT RETAINED	PERCENT CUMULATIVE	PERCENT FINER
4	182.99	182.99	34.89		65.11
10	128.68	311.67	59.43		40.57
20	8.00	319.67	60.96		39.04
40	17.14	336.81	64.23		35.77
80	37.80	374.61	71.63		28.37
100	87.81	462.42	88.18		11.82
200	30.52	492.94	94.00		6.00

WT OF DRY SOIL : 524.38
SPECIFIC GRAVITY : 2.655
LOCATION : Center of the proposed weir site.

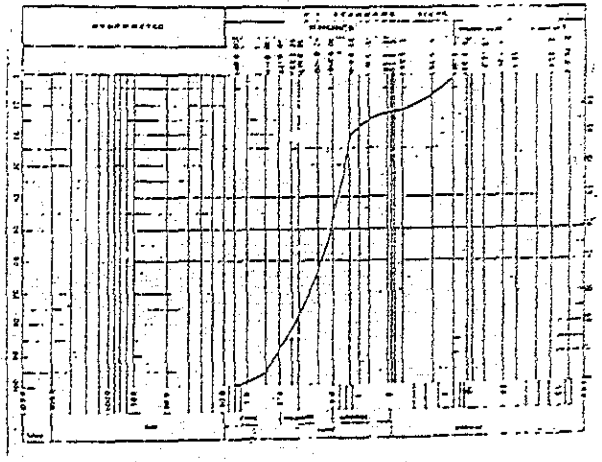


HYDROMETER TEST SIEVE ANALYSIS

GRAIN SIZE DISTRIBUTION

SEIVE NO	WT. RETAINED	WT. SOIL RETAINED	PERCENT RETAINED	PERCENT CUMULATIVE	PERCENT FINER
4	28.55	28.55	6.94		93.06
10	23.80	52.35	12.72		87.28
20	32.30	84.65	20.52		79.48
40	105.32	189.77	46.12		53.88
60	146.18	335.95	86.50		13.50
100	55.82	391.77	95.20		4.80
200	15.72	407.49	99.03		0.97

WT OF DRY SOIL : 411.49
SPECIFIC GRAVITY : 2.605
LOCATION : 500 m in the downstream the proposed weir site.



4.1.4 Planning of temporary works

a) Construction method and cofferdam

o The construction method is Coupure method which utilizes the bending part of river by short cut.

o Construction of body works is dry work as a rule.

o Duration of the construction is dry season as a rule.

o Coefferdam is built up & downstreams of the river in the time of construction of dikes in the present river area.
And construction method of cofferdam is to close by soil. As the capacity of discharge of the present river is assumed about 400m^3/s, the scale of cofferdam is enough to close the present river section under the construction of dry works.

o In the time of construction of cofferdam, Coupure canal and the constructed canal of Scouring sluice can be utilized.

b) Construction road

As construction road, the road between Dardar and the Project (About Km) should be repaired. Presently as there is working road of the width of about 1.5m to get into the construction area, it is necessary to build temporary road (about 1.03 Km and a bridge of about 15m).

o The construction material for cofferdam is from upstream of the works in the left bank side. It is necessary to build a temporary bridge (ℓ = 35.0m) for carrying in.

c) Spoil-bank

o A spoil-bank of weir can be upstream side of right river bank.

4.1.5 Construction materials

Main Materials of Weir is as follows by the study.

o Cement: From Bakkanbar or North Sumatra (Padan)

o Reinforcement: " "

o Sand Gravel: Batanrob

o Boulder: Batanrob or North Sumatra (Barumun)

o Stone: North Sumatra, West Smatra
Under construction of weir in KAITI is reinforcement structure but stone is not used.

4.2 Irrigation System

(1) Water Resources

The irrigation water for the project is taken from Kumu weir for wet and dry season paddy.

The maximum and minimum intake discharge are as follows.

	Maximum	Minimum
Wet season paddy	9.34 m^3/s	0.44 m^3/s
Dry season paddy	4.77	0.19
Upland crops	0.43	0.14

(2) Distribution method of irrigation water

Golongan system and plot to plot irrigation will be adopted for the project area.

As to the wet paddy, the whole area of 7,300 ha will be divided into three Golongan blocks. The area of one Golongan block will become about 2,400 ha. For the sake of canal capacity, however, the Golongan system will be adopted about each secondary canal during wet season paddy cultivation. Conception of Golongan system is shown Fig. V-17.

On the other hand, two Golongan systems are not accepted in dry season because longer cultivation period will be obstructed by a shortage of river discharge especially during dry season of Batang Kumu river.

Plot to plot irrigation method will be taken at steep slope fields at every several plots. In case of flat area, separated canals for irrigation and drainage will be equipped in order to make a plain farming practice.

(3) Cropping Period and Irrigation Area

The dry season paddy cultivation is proposed to start one month after the harvest of the wet season paddy and the period to release water from canal for operation and maintenance is also proposed one month after completion of irrigation period of the dry season paddy cultivation.

The following table shows the most applicable case on the basis of the study.

Season's crop	Commencement date of puddling	Irrigation area	Max.Diversion requirement
Wet paddy	Oct. 1	7,300 ha	1.28/s/ha
Dry paddy	Feb. 26	3,100	1.54
Dry upland	Apr. 1	2,700	0.16

Taking into consideration resorting a weir without storage effect, fluctuation of average ten days discharge, the planning total household of transmigrants, distribution area for paddy cultivation per household, surplus water to downstream etc., the most appropriate cropping areas in the both seasons are obtained as the above table.

(4) Ten Days Intake Discharge

The ten days intake discharge for paddy cultivation of 7.300 ha in wet season and 3,100 ha in the dry season are estimated as shown in Table V-27 in the Clause 3.4. Water requirement for second crop in the dry season will be used as a supplemental irrigation.

(5) Diversion Requirement of Development Stage

During the development stage, the irrigation efficiency will be planned as 0.50 because new reclaimed paddy fields will need more irrigation water.

Therefore the diversion discharge will increase during development stage for paddy fields. These increasement of diversion discharge will be conveyed using canal free board as much as possible.

The relation of the diversion discharge and canal capacity will be studied in next stage.

Table V-30 TEN DAYS INTAKE DISCHARGE

Period	Wet season, 7,300 ha River discharge	Intake discharge	Period	Dry season, 3,100 ha River discharge	Intake discharge	Polowijo 2,700 ha Intake discharge
	m3/s	m3/s	Feb.3	8.42m3/s	2.67m3/s	m3/s
Oct.1	10.03	4.02	Mar.1	9.74	2.14	–
2	8.11	7.96	2	9.48	4.31	–
3	7.69	7.37	3	8.42	4.77	–
Nov.1	10.21	9.34	Apr.1	7.66	3.97	–
2	9.27	8.91	2	10.79	3.26	–
3	12.86	5.40	3	8.79	3.66	–
Dec.1	16.52	4.02	May.1	9.10	4.03	–
2	16.43	3.21	2	9.44	4.56	–
3	19.15	5.04	3	6.30	4.25	–
Jan.1	15.67	6.42	Jun.1	7.26	4.43	0.14
2	11.17	7.52	2	5.63	4.31	0.19
3	8.84	8.18	3	3.55	3.38	0.14
Feb.1	7.13	6.42	Jul.1	4.93	2.14	0.43
2	7.03	4.45	2	4.67	0.59	0.38
3	8.42	2.92	3	6.04	–	0.38
Mar.1	9.74	0.44	Aug.1	4.83	–	0.38
2	9.48	–	2	4.57	–	0.43
3	8.42	–	3	4.46	–	0.24

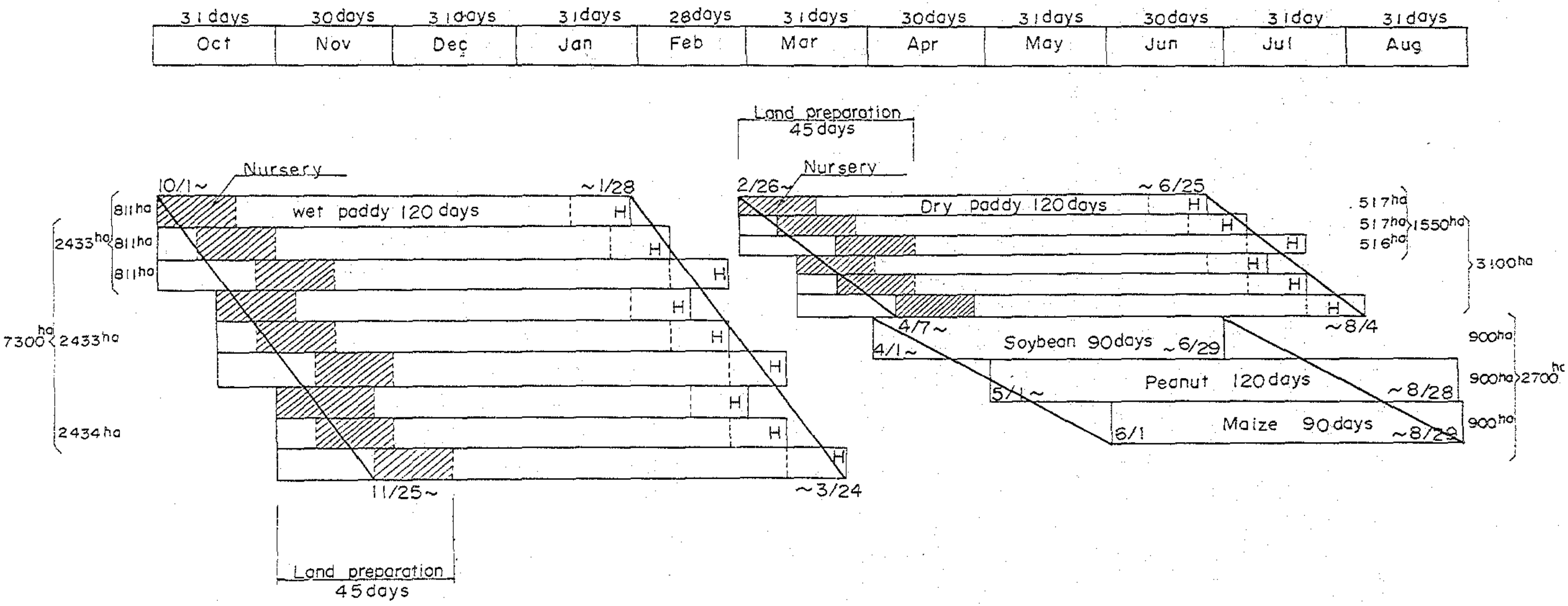


Fig.V-17 Conception of GOLONGAN System

4.3 Irrigation Canal Networks

(1) Alignment of main canal

The project area lies across the Batang Kumu river, then both-side intake method can be considered. However the right bank near Kotabangun village has high ground elevation along the length of about 400m in closely parralel with Batang Kumu river. Therefore the highest height of canal excavation will become about 20m and bench cuts every 3m become seven or eight steps.

From the view point of topographical condition above, one-side intake method is accepted for the Kumu diversion weir. After all a link canal is equipped between the diversion weir and the first diversion structure along the left bank of Batan Kumu river.

The left and right bank main canals are equipped in downstream of the first diversion structure. As to the right bank main canal, a syphon or an aqueduct structure will be constructed for crossing the Batang Kumu river.

All canal route is located in national land such as forest land, transmigration area,etc. but upstream of right bank main canal has to run about 5 Km through the concession area of P.T. Hutahaean, that is, rubber plantation area in near future.

(2) Scale of Irrigation Canal

Name of Canal	Design Discharge	Length	Slope
Link Canal (C-1)	9.34 m3/S	2,612 m	1/5,300
Left bank main canal			
C-2	7.38	9,046	1/5,100
C-3	4.80	3,236	1/4,300
C-5	3.39	5,963	1/3,900
C-7	2.23	4,318	1/3,800
S-2	1.38	3,047	1/3,800
Sub Total		25,610	
Right bank main canal			
C-4	4.59	10,718	1/4,100
C-6	3.16	5,227	1/3,800
C-7	2.36	1,845	1/3,800
S-1	1.66	893	1/3,800
Sub Total		18,683	
Total		46,905	

(3) Type of Canal

For the purpose of prevention of scour and erosion, lining of canals is considered and strongly recommended in the project area having the soil of cilty sands and clayey sands as the results of field investigation and soil mechanical tests.

(4) Water Depth of Design Discharge

As to the design water depth, there is a formula of Haring Huizen as a criteria of PROSIDA in Indonesia. However its formula has the tendency that water depth becomes deep in case of small discharge of canal. Therefore the corrected formula is adpoted as follows.

$$h = 0.887 \times Q^{0.277}$$

where h is water depth (m)
Q is design discharge m3/sec

The above coefficients was decided upon the Table A.2.1 to A.2.3 in the Design Criteria, CANALS, KP-03.

(5) Thin concrete lining for Link, Main & Secondary Canal

Design standard for thin concrete lining canal is as follows.

Design discharge : In case net irrigable area is larger than or equal to 6,235 ha,
$Q = A \times 1.28$ l/s/ha (Min 7.98 m3/S)
In case less than 1,550 ha,
$Q = A \times 1.73$ l/s/ha (Max 2.68 m3/s)

Application : Normal water depth d > 1.00 m

Gradient of inside slope : $Q \geq 1.50$ m3/s 1 : 1.5
$1.5 \geq Q \geq 1.0$ m3/s 1 : 1.0

Ratio between bed width of canal and water depth :
B/h = 1 - 2
Thickness of concrete lining ; t = 10 cm

Minimum width ; B= 1.00 m
Coefficient of roughness ; K = 70

Free boad;

Discharge	Lining	Part over lining	Total
0.5 < Q <1.5	0.20 m	0.30 m	0.50 m
1.5 < Q <5.0	0.25	0.35	0.60
5.0 < Q<10.0	0.30	0.45	0.75

Width Inspection road : B = 5.00 m
Width without inspection road : B = 3.00 m

(6) Earth canal

Earth canal type is adopted in case that normal water depth is less than 1.00 meter considering the soil conditions.

Therefore the type is occured in the embankment parts of secondary and tertiary canals, and a part of main canal.

a. Water depth :

As to the design water depth, the corrected formula is adopted as the same method of thin concrete lining canal.

b. Maximum velocity/minimum velocity

From the consistency test results and soil classification, the maximum velocity is taken as 0.7 m/sec as follows.

$$V\ max = Vb \times A \times B \times C$$
$$= 0.8 \times 1.1 \times 0.8 \times 1.0 = 0.70\ m/s$$

where V max is maximum allowable velocity in m/s
V b is basic velocity in m/s
A is correction factor for void ratio of canal surface
B is correction factor for water depth
C is correction factor for curvature

As to the minimum velocity, it is taken as 0.30m/s

c. Side slope :

Water depth + free board	$D \leq 1.0m$,	1 : 1
"	$1.0 < D \leq 2.0m$,	1 : 1.5

d. Free board:

Discharge	$Q \leq 0.5$	: 40 cm
	$0.5 < Q \leq 1.5$	: 50 "
	$1.5 < Q \leq 5.0$	: 60 "

e. Strikler roughness coefficients for earthen canal:

Discharge	$Q \leq 1.0$:	K = 35
	1.0 $Q \leq 5.0$:	K = 40

f. Ration of width and water depth :

Discharge	$Q \leq 0.3$:	b/h = 1.0
	$0.3 < Q \leq 0.5$:	1.0 - 1.2
	$0.5 < Q \leq 0.75$:	1.2 - 1.3
	$0.75 < Q \leq 1.00$:	1.3 - 1.5
	$1.00 < Q \leq 1.50$:	1.5 - 1.8
	$1.50 < Q \leq 3.00$:	1.8 - 2.3

g. Width of inspection road (B) and opposite embankment (B')

Discharge	$Q \leq 1$	B = 3.00m,	B' = 1.00m
	$1 < Q \leq 5$	B = 5.00m,	B' = 1.50m
	$5 < Q \leq 10$	B = 5.00m,	B' = 3.00m

Table V-31 SCALE OF CANAL (1/2)

Name of Canal	C-Section	D.Discharge Q m3/S	Length L m	Slope I	Irrigated Area A ha	Remarks
Link Canal	C−1	9.34	2,612	1/5300	7,300	Concrete lining
Left-side Main Canal						
BK. 1 ~BL. 6	C−2	7.38	9,046	1/5100	4,500	〃
BL. 6 ~BL. 9	C−3	4.80	3,236	1/4300	2,926	〃
BL. 9 ~BL.15	C−5	3.39	5,963	1/3900	2,070	〃
BL.15 ~BL.18	C−7	2.23	4,318	1/3800	1,287	〃
BL.18 ~BL.20 (E.P)	C−2	1.38	3,047	1/3800	799	Earth Canal
Total			25,610			
Right-Side Main Canal						
BK. 1 ~BR. 3	C−4	4.59	10,718	1/4100	2,800	Concrete Lining
BR. 3 ~BR. 7	C−6	3.16	5,227	1/3800	1,928	〃
BR. 7 ~BR. 9	C−7	2.36	1,845	1/3800	1,365	〃
BR. 9 ~BR.10 (E.P)	S−1	1.66	893	1/3800	959	Earth Canal
Total			18,683			
Right-Side Secondery Canal						
LR-1						
B. 0 ~B. 3	S−9	0.45		1/3100	259	Earth Canal
B. 3 ~B. 5 (E.P)	S−11	0.21		1/2600	124	〃
Total			5,635			
LR-2						
B. 0 ~B. 4	C−8	2.09		1/3800	1,208	Concrete lining
B. 4 ~B. 5	S−1	1.66		1/3800	959	Earth Canal
B. 5 ~B. 8	S−7	0.65		1/2900	378	〃
B. 8 ~B.11 (E.P)	S−10	0.33		1/3100	192	〃
Total			11,836			
LR-2ki						
B. 0 ~B. 3	S−5	0.76		1/2900	437	Earth Canal
B. 3 ~B. 5 (E.P)	S−10	0.31		1/3100	177	〃
Total			5,055			
LR-3	S−10	0.37	2,152	1/3100	213	〃
LR-4	S−11	0.21	1,334	1/2600	123	〃
LR-5						
B. 0 ~B. 3	S−6	0.71		1/2700	409	〃
B. 3 ~B. 4 (E.P)	S−11	0.15		1/2700	87	〃
Total			5,456			
LR-6						
B. 0 ~B. 1	S−7	0.61		1/3100	355	〃
B. 1 ~B. 3 (E.P)	S−10	0.35		1/3100	205	〃
Total			3,077			
LR-7	S−10	0.39	2,246	1/3000	224	〃
LR-8						
B. 0 ~B. 3	S−3	1.06		1/3800	610	〃
B. 3 ~B. 5	S−8	0.49		1/3100	286	〃
B. 5 ~B. 8 (E.P)	S−10	0.28		1/3100	164	〃
Total			7,067			

