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JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
THE REPUBLIC OF CAMEROON
SOCIETE NATIONALE D'ELECTRICITE DU CAMEROUN

FEASIBILITY STUDY
ON
MEMVE ELE HYDROELECTRIC POWER DEVELOPMENT PROJECT

FINAL REPORT
APPENDIX V
HYDRAULIC CALCULATIONS

OCTOBER 1993

NIPPON KOEI CO., LTD.

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FINAL REPORT

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1. Headloss Calculation

1.1 General

The waterway is composed of such structures as an intake, a headrace channel, a head pond, a penstock intake, penstock lines, turbines, draft tunnels, tailrace tunnels and an outlet. The headlosses in the said waterway are calculated hereinafter and summarized in Table 1.

Following plant discharge is taken into account for the headlosses calculation:

Max. plant discharge	450 m3/s
2 units operation	225 m3/s

1.2 Calculations

Numbers in parentheses hereinafter are the headlosses for the two units operation.

1) Intake

Loss at entrance

$he=fe.(V2^2)/(2g)=0.006$ m (0.002 m)

$fe=0.5$

$V2=0.50$ m/s (0.25 m/s)

Loss due to screen

$hr=fr.(V1^2)/(2g)=0.004$ m (0.001 m)

$fr=b.\sin(\theta).(t/b)^{(4/3)}=0.350$

$b=2.34$ $(\theta)=71.6$ degree $(t/b)=0.25$

$V1=0.50$ m/s (0.25m/s)

Considering that the screen area is reduced at 25% due to trash.

$(\delta)b/b=0.25$ $fr=1.32$

hr=0.017 m (0.004)

Loss due to gradual contraction

hgc=fgc.(V2^2)/(2g)=0.012 m (0.003 m)

A2/A1=162/960=0.17

fgc=0.03 (theta=24.4 degrees)

V2=2.78 m/s (1.39 m/s)

Loss due to friction

hf=I.L=0.003 m (0.001 m)

L=280 m

I=(V.n/(R^(2/3)))^2

n=0.014

R=5.36

V=0.75 m/s (0.375 m/s)

2) Headrace Channel

Lose due to bend 1

hb=fb1.fb2.(V^2)/(2g)=0.024 m (0.006 m)

r/D=10 fb1=0.1

(theta)=29 degrees fb2=0.6

V=2.78 m/s (1.39 m/s)

Loss due to bend 2

hb=fb1.fb2.(V^2)/(2g)=0.028 m (0.007 m)

r/D=10 fb1=0.1

(theta)=43 degree fb2=0.72

Loss due to friction

hf=I.L=0.524 m (0.131 m)

L=2,100 m

I=(V.n/(R^(2/3)))^2

V=2.78 m/s (1.39 m/s)

R=(B+mho)ho/(B+2SQR(1+m^2)ho)=3.87

3) Head Pond

<u>Loss due to expansion</u>

hge=fge.(V1^2)/(2g)=0.394 m (0.099 m)

fge=1

V1=2.78 m/s (1.39 m/s)

4) Penstock Intake

<u>Loss at Entrance</u>

he=fe.(V2^2)/(2g)=0.004 m

fe=0.5

V2=0.40 m/s

<u>Loss due to screen</u>

hr=fr.(V1^2)/(2g)=0.003 m

fr=b.sin(theta).(t/b)^(4/3)

b=2.34 (theta)=71.5 degrees (t/b)=0.25

V1=0.40 m/s

<u>Loss due to gradual contraction</u>

hgc=fgc.(V2^2)/(2g)=0.012 m

A2/A1=36/280=0.13

fgc=0.025 (theta)=22.6 degrees

V2=3.125 m/s

5) Penstock Line

<u>Loss due to vertical bend</u>

2hb=2.fb1.fb2.(V^2)/(2g)=2x0.121=0.242 m

r/D=2 fb1=0.15

(theta)=90 degrees   fb2=1.0

V=3.98 m/s

Loss due to gradual contraction

hgc=fgc.(V2^2)/(2g)=0.029 m

fgc=0.007 (theta)=12.7 degrees

A2/A1=0.44

V2=8.95 m/s

Loss due to friction

hf=f.(L/d).(V^2)/(2g)=0.126 m

f=(124.5.n^2)(D^(1/3))

L=95 m

D=6.0

n=0.012

V=3.98 m/s

hf = 0.138 m

L=12m

D=4.0 m

n=0.012

V=8.95 m/s

6) Draft Tunnel

Loss due to friction

hf=0.039 m

L=45 m

D=6.9 m

n=0.014

V=3.01 m/s

Loss due to confluence

hj=fj.(V1^2)/(2g)=0.254 m

fj=0.55

V=3.01 m/s

7) Tailrace Tunnel

Loss due to bend

hb=fb1.fb2.(V^2)/(2g)=0.032 m

r/D=15 fb1=0.1

(theta)=22 degrees fb2=0.5

V=3.54 m/s

Loss due to friction

hf=1.167 m

L=1,400 m

D=9.0 m

V=3.54 m/s

n=0.014

8) Tailrace Outlet

Loss due to expansion

he=fe.(V1^2)/(2g)=0.639 m

fe=1

V=3.54 m/s

Critical flow depth above end sill at outlet

hc=((1.1.Q^2)/(9.8.b^2))^(1/3)=2.00 m

Q=450 m3/s

b=53 m

As the top elevation of the end sill is set at EL.334.0 m, the tail water level (TWL) becomes EL.336.0 m.

2. Discharge Capacity of Headrace Channel

The headrace channel has a capacity to convey the maximum plant discharge 450 m3/s with the full supply level FSL. 392 m at the intake. The channel is of trapezoidal section with concrete lining. It's dimension is 15 m wide at the bottom having 1:2.0 (vertical : horizontal) side walls. The channel has a gradient of 1/4,000. At the beginning of the channel, the elevation of the invert is set at EL. 385 m. The channel has to convey the maximum plant discharge with the uniform flow depth 6.0 m.

The conditions of the hydraulic calculations are:

- Discharge: 450 m3/s,
- Channel gradient: 1/4,000,
- Roughness coefficient: 0.014,
- Bottom width of channel: 15 m, and
- Side wall slope: 1:2.0 (vertical : horizontal).

The calculation results are:

- Uniform flow depth: 6.00 m and
- Critical flow depth: 3.35 m.

3. Spillway Discharge Capacity

The spillway is designed to discharge the 10,000-year-probable flood of 3,450 m3/s as peak discharge with a pond water level at EL. 392 m. No retention effect of the pond is counted.

The discharge over an ogee crest is given by the equation such as:

$$Q = C\ L\ H_e^{1.5}$$

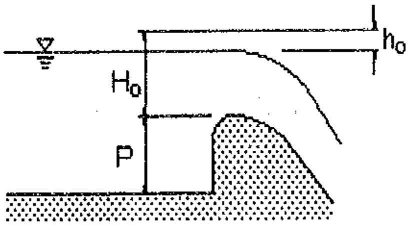
where Q: discharge (m3/s),

C: discharge coefficient,

L: effective length of the crest, and

H: actual head being considered on the crest, including velocity of approach head.

The profile and section of the spillway are shown in Figs. 1 to 3. Free discharge coefficient for the design head is obtained to be 2.1 from Fig. 4.



P/H = 5.5 / 10.0 = 0.55

C_0 = 3.81 from Fig. 4 (for cubic feet per sec.)

C = C_0 x 0.552 = 2.10 (for m3/s)

The vertical distance from the crest of overflow to the downstream apron and the depth of flow in the downstream channel are factors that alter the discharge coefficient. The flow rating curve at the spillway site is not clear. However, it is assumed that the maximum water level during the flood is at around EL. 385 m from the topographic condition. The modified discharge coefficient resulting from apron effects is obtained from Fig. 5.

(hd + d) / He = (7.0 + 8.5) / 10.0 = 1.55

Cs / C = 0.99

Cs = 0.99 x 2.10 = 2.08

Then, Q = C L H 1.5

= 2.08 x (5 x 11.0) x 101.5 = 3,620 m3/s

The discharge capacity 3,620 m3/s is greater than the design flood 3,450 m3/s.

4. Surging Analysis

4.1 General

The tailrace surge tunnel is provided on the waterway to mitigate water hammer pressure occurring at the time of load change. Surging accompanied with load change is analyzed in this section.

The analysis comprises the examination for surging water level and the hydraulic stability of surge tank.

4.2 Hydraulic Stability

In practice, the governor of a turbine does not ensure constant discharge but constant power. As theoretical power output is represented by wHQ, the output of turbine is written as follows:

$$P = \eta w Q H_0 = \text{const.}$$

where P: power output,
Q: discharge,
H_0: available head,
η: efficiency, and
w: unit weight of water.

While the oscillation of surging wave still remains in the surge tunnel, namely while H_0 varies, discharge Q varies in the opposite direction by the operation of the governor. The change of discharge Q causes the self-exciting action of surging. If the damping force by friction is superior to the self-exciting force, the amplitude or surging reduces and will finally stable.

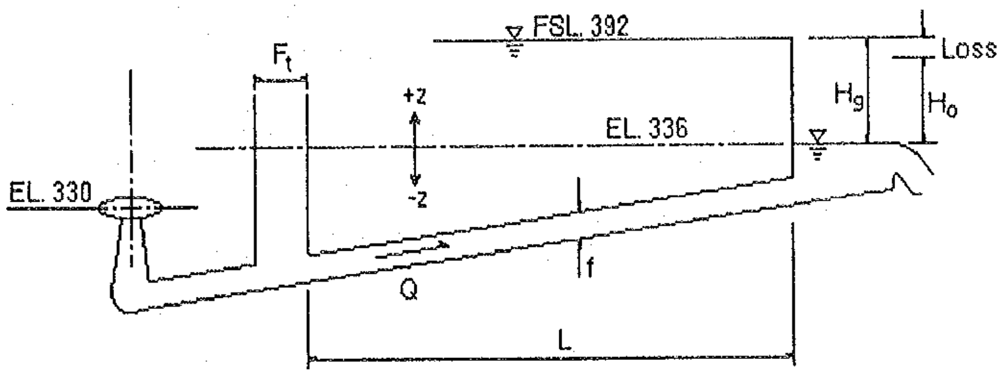
Applying Thoma's conditions shown below, surging stability in the tailrace surge tunnel is examined.

Static stability condition

$h_0 < H_g / 3 \text{ to } H_g / 6$

Dynamic stability condition

$Ft > L_f / (2\ C \cdot g\ H_0)$



where $Q = 450 / 2 = 225$ m3/s,

$Hg = 392 - 336 = 56$ m, $H_0 = 52.3$ m,

$L = 1,350$ m,

$f = \pi \times 9.0^2 / 4 = 63.6$ m2,

$v_0 = 225 / 63.6 = 3.54$ m/s,

$h_l = 1.84$ m (headloss in tailrace tunnel),

$h_0 = h_l + v^2 / (2g) = 1.84 + 0.64 = 2.48$ m, and

$C = ho / v^2 = 0.198$

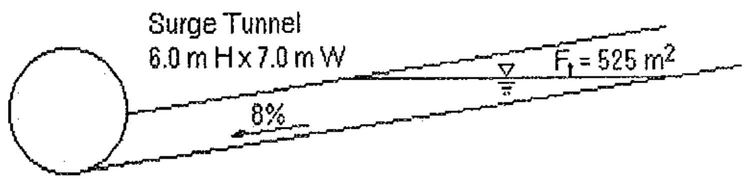
Static stability condition

$h_o < H_g / 3$ to $H_g / 6 = 17.7$ m to 9.3 m

Dynamic stability condition

$Ft > L_f / (2\,C\,g\,H_o)$ $= 1,350 \times 63.6 / (2 \times 0.198 \times 9.8 \times 52.3)$

$= 423$ m



4.3 Surging Water Level

Notations follow:

Z: Surging water level (m),

v: velocity in tailrace tunnel (m/s),

L: length of tailrace tunnel = 1,350 (m),

f: area of tailrace tunnel = 63.6 (m2),

Q: turbine discharge = 225 (m3/s), and

F: area of surge tunnel = 525 (m2).