Table V-31 SCALE OF CANAL (2/2)

Name of Canal	C-Section	D.Discharge Q m3/S	Length L m	Slope I	Irrigated Area A ha	Remarks
L-8ki	S-11	0.23	1,115	1/2600	131	
LL-1	S-11	0.20	5,145	1/2700	115	
Right-side Secondary Canal						
RL-1						
B. 0～B. 3	S-7	0.59		1/3200	342	
B. 3～B. 5	S-11	0.23		1/2400	134	
(E.P)						
Total			4,035			
RL-2	S-11	0.24	2,040	1/2300	136	
RL-3						
B. 0～B. 2	S-7	0.59		1/3200	342	
B. 2～B. 4	S-10	0.28		1/3100	160	
(E.P)						
Total			3,926			
RL-4						
B. 0～B. 2	S-7	0.66		1/2900	379	
B. 2～B. 5	S-10	0.33		1/3100	193	
(E.P)						
Total			4,834			
RL-5	S-11	0.21	2,346	1/2600	124	
RL-6						
B. 0 B. 4	S-4	1.01		1/3600	586	
B. 4～B. 6	S-7	0.54		1/3200	312	
B. 6～B.10	S-10	0.28		1/3100	163	
(E.P)			10,311			
Total						
RR-1						
B. 0～B. 2	S-8	0.53		1/3100	307	
B. 2～B. 3	S-10	0.28		1/3100	163	
(E.P)						
Total			2,608			

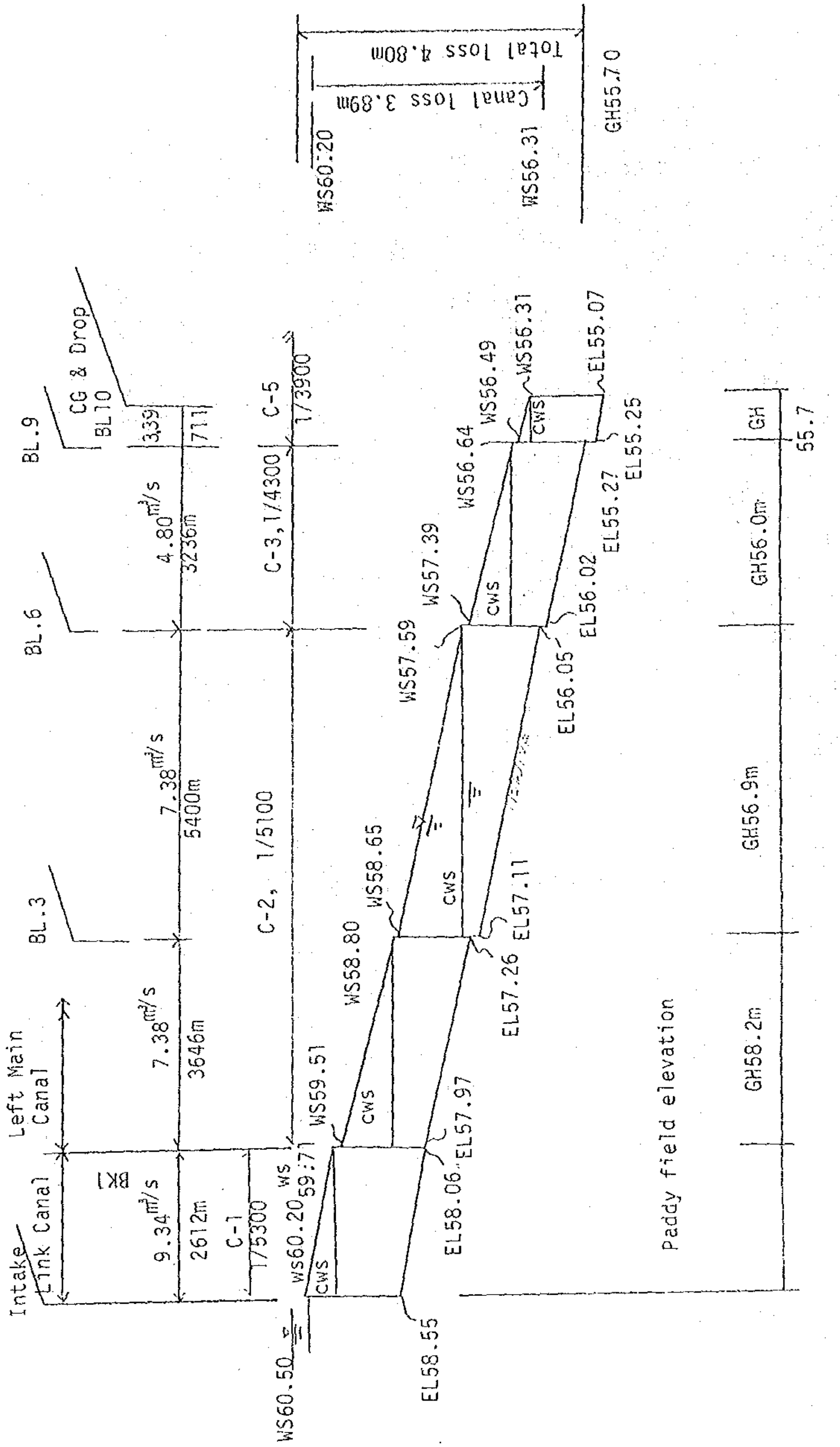


Fig.V-18 Profile of Left Bank Main Canal & Paddy Field Elevation

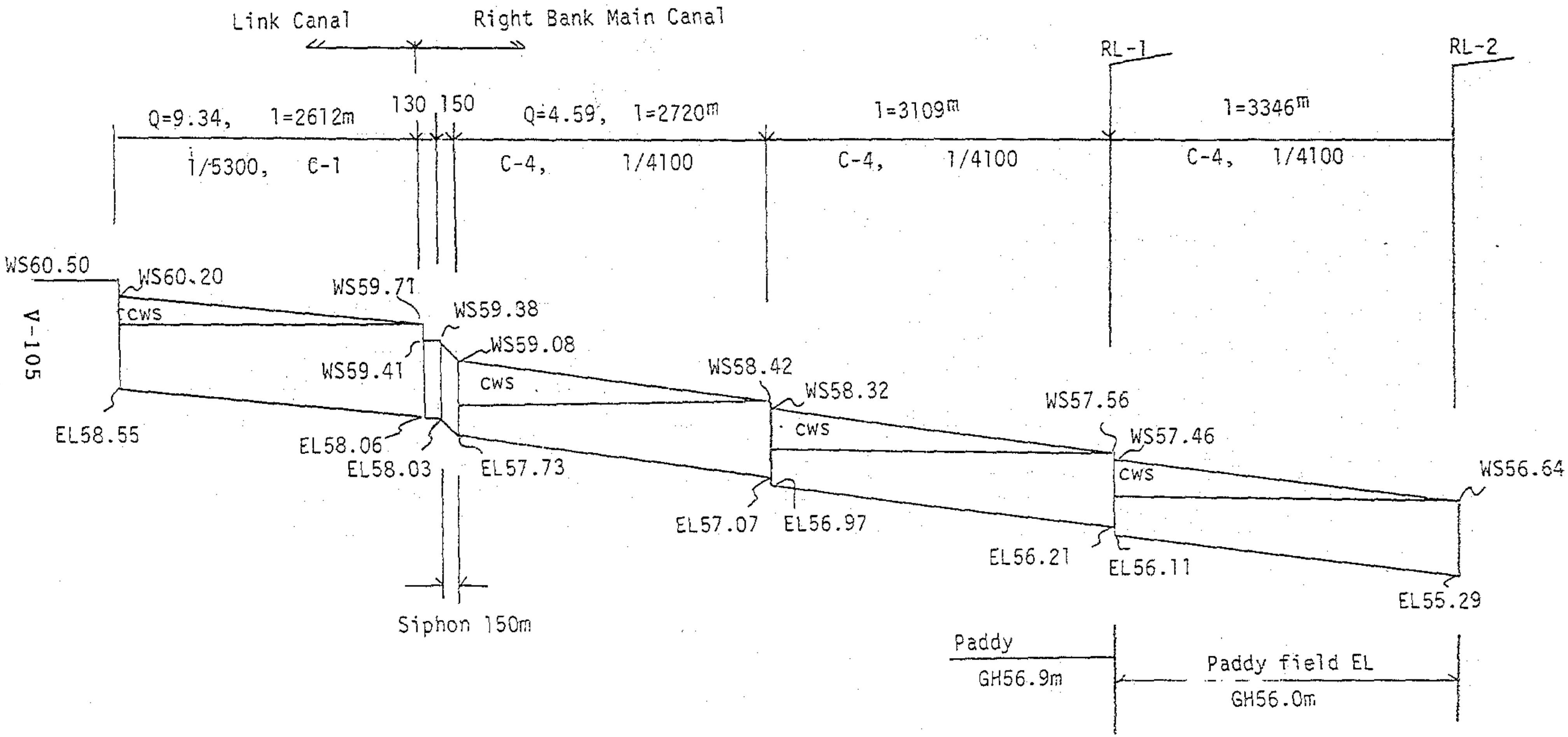


Fig.V-19 Profile of Right Bank Main Canal & Paddy Field Elevation

Fig.V-20 Standard Section of Thin Concrete Lining Canal

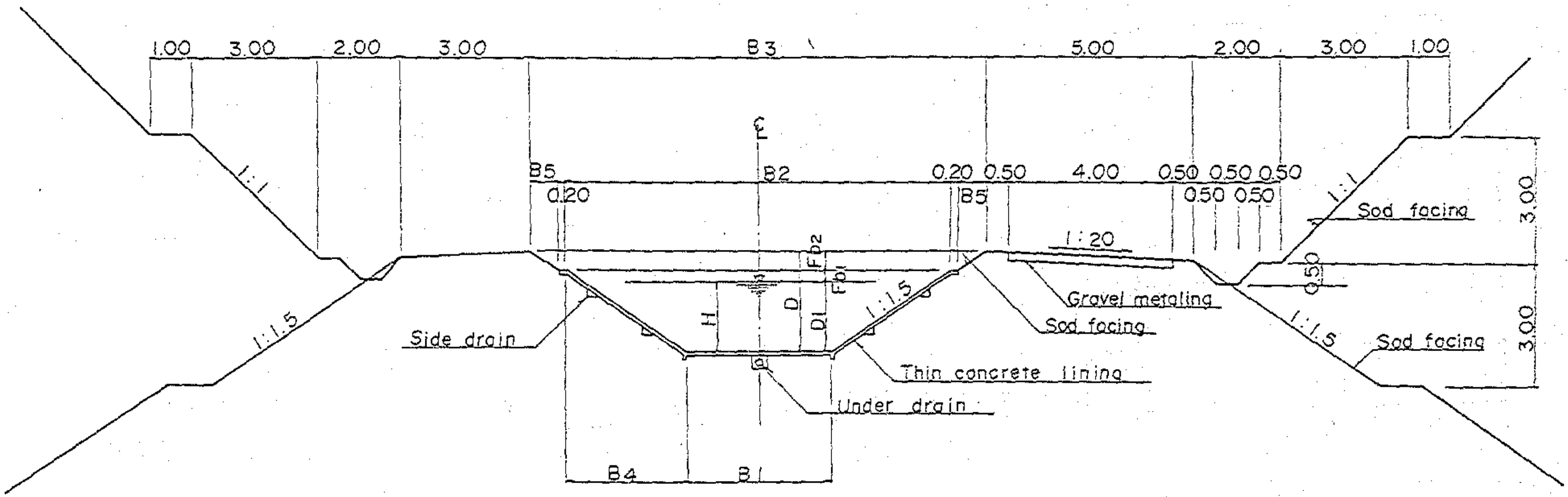


Table V-32 DIMENSION OF CONCRETE LINING CANAL

No.	Q m3/s	m	B1 m	B2 m	B3 m	B4 m	B5 m	H m	Fb1 m	Fb2 m	D1 m	D m	I m
C-1	9.34	1.5	3.30	9.15	10.90	2.925	0.675	1.65	0.30	0.45	1.95	2.40	1/5300
C-2	7.38	1.5	2.80	8.35	10.10	2.775	0.675	1.54	0.31	0.45	1.85	2.30	1/5100
C-3	4.80	1.5	1.80	6.75	8.20	2.475	0.525	1.37	0.28	0.35	1.65	2.00	1/4300
C-4	4.59	1.5	1.70	6.50	7.95	2.400	0.525	1.35	0.25	0.35	1.60	1.95	1/4100
C-5	3.39	1.5	1.30	5.80	7.25	2.250	0.525	1.24	0.26	0.35	1.50	1.85	1/3900
C-6	3.16	1.5	1.20	5.70	7.15	2.250	0.525	1.22	0.28	0.35	1.50	1.85	1/3800
C-7	2.36	1.5	1.00	5.20	6.65	2.100	0.525	1.11	0.29	0.35	1.40	1.75	1/3800
C-8	2.09	1.5	1.00	4.90	6.35	1.950	0.525	1.05	0.25	0.35	1.30	1.65	1/3800

Fig.V-21 Standard Section of Earth Canal

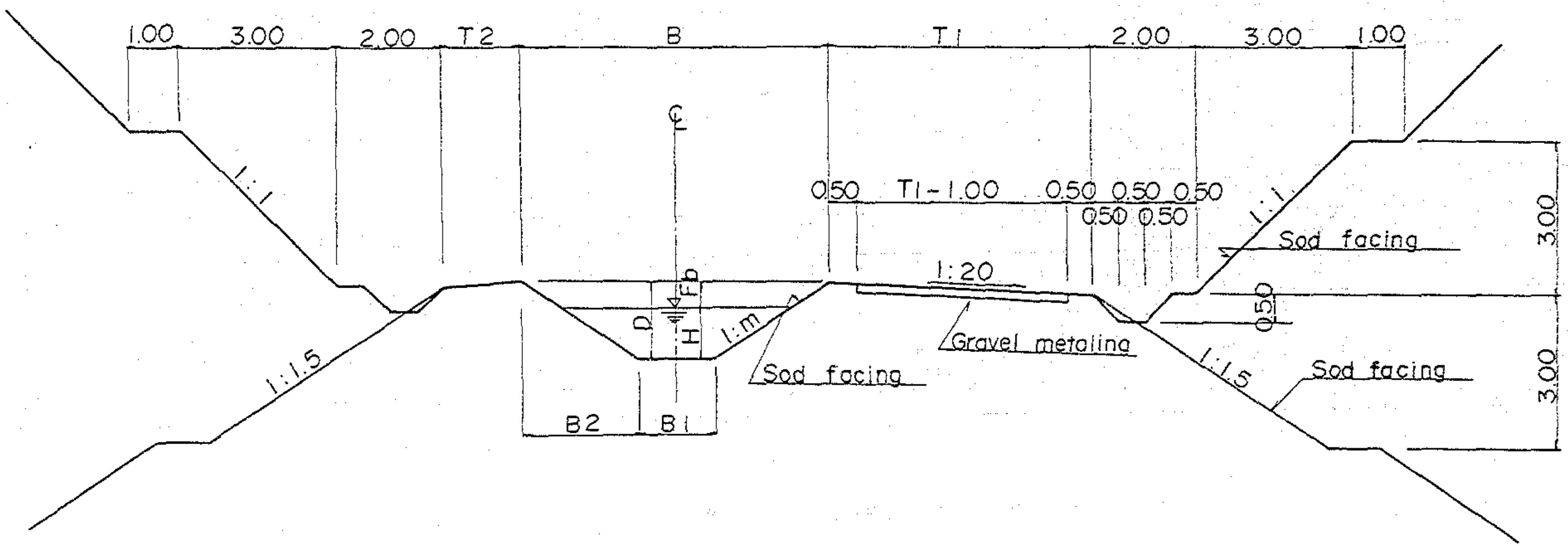


Table V-33 DIMENSION OF EARTH CANAL

No.	Q m3/s	H m	Fb m	D m	B1 m	m	B2 m	B m	T1 m	T2 m	I
S-1	1.66	1.00	0.60	1.60	2.00	1.5	2.400	6.80	5.00	3.00	1/3800
S-2	1.38	0.95	0.50	1.45	1.80	1.5	2.175	6.15	5.00	3.00	1/3800
S-3	1.06	0.90	0.50	1.40	1.40	1.5	2.100	5.60	5.00	2.00	1/3800
S-4	1.01	0.89	0.51	1.40	1.30	1.5	2.100	5.50	5.00	2.00	1/3600
S-5	0.76	0.82	0.53	1.35	1.10	1.5	2.025	5.15	3.00	2.00	1/2900
S-6	0.71	0.81	0.54	1.35	1.00	1.5	2.025	5.05	3.00	2.00	1/2700
S-7	0.66	0.79	0.51	1.30	1.00	1.5	1.950	4.90	3.00	2.00	1/2900
S-8	0.53	0.74	0.51	1.25	0.90	1.5	1.875	4.65	3.00	2.00	1/3100
S-9	0.45	0.71	0.44	1.15	0.80	1.5	1.725	4.25	3.00	2.00	1/3100
S-10	0.39	0.68	0.42	1.10	0.70	1.5	1.650	4.00	3.00	2.00	1/3000
S-11	0.24	0.60	0.40	1.00	0.60	1.0	1.500	3.60	3.00	2.00	1/2300