Surging water level is obtained by the following formula:

$$\frac{dY}{dx} = \frac{2}{\varepsilon}(-x \pm Y)$$

where $Y = y^2$, $\varepsilon = Lfv_0^2 / (gh_0^2F)$,

$y = v / v_0$, $x = z / h_0$

a) In case that the surging water level lowers to the crown of tailrace outlet EL. 332 m after the full load rejection.

$$y_1^2 = x_1 + \frac{\varepsilon}{2}[1 - e^{\frac{2}{\varepsilon}(x_1 - 1)}]$$

$Z_1 = 332 - 326 = -4.0$ m

Then,

$x_1 = -4.0 / 2.48 = -1.613$

$$\varepsilon = \frac{1{,}350 \times 63.6 \times 3.54^2}{9.8 \times 2.48^2 \times 525} = 34.0$$

$$y_1^2 = -1.613 + \frac{34.0}{2}(1 - e^{-0.154})$$

$y_1 = 0.899$

Then, $v_1 = 0.899 \times 3.54 = 3.18$ m/s

b) Lowest Surging Water Level ($y_b = 0$)

$y_b = 0 \rightarrow x_b = -5.2$

$Z_b = -5.2 \times 2.48 = -12.9$ m (LSWL. 323.1 m)

c) In case that the surging water level reaches the crown of the tailrace outlet at EL. 332 m from LSWL:

$$Y = -x + \frac{\varepsilon}{2} + Ce^{-\frac{2}{\varepsilon}x}$$

$0 = 0.52 + 17.0 + 1.358C$

Then, $C = -16.35$

$x_2 = -1.613 \rightarrow Y = 0.636$

$y_2 = 0.797 \rightarrow v_2 = 2.82$ m/s

d) Maximum surging water level

$$x_m = \frac{\varepsilon}{2} + (y_2^2 + x_2 - \frac{\varepsilon}{2})e^{\frac{2}{\varepsilon}(x_2 - x_m)}$$

$$x_m = 17.0 + (0.636 - 1.613 - 17.0)e^{\frac{2}{\varepsilon}(-1.613 - x_m)}$$

$$x_m = 17.0 + 17.99e^{0.0588(-1.613 - x_m)} = 4.3$$

Then, $Z_m = 4.3 \times 2.48 = 10.66$ (HSWL. 346.7 m)

5. Waterhammer Analysis

The waterhammer caused by load (discharge) variation at turbines or guide vanes acts as inner pressure rise being one of the essential design loads for of penstock and tunnels of waterway.

- Static head at guide vane: $H_0 = 62$ m
- Maximum turbine discharge: $Q_0 = 450 / 4 = 112.5$ m3/s
- Propagation velocity: $a = 777$ m/s
- Closing time: $t = 3, 4, 5$ sec.

Equivalent flow area (A_m) and length of penstock (L) are as follows:

A_i (m2)	L_i (m)
6.0 X 6.0 = 36.0	32.0
6.0 dia. = 28.3	90.0
4.0 dia. = 12.6	21.0

$$A_m = \frac{\sum L_i}{\sum(\frac{L_i}{A_i})} = \frac{143}{0.89 + 3.18 + 1.67} = 24.9 m^3$$

Average velocity in Penstock (v_o):

$v_o = 112.5 / 24.9 = 4.52$ m/s

$2 L / a = 2 \times 143 / 777 = 0.369$ sec. < 3 sec.

$\rho = a v_o / (2g H_o) = 777 \times 4.52 / (2 \times 9.8 \times 62) = 2.89$

$\theta = T / (2 L / a)$

Pressure rise: $H'_{max} = (h_{max} + H_o) / H_o$ is obtained from Fig. 6.

T (sec)	θ	ζ^2_{max}
3	8.13	1.425
4	10.8	1.31
5	13.6	1.24

6. Maximum Possible Power Generation

Two sets of the maximum possible energy production from Memve Ele power plant were examined. They are of i) Flow-duration method and ii) Energy production simulation based on monthly runoff record and its expansion.

(1) Estimate of Maximum Possible Energy Production by Flow-Duration Method

Following conditions are applied:

- Maximum turbine discharge: $Q = 450$ m3/s,
- Rated head: $He = 52.3$ m, and
- Combined efficiency: $\eta = 0.873$

The flow-duration curve for the Ntem is shown in Fig. 7. The maximum possible energy production is obtained to be 1,140 GWh/year as following:

Output factor: $f = \frac{Polygon(abcde)}{\mathrm{Rectangle}(abcd)}$ = 0.645

Output: $P = 9.8QH\eta$ = 201,300 kW

Maximum possible energy production:

$E = 8,760fP$ = 1,140 GWh/year

(2) Estimate of Maximum Possible Energy Production by Simulation Method

Following assumptions are made:

- Maximum turbine discharge: Q_{max} = 450 m3/s,
- Minimum turbine discharge: Q_{min} = 45 m3/s,
- Head: Varies approximately from 52.3 m to 51.3 m,
- Combined efficiency: η = 0.873,
- Maximum power output: P = 201,300 kW,
- Full supply level: FSL = 392 m,
- Minimum operating level: MOL = 391 m,
- Tail water level: TWL = 336 m,
- Spillway capacity: Q = 3,450 m3/s,
- Duty flow for downstream: Q = 0 m3/s, and
- Runoff record used: 1957 to 1992

The basics of the energy generation simulation are as:

$$E = (\sum_{i=1}^{n} 9.8\,\eta H_e Q_i T)\frac{12}{n}$$

where E: estimated annual energy generation (kWh/year)

Q_i: runoff record of month i

n: number of runoff records

T: 720 hours/month = 24 hours/day x 30 days/month

The simulation resulted E = 1,176 GWh/year as shown Table 2.

(3) Conclusion

Looking at the conservative value, the energy of 1,140 GWh/year by the flow-duration method is determined as the estimate of Memve Ele's annual possible energy generation.

Table 1 Summary of Headlosses in Waterway (unit: m)

	Q=450 m3/s	Q=225 m3/s
1. Intake		
Entrance	0.006	0.002
Screen	0.017	0.004
Contraction	0.012	0.003
Friction	0.003	0.001
2. Headrace Channel		
Bend	0.052	0.013
Friction	0.524	0.131
3. Head Pond		
Expansion	0.394	0.099
4. Penstock Intake		
Entrance	0.004	0.004
Screen	0.003	0.003
Contraction	0.012	0.012
5. Penstock		
Bend	0.242	0.242
Contraction	0.029	0.029
Friction	0.264	0.264
6. Draft Tunnel		
Friction	0.039	0.039
Confluence	0.254	0.254
7. Tailrace Tunnel		
Bend	0.032	0.032
Friction	1.167	1.167
8. Tailrace Outlet		
Expansion	0.639	0.639
9. Total	3.693	2.938

Table 2 Energy Production Simulation

Small Scale Development Case (Runoff from only Ntem River)
Discharge modified by 1.0

Year	Month	Q.in	Q.duty	Q.plant	Q.spill	WL	V	P.ave	E.ann
		(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m)	(mill.m3)	(MW)	(GWh)
1957	1	288.0	0.0	290.0	0.0	391.00	0.00	133.4	96.1
1957	2	140.0	0.0	140.0	0.0	391.00	0.00	66.0	47.5
1957	3	164.0	0.0	164.0	0.0	391.00	0.00	77.0	55.4
1957	4	295.0	0.0	295.0	0.0	391.00	0.00	135.8	97.8
1957	5	441.0	0.0	441.0	0.0	391.00	0.00	195.4	140.7
1957	6	479.0	0.0	450.0	26.0	392.00	8.05	200.0	144.0
1957	7	273.0	0.0	277.0	0.0	391.00	0.00	127.6	91.9
1957	8	113.0	0.0	113.0	0.0	391.00	0.00	53.3	38.4
1957	9	261.0	0.0	261.0	0.0	391.00	0.00	120.7	86.9
1957	10	1,019.0	0.0	450.0	566.0	392.00	8.05	200.0	144.0
1957	11	873.0	0.0	450.0	423.0	392.00	8.05	200.0	144.0
1957	12	566.0	0.0	450.0	116.0	392.00	8.05	200.0	144.0
1958	1	178.0	0.0	181.0	0.0	391.00	0.00	84.6	60.9
1958	2	110.0	0.0	110.0	0.0	391.00	0.00	52.0	37.5
1958	3	94.0	0.0	94.0	0.0	391.00	0.00	44.5	32.1
1958	4	196.0	0.0	196.0	0.0	391.00	0.00	91.7	66.0
1958	5	361.0	0.0	361.0	0.0	391.00	0.00	163.5	117.7
1958	6	183.0	0.0	183.0	0.0	391.00	0.00	85.5	61.6
1958	7	53.0	0.0	53.0	0.0	391.00	0.00	24.9	17.9
1958	8	24.0	0.0	0.0	21.0	392.00	8.05	0.0	0.0
1958	9	61.0	0.0	64.0	0.0	391.00	0.00	30.4	21.9
1958	10	547.0	0.0	450.0	94.0	392.00	8.05	200.0	144.0
1958	11	495.0	0.0	450.0	45.0	392.00	8.05	200.0	144.0
1958	12	317.0	0.0	320.0	0.0	391.00	0.00	146.3	105.4
1959	1	143.0	0.0	143.0	0.0	391.00	0.00	67.2	48.4
1959	2	114.0	0.0	114.0	0.0	391.00	0.00	53.5	38.5
1959	3	92.0	0.0	92.0	0.0	391.00	0.00	43.2	31.1
1959	4	179.0	0.0	179.0	0.0	391.00	0.00	83.6	60.2
1959	5	453.0	0.0	450.0	0.0	392.00	8.05	200.0	144.0
1959	6	249.0	0.0	252.0	0.0	391.00	0.00	116.9	84.2
1959	7	133.0	0.0	133.0	0.0	391.00	0.00	62.8	45.2
1959	8	88.0	0.0	88.0	0.0	391.00	0.00	41.6	30.0
1959	9	312.0	0.0	312.0	0.0	391.00	0.00	142.9	102.9
1959	10	995.0	0.0	450.0	542.0	392.00	8.05	200.0	144.0
1959	11	1,176.0	0.0	450.0	726.0	392.00	8.05	200.0	144.0
1959	12	608.0	0.0	450.0	158.0	392.00	8.05	200.0	144.0
1960	1	170.0	0.0	173.0	0.0	391.00	0.00	81.3	58.5
1960	2	174.0	0.0	174.0	0.0	391.00	0.00	81.7	58.8
1960	3	202.0	0.0	202.0	0.0	391.00	0.00	94.5	68.0
1960	4	407.0	0.0	407.0	0.0	391.00	0.00	182.0	131.0
1960	5	369.0	0.0	369.0	0.0	391.00	0.00	166.7	120.0
1960	6	485.0	0.0	450.0	32.0	392.00	8.05	200.0	144.0
1960	7	217.0	0.0	221.0	0.0	391.00	0.00	102.7	73.9
1960	8	168.0	0.0	168.0	0.0	391.00	0.00	78.9	56.8
1960	9	216.0	0.0	216.0	0.0	391.00	0.00	100.4	72.3
1960	10	1,004.0	0.0	450.0	551.0	392.00	8.05	200.0	144.0
1960	11	1,304.0	0.0	450.0	854.0	392.00	8.05	200.0	144.0
1960	12	706.0	0.0	450.0	256.0	392.00	8.05	200.0	144.0
1961	1	275.0	0.0	278.0	0.0	391.00	0.00	128.3	92.4
1961	2	288.0	0.0	288.0	0.0	391.00	0.00	132.6	95.5
1961	3	179.0	0.0	179.0	0.0	391.00	0.00	83.8	60.3
1961	4	427.0	0.0	427.0	0.0	391.00	0.00	189.9	136.7
1961	5	358.0	0.0	358.0	0.0	391.00	0.00	162.4	116.9