Table V-34 HYDRAULIC CALCULATION OF CONCRETE LINING CANAL

CALCULATION OF CANAL SLOPE

Q m3/s	h m	B/h	Bl m	m	K	Fb m	H+Fb m	A m2	V m/s	P m	R	R4/3	n	I	1/I
9.34	1.65	2.00	3.30	1.5	70.00	0.75	2.40	9.529	0.980	9.249	1.030	1.041	0.0143	0.000189	5296
7.38	1.54	1.82	2.80	1.5	70.00	0.75	2.29	7.869	0.938	8.353	0.942	0.924	0.0143	0.000195	5136
4.80	1.37	1.31	1.80	1.5	70.00	0.60	1.97	5.281	0.909	6.740	0.784	0.722	0.0143	0.000234	4277
4.59	1.35	1.26	1.70	1.5	70.00	0.60	1.95	5.029	0.913	6.567	0.766	0.701	0.0143	0.000243	4112
3.39	1.24	1.05	1.30	1.5	70.00	0.60	1.84	3.918	0.865	5.771	0.679	0.597	0.0143	0.000256	3899
3.16	1.22	0.98	1.20	1.5	70.00	0.60	1.82	3.697	0.855	5.599	0.660	0.575	0.0143	0.000260	3847
2.36	1.11	0.90	1.00	1.5	70.00	0.60	1.71	2.958	0.798	5.002	0.591	0.496	0.0143	0.000262	3814
2.23	1.08	0.93	1.00	1.5	70.00	0.60	1.68	2.830	0.788	4.894	0.578	0.482	0.0143	0.000264	3792
2.09	1.05	0.95	1.00	1.5	70.00	0.60	1.65	2.704	0.773	4.786	0.565	0.467	0.0143	0.000262	3822

Table V-35 HYDRAULIC CALCULATION OF EARTH CANAL

CALCULATION OF CANAL SLOPE

Q m3/s	h m	B/h	B1 m	m	K	Fb m	H+Fb m	A m2	V m/s	P m	R	R4/3	n	I	1/I
1.66	1.00	2.00	2.00	1.5	40.00	0.60	1.60	3.500	0.474	5.606	0.624	0.534	0.0250	0.000263	3796
1.38	0.95	1.89	1.80	1.5	40.00	0.50	1.45	3.064	0.450	5.225	0.586	0.491	0.0250	0.000258	3870
1.06	0.90	1.55	1.40	1.5	40.00	0.50	1.40	2.481	0.427	4.650	0.534	0.433	0.0250	0.000264	3792
1.01	0.89	1.46	1.30	1.5	40.00	0.50	1.39	2.343	0.431	4.507	0.520	0.418	0.0250	0.000278	3599
0.76	0.82	1.34	1.10	1.5	35.00	0.50	1.32	1.918	0.396	4.064	0.472	0.367	0.0286	0.000350	2861
0.71	0.81	1.24	1.00	1.5	35.00	0.50	1.31	1.783	0.398	3.909	0.456	0.351	0.0286	0.000369	2707
0.66	0.79	1.26	1.00	1.5	35.00	0.50	1.29	1.728	0.382	3.850	0.449	0.344	0.0286	0.000347	2880
0.61	0.77	1.29	1.00	1.5	35.00	0.50	1.27	1.671	0.365	3.789	0.441	0.336	0.0286	0.000325	3080
0.59	0.77	1.30	1.00	1.5	35.00	0.50	1.27	1.647	0.358	3.763	0.438	0.332	0.0286	0.000316	3168
0.53	0.74	1.21	0.90	1.5	35.00	0.50	1.24	1.500	0.353	3.582	0.419	0.313	0.0286	0.000326	3066
0.45	0.71	1.13	0.80	1.5	35.00	0.40	1.11	1.327	0.339	3.364	0.395	0.289	0.0286	0.000325	3077
0.39	0.68	1.02	0.70	1.5	35.00	0.40	1.08	1.179	0.331	3.164	0.373	0.268	0.0286	0.000334	2995
0.37	0.67	1.04	0.70	1.5	35.00	0.40	1.07	1.152	0.321	3.128	0.368	0.264	0.0286	0.000320	3126
0.24	0.60	1.00	0.60	1.0	35.00	0.40	1.00	0.715	0.336	2.290	0.312	0.212	0.0286	0.000434	2302
0.23	0.59	1.02	0.60	1.0	35.00	0.40	0.99	0.703	0.327	2.270	0.310	0.209	0.0286	0.000418	2391
0.21	0.58	1.04	0.60	1.0	35.00	0.40	0.98	0.677	0.310	2.228	0.304	0.204	0.0286	0.000386	2593
0.20	0.57	1.06	0.60	1.0	35.00	0.40	0.97	0.663	0.302	2.206	0.301	0.201	0.0286	0.000369	2709

4.4 Drainage Canal

(1) Drainage System

Provision of a suitable drainage facility is one of the important factor to improve agricultural productivity in the low-lying land of the project.

Most natural streams which are located in the project area will become main drainage canal, while smaller drainage canal, that is, secondary drain will be provided according to land and soil conditions. However some of secondary drain will be constructed along the line of old river.

Secondary drain is planned to connect tertiary drains and natural stream, further tertiary drain will collect the drainage water from quaternary drains to the secondary drain.

(2) Design discharge

Design discharge analysis will be divided into two methods namely drainage requirement for ricefields and non-rice fields.

Design capacity for rice fields is calculated using the following conditions.

a. Return period of design discharge : 5 years
b. 3 days consecutive rain fall : 161 mm
c. Design discharge;

$$Q\ 1 = 1.62\ Dm x A.^{0.92} \quad (A \geq 400\ ha)$$
$$Q\ 1 = Dm \times A \quad (A < 400\ ha)$$

where Q 1 is design discharge (l/s)
Dm is drainage modulus (l/s/ha)
A is drainage area (ha)

The drainage modulus is taken 3.8 l/s/ha. If the drainage area is less than 400 ha, the drainage discharge per unit area is taken as constant.

As to the drainage requirement at non-rice fields such as villages, roads and non-agric land, Mc-Math empirical formula (by Prosida/Harza) will be applied as follows.

$$Q\ 2 = 0.023 \times c \times i \times A^{4/5} \times S^{1/5}$$

where Q_2 is design discharge (m3/sec)
c is run off coefficient 0.80
i is rainfall intensity (cm/hr)
R24 (1/5) = 110 mm/day = 4.6 cm/hr
R24 (1/25) = 129 mm = 5.4 cm/hr
A is drainage area. Max. area 10,000 ha

S is average ground slope of drainage area

The design drainage discharge combines those of rice fields and non-rice fields. Then total drainage discharges will be Qd equals to 1.15 x (Q1 + Q2).

The design discharge is estimated by using the beforementioned methods for representative secondary drain as bellow.

a. In case of combination of ricefields and non rice fields

Name of drain		A-1	B-13
Area of rice fields	A1	1850	220
Area of non rice fields	A2	400	120
Drainage modulus	Dm	3.8	3.8
Run off coefficient	C	0.8	0.8
Rainfall intensity	i	4.6	4.6
Ground slope	S	0.00143	0.00143
Design discharge	Q1	6.24	0.84
"	Q2	2.76	1.05
1.15 (Q1+Q2)	Q	10.40	1.10

b. In case of ricefields

Area of rice fields	A1	100	200	300	400	500	600 ha
Drainage modulus	Dm	3.8	3.8	3.8	3.8	3.8	3.8
Design discharge	Q1	0.38	0.76	1.14	1.52	1.87	2.21
1.15 x Q1	Q	0.40	0.90	1.30	1.70	2.20	2.50

(3) Canal dimension

- For the drainage canal, earthen type will be adopted taking the construction cost into consideration.

- The maximum design water level is equal to ground level.

- Maximum velocity of 1.5 times the maximum velocity of conveyance canal will be adopted.

- Free boad is taken from irrigation design standard KP-03 "CANALS" as follows.

Qd < 0.1 m3/s	Fb =	0.40 m
$0.1 \leq$ Qd < 0.5		0.45
$0.5 \leq$ Qd < 1.0		0.50

1.0 ≤ Qd < 1.5	0.55
1.5 ≤ Qd < 2.5	0.60
2.5 ≤ Qd < 3.0	0.65
3.0 ≤ Qd < 4.5	0.70
4.5 ≤ Qd < 6.0	0.75
6.0 ≤ Qd < 9.0	0.80
9.0 ≤ Qd <15.0	0.85

- Side slope : every excavation depth D

D ≤ 1.0m	1 : 1
1.0 < D ≤ 1.5	1 : 1.5
1.5 < D	1 : 2.0

- Width-depth ratio : b/h = 1 to 3

- Strikler's roughness coefficients

  h ≥ 1.5 m ; K = 30
  h < 1.5 m K = 25

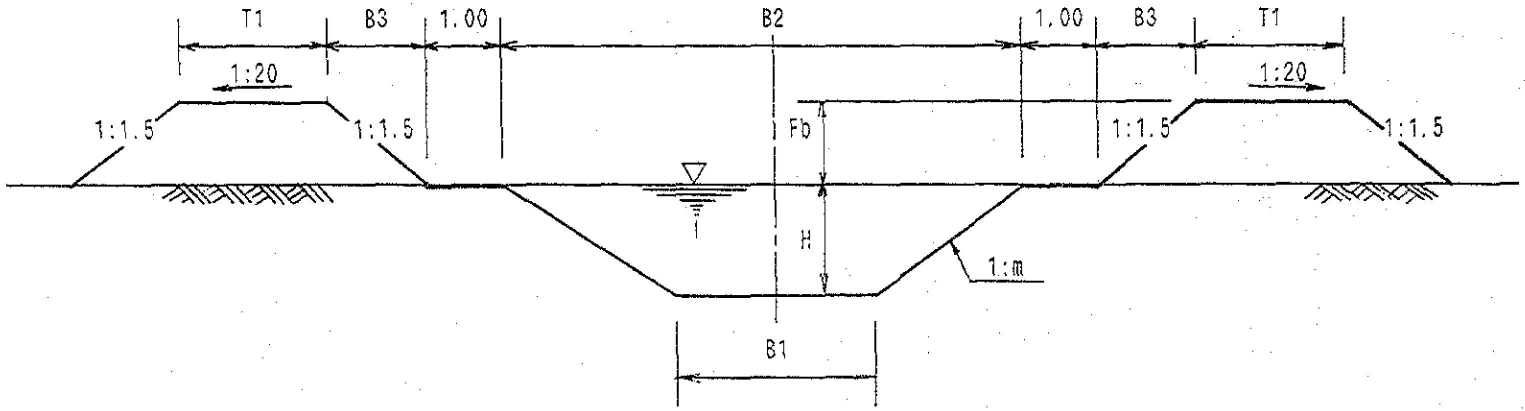
(4) Length of secondary drain

Place	Nos.	Length
Left bank Right bank	20 26	27.74 Km 28.71 Km
Total	46	56.45 Km

V-36 LIST OF DRAINAGE CANAL

Left Bank				Right Bank			
Division	Canal Name	Length (Km)	Structure(Nos)	Division	Canal Name	Length (Km)	Structure(Nos)
II	A-1	1.31	1	V	B-1	0.50	
III	2	1.78	1	〃	2	1.44	1
〃	3	0.61		VII	3Ka	0.65	
〃	4	2.43	1	V	3Ki	0.97	1
VI	5	3.17	2	〃	4	0.74	
〃	6	0.42		〃	5	1.12	1
〃	7	3.45	2	〃	6Ka	1.20	1
〃	7Ki	0.29		〃	6Ki	0.83	
〃	8	0.68		VII	7	1.18	1
〃	9	0.40		〃	8	0.65	
〃	10	0.42		〃	9	0.45	
III	11	1.59	1	〃	10	0.70	
VI	12	1.42	1	V	11	1.67	1
〃	13Ka	0.91		VI	12	1.10	
〃	13Ki	1.54	1	〃	13	2.65	2
〃	14	1.60	1	〃	13Ki	0.46	
〃	15Ka	1.83	1	〃	14	1.95	2
〃	15Ki	1.16	1	〃	14Ka	0.25	
〃	15KiKa	1.26	1	VII	15	1.13	1
IV	16	1.47	1	〃	16	0.85	
				〃	17	1.87	1
				〃	18	1.94	1
				〃	18Ki	0.78	
				VI	19	0.95	
				〃	20	0.48	
				〃	21	2.20	1
Sub Total				Sub Total			
II		1.31	1				
III		6.41	3	V		8.47	5
IV		1.47	1	VI		10.04	5
IV		18.55	10	VII		10.20	4
Grand Total		27.74	15	Grand Total		28.71	14

Fig.V-22 Standard Section of Drainage Canal



Dimension								
TYPE	Q (m3/s)	B1 (m)	H (m)	Fb (m)	m	B2 (m)	B3 (m)	T1 (m)
D-1	6.10	2.00	1.50	0.80	2	8.00	1.200	3.00
D-2	1.40	1.00	0.95	0.55	1.5	3.85	0.825	1.50
D-3	0.70	1.00	0.70	0.50	1.5	3.10	0.750	1.50

Total Length								
TYPE	Div. II	Div. III	Div. IV	Div. V	Div. VI	Div. VII	Div. VIII	Total
D-1	Km 1.3	Km -	Km -	Km -	Km 1.0	Km 1.4	Km -	Km 3.7
D-2	-	5.8	-	4.7	7.1	3.2	6.9	27.7
D-3	-	0.6	1.5	3.7	2.0	14.0	3.3	25.1
Total								56.5
Bridge	1	3	1	5	5	10	4	Nos 29

4.5 Related Structures of Main & Secondary System

As for the related structures, the following facilities are required.

a. Intake structure
b. Divesion structures
c. Turnouts
d. Check gates
e. Parshall flume and other measuring devices
f. Syphon and aqueduct if necessary
g. Culvert
h. Waste way
i. Drops
j. Drainage culverts
k. Bridges
l. Inspection roads
m. Access roads
n. Others if necessary

Number of structures are summarized in Table V-36.

(1) Parshall Flume of Diversion Structure BK1.

Width 10 feet type is used for the parshall flume from the diversion discharge. The head loss is estimated to be 0.30 m as safety allowance.

(2) Syphon structure of Right Bank Main Canal

The scale of the syphon is estimated as bellow.

Design discharge	: Q = 4.59 m^3/s
Length	: L = 150 m
Size	: 2.00 x 2.00 m
Type	: Reinforced Concrete Box
Water Pressure	: H = 10 meter
Head loss	: Hf = 0.30 m
Velocity	: V = 1.15 m/s
Energy slope	: I = 1/1,473

Table V-37 RELATED STRUCTURES OF MAIN & SEC.CANAL

CANAL (STAGE-I)	Division	Length (m)	Diversion Str.	Turnout Gate	Check Gate	Spillway	Drop	Drainage Culvert	Bridge	Total (Nos.)
Link	Div. I	2, 612	1	–	1	2 ※	–	5	1	10
Main	Div. II	9, 046	2	5	2	4	–	18	5	36
	III	8, 009	3	6	3	3	2	16	4	37
	IV	8, 555	3	11	5	3	3	17	5	47
	V	12, 166	4	2	5	4	–	24	7	46
	VI	6, 517	2	12	6	2	–	13	4	39
	Sub-Total	44, 293	14	36	21	16	5	88	25	205
Sec.	Div. II	10, 737	–	17	9	4	1	22	5	58
	III	16, 675	1	31	13	6	1	33	8	93
	IV	7, 028	1	17	6	3	1	14	4	46
	V	7, 010	–	16	6	3	1	14	4	44
	VI	16, 580	–	32	13	6	1	33	8	93
	Sub-Total	58, 030	2	113	47	22	5	116	29	334
	Total	104, 935	17	149	69	40	10	209	55	549
(STAGE-II)	Div. VII	15, 678	–	24	12	5	1	31	8	81
	VIII	6, 510	–	9	5	2	1	13	3	33
	Total	22, 188	–	33	17	7	2	44	11	114
Grand TOTAL		127, 123	17	182	86	47	12	253	66	663

Note : ※ includes one sand trap structure in the downstream of intake.

4.6 Tertiary Canal and On-Farm Facilities

(1) Command area

As the general criteria for tertiary unit development, the following standards will be accepted being based on Design Criteria, Tertiary Units, KP-05.

Size of tertiary unit	:	50 - 100 ha
Size of quaternary unit	:	8 - 15 ha
Length of tertiary canal	:	< 1500 m
Length of quarernary canal	:	< 500 m
Distance between quaternary canal and drainage canal	:	< 300 m

(2) Design criteria for unlined irrigation canals

The following criteria will be applied for unlined irrigation canals. (from design standard, KP-05)

Design Characteristics	Unit	Tertiary Canal	Quaternary canal
Max. velocity	m/s	following design graphs	
Min. velocity	m/s	0.20	0.20
K. Values	-	35	30
Min. bottom width	m	0.30	0.30
Side slopes	-	1 : 1	1 : 1
Min. embankment width	m	0.50	0.40
Min. free board	m	0.30	0.20

Note - The bottom width will be equal to the water depth (b/h = 1).