Table 2 Energy Production Simulation

Small Scale Development Case (Runoff from only Ntem River)
Discharge modified by 1.0

Year	Month	Q.in	Q.duty	Q.plant	Q.spill	WL	V	P.ave	E.ann
		(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m)	(mill.m3)	(MW)	(GWh)
1961	6	426.0	0.0	426.0	0.0	391.00	0.00	189.6	136.5
1961	7	123.0	0.0	123.0	0.0	391.00	0.00	57.7	41.6
1961	8	65.0	0.0	65.0	0.0	391.00	0.00	30.8	22.2
1961	9	222.0	0.0	222.0	0.0	391.00	0.00	103.4	74.5
1961	10	749.0	0.0	450.0	296.0	392.00	8.05	200.0	144.0
1961	11	779.0	0.0	450.0	329.0	392.00	8.05	200.0	144.0
1961	12	337.0	0.0	341.0	0.0	391.00	0.00	155.0	111.6
1962	1	110.0	0.0	110.0	0.0	391.00	0.00	51.9	37.4
1962	2	102.0	0.0	102.0	0.0	391.00	0.00	48.3	34.8
1962	3	264.0	0.0	264.0	0.0	391.00	0.00	122.2	88.0
1962	4	873.0	0.0	450.0	420.0	392.00	8.05	200.0	144.0
1962	5	866.0	0.0	450.0	416.0	392.00	8.05	200.0	144.0
1962	6	561.0	0.0	450.0	111.0	392.00	8.05	200.0	144.0
1962	7	216.0	0.0	219.0	0.0	391.00	0.00	102.0	73.4
1962	8	115.0	0.0	115.0	0.0	391.00	0.00	54.4	39.1
1962	9	278.0	0.0	278.0	0.0	391.00	0.00	128.3	92.3
1962	10	712.0	0.0	450.0	259.0	392.00	8.05	200.0	144.0
1962	11	637.0	0.0	450.0	187.0	392.00	8.05	200.0	144.0
1962	12	556.0	0.0	450.0	106.0	392.00	8.05	200.0	144.0
1963	1	199.0	0.0	203.0	0.0	391.00	0.00	94.6	68.1
1963	2	165.0	0.0	165.0	0.0	391.00	0.00	77.2	55.6
1963	3	265.0	0.0	265.0	0.0	391.00	0.00	122.5	88.2
1963	4	325.0	0.0	325.0	0.0	391.00	0.00	148.3	106.8
1963	5	514.0	0.0	450.0	61.0	392.00	8.05	200.0	144.0
1963	6	334.0	0.0	337.0	0.0	391.00	0.00	153.4	110.4
1963	7	387.0	0.0	387.0	0.0	391.00	0.00	174.3	125.5
1963	8	171.0	0.0	171.0	0.0	391.00	0.00	80.1	57.7
1963	9	447.0	0.0	447.0	0.0	391.00	0.00	197.8	142.5
1963	10	926.0	0.0	450.0	473.0	392.00	8.05	200.0	144.0
1963	11	671.0	0.0	450.0	221.0	392.00	8.05	200.0	144.0
1963	12	347.0	0.0	350.0	0.0	391.00	0.00	158.9	114.4
1964	1	186.0	0.0	186.0	0.0	391.00	0.00	86.9	62.6
1964	2	125.0	0.0	125.0	0.0	391.00	0.00	58.8	42.3
1964	3	183.0	0.0	183.0	0.0	391.00	0.00	85.8	61.8
1964	4	497.0	0.0	450.0	44.0	392.00	8.05	200.0	144.0
1964	5	425.0	0.0	428.0	0.0	391.00	0.00	190.2	137.0
1964	6	425.0	0.0	425.0	0.0	391.00	0.00	189.0	136.1
1964	7	211.0	0.0	211.0	0.0	391.00	0.00	98.4	70.8
1964	8	80.0	0.0	80.0	0.0	391.00	0.00	37.9	27.3
1964	9	789.0	0.0	450.0	336.0	392.00	8.05	200.0	144.0
1964	10	789.0	0.0	450.0	339.0	392.00	8.05	200.0	144.0
1964	11	1,165.0	0.0	450.0	715.0	392.00	8.05	200.0	144.0
1964	12	492.0	0.0	450.0	42.0	392.00	8.05	200.0	144.0
1965	1	257.0	0.0	260.0	0.0	391.00	0.00	120.2	86.6
1965	2	218.0	0.0	218.0	0.0	391.00	0.00	101.4	73.0
1965	3	362.0	0.0	362.0	0.0	391.00	0.00	163.8	117.9
1965	4	499.0	0.0	450.0	45.0	392.00	8.05	200.0	144.0
1965	5	548.0	0.0	450.0	98.0	392.00	8.05	200.0	144.0
1965	6	501.0	0.0	450.0	51.0	392.00	8.05	200.0	144.0
1965	7	253.0	0.0	256.0	0.0	391.00	0.00	118.4	85.3
1965	8	179.0	0.0	179.0	0.0	391.00	0.00	83.6	60.2
1965	9	411.0	0.0	411.0	0.0	391.00	0.00	183.7	132.2
1965	10	1,064.0	0.0	450.0	611.0	392.00	8.05	200.0	144.0

Table 2 Energy Production Simulation

Small Scale Development Case (Runoff from only Ntem River)
Discharge modified by 1.0