(3) Scale of Facilities

Facility	Unit	Left Bank	Right Bank	Total
Irrigation Area	ha	4,500	2,800	7,300
Tertiary Irrigation Canal	Km	76	47	123
Tertiary Drainage Canal	"	73	46	119
Quartenary Irrigation Canal	"	224	139	363
Quartenary Drainage Canal	"	45	28	73
Farm Road	"	90	56	146
Land Clearing	ha	600	400	1,000
Land Levelling	"	3,000	2,000	5,000

Table V-38 Tertiary System

Division	1st Stage		2nd Stage		Construction Period				Remark
	Left bank	Right bank	Left bank	Right bank	1993/94	1994/95	1995/96	1996/97	
	ha	ha	ha	ha	ha	ha	ha	ha	
II	471				230	241			SKP-C/DU
III	897				150	600	147		SKP-C/DU, DK-4, R/K, D/DU
IV	251					190	61		SKP-D/DU
V		470			230	240			SKP-C/DK-2, DK-3
VI		981			160	650	171		SKP-C/DK-3, SKP-D/DK-1, DK-3
VII			2,881			720	1,440	721	DK-6, 7, 8, 9, 10, 11
VIII				1,349		340	670	339	DK-12, 13, 14
Sub Total	1,619	1,451	2,881	1,349	770	2,981	2,489	1,060	
Total	Existing Transmigrant 3,070		Resettlement 4,230						
Grand Total	7,300				7,300				

CHAPTER 5 OTHER WORKS

5.1 Study of Small-scale Hydro-power Generation

5.1.1 Outline

Small-scale hydro-power generation is to utilize the energy of elevation head which a weir holds in it being a structure of water resources.

In this study, economic valuation is taken place by rough estimation of generated output, generated energy, construction cost etc, based on the design scale of weir in this project.

5.1.2 Rough estimation of generated output

a) Rough determination of headwater and tailwater level.

In case of weir, overflow depth in upstream and depth of river in downstream are changed by amount of discharge in the river. However, the changes of water level in up & down streams are treated to be the similar changes.

- o Headwater level is the elevation of crest
  EL 60.60 = WL 60.60
- o Tailwater level is the elvation of river bed
  EL 55.10 = WL 55.10

b) Rough estimation of effective head

Effective head is the one which is subtracted total loss head from total head. In this study about 8% of total head is considered as rough loss head.

- Total head Ho = WL60.60 - WL55.10 = 5.50 m
- Effective head H = 5.50 - (5.50 x 0.08) ≒ 5.00 mm

c) Rough estimation of maximum discharge

Maximum discharge is given by Discharge-Duration Curve based on each 10 days discharge of river (average discharge from 1970 to 1988) and irrigation requirement at the spot of weir. But, as Discharge-Duration Curve is different in each river, it is generally studied by setting study case according to the condition of discharge.

In this study, ordinary water discharge (discharge not less than 185 days in a year) is taken for it. (See the following figures of Discharge-Duration Curve and Average Ten Days River Discharge)

o Maximum discharge $Q = 10.50\ m^3/s$

d) Rough estimation of kinds of turbine & generation, and the efficiency
Efficiency of turbine & generation is different by the kind & scale of them.

Fig.V-23 Discharge-Duration Curve of Bt.Kumu

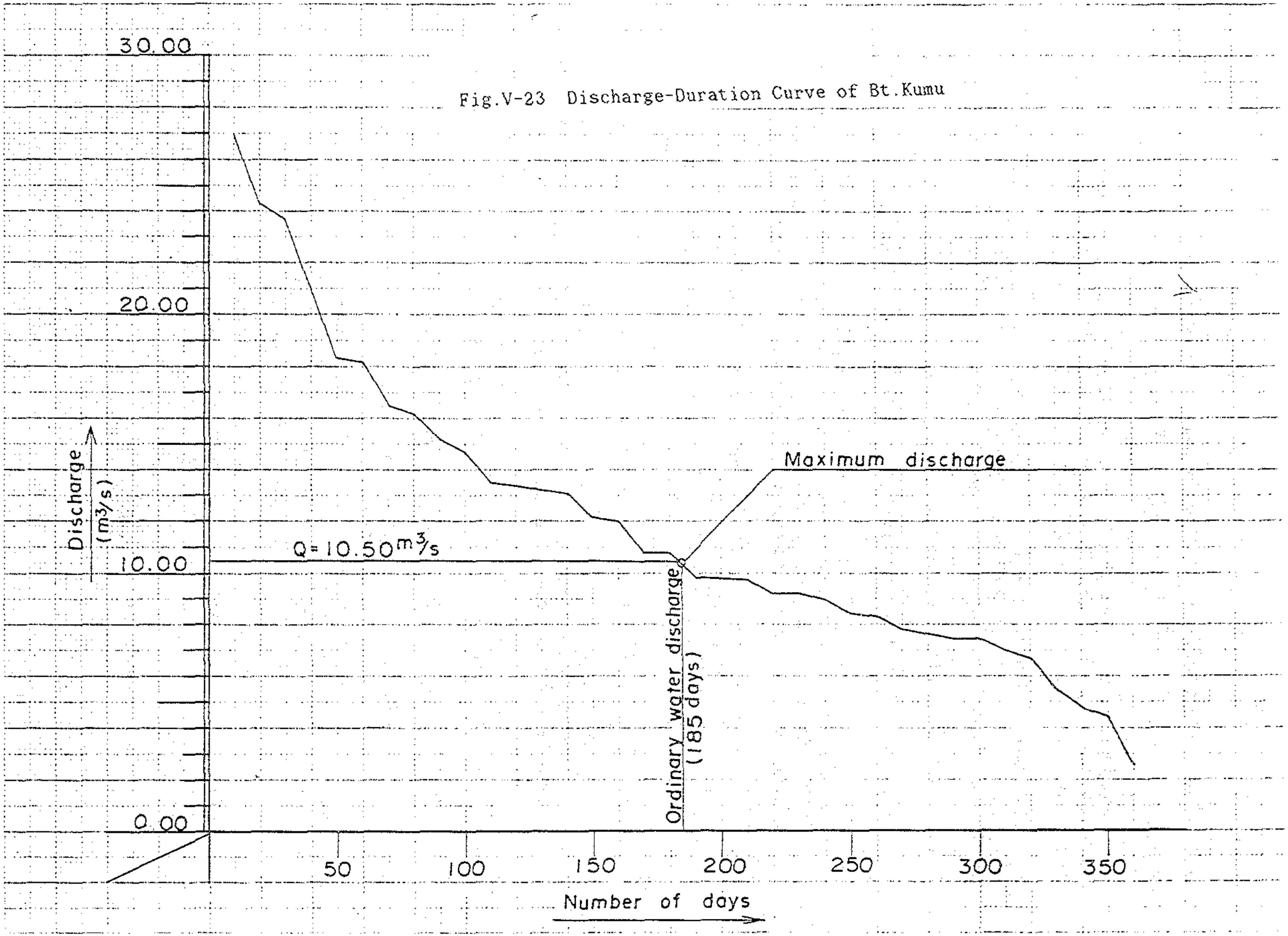
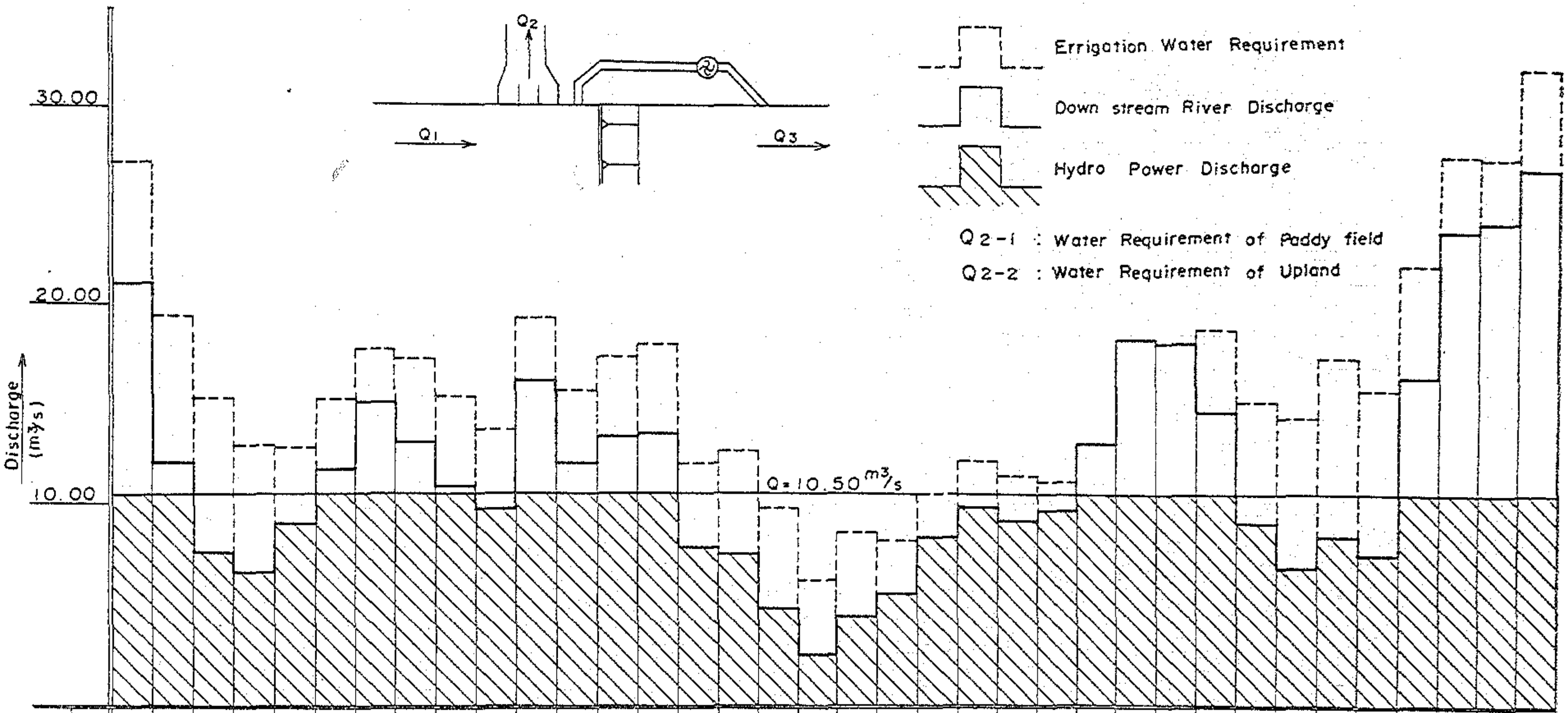


Fig.V-24 Average Ten Days River Discharge



	JAN 1	JAN 2	JAN 3	FEB 1	FEB 2	FEB 3	MAR 1	MAR 2	MAR 3	APR 1	APR 2	APR 3	MAY 1	MAY 2	MAY 3	JUN 1	JUN 2	JUN 3
Q3 (m³/s)	21.05	12.15	7.62	6.73	9.00	11.78	15.22	13.18	10.78	9.71	16.19	12.06	13.39	13.50	7.79	7.51	4.77	2.54
Q2-1	6.13	7.23	7.71	6.21	3.76	3.49	2.58	4.14	4.60	3.97	3.07	3.63	4.00	4.53	4.25	4.40	4.11	2.90
Q2-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.76	0.96	0.76
Q1 (m³/s)	27.18	19.38	15.33	12.94	12.76	15.27	17.80	17.32	15.38	13.68	19.26	15.69	17.39	18.03	12.04	12.67	9.84	6.20

	JUL 1	JUL 2	JUL 3	AUG 1	AUG 2	AUG 3	SEP 1	SEP 2	SEP 3	OCT 1	OCT 2	OCT 3	NOV 1	NOV 2	NOV 3	DEC 1	DEC 2	DEC 3
Q3 (m³/s)	4.38	5.47	8.28	9.90	9.22	9.71	13.12	18.33	18.17	14.75	9.18	7.02	8.37	7.46	16.55	23.69	24.28	27.00
Q2-1	1.57	0.59	0	0	0	0	0	0	0	4.02	5.99	7.37	9.05	8.36	5.40	3.95	3.21	5.04
Q2-2	2.67	2.10	2.28	2.28	2.29	1.52				0	0	0	0	0	0	0	0	0
Q1 (m³/s)	8.62	8.16	10.56	12.18	11.51	11.23	13.12	18.33	18.17	18.77	15.17	14.39	17.42	15.82	21.95	27.64	27.49	32.04

o Kind of turbine
In this study, the kind of turbine is selected TUBULA by the following figure of selection of turbine

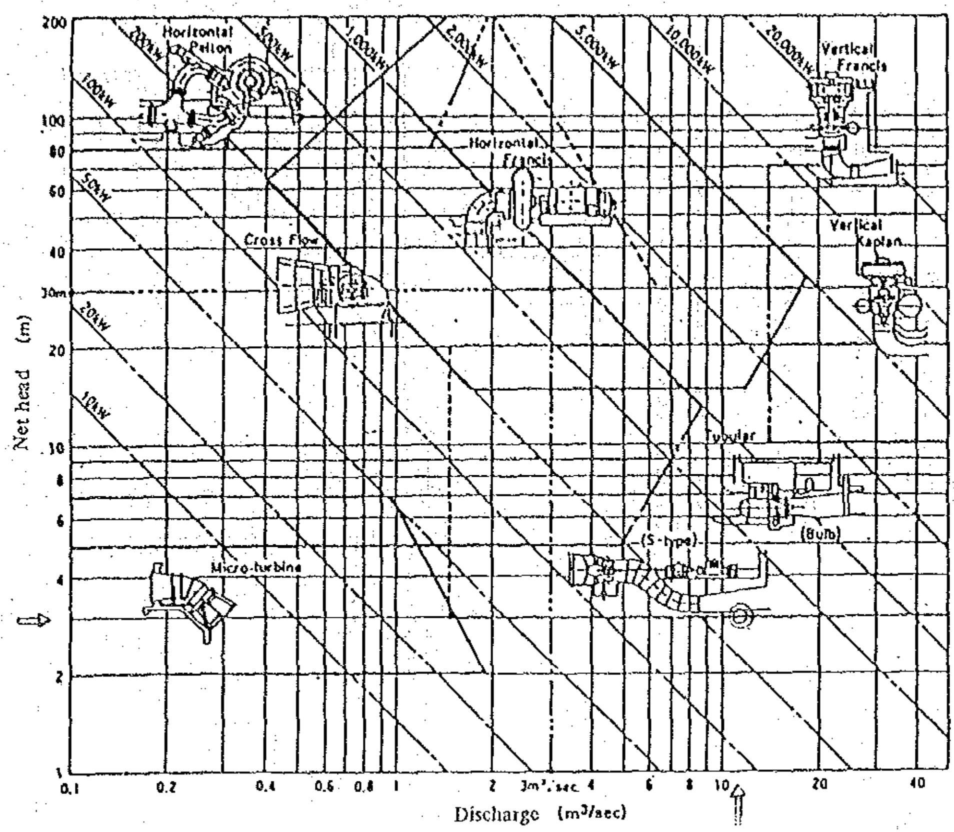


Fig. V-25 Turbine Selection Diagram

o Total efficiency (Efficiency of turbine + Efficiency of generation)
See the following figure of Combined Efficiency vs. Discharge Curve (TUBULAR).

5.1.3 Rough estimation of generated energy

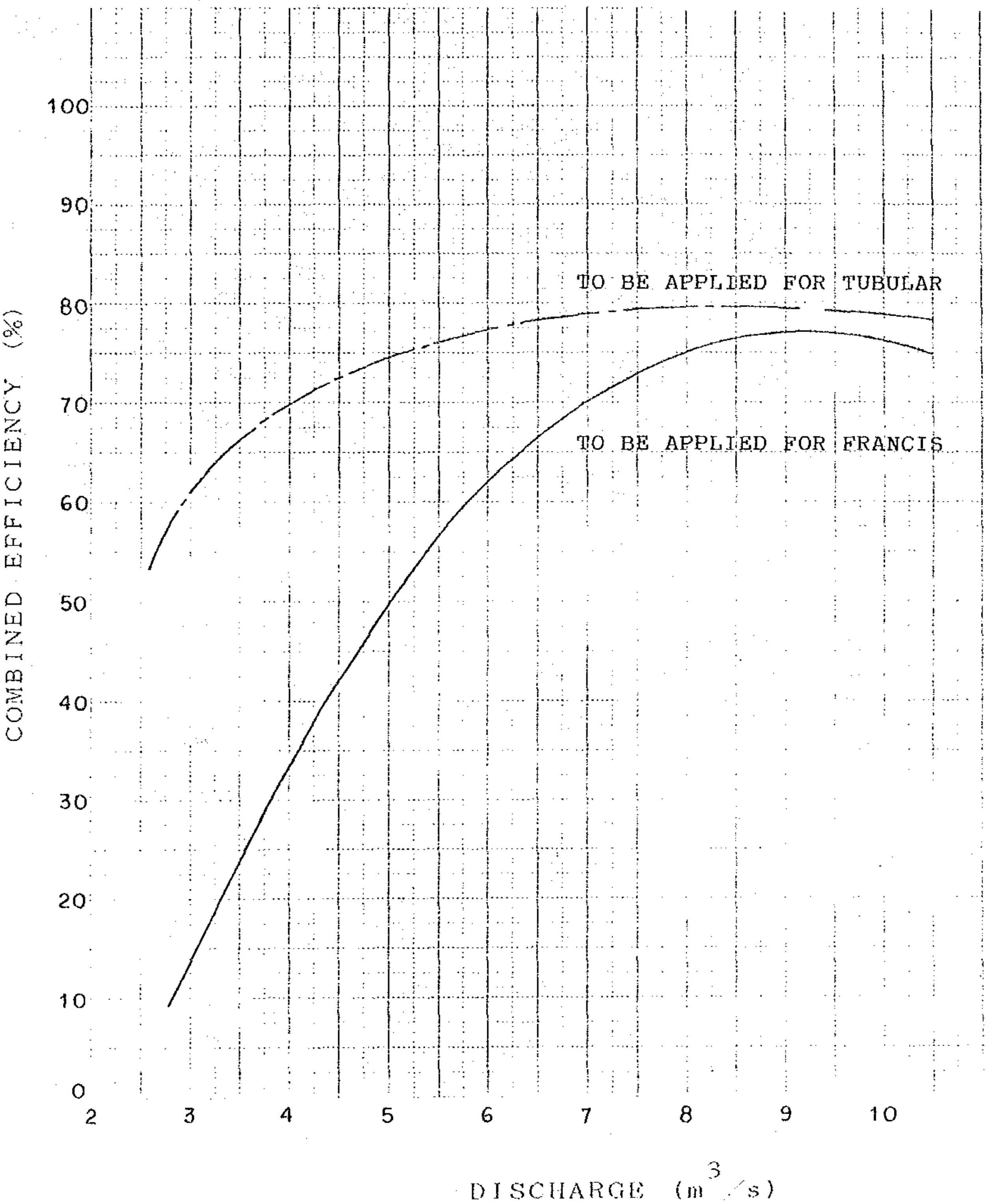
a) Calculation of generated output

When effective head H (m) and discharge Q (m^3/s) are given generated output (KW) can be calculated by the following formula.

$P = 9.8 \times Q \times H \times \eta$ (KW)
Here η: Total efficiency
H: Effective head = 5.00 m

Calculation of 10 days generated output is shown in the following table and the result in this case is as follows.

COMBINED EFFICIENCY VS. DISCHARGE



- o Maximum generated output Pmax = 400 KW
- o Average " P = 345 KW
- o Minimum " Pmin = 66 KW
- o (Pmin/Pmax) x 100 = 16.5%

b) Generated energy (Annual total in the following table)

- o Annual possible power generation ΣP = 3,021,380 Kwh

c) Estimation of family numbers for electric supply

- o Annual consumption of electricity per family
  ΣW = 100 w/h x 24 h x 365 days = 876 Kwh/Y
  (By the data of PLN in villages, the annual comsumption is 92.6 w/h = 800Kwh/Y)
- o Family numbers of electric supply in relation with electric supply ratio (α).
  (The objective ratio of PLN in 1988 is α = 13%)
  Family numbers of electric supply = ΣP/α/ΣW

	ΣP		α		ΣP	Family Nos.
In case of α = 13%	3,021,380	/	0.13	/	876	26,530 fs
α = 25"	"	/	0.25	/	"	13,790 "
α = 50"	"	/	0.50	/	"	6,890 "
α = 60"	"	/	0.60	/	"	5,740 "
α = 70"	"	/	0.70	/	"	4.920 "
α = 80"	"	/	0.80	/	"	4,310 "
α = 90"	"	/	0.90	/	"	3,830 "
α = 100"	"	/	1.00	/	"	3,440 "

Table V-38 CALCULATION OF GENERATED ENERGY

Generated output P = 9.8 x Q x H η = 9.8 x Q x 5.0 x η = Q x 49 x (jw)
Generated Energy KWh = Generated output (P) x Generating Hours (hr)

Month	Each 10 days	Q3 (m^3/s)	Q3/ 10.5 × 100%	Total Efficiency η	Generated output (Kw)	Days (N)	Hours (hr)	Generated Energy (Kwh)
J	1	10.50	100	78.5	404	10	240	96,960
A	2	10.50	100	78.5	404	10	240	96,960
N	3	7.62	73	79.5	297	11	264	78,408
F	1	6.73	64	78.5	259	10	240	62,160
E	2	9.00	86	79.5	351	10	240	84,240
B	3	10.50	100	78.5	404	8	192	77,568
M	1	10.50	100	78.5	404	10	240	96,960
A	2	10.50	100	78.5	404	10	240	96,960
R	3	10.50	100	78.5	404	11	264	106,656
A	1	9.71	92	79.0	376	10	240	90,240
P	2	10.50	100	78.5	404	10	240	96,960
R	3	10.50	100	78.5	404	10	240	96,960
M	1	10.50	100	78.5	404	10	240	96,960
A	2	10.50	100	78.5	404	10	240	96,960
Y	3	7.79	74	79.5	303	11	264	79,992
J	1	7.51	72	79.5	293	10	240	70,320
U	2	4.77	45	73.5	172	10	240	41,280
N	3	2.54	24	53.0	66	10	240	15,840
J	1	4.38	42	71.5	153	10	240	36,720
U	2	5.47	52	76.0	204	10	240	48,960
L	3	8.28	79	79.5	323	11	264	85,272
A	1	9.90	94	79.0	383	10	240	91,920
U	2	9.22	88	79.5	359	10	240	86,160
G	3	9.71	92	79.0	376	11	264	99,264
S	1	10.50	100	78.5	404	10	240	96,960
E	2	10.50	100	78.5	404	10	240	96,960
P	3	10.50	100	78.5	404	10	240	96,960
O	1	10.50	100	78.5	404	10	240	96,960
C	2	9.18	87	79.5	358	10	240	85,920
T	3	7.02	67	79.0	272	11	264	71,808
N	1	8.37	80	79.5	326	10	240	78,240
O	2	7.46	71	79.0	289	10	240	69,360
V	3	10.50	100	78.5	404	10	240	96,960
D	1	10.50	100	78.5	404	10	240	96,960
E	2	10.50	100	78.5	404	10	240	96,960
C	3	10.50	100	78.5	404	11	264	96,960
Total						day 365	hr 8,760	Kwh 3,021,384

o Annual possible power generation
KWh = 3,021,380 Kwh

o Maximum generated output (Q = 10.5 m^3/s)
Pmax = 404 ≒ 400 kw

o Annual average generated output
P = 3,021,380/8,760 = 345 kw

o Annual average discharge
Q = 345/(9.8 × 5.0 × 0.90) ≒ 7.8 m^3/s

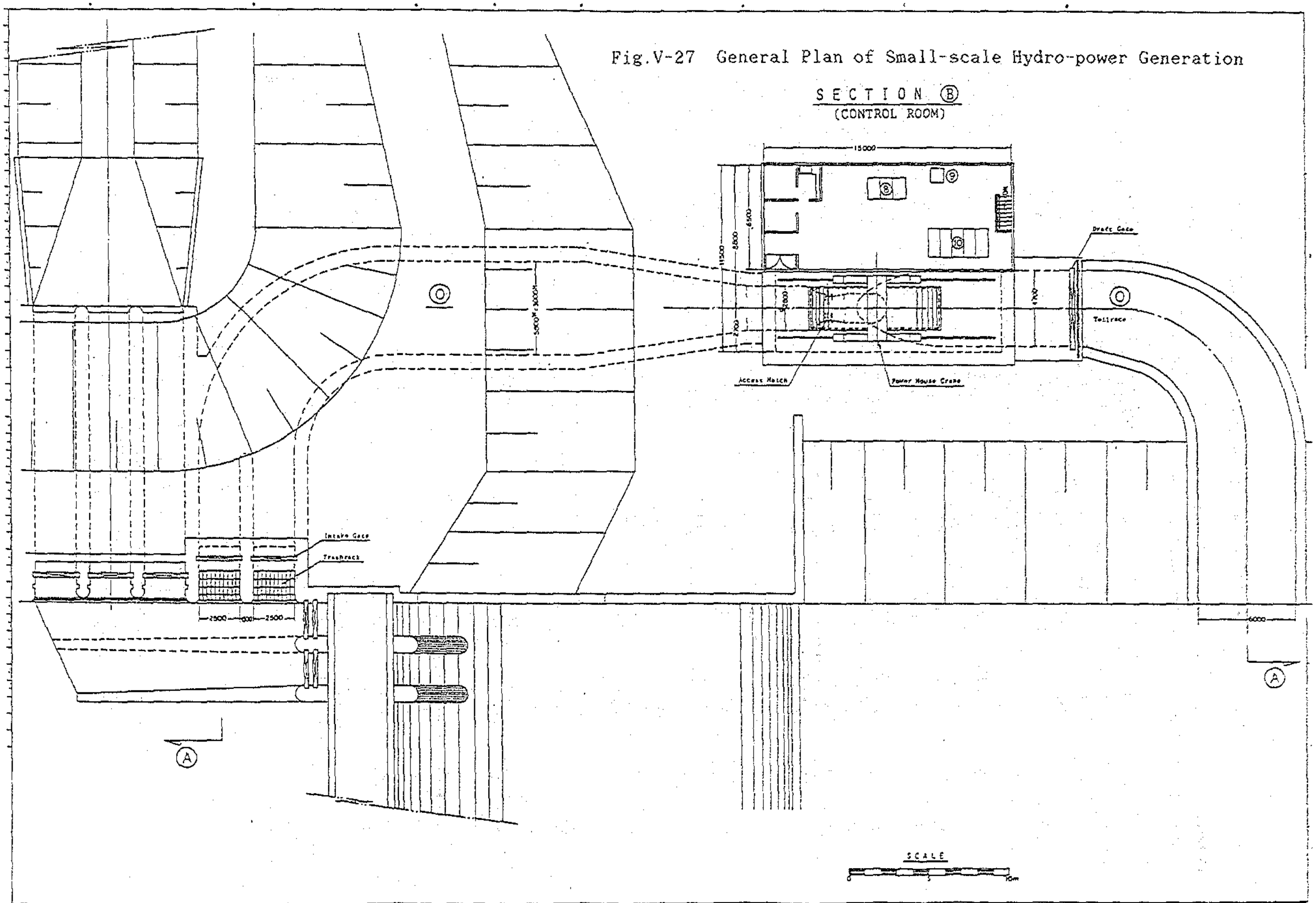
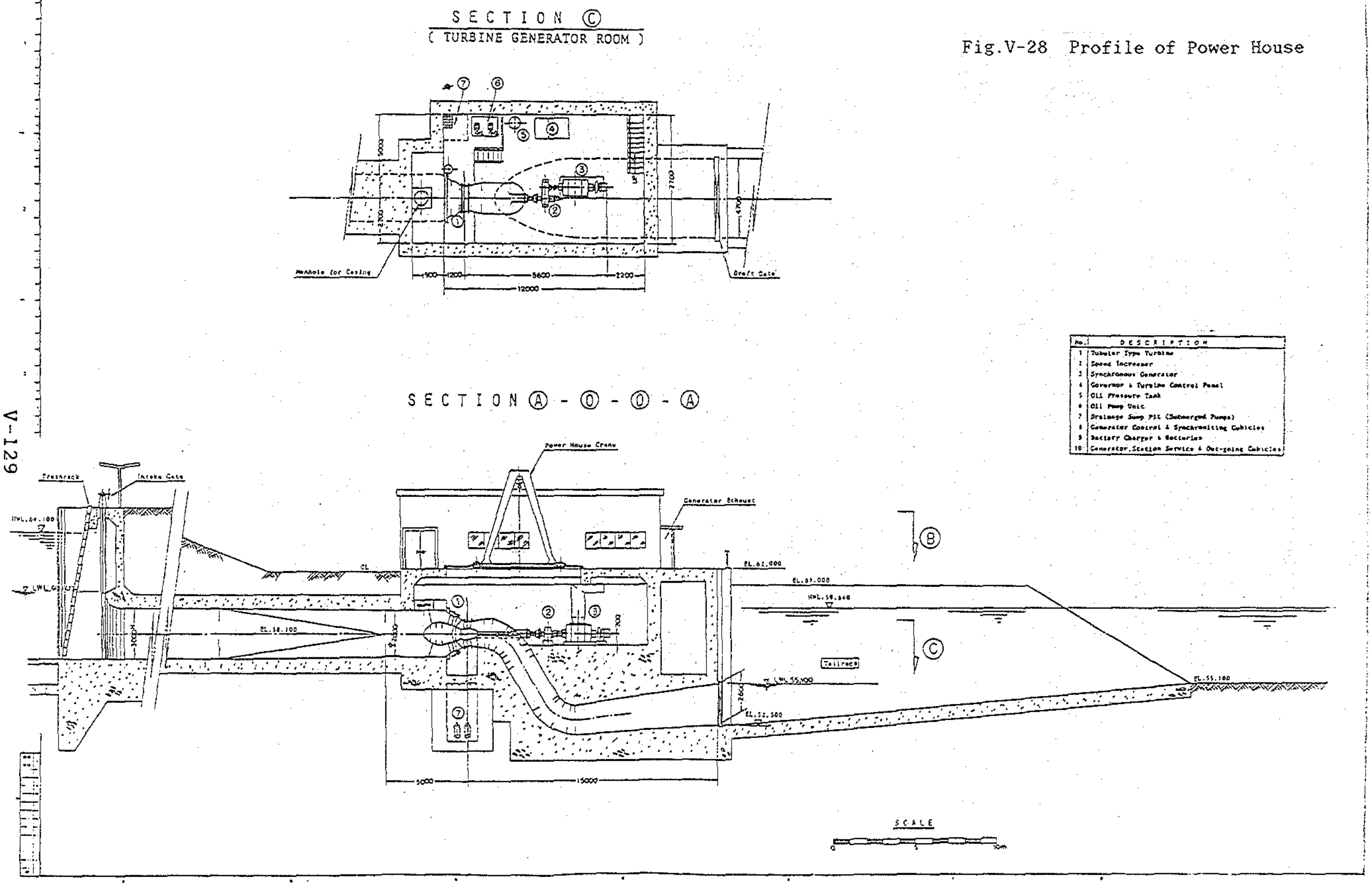


Fig.V-27 General Plan of Small-scale Hydro-power Generation

Fig.V-28 Profile of Power House



No.	DESCRIPTION
1	Tubular Type Turbine
2	Speed Increaser
3	Synchronous Generator
4	Governor & Turbine Control Panel
5	Oil Pressure Tank
6	Oil Pump Unit
7	Drainage Sump Pit (Submerged Pumps)
8	Generator Control & Synchronizing Cubicles
9	Battery Charger & Batteries
10	Generator, Station Service & Out-going Cubicles

- o Minimum generated output ($Q = 2.54\ m^3/s$)
  P = 66 Kw
- o Annual water utilization ratio
  = (7.8/10.50) × 100 = 75%
- o Variation between Pmax & Pmin
  ΔP = 404 kw - 66 kw = 338 kw

5.1.4 Economic Evaluation

In this study, comparative study is taken between hydro-power and diesel generations, and the economic valuation is done unit construction cost per generated energy (Kwh) which is calculated by construction unit cost method.

There are still some more valuation factors beside the economic such as the necessity of electricity and extension effect etc.

Comparative conditions are given as follows

- o Capacity of maximum generated output of diesel generation is the same with the case of small-scale hydro-power generation, ie. P + 400 kw.
- o Annual possible generated energy
  ΣP = 400 Kw × 24 hr × 365 days = 3,504,000 kwh
- o Annual water utilization ratio is 75% in case of Small-scale hydro-power generation. When it is by diesel generation, electric supply can be constant throughout a year. Thus, for keeping the same conditional level, the plan of small-scale hydro-power generation also keeps the facility of Diesel generation to inclease the capacity of 25%.
- o Excessive annual generated energy by diesel generation against the hydro-power.
  3,504,000 - 3,021,380 = 482,620 Kwh.
- o Maximum generated output by diesel power in the plan of the hydro-power.
  ΔP = Pmax - Pmin = 338 ≒ 340 kw.
- o Fuel expense of the diesel is calculated in 20 years which are the standard durable period of water turbine and generator.
- o Fuel expense of diesel generation in 20 years.
  (The plan of small-scale hydropower generation):
  220 KVA × 2 Nos
  l. per year = (51 l/h × 8760 hr/y × 2 Nos) × 0.25
  = 223,380 l.
  l. per 20 years = 223,380 l. × 20 = 4,467,600 l.
  (The plan of diesel generation): 170 KVA × 3 Nos
  l. per year = 39 l/h × 8,760 hr/y × 3 Nos
  = 1,024,920 l.
- o Exchange rate
  US$ 1.0 = ¥125 = Rp 1625 Yen = 13.0 Rp
- o Rough construction cost (See the following table)

Table V-39 COMPARISON OF APPROXIMATE CONSTRUCTION COST FOR HYDRO-POWER GENERATION

Comparative plan / Item	Small-scale Hydro-power Λενεℓαττον θ)αν						Diesel Generation Plan		
	Small-scale Hydro-power Generation			Diesel Generation					
Maximum generated output	400 Kw			340 Kw			400 Kw		
Annual possible generated energy	3,021,380 Kwh			482,620 Kwh			3,504,000 Kwh		
Numbers of generator	500 KVA x 1 No.			220 KVA x 2 Nos.			170 KVA x 3 Nos.		
Fuel	---			4,467,6700 L.			20,498,400 L.		
Approximate construction cost	Numbers	Unit cost	Cost	Numbers	Unit cost	Cost	Numbers	Unit cost	Cost
(1) Electric equipment			Yen x 1,000			Yen x 1,000			Yen x 1,000
Water turbine	1	set	150,000	---	---	---	---	---	---
Generator	1	"	55,000	2	16,000	32,000	3	9,000	27,000
Accessory	1	"	231,000	1	set	120,000	1	set	150,000
Transmission line	84.1 km	1,500	126,000	---	---	---	84.1 km	1,500	126,000
Installation cost	1	set	100,000	1	set	15,000	1	set	20,000
Transportation cost etc.	1	"	66,000	1	"	16,000	1	"	32,000
Sub-total			728,000			183,000			355,000
(2) Civil works									
Power station (Civil)	1	set	35,000	1	set	1,000	1	set	2,000
" (Building)	15.0x6.5	100	10,000	12.5x12.5	100	15,000	12.5x12.5	100	31,000
Pipeline etc.	30.0 m	500	15,000	---	---	---	---	---	
Sut-total			60,000			16,000			33,000
(3) Total			788,000			199,000			388,000

Table V-40 ECONOMIC COMPARISON FOR HYDRO-POWER & DIESEL ELECTRIC POWER

	Small-scale Hydro-power Generation Plan		Diesel Generation Plan	
(1) Annual possible generated energy				
Small-scale Hydro-power generation	3,021,380 kwh		———	
Diesel generation	482,620 kwh		3,504,000 kwh	
Sub-total	3,504,000 kwh		3,504,000 kwh	
(2) Approximate construction cost	(Unit: 1,000 Yen)			
Small-scale hydro-power generation	788,000		———	
Diesel generation	199,000		388,000	
Sub-total	987,000		388,000	
(3) Fuel cost for 20 years	37,970		174,240	
(4) Total (2)+(3)	1,024,970		562,240	
(5) Construction cost per KWH	Yen exchange rate	Rp exchange rate	Y.E.R.	Rp.E.R.
Initial (2)/(1)	282	3,666	111	1,443
Running (4)/(1)	293	3,809	160	2,080
Ratio	183		100	

o Unit cost of fuel 110Rp/LIT. = 8.5 Yen/LIT.