Year	Month	Q.in	Q.duty	Q.plant	Q.spill	WL	V	P.ave	E.ann
		(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m)	(mill.m3)	(MW)	(GWh)
1965	11	971.0	0.0	450.0	521.0	392.00	8.05	200.0	144.0
1965	12	378.0	0.0	381.0	0.0	391.00	0.00	171.6	123.5
1966	1	173.0	0.0	173.0	0.0	391.00	0.00	81.1	58.4
1966	2	161.0	0.0	161.0	0.0	391.00	0.00	75.6	54.5
1966	3	167.0	0.0	167.0	0.0	391.00	0.00	78.1	56.3
1966	4	504.0	0.0	450.0	51.0	392.00	8.05	200.0	144.0
1966	5	1,039.0	0.0	450.0	589.0	392.00	8.05	200.0	144.0
1966	6	909.0	0.0	450.0	459.0	392.00	8.05	200.0	144.0
1966	7	781.0	0.0	450.0	331.0	392.00	8.05	200.0	144.0
1966	8	311.0	0.0	314.0	0.0	391.00	0.00	143.9	103.6
1966	9	436.0	0.0	436.0	0.0	391.00	0.00	193.3	139.2
1966	10	819.0	0.0	450.0	366.0	392.00	8.05	200.0	144.0
1966	11	1,198.0	0.0	450.0	748.0	392.00	8.05	200.0	144.0
1966	12	557.0	0.0	450.0	107.0	392.00	8.05	200.0	144.0
1967	1	199.0	0.0	202.0	0.0	391.00	0.00	94.4	67.9
1967	2	156.0	0.0	156.0	0.0	391.00	0.00	73.2	52.7
1967	3	123.0	0.0	123.0	0.0	391.00	0.00	57.8	41.6
1967	4	161.0	0.0	161.0	0.0	391.00	0.00	75.8	54.5
1967	5	542.0	0.0	450.0	89.0	392.00	8.05	200.0	144.0
1967	6	654.0	0.0	450.0	204.0	392.00	8.05	200.0	144.0
1967	7	266.0	0.0	269.0	0.0	391.00	0.00	124.4	89.5
1967	8	102.0	0.0	102.0	0.0	391.00	0.00	48.0	34.5
1967	9	397.0	0.0	397.0	0.0	391.00	0.00	178.2	128.3
1967	10	1,278.0	0.0	450.0	825.0	392.00	8.05	200.0	144.0
1967	11	1,232.0	0.0	450.0	782.0	392.00	8.05	200.0	144.0
1967	12	509.0	0.0	450.0	59.0	392.00	8.05	200.0	144.0
1968	1	184.0	0.0	187.0	0.0	391.00	0.00	87.6	63.1
1968	2	182.0	0.0	182.0	0.0	391.00	0.00	85.0	61.2
1968	3	276.0	0.0	276.0	0.0	391.00	0.00	127.4	91.7
1968	4	328.0	0.0	328.0	0.0	391.00	0.00	149.5	107.7
1968	5	752.0	0.0	450.0	299.0	392.00	8.05	200.0	144.0
1968	6	637.0	0.0	450.0	187.0	392.00	8.05	200.0	144.0
1968	7	205.0	0.0	208.0	0.0	391.00	0.00	97.2	70.0
1968	8	96.0	0.0	96.0	0.0	391.00	0.00	45.4	32.7
1968	9	310.0	0.0	310.0	0.0	391.00	0.00	142.1	102.3
1968	10	741.0	0.0	450.0	288.0	392.00	8.05	200.0	144.0
1968	11	923.0	0.0	450.0	473.0	392.00	8.05	200.0	144.0
1968	12	608.0	0.0	450.0	158.0	392.00	8.05	200.0	144.0
1969	1	215.0	0.0	218.0	0.0	391.00	0.00	101.6	73.2
1969	2	226.0	0.0	226.0	0.0	391.00	0.00	105.1	75.7
1969	3	499.0	0.0	450.0	46.0	392.00	8.05	200.0	144.0
1969	4	595.0	0.0	450.0	145.0	392.00	8.05	200.0	144.0
1969	5	518.0	0.0	450.0	68.0	392.00	8.05	200.0	144.0
1969	6	417.0	0.0	420.0	0.0	391.00	0.00	187.3	134.9
1969	7	220.0	0.0	220.0	0.0	391.00	0.00	102.6	73.9
1969	8	183.0	0.0	183.0	0.0	391.00	0.00	85.9	61.8
1969	9	387.0	0.0	387.0	0.0	391.00	0.00	174.3	125.5
1969	10	858.0	0.0	450.0	405.0	392.00	8.05	200.0	144.0
1969	11	1,029.0	0.0	450.0	579.0	392.00	8.05	200.0	144.0
1969	12	381.0	0.0	384.0	0.0	391.00	0.00	172.9	124.5
1970	1	158.0	0.0	158.0	0.0	391.00	0.00	74.3	53.5
1970	2	121.0	0.0	121.0	0.0	391.00	0.00	57.0	41.1
1970	3	275.0	0.0	275.0	0.0	391.00	0.00	127.0	91.4

Table 2 Energy Production Simulation

Small Scale Development Case (Runoff from only Ntem River)
Discharge modified by 1.0

Year	Month	Q.in	Q.duty	Q.plant	Q.spill	WL	V	P.ave	E.ann
		(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m)	(mill.m3)	(MW)	(GWh)
1970	4	318.0	0.0	318.0	0.0	391.00	0.00	145.5	104.8
1970	5	357.0	0.0	357.0	0.0	391.00	0.00	161.9	116.6
1970	6	550.0	0.0	450.0	97.0	392.00	8.05	200.0	144.0
1970	7	279.0	0.0	282.0	0.0	391.00	0.00	130.0	93.6
1970	8	186.0	0.0	186.0	0.0	391.00	0.00	87.0	62.7
1970	9	362.0	0.0	362.0	0.0	391.00	0.00	164.1	118.2
1970	10	1,007.0	0.0	450.0	554.0	392.00	8.05	200.0	144.0
1970	11	1,524.0	0.0	450.0	1,074.0	392.00	8.05	200.0	144.0
1970	12	383.0	0.0	386.0	0.0	391.00	0.00	173.9	125.2
1971	1	202.0	0.0	202.0	0.0	391.00	0.00	94.5	68.1
1971	2	90.0	0.0	90.0	0.0	391.00	0.00	42.3	30.5
1971	3	160.0	0.0	160.0	0.0	391.00	0.00	75.2	54.2
1971	4	304.0	0.0	304.0	0.0	391.00	0.00	139.6	100.5
1971	5	268.0	0.0	268.0	0.0	391.00	0.00	123.9	89.2
1971	6	222.0	0.0	222.0	0.0	391.00	0.00	103.5	74.5
1971	7	149.0	0.0	149.0	0.0	391.00	0.00	69.9	50.3
1971	8	116.0	0.0	116.0	0.0	391.00	0.00	54.5	39.2
1971	9	321.0	0.0	321.0	0.0	391.00	0.00	146.8	105.7
1971	10	829.0	0.0	450.0	376.0	392.00	8.05	200.0	144.0
1971	11	811.0	0.0	450.0	361.0	392.00	8.05	200.0	144.0
1971	12	342.0	0.0	345.0	0.0	391.00	0.00	157.0	113.0
1972	1	111.0	0.0	111.0	0.0	391.00	0.00	52.5	37.8
1972	2	83.0	0.0	83.0	0.0	391.00	0.00	39.4	28.3
1972	3	161.0	0.0	161.0	0.0	391.00	0.00	75.4	54.3
1972	4	398.0	0.0	398.0	0.0	391.00	0.00	178.4	128.5
1972	5	335.0	0.0	335.0	0.0	391.00	0.00	152.5	109.8
1972	6	321.0	0.0	321.0	0.0	391.00	0.00	146.8	105.7
1972	7	127.0	0.0	127.0	0.0	391.00	0.00	59.6	42.9
1972	8	101.0	0.0	101.0	0.0	391.00	0.00	47.8	34.4
1972	9	372.0	0.0	372.0	0.0	391.00	0.00	168.1	121.1
1972	10	810.0	0.0	450.0	357.0	392.00	8.05	200.0	144.0
1972	11	909.0	0.0	450.0	459.0	392.00	8.05	200.0	144.0
1972	12	310.0	0.0	313.0	0.0	391.00	0.00	143.4	103.3
1973	1	199.0	0.0	199.0	0.0	391.00	0.00	92.8	66.8
1973	2	137.0	0.0	137.0	0.0	391.00	0.00	64.3	46.3
1973	3	194.0	0.0	194.0	0.0	391.00	0.00	90.8	65.4
1973	4	315.0	0.0	315.0	0.0	391.00	0.00	144.1	103.8
1973	5	431.0	0.0	431.0	0.0	391.00	0.00	191.7	138.0
1973	6	581.0	0.0	450.0	127.0	392.00	8.05	200.0	144.0
1973	7	248.0	0.0	251.0	0.0	391.00	0.00	116.4	83.8
1973	8	175.0	0.0	175.0	0.0	391.00	0.00	82.1	59.1
1973	9	286.0	0.0	286.0	0.0	391.00	0.00	131.7	94.8
1973	10	627.0	0.0	450.0	173.0	392.00	8.05	200.0	144.0
1973	11	620.0	0.0	450.0	170.0	392.00	8.05	200.0	144.0
1973	12	278.0	0.0	281.0	0.0	391.00	0.00	129.5	93.2
1974	1	138.0	0.0	138.0	0.0	391.00	0.00	64.9	46.7
1974	2	147.0	0.0	147.0	0.0	391.00	0.00	68.9	49.6
1974	3	209.0	0.0	209.0	0.0	391.00	0.00	97.5	70.2
1974	4	333.0	0.0	333.0	0.0	391.00	0.00	151.9	109.3
1974	5	707.0	0.0	450.0	254.0	392.00	8.05	200.0	144.0
1974	6	539.0	0.0	450.0	89.0	392.00	8.05	200.0	144.0
1974	7	187.0	0.0	190.0	0.0	391.00	0.00	88.8	63.9
1974	8	186.0	0.0	186.0	0.0	391.00	0.00	87.1	62.7

Table 2 Energy Production Simulation

Small Scale Development Case (Runoff from only Ntem River)
Discharge modified by 1.0