As seen above, small-scale hydro-power generation is about 1.8 times higher in running cost compared with Diesel generation.

APPENDIX VI

IMPLEMENTATION SCHEDULE AND COST ESTIMATE

CHAPTER 1 IMPLEMENTATION SCHEDULE

1.1 General

Implementation of the Project works is divided into two stages, that is, the first development stage for the existing transmigration areas and the second for new transmigration areas taking the time of water distribution and resettlement schedule at an early stage into account.

Plan of total construction period is eight(8) years from 1989 to 1996. Three(3) years from 1989 to 1991 are necessary period for survey and detailed design concerning weir, irrigation and drainage facilities, and tertiary system.

The construction in the first stage is divided into six(6) work divisions consisting of weir, link canal,main and secondary irrigation canal, drainage canal, tertiary system, etc. in relation to the existing transmigration area. The construction period of the first stage is four(4) years including preparatory work, such as tendering, construction of office and quarters, connecting road, etc. and land acquisition from 1991 to 1995 as shown in Fig. VI-2.

As to the second stage, the constructin period is three(3) years from 1994 to 1996 overlapping with the period of first stage. The work consists of two divisions that are left and right bank of Kumu river.

The main work divisions are as follows;

Table VI-1 WORK DIVISION & QUANTITY(1/3)

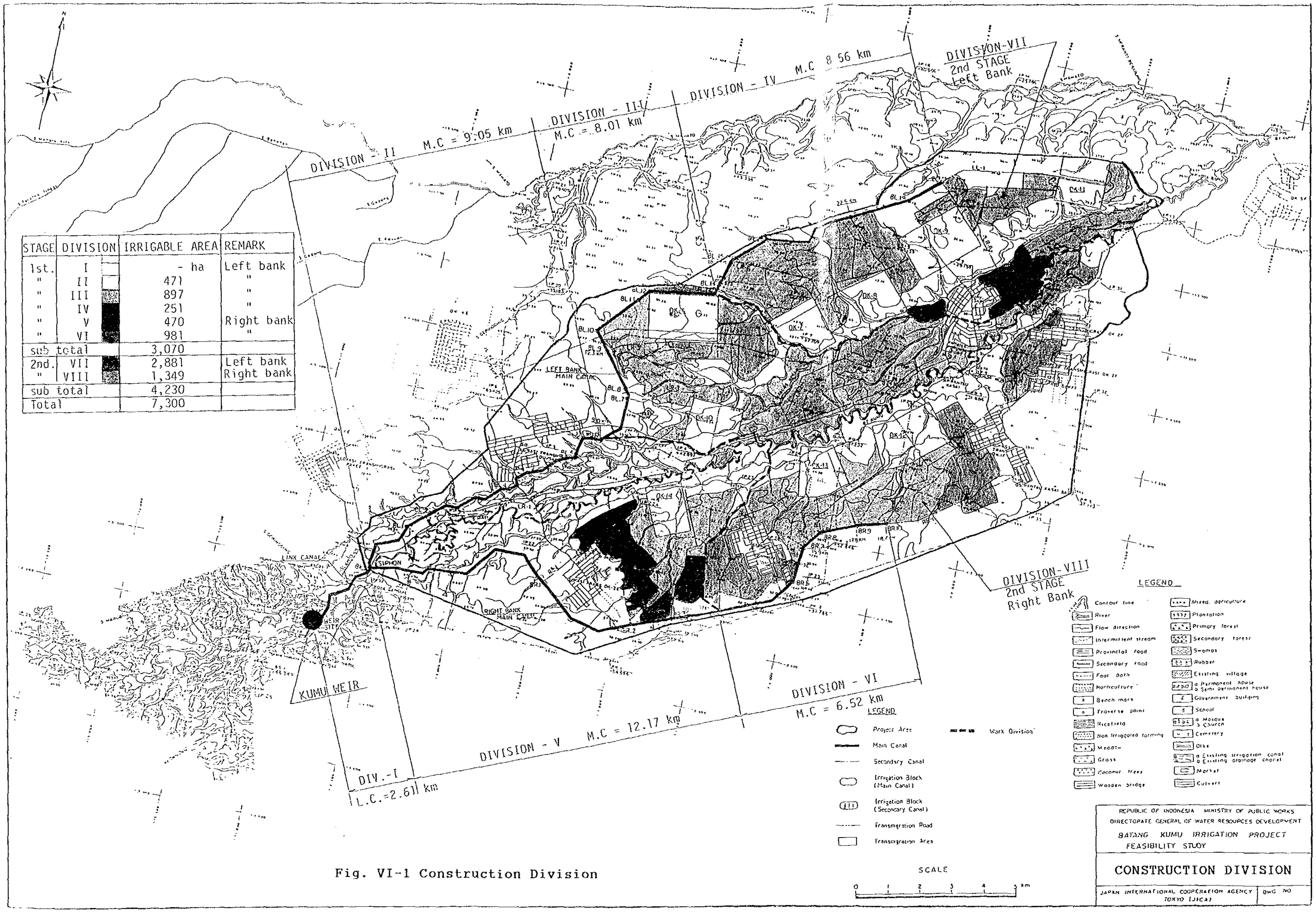
Stage	Work Division	Main Works	Construction Year
First	W. D－I (Left Bank)	Weir(H=5.5m, B=50m) Link canal(L=2.61km) Construction of Canal Facilities Diversion Structure : (M.C) 1 Check Gate : (M.C) 1 Spillway : (M.C) 2 Drainage Culvert : (M.C) 5 Bridge : (M.C) 1	Year. 1992 ～ 1994

Table VI-1 WORK DIVISION & QUANTITY (2/3)

Stage	Work Division	Main Works	Construction Year
First	W. D-II (Left Bank)	Left-side Main Canal(L=9.05km) Secondary Canal(L=10.74km) Drainage Canal(L=1.31km) Tertiary Development(471ha) Construction of Canal Facilities Diversion Structure : (M.C) 2 Turnout : (M.C) 5, (S.C) 17 Check Gate : (M.C) 2, (S.C) 9 Spillway : (M.C) 4, (S.C) 4 Drop : (S.C) 1 Drainage Culvert : (M.C) 18, (S.C) 22 Bridge : (M.C) 5, (S.C) 5 Bridge : (D.C) 1	Year. 1992 ~ 1994
First	W. D-III (Left Bank)	Left-side Main Canal(L=8.01km) Secondary Canal(L=16.68km) Drainage Canal(L=6.41km) Tertiary Development(897ha) Construction of Canal Facilities Diversion Structure : (M.C) 3, (S.C) 1 Turnout : (M.C) 6, (S.C) 31 Check Gate : (M.C) 3, (S.C) 13 Spillway : (M.C) 3, (S.C) 6 Drop : (M.C) 2, (S.C) 1 Drainage Culvert : (M.C) 16, (S.C) 33 Bridge : (M.C) 4, (S.C) 8 Bridge : (D.C) 3	Year. 1993 ~ 1995
First	W. D-IV (Left Bank)	Left-side Main Canal(L=8.56km) Secondary Canal(L=7.03km) Drainage Canal(L=1.47km) Tertiary Development(251ha) Construction of Canal Facilities Diversion Structure : (M.C) 3, (S.C) 1 Turnout : (M.C) 11, (S.C) 17 Check Gate : (M.C) 5, (S.C) 6 Spillway : (M.C) 3, (S.C) 3 Drop : (M.C) 3, (S.C) 1 Drainage Culvert : (M.C) 17, (S.C) 14 Bridge : (M.C) 5, (S.C) 4 Bridge : (D.C) 1	Year. 1993 ~ 1995
First	W. D-V (Right Bank)	Right-side Main Canal(L=12.17km) Secondary Canal(L=7.01km) Drainage Canal(L=8.47km) Tertiary Development(470ha) Construction of Canal Facilities Syphon : (M.C) 1 Diversion Structure : (M.C) 4 Turnout : (M.C) 2, (S.C) 16 Check Gate : (M.C) 5, (S.C) 6 Spillway : (M.C) 4, (S.C) 3 Drop : (M.C) -, (S.C) 1 Drainage Culvert : (M.C) 24, (S.C) 14 Bridge : (M.C) 7, (S.C) 4 Bridge : (D.C) 5	Year. 1992 ~ 1994

Table VI-1 WORK DIVISION & QUANTITY (3/3)

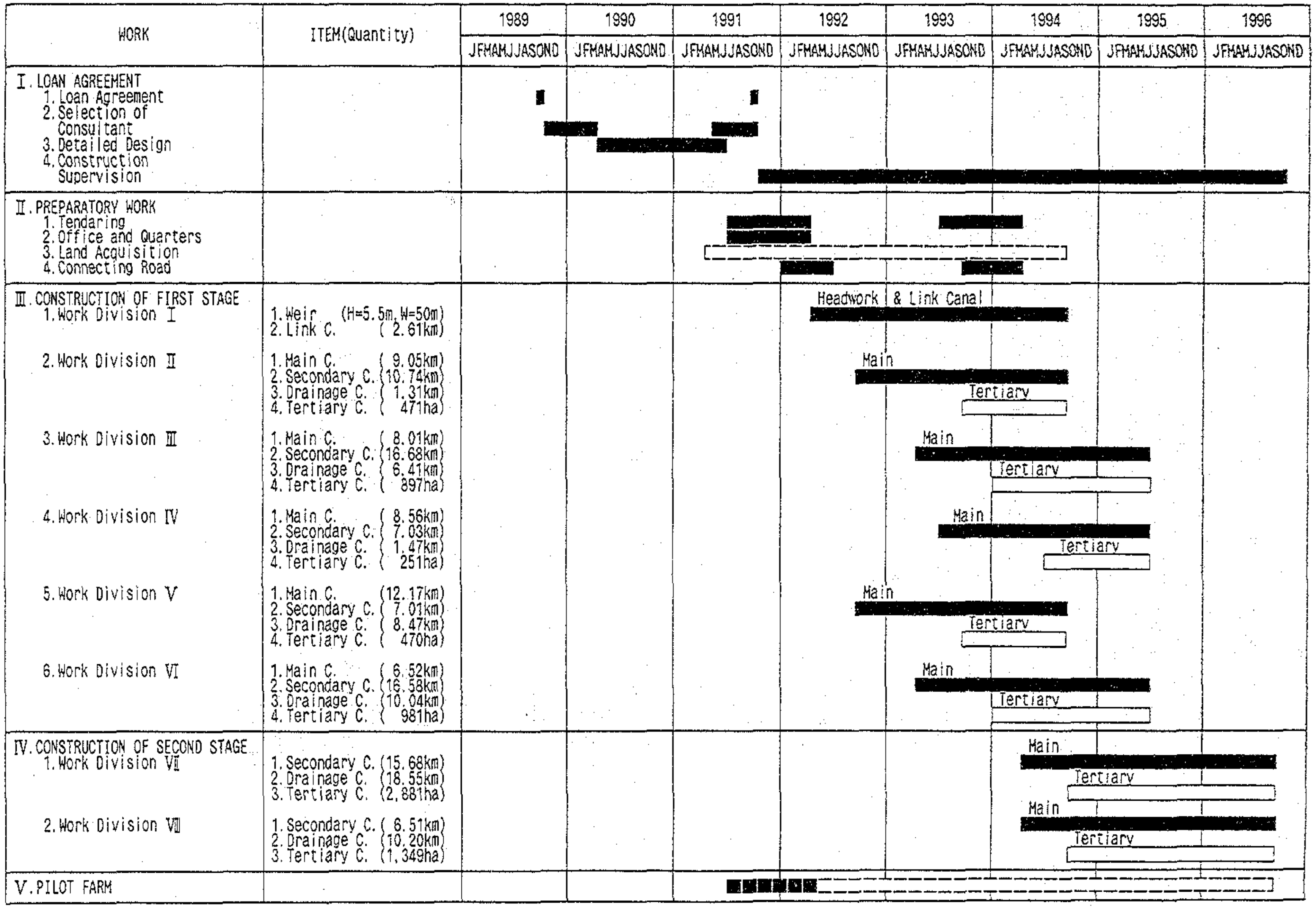
Stage	Work Division	Main Works	Construction Year
First	W. D-VI (Right Bank)	Right-side Main Canal(L=6.52km) Secondary Canal(L=16.58km) Drainage Canal(L=10.04km) Tertiary Development(981ha) Construction of Canal Facilities Diversion Structure : (M.C) 2 Turnout : (M.C) 12, (S.C) 32 Check Gate : (M.C) 6, (S.C) 13 Spillway : (M.C) 2, (S.C) 6 Drop : (S.C) 1 Drainage Culvert : (M.C) 13, (S.C) 33 Bridge : (M.C) 4, (S.C) 8 Bridge : (D.C) 5	Year. 1993 ~ 1995
Second	W. D-VII (Left Bank)	Secondary Canal(L=15.68km) Drainage Canal(L=18.55km) Tertiary Development(2,881ha) Construction of Canal Facilities Turnout : (S.C) 24 Check Gate : (S.C) 12 Spillway : (S.C) 5 Drop : (S.C) 1 Drainage Culvert : (S.C) 31 Bridge : (S.C) 8 Bridge : (D.C) 10	Year. 1994 ~ 1996
Second	W. D-VIII (Right Bank)	Secondary Canal(L=6.51km) Drainage Canal(L=10.20km) Tertiary Development(1,349ha) Construction of Canal Facilities Turnout : (S.C) 9 Check Gate : (S.C) 5 Spillway : (S.C) 2 Drop : (S.C) 1 Drainage Culvert : (S.C) 13 Bridge : (S.C) 3 Bridge : (D.C) 4	Year. 1994 ~ 1996



STAGE	DIVISION	IRRIGABLE AREA	REMARK
1st.	I	- ha	Left bank
"	II	471	"
"	III	897	"
"	IV	251	"
"	V	470	Right bank
"	VI	981	"
sub total		3,070	
2nd.	VII	2,881	Left bank
"	VIII	1,349	Right bank
sub total		4,230	
Total		7,300	

Fig. VI-1 Construction Division

Fig.VI-2 Project Implementation Program



1.2 Basic Assumption

a) Conversion Rate of Earth Volume

Earth volumes are changeable according to the natural conditions as they are. Naturally placed earth materials would increase the volume after excavation and decrease after compaction.

These changes of volume should be considered for estimation of produced volumes by construction machinery or earth moving plan. The conversion rates of earth volumes are assumed as follows:

Abbreviation	Class of earth	Apparent Unit Weight	Conversion Rate		
			In Place	In Loose	In Compaction
S	Sand	1.7	1.00	1.20	0.95
N/S	Normal Soil	1.6	1.00	1.25	0.90
C/S	Clayer Soil	1.8	1.00	1.35	0.90
G & W/R	Gravel & Weathered Rock	1.9	1.00	1.20	1.00
R	Excavated Rock	2.5	1.00	1.50	1.20

b) Workable Days

Earth works are mostly affected by rainfall. Since embankment of impervious materials are controlled by moisture density. Special attension must be paid to execute the construction works for rain days. Suspension days of these earth works caused by rainfall are assumed as following criteria according to the daily rainfall intensity

Daily Rainfall Intensity (mm/day)	Suspension of Work (day)
0 - 10	0
10 - 30	1
30 - 50	2
50 - 100	3
more than 100	4

Annual mean workable days were estimated on the basis of the above criteria and the rainfall records in DALUDALU observatory, the nearest station to the project, for recent 7 years.

Year	Jan.	Feb.	Mar.	Apr.	May	June.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1981	18	18	29	22	24	28	23	27	24	22	24	26
1982	28	24	20	16	22	21	29	29	20	21	19	20
1983	23	24	26	25	25	22	22	28	25	17	25	18
1984	22	20	21	19	22	21	24	22	29	24	21	18
1985	24	26	16	27	24	30	27	25	18	22	19	17
1986	18	24	17	14	25	21	28	28	23	16	15	13
1987	26	27	26	18	16	24	27	23	21	18	20	14
Total	159	163	155	141	158	167	180	182	160	140	143	126
Mean	22.7	23.3	22.1	20.1	22.6	23.9	25.7	26.0	22.9	20.0	20.4	18.0

Note:

Mean of Wet Season: Jan - Apr, Oct - Dec

$$\frac{22.7+23.3+22.1+20.1+20.0+20.4+18.0}{7} = 20.9 = 21$$

Mean of Dry Season: May - Sep

$$\frac{22.6+23.9+25.7+26.0+22.9}{5} = 24.2 = 24$$

Therefore, workable days for impevious materials are decided to be 21 days in the Wet season and 24 days in the Dry season, and total 267 days in a year.

c) Construction materials

The explanation of construction materials are shown in Appendix II, Geology and Soil Mechanics.

The technical point in addition to them are shown as follows:

i) Concrete materials

- o Cement : Bangkinang or Padan
- o Iron bar : - do -
- o Aggregate: The river side area of Batang-Lubuk or the river side area of Batang-Sosa
- o Big stone: The river side area of Batang-Lubuk or Some area of North Sumatra

Note:

The river side area of Batang- Kumu produce gravelly sands. It is generally low gravel content and its maximum particle size is relatively small. It is not suitable condition for getting the aggregate steadily both in quality and quantity.

The river side area of Batang - Lubuk have several quarry places and produce the aggregate.

The river side area of Batang - Sosa is located in the near places of project area, compared with the area of Batang-Lubuk. Therefore, it will be proposed to investigate the volume and the quality of aggregate. If the road condition from the quarry to the project area improves, the area of Ujung-Batu, producing the suitable condition for the volume and the quality of aggregate, are also proposed to be investigated.

ii) Embankment materials

o Impervious materials

Weathering products of the bed rock of Tup or Tmt Formation are suitable for impervious materials of the weir and the canals.

The embankment material of Sub-dike of weir is planned to be collected from the hillside in the left bank side of the river. This material can be utilized for the embankment of the upstream canal.

o Semi-pervious material

Sandy gravel layer which was quite newly depositted is suitable as semi-pervious material. As it is scattered in the right side of the B.T. Kumu river, the material from the excavation of weir is to be utilized for the downstream embankment. It can be also utilized on the outside of the canal embankment.

- Rock materials

  It is not found in any place around the project area. Hence, gravel in river bed will be purchased.

1.3 *Implementation Schedule*

1.3.1 Preparatory Works

The time required for the preparatory works such as survey and investigation, and construction of connecting road, of project office and quarters, and land acquisition is estimated to be 4 years for first and second stage construction as shown in Fig. VI-2.

The survey and investigation work will be completed before start of the detailed design.

The construction of connecting road and of project office and quarters will be completed prior to the major construction work.

The land aquisition for the construction of project facilities will be completed one year ahead of the construction work.

1.3.2 Intake Facilities (First Stage)

The construction of the weir would be executed by Coupure. Coupure method is one of the dry work methods on a meandering river, prevailing in Indonesia.

The construction of the weir would be divided into 3 works.

The first work : Preparing, short cut excavation (Earth works)
The second work : Construction of Weir (Earth works, Concrete works)
The third work : Embankment, Relative Work, Clearing

o <u>The first work</u>

The construction of the access road (=1.0 km, B=5.0 m) and the temporary bridge (=15.0 m, B=5.0 m), as preparing work would commence. The construction of the short cut excavation, connecting to the weir, will be executed by construction equipment (Bulldozer, backhoe, etc.). The finishing work will be executed by manpower. The excavated soil and weathering rock will be carried out to spoil area, and stocked there. They will be used for the embankment of down stream.

o <u>The second work</u>

The construction of the weir will be desired to execute in dry season. The excavation of weir will be executed by Lipper dozzer or breaker, etc. The materials of excavation will be used for the embankment of down stream. The concrete work will be executed by concrete plant.

At the time of the completion of the construction of weir, Main River direction will be changed to the weir.

- <u>The third work</u>

The construction of Sub-dike embankment will be desired to execute in dry season. The materials from borrow-pit are spreading by Bulldozer, and compacted by vibration Roller.
At the time of the completion of the embankment work, the Relative work, such as installing of the gates, will be executed and finally, the construction of clearing will be completed.

1.3.3 Main & Secondary System (First and Second Stage)

The construction of Main & Secondary System consists of main canal, secondary canal, drainage canal and relative structures.

The construction schedule of the Irrigation and Drainage for the first stage will commence from the upside to the downside before the construction of the second stage works. The construction of existing road such as repairing or widening, and of new road and of drainage canal will commence as early as possible.

The construction of the Main canal, secondary canal and of the crossing structures will be executed by Construction Equipment. The finishing work will be executed by manpower.

The construction of Drainage and Relative Structures would be mainly undertaken by manpower so as to increase the employment opportunity in and around the project area.

1.3.4 Tertiary System (First and Second Stage)

The construction schedule of tertiary system will commence from October 1993, and completed by the end of October 1996.

According to the progress of the Division Work I ~ VIII, tertiary development follows in order.

The construction work will be executed by manpower to increase the opportunities of people's employment in and around the project area.

1.3.5 Proposed Tentative Resettlement Schedule (Second Stage)

One or two years before the construction of tertiary canals, the resettlement in this project area should be carried out by the Government under the Ministry of Transmigration including land clearing and land reclamation works.

From the view of both irrigation and transmigration projects, a tentative resettlement schedule is proposed taking the construction schedule of tertiary development into consideration as shown in Table VI-2.

1.4 Construction Machinery

The major civil works of the project would principally be carried out by heavy construction machinery.

The type and number of construction machinery to be required for the majour civil works are estimated based on the work quantity, construction time schedule and the natural condition in the project area. Following shows the required type and numbers of construction machinery.

Equipment	Specification	Nos.
1. Bulldozer	15 ton class	6 sets
2. Lipper dozer	21 ton class	1 set
3. Backhoe shovel	0.7 m^3 class	8 sets
4. Tractor shovel	1.8 m^3 class	4 sets
5. Dump track	8 ton class	more than 20 sets
6. Vibration Roller	6 ton class	3 sets
7. Vibration Roller	1 ton class	3 sets

Table. VI-2 PROPOSED TENTATIVE RESETTLEMENT SCHEDULE

Item	Village	1990	1991	1992	1993	1994	1995	1996
Tertiary Development								
1st stage	SKP-C, D					Existing : 3,070ha		
2nd Stage	New						New : 4,230ha	
Resettlement								
Preparatory		4,230kk						
Left bank	DK- 6		600kk					
〃	DK- 7		400kk					
〃	DK- 8			400kk				
〃	DK- 9			600kk				
〃	DK-10				480kk			
〃	DK-11				401kk			
Right bank	DK-12		600kk					
〃	DK-13		400kk					
〃	DK-14				349kk			

CHAPTER 2 COST ESTIMATE

2.1 Construction Cost

2.1.1 Conditions

The construction cost is estimated based on the following conditions.

(1) The exchange rate used in the estimate is:

US$1 = Rp1,710
= ¥125

(2) Civil engineering works are to be carried out on the contract basis using contractor's own heavy construction machinery and equipment.

(3) Taxes on the construction materials, machinery and equipment to be imported from abroad are exempted from the estimate of construction cost.

(4) The construction cost comprises foreign and local currency portions. The local currency portion is estimated based on the current prices in Riau Province in April 1988 and the data collected from the on-going projects in the province. The foreign currency portion is estimated based on the CIF prices at Pakanbaru referring to the FOB prices of materials, machinery and equipment in Japan in December 1988. The classification of local and foreign currency portions is defined as follows:

<u>Local currency portion</u>

- Labor force,
- sand, gravel and wooden materials,
- fuel, oil, etc.,
- inland transportation costs,
- contractors' general expenses and profit,
- expenses of engineering services for local consultant, and
- minor works.

<u>Foreign currency portion</u>

- reinforcement bar and other structural steel,
- cement,
- steel gates, diesel generators, motor and other metal works,
- depreciation costs for heavy construction machinery and equipment,
- vehicles to be required for the construction

supervision and O & M equipment for the project operation,
- contractors' general expenses and profit, and
- expense and fee of engineering services by foreign consultant.

(5) For the construction of the quaternary network, only the costs of materials necessary for the construction of the division boxes and culverts are included in the estimate. The construction works of the quaternary network are to be carried out by local farmers themselves under the guidance of the project office.

(6) Cost for jungle clearing is partly included in the preparation cost.

(7) The physical contingency related to the construction quantities, around 5% of the direct costs, is included in the construction cost in view of the preliminary nature of the estimate. The price contingency; 3.6% per annum for the foreign currency portion and 10% per annum for the local currency portion, is also included in the project cost.

(8) The associated costs to be financed by the Government such as the costs for strengthening the extension services, facilities of the water users' association, and improvement of the social infrastructures are not included in the estimate.

2.1.2 Estimate of Construction Cost

The total construction costs of the project are estimated at US$43 million, which comprise US$19 million equivalent of local currency and US$24 million of foreign currency. The summary and breakdown of the cost estimate are shown in Table VI-3 through Table VI-12.

The prices of local materials and labour used in the estimate and the unit rates for major works are as shown in Table VI-13, VI-14, and VI-15 respectively.

2.1.3 Annual Disbursement Schedule

The annual disbursement schedule is worked out based on the construction time schedule. The details are stated in Table VIII-14 in Appendix VIII, Project Evaluation.

Annual Disbursement schedule

Year	Foreign Portion (10^3US$)	Local Portion (10^3US$)	Total (10^3US$)
1990	1,428	405	1,833
1991	1,029	499	1,528
1992	2,272	1,586	3,858
1993	6,518	5,476	11,994
1994	8,048	6,813	14,861
1995	3,371	2,716	6,087
1996	1,274	1,089	2,363
Total	23,940	18,584	42,524

2.2 Annual Operation and Maintenance Costs

The annual operation and maintenance costs include the salaries of project administrative and water control staffs, the materials and labor costs for repair and maintenance of project facilities, the costs for operation, repair and maintenance of O & M equipment, and the running costs of project facilities including diesel generators.

The annual operation and maintenance costs are counted to be Rp.30,000 per ha.

2.3 Replacement Costs

Some of the facilities, especially mechanical and electrical works have shorter useful life than the civil works and are require replacement at a certain time within the project useful life.

The replacement costs and the useful lives of these facilities are listed in Table VI-16.

Table VI-3 SUMMARY OF PROJECT COST

Unit: 10^3 US$

Item	Foreign Portion	Local Portion	Total
1. Preparatory Expenses	840	360	1,200
2. Civil Work for 1st Stage			
2.1 Head Work (Div-I)	1,719	583	2,302
Link Canal (〃)	393	261	654
2.2 Main & Sec. (Div-II)	1,698	1,347	3,045
Tertiary (〃)	214	92	306
2.3 Main & Sec. (Div-III)	1,616	1,192	2,808
Tertiary (〃)	318	136	454
2.4 Main & Sec. (Div-IV)	1,049	773	1,822
Tertiary (〃)	154	66	220
2.5 Main & Sec. (Div-V)	1,671	1,218	2,889
Tertiary (〃)	186	80	266
2.6 Main & Sec. (Div-VI)	1,471	1,088	2,559
Tertiary (〃)	428	183	611
Sub-Total	10,917	7,019	17,936
3. Civil Work for 2nd Stage			
3.1 Secondary (Div-VII)	756	593	1,349
Tertiary (〃)	1,220	523	1,743
3.2 Secondary (Div-VIII)	312	269	581
Tertiary (〃)	573	246	819
Sub-Total	2,861	1,631	4,492
4. O&M Facilities	524	175	699
5. Land Acquisition Cost	-	180	180
6. Administration Cost	-	657	657
7. Engineering Service			
7.1 Detailed Design	1,440	160	1,600
7.2 Construction S/V	2,160	240	2,400
Sub-Total	3,600	400	4,000
Total	18,742	10,422	29,164
8. Physical Contingency	937	521	1,458
Total	19,679	10,943	30,622
9. Price Contingency	4,261	7,641	11,902
Grand Total	23,940	18,584	42,524

Table VI-4 BREAKDOWN OF DIRECT CONSTRUCTION COST FOR PREPARATORY EXPENSE

Works	Unit	Q'ty	Unit Price	Cost
			Rp	10^3Rp (10^3US$)
1. Project office and quarters				
1.1 Main office	m^2	1,000		
1.2 Repair shop	m^2	200		
1.3 Store house	m^2	200		
1.4 Quarters	m^2	1,500		
Sub Total		2,900	100,000	290,000 (170 US$)
2. Connecting Road	m	33,300	20,000	666,000 (389 US$)
3. Clearing	ha	1,000	1,000,000	1,000,000 (585 US$)
4. Survey and investigation	Ls	1		96,000 (56 US$)
TOTAL				2,052,000 (1,200 US$)

Table VI-5 BREAK DOWN OF DIRECT CONSTRUCTION COST FOR DIVISION I(Head Works & Link Canal)

Works	Unit	Q'ty	Foreign Portion	Local Portion
			(10^3 Rp)	(10^3 Rp)
1.Head Work				
1.1 General Expense	L.S.	1	267,238	90,606
1.2 Civil Works				
1.2.1 Site clearing	100	3,300	23,100	9,900
1.2.2 Excavoti on(Nomal)	m3	188,900	615,865	48,494
1.2.3 Excavoti on(Rock)	m3	13,300	52,086	3,810
1.2.4 Back Fill	m3	16,100	30,585	2,198
1.2.5 Miscellaneous	L.S.	1	184,928	22,675
1.3 Embankment Works				
1.3.1 Stripping	m3	10,800	13,856	194
1.3.2 Eearth Fill	m3	56,500	112,944	1,808
1.3.3 Lining		7,100	67,983	32,731
1.3.4 Sod Facing		8,100	—	45,725
1.3.5 Miscellaneous	L.S.	1	14,113	198
1.4 Concrete Works				
1.4.1 Concrete(reignforced)	m3	6,100	569,350	330,998
1.4.2 Concrete	m3	4,000	272,172	141,140
1.4.3 Miscellaneous	L.S.	1	244,153	26,306
1.5 Related Works				
1.5.1 Gobion		2,400	—	148,819
1.5.2 Gate	L.S.	1	401,250	—
1.5.3 Access	m	1,030	—	30,900
1.5.4 Bridge	Nos.	2	60,000	60,000
1.5.5 Miscellaneous	L.S.	1	9,995	160
Total			2,939,610	996,662
2.Link Canal				
2.1 General Expense	L.S.	1	87,552	58,107
2.2 Civil Works				
2.2.1 Site clearing	100	650	4,550	1,950
2.2.2 Excavation	m3	75,487	193,473	2,944
2.2.3 Earth Fill	m3	—	—	—
2.3 Concrete Lining	m3	2,873	268,154	98,846
2.4 Concrete Form		28,993	—	191,905
2.5 Sod Faeing		—	—	—
2.6 Related Structure	L.S.	1	117,500	47,500
Total			671,229	445,485
Grand Total			3,610,839	1,442,147

Table VI-6 BREAK DOWN OF DIRECT CONSTRUCTION COST FOR DIVISION II

Works	Unit	Q'ty	Foreign Portion	Local Portion
			(10^3 Rp)	(10^3 Rp)
1. Main Canal				
1.1 General Expense	L.S.	1	233,082	190,883
1.2 Civil Works				
1.2.1 Site clearing	100m2	1,963	13,741	5,889
1.2.2 Excavation	m3	85,937	220,257	3,351
1.2.3 Earth Fill	m3	39,802	79,564	1,274
1.3 Concrete Lining	m3	9,046	844,317	311,228
1.4 Concrete Form	m2	89,555	—	592,764
1.5 Sod Facing	m2	34,375	—	194,047
1.6 Related Structure	L.S.	1	396,000	164,000
Sub-Total			1,786,961	1,463,436
2. Secondary Canal				
2.1 General Expense	L.S.	1	137,710	104,563
2.2 Civil Works				
2.2.1 Site clearing	100m2	1,855	12,985	5,565
2.2.2 Excavation	m3	7,706	19,750	301
2.2.3 Earth Fill	m3	114,247	228,380	3,656
2.3 Concrete Lining	m3	3,061	285,701	105,313
2.4 Concrete Form	m2	32,653	—	216,130
2.5 Sod Facing	m2	58,757	—	219,869
2.6 Related Structure	L.S.	1	371,250	146,250
Sub-Total			1,055,776	801,647
3. Drainage Canal				
3.1 General Expense	L.S.	1	7,984	5,039
3.2 Civil Works				
3.2.1 Site clearing	100m2	299	2,093	897
3.2.2 Excavation	m3	9,825	25,181	383
3.2.3 Earth Fill	m3	8,777	17,545	281
3.3 Sod Facing	m2	7,598	—	28,432
3.4 Related Structure	L.S.	1	8,400	3,600
Sub-Total			61,203	38,632
Total			2,903,940	2,303,715
4. Tertiary System				
4.1 Tertiary System	ha	471	225,515	96,649
4.2 Land Reclamation	ha	390	140,049	60,021
Sub-Total			365,564	156,670
Total			365,564	156,670
Grand Total			3,269,504	2,460,385

Table VI-7 BREAK DOWN OF DIRECT CONSTRUCTION COST FOR DIVISION III

Works	Unit	Q'ty	Foreign Portion	Local Portion
			(10^3 Rp)	(10^3 Rp)
1.Main Canal				
1.1 General Expense	L.S.	1	196,345	154,487
1.2 Civil Works				
1.2.1 Site clearing	100m2	1,789	12,523	5,367
1.2.2 Excavation	m3	34,949	89,574	1,363
1.2.3 Earth Fill	m3	131,258	262,385	4,200
1.3 Concrete Lining	m3	5,930	553,482	204,022
1.4 Concrete Form	m2	60,100	—	397,802
1.5 Sod Facing	m2	45,732	—	258,157
1.6 Related Structure	L.S.	1	391,000	159,000
Sub-Total			1,505,309	1,184,398
2.Secondary Canal				
2.1 General Expense	L.S.	1	151,472	94,868
2.2 Civil Works				
2.2.1 Site clearing	100	2,812	19,684	8,436
2.2.2 Excavation	m3	4,456	11,421	174
2.2.3 Earth Fill	m3	191,226	382,261	6,119
2.3 Concrete Lining	m3	—	—	—
2.4 Concrete Form	m2	—	—	—
2.5 Sod Facing	m2	101,731	—	380,678
2.6 Related Structure	L.S.	1	596,450	237,050
Sub-Total			1,161,288	727,325
3.Drainage Canal				
3.1 General Expense	L.S.	1	12,648	16,404
3.2 Civil Works				
3.2.1 Site clearing	100m2	904	6,328	2,712
3.2.2 Excavation	m3	14,194	36,379	553
3.2.3 Earth Fill	m3	8,211	16,414	263
3.3 Sod Facing	m2	25,396	-	95,032
3.4 Related Structure	L.S.	1	25,200	10,800
Sub-Total			96,969	125,764
Total			2,763,566	2,037,487
4. Tertiary System				
4.1 Tertiary System	ha	897	429,484	184,064
4.2 Land Reclamation	ha	320	114,912	49,248
Sub-Total			544,396	233,312
Total			544,396	233,312
Grand Total			3,307,962	2,270,799

Table VI-8 BREAK DOWN OF DIRECT CONSTRUCTION COST FOR DIVISION IV

Works	Unit	Q'ty	Foreign Portion	Local Portion
			(10^3 Rp)	(10^3 Rp)
1.Main Canal				
1.1 General Expense	L.S.	1	161,488	126,135
1.2 Civil Works				
1.2.1 Site clearing	100m2	1,742	12,194	5,226
1.2.2 Excavation	m3	10,006	25,645	390
1.2.3 Earth Fill	m3	121,892	243,662	3,901
1.3 Concrete Lining	m3	3,424	319,582	117,803
1.4 Concrete Form	m2	36,084	—	238,840
1.5 Sod Facing	m2	50,530	—	285,242
1.6 Related Structure	L.S.	1	475,500	189,500
Sub-Total			1,238,071	967,037
2.Secondary Canal				
2.1 General Expense	L.S.	1	69,778	42,552
2.2 Civil Works				
2.2.1 Site clearing	100	1,170	8,190	3,510
2.2.2 Excavation	m3	1,403	3,596	54
2.2.3 Earth Fill	m3	80,066	160,052	2,562
2.3 Concrete Lining	m3	—	—	—
2.4 Concrete Form	m2	—	—	—
2.5 Sod Facing	m2	42,865	—	160,401
2.6 Related Structure	L.S.	1	293,350	117,150
Sub-Total			534,966	326,229
3.Drainage Canal				
3.1 General Expense	L.S.	1	2,739	3,617
3.2 Civil Works				
3.2.1 Site clearing	100m2	193	1,351	4,579
3.2.2 Excavation	m3	2,058	5,275	80
3.2.3 Earth Fill	m3	1,617	3,232	52
3.3 Sod Facing	m2	5,292	—	19,803
3.4 Related Structure	L.S.	1	8,400	3,600
Sub-Total			20,997	27,731
Total			1,794,034	1,320,997
4. Tertiary System				
4.1 Tertiary System	ha	251	120,179	51,505
4.2 Land Reclamation	ha	400	143,640	61,560
Sub-Total			263,819	113,065
Total			263,819	113,065
Grand Total			2,057,853	1,434,062

Table VI-9 BREAK DOWN OF DIRECT CONSTRUCTION COST FOR DIVISION V

Works	Unit	Q'ty	Foreign Portion	Local Portion
			$(10^3$ Rp)	$(10^3$ Rp)
1.Main Canal				
1.1 General Expense	L.S.	1	287,315	208,491
1.2 Civil Works				
1.2.1 Site clearing	100m2	2,607	18,249	7,821
1.2.2 Excavation	m3	115,754	296,677	4,514
1.2.3 Earth Fill	m3	39,820	79,600	1,274
1.3 Concrete Lining	m3	9,588	894,906	329,875
1.4 Concrete Form	m2	97,097	—	642,685
1.5 Sod Facing	m2	26,531	—	149,768
1.6 Related Structure	L.S.	1	626,000	254,000
Sub-Total			2,202,747	1,598,428
2.Secondary Canal				
2.1 General Expense	L.S.	1	68,606	41,736
2.2 Civil Works				
2.2.1 Site clearing	100m2	1,200	8,400	3,600
2.2.2 Excavation	m3	1,601	4,104	62
2.2.3 Earth Fill	m3	83,677	167,270	2,678
2.3 Concrete Lining	m3	—	—	—
2.4 Concrete Form	m2	—	—	—
2.5 Sod Facing	m2	43,158	—	161,497
2.6 Related Structure	L.S.	1	277,600	110,400
Sub-Total			525,980	319,973
3.Drainage Canal				
3.1 General Expense	L.S.	1	16,793	21,544
3.2 Civil Works				
3.2.1 Site clearing	100m2	1,162	8,134	3,486
3.2.2 Excavation	m3	16,115	41,303	628
3.2.3 Earth Fill	m3	10,263	20,515	328
3.3 Sod Facing	m2	32,384	—	121,181
3.4 Related Structure	L.S.	1	42,000	18,000
Sub-Total			128,745	165,167
Total			2,857,472	2,083,568
4. Tertiary System				
4.1 Tertiary System	ha	470	225,036	96,444
4.2 Land Reclamation	ha	260	93,366	40,014
Sub-Total			318,402	136,458
Total			318,402	136,458
Grand Total			3,175,874	2,220,026

Table VI-10 BREAK DOWN OF DIRECT CONSTRUCTION COST FOR DIVISION VI

Works	Unit	Q'ty	Foreign Portion	Local Portion
			$(10^3 Rp)$	$(10^3 Rp)$
1.Main Canal				
1.1 General Expense	L.S.	1	154,498	121,580
1.2 Civil Works				
1.2.1 Site clearing	100m2	1,418	9,926	4,254
1.2.2 Excavation	m3	3,744	9,596	146
1.2.3 Earth Fill	m3	136,952	273,767	4,382
1.3 Concrete Lining	m3	3,752	350,197	129,088
1.4 Concrete Form	m2	38,639	—	255,752
1.5 Sod Facing	m2	47,549	—	268,414
1.6 Related Structure	L.S.	1	386,500	148,500
Sub-Total			1,184,484	932,116
2.Secondary Canal				
2.1 General Expense	L.S.	1	150,437	94,346
2.2 Civil Works				
2.2.1 Site clearing	100m2	2,785	19,495	8,355
2.2.2 Excavation	m3	3,461	8,871	135
2.2.3 Earth Fill	m3	191,771	383,350	6,137
2.3 Concrete Lining	m3	—	—	—
2.4 Concrete Form	m2	—	—	—
2.5 Sod Facing	m2	101,429	—	379,547
2.6 Related Structure	L.S.	1	591,200	234,800
Sub-Total			1,153,353	723,320
3.Drainage Canal				
3.1 General Expense	L.S.	1	23,260	26,650
3.2 Civil Works				
3.2.1 Site clearing	100m2	1,485	10,395	4,455
3.2.2 Excavation	m3	26,196	67,140	1,022
3.2.3 Earth Fill	m3	17,774	35,530	569
3.3 Sod Facing	m2	41,054	—	153,624
3.4 Related Structure	L.S.	1	42,000	18,000
Sub-Total			178,325	204,320
Total			2,516,162	1,859,756
4. Tertiary System				
4.1 Tertiary System	ha	981	469,703	201,301
4.2 Land Reclamation	ha	730	262,143	112,347
Sub-Total			731,846	313,648
Total			731,846	313,648
Grand Total			3,248,008	2,173,404

Table VI-11 BREAK DOWN OF DIRECT CONSTRUCTION COST FOR DIVISION VII

Works	Unit	Q'ty	Foreign Portion	Local Portion
			$(10^3$ Rp)	$(10^3$ Rp)
1.Main Canal				
1.1 General Expense	L.S.	—	—	—
1.2 Civil Works				
1.2.1 Site clearing	100m2	—	—	—
1.2.2 Excavation	m3	—	—	—
1.2.3 Earth Fill	m3	—	—	—
1.3 Concrete Lining	m3	—	—	—
1.4 Concrete Form	m2	—	—	—
1.5 Sod Facing	m2	—	—	—
1.6 Related Structure	L.S.	—	—	—
Sub-Total			—	—
2.Secondary Canal				
2.1 General Expense	L.S.	1	130,198	85,482
2.2 Civil Works				
2.2.1 Site clearing	100m2	2,433	17,031	7,299
2.2.2 Excavation	m3	2,285	5,857	89
2.2.3 Earth Fill	m3	162,532	324,902	5,201
2.3 Concrete Lining	m3	—	—	—
2.4 Concrete Form	m2	—	—	—
2.5 Sod Facing	m2	93,932	—	351,494
2.6 Related Structure	L.S.	1	520,200	205,800
Sub-Total			998,188	655,365
3.Drainage Canal				
3.1 General Expense	L.S.	1	38,437	46,879
3.2 Civil Works				
3.2.1 Site clearing	100m2	2,603	18,221	7,809
3.2.2 Excavation	m3	37,485	96,074	1,462
3.2.3 Earth Fill	m3	28,991	57,953	928
3.3 Sod Facing	m2	71,172	—	266,326
3.4 Related Structure	L.S.	1	84,000	36,000
Sub-Total			294,685	359,403
Total			1,292,873	1,014,768
4. Tertiary System				
4.1 Tertiary System	ha	2,881	1,379,423	443,386
4.2 Land Reclamation	ha	1,970	707,427	303,183
Sub-Total			2,086,850	746,569
Total			2,086,850	746,569
Grand Total			3,379,723	1,761,337

Table VI-12 BREAK DOWN OF DIRECT CONSTRUCTION COST FOR DIVISION VIII

Works	Unit	Q'ty	Foreign Portion	Local Portion
			(10^3 Rp)	(10^3 Rp)
1.Main Canal				
1.1 General Expense	L.S.	—	—	—
1.2 Civil Works				
1.2.1 Site clearing	100m2	—	—	—
1.2.2 Excavation	m3	—	—	—
1.2.3 Earth Fill	m3	—	—	—
1.3 Concrete Lining	m3	—	—	—
1.4 Concrete Form	m2	—	—	—
1.5 Sod Facing	m2	—	—	—
1.6 Related Structure	L.S.	—	—	—
Sub-Total			—	—
2.Secondary Canal				
2.1 General Expense	L.S.	1	51,388	34,757
2.2 Civil Works				
2.2.1 Site clearing	100m2	977	6,839	2,931
2.2.2 Excavation	m3	651	1,669	25
2.2.3 Earth Fill	m3	61,846	123,630	1,979
2.3 Concrete Lining	m3	—	—	—
2.4 Concrete Form	m2	—	—	—
2.5 Sod Facing	m2	38,409	—	143,727
2.6 Related Structure	L.S.	1	210,450	83 050
Sub-Total			393,976	266,469
3.Drainage Canal				
3.1 General Expense	L.S.	1	18,178	25,136
3.2 Civil Works				
3.2.1 Site clearing	100m2	1,412	9,884	4,236
3.2.2 Excavation	m3	20,490	52,516	799
3.2.3 Earth Fill	m3	12,600	25,187	403
3.3 Sod Facing	m2	39,480	—	147,734
3.4 Related Structure	L.S.	1	33,600	14,400
Sub-Total			139,365	192,708
Total			533,341	459,177
4. Tertiary System				
4.1 Tertiary System	ha	1,349	645,901	276,815
4.2 Land Reclamation	ha	930	333,963	143,127
Sub-Total			979,864	419,942
Total			979,864	419,942
Grand Total			1,513,205	879 119

Table VI-14 PRICE LIST OF LOCAL MATERRIALS

Item	Unit	Unit Price
		(RP)
I. Materials		
1. Grovel(sieved)	m3	3,500
2. Sand	m3	2,000
3. Big stone	m3	5,000
4. Nail	kg	1,500
5. Wire	kg	1,500
6. Clment	Zak	6,500
II. Fuel and Lubricant		
1. Gasoline	Lit.	285
2. Diesel	Lit.	225
3. Oil	Lit.	1,000

Table VI-15 LIST OF UNIT RATE FOR MAJOR WORKS(1/3)

Works Item	Unit	Foreign Portion	Local Portion	Total
I.Earth Works		(Rp)	(Rp)	(Rp)
1.Excavation by Man Power (soil condition-normal)	m3	—	3,500	3,500
2.Excavation by Man Power (soil condition-hard soil)	m3	—	4,665	4,665
3.Excavation by Man Power (soil condition- soilircluded stone)	m3	—	7,000	7,000
4.Excavation by Man Power (soil condition- Rocky soil)	m3	—	9,330	9,330
5.Hauling of Earth Materials by Man Power(Distance 30m)	m3	—	1,370	1,370
6.Hauling of Earth Materials by Trolly (Distance 50m)	m3	—	475	475
7.Gathering Gravel at Site (including tronsportation cost at 100m)	m3	—	7,044	7,044
8.Gathering Sand at Site (including tronsportation cost at 100m)	m3	—	5,989	5,989
9.Rock Breaking by Pick Hammer	m3	9,841	3,818	13,659
10.Falling and Pulling out of root	m3	—	25,145	25,145
11.Excluding Sundries Stones From soil	m3	—	7,885	7,885
12.Smoothing of Face Excavated or Filled up	m3	—	1,890	1,890
13.Campacting by Man Power (normal soil)	m3	—	1,660	1,660
14.Campacting by Compactor (normal soil)	m3	225	955	1,180
.Concrete Works,etc				
15.Concrete B-1 (mixed by portable concrete mixer)	m3	68,043	34,319	102,362
16.Concrete 28=125kg (mixed by portable concrete mixer)	m3	81,961	34,405	116,366
17.Concrete 28=175kg (mixed by portable concrete mixer)	m3	93,336	34,405	127,741

Table VI-15 LIST OF UNIT RATE FOR MAJOR WORKS(2/3)

Works Item	Unit	Foreign Portion	Local Portion	Total
		(Rp)	(Rp)	(Pp)
18.Concrete 28=255kg (Mixed by portable concrete mixer)	m3	100,272	34,701	134,973
19.Wooden Form of Concrete (Lining Type I)	m2	—	6,619	6,619
20.Wooden Form of Concrete (Lining Type II)	m2	—	3,865	3,865
21.Processing & Assembling of Reinforced Iron Bor	kg	800,500	86,250	886,750
22.Making Gabion Wire Diameter 4mm	m3	131,451	56,422	187,873
23.Stone for Lining	m3	9,575	4,610	14,185
24.Sod Facing Type I	m2	—	5,645	5,645
25.Sod Facing Type II	m2	—	3,742	3,742
.Construction Equipment Works				
Eq-1.Excavation by Bulldozer (15th class)				
Soil Condition-(Sand)	m3	1,099	15	1,114
-(Normal)	m3	1,283	18	1,301
-(Clay)	m3	1,538	22	1,560
-(Graval)	m3	1,538	22	1,560
Eq-2.Ripping by Ripper dozer (21th class)				
Soil Condition(Rock)	m3	922	10	932
Eq-3.Excavation by Back How Shovel(0.7m3 class)				
Soil Condition-(Sand)	m3	1,189	19	1,208
-(Normal)	m3	1,280	21	1,301
-(Clay)	m3	1,513	24	1,537
-(Graval)	m3	1,666	27	1,693
Eq-4.Loading by Tractor Shovel(1.8T.S class)				
Soil Condition-(Sand)	m3	1,397	23	1,420
-(Normal)	m3	1,397	23	1,420
-(Clay)	m3	1,397	23	1,420
-(Graval)	m3	1,596	26	1,622
Eq-5.Hauling by Dunp Track (8t class)				
Soil Condition-(Sand) L=40km	m3	23,648	547	24,208
Eq-6.Hauling by Dunp Track (8t class)				
Soil Condition-(Normal)				
Distance -(L=100m)	m3	1,311	29	1,340

Table VI-15 LIST OF UNIT RATE FOR MAJOR WORKS(3/3)

Works Item	Unit	Foreign Portion	Local Portion	Total
		(Rp)	(Rp)	(Rp)
Eq- 7.Hauling by Dump Track (8t class) Soil Condition-(Soil including stones gathered stones)				
Distance -(L=100m)	m3	1,383	31	1,414
Distance -(L=40000m)	m3	26,480	590	27,070
Eq- 8.Hauling by Dump Track (8t class) Soil Condition-(big stones)				
Distance -(L=80000m)	m3	34,817	799	35,616
Eq- 9.Spreading by Buiidozer (15t class)	m3	896	13	909
Eq-10.Compaction of Vibration Day(6-7t class)	m3	1,103	19	1,122
Eq-11.Operation of Bulldozer Day(15t class)	day	497,532	7,000	504,532
Eq-12.Operation of Bulldozer Day(21t class)	day	619,807	7,000	626,807
Eq-13.Operation of Back How Shovel(0.7m3 class)	m3	436,257	7,000	443,257
Eq-14.Operation of Tractor Shovel(1.8m3 class)	m3	422,391	7,000	429,391
Eq-15.Operation of Dump Track(8t class)	m3	200,134	4,500	204,634
Eq-16.Operation of Vibration Roller(6-7t class)	m3	414,537	7,000	421,537

Table VI-16 REPLACEMENT COST AND USEFUL LIFE

Item	Useful Life	Replacement Cost
	(Years)	(US$)
1. O&M Equipment	10	1,343,000
2. Project Facilities		
Gate of head works	30	235,000
Gate of irrigation facilities	30	526,000
Total		1,343,000