Year	Month	Q.in	Q.duty	Q.plant	Q.spill	WL	V	P.ave	E.ann
		(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m)	(mill.m3)	(MW)	(GWh)
1974	9	329.0	0.0	329.0	0.0	391.00	0.00	150.1	108.1
1974	10	737.0	0.0	450.0	283.0	392.00	8.05	200.0	144.0
1974	11	931.0	0.0	450.0	481.0	392.00	8.05	200.0	144.0
1974	12	399.0	0.0	402.0	0.0	391.00	0.00	180.2	129.7
1975	1	140.0	0.0	140.0	0.0	391.00	0.00	65.7	47.3
1975	2	199.0	0.0	199.0	0.0	391.00	0.00	92.8	66.8
1975	3	195.0	0.0	195.0	0.0	391.00	0.00	91.1	65.6
1975	4	408.0	0.0	408.0	0.0	391.00	0.00	182.7	131.5
1975	5	366.0	0.0	366.0	0.0	391.00	0.00	165.5	119.2
1975	6	253.0	0.0	253.0	0.0	391.00	0.00	117.1	84.3
1975	7	224.0	0.0	224.0	0.0	391.00	0.00	104.1	75.0
1975	8	101.0	0.0	101.0	0.0	391.00	0.00	47.5	34.2
1975	9	130.0	0.0	130.0	0.0	391.00	0.00	61.1	44.0
1975	10	655.0	0.0	450.0	202.0	392.00	8.05	200.0	144.0
1975	11	1,101.0	0.0	450.0	651.0	392.00	8.05	200.0	144.0
1975	12	591.0	0.0	450.0	141.0	392.00	8.05	200.0	144.0
1976	1	195.0	0.0	198.0	0.0	391.00	0.00	92.7	66.8
1976	2	186.0	0.0	186.0	0.0	391.00	0.00	87.0	62.7
1976	3	240.0	0.0	240.0	0.0	391.00	0.00	111.5	80.3
1976	4	384.0	0.0	384.0	0.0	391.00	0.00	173.0	124.5
1976	5	393.0	0.0	393.0	0.0	391.00	0.00	176.5	127.1
1976	6	616.0	0.0	450.0	163.0	392.00	8.05	200.0	144.0
1976	7	318.0	0.0	321.0	0.0	391.00	0.00	146.7	105.6
1976	8	132.0	0.0	132.0	0.0	391.00	0.00	62.2	44.8
1976	9	188.0	0.0	188.0	0.0	391.00	0.00	88.0	63.4
1976	10	885.0	0.0	450.0	432.0	392.00	8.05	200.0	144.0
1976	11	1,018.0	0.0	450.0	568.0	392.00	8.05	200.0	144.0
1976	12	482.0	0.0	450.0	32.0	392.00	8.05	200.0	144.0
1977	1	196.0	0.0	199.0	0.0	391.00	0.00	92.9	66.9
1977	2	182.0	0.0	182.0	0.0	391.00	0.00	85.3	61.4
1977	3	223.0	0.0	223.0	0.0	391.00	0.00	103.7	74.7
1977	4	381.0	0.0	381.0	0.0	391.00	0.00	171.7	123.6
1977	5	241.0	0.0	241.0	0.0	391.00	0.00	112.0	80.6
1977	6	171.0	0.0	171.0	0.0	391.00	0.00	80.2	57.7
1977	7	166.0	0.0	166.0	0.0	391.00	0.00	78.0	56.2
1977	8	170.0	0.0	170.0	0.0	391.00	0.00	79.8	57.5
1977	9	187.0	0.0	187.0	0.0	391.00	0.00	87.5	63.0
1977	10	897.0	0.0	450.0	444.0	392.00	8.05	200.0	144.0
1977	11	1,062.0	0.0	450.0	612.0	392.00	8.05	200.0	144.0
1977	12	596.0	0.0	450.0	146.0	392.00	8.05	200.0	144.0
1978	1	165.0	0.0	168.0	0.0	391.00	0.00	78.8	56.8
1978	2	66.0	0.0	66.0	0.0	391.00	0.00	31.3	22.6
1978	3	157.0	0.0	157.0	0.0	391.00	0.00	73.8	53.2
1978	4	375.0	0.0	375.0	0.0	391.00	0.00	169.3	121.9
1978	5	828.0	0.0	450.0	375.0	392.00	8.05	200.0	144.0
1978	6	582.0	0.0	450.0	132.0	392.00	8.05	200.0	144.0
1978	7	276.0	0.0	280.0	0.0	391.00	0.00	128.9	92.8
1978	8	99.0	0.0	99.0	0.0	391.00	0.00	46.6	33.5
1978	9	282.0	0.0	282.0	0.0	391.00	0.00	129.8	93.4
1978	10	653.0	0.0	450.0	200.0	392.00	8.05	200.0	144.0
1978	11	627.0	0.0	450.0	177.0	392.00	8.05	200.0	144.0
1978	12	267.0	0.0	270.0	0.0	391.00	0.00	124.7	89.8
1979	1	143.0	0.0	143.0	0.0	391.00	0.00	67.3	48.4

Table 2 Energy Production Simulation

Small Scale Development Case (Runoff from only Ntem River)
Discharge modified by 1.0

Year	Month	Q.in	Q.duty	Q.plant	Q.spill	WL	V	P.ave	E.ann
		(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m)	(mill.m3)	(MW)	(GWh)
1979	2	104.0	0.0	104.0	0.0	391.00	0.00	49.0	35.3
1979	3	220.0	0.0	220.0	0.0	391.00	0.00	102.4	73.7
1979	4	331.0	0.0	331.0	0.0	391.00	0.00	150.8	108.6
1979	5	529.0	0.0	450.0	76.0	392.00	8.05	200.0	144.0
1979	6	464.0	0.0	450.0	14.0	392.00	8.05	200.0	144.0
1979	7	261.0	0.0	264.0	0.0	391.00	0.00	122.0	87.8
1979	8	136.0	0.0	136.0	0.0	391.00	0.00	64.2	46.2
1979	9	327.0	0.0	327.0	0.0	391.00	0.00	149.3	107.5
1979	10	685.0	0.0	450.0	232.0	392.00	8.05	200.0	144.0
1979	11	833.0	0.0	450.0	383.0	392.00	8.05	200.0	144.0
1979	12	324.0	0.0	327.0	0.0	391.00	0.00	149.5	107.6
1980	1	153.0	0.0	153.0	0.0	391.00	0.00	71.9	51.7
1980	2	89.0	0.0	89.0	0.0	391.00	0.00	42.1	30.3
1980	3	109.0	0.0	109.0	0.0	391.00	0.00	51.3	36.9
1980	4	334.0	0.0	334.0	0.0	391.00	0.00	152.1	109.5
1980	5	309.0	0.0	309.0	0.0	391.00	0.00	141.7	102.0
1980	6	436.0	0.0	436.0	0.0	391.00	0.00	193.5	139.3
1980	7	134.0	0.0	134.0	0.0	391.00	0.00	63.2	45.5
1980	8	178.0	0.0	178.0	0.0	391.00	0.00	83.5	60.1
1980	9	392.0	0.0	392.0	0.0	391.00	0.00	176.2	126.8
1980	10	896.0	0.0	450.0	443.0	392.00	8.05	200.0	144.0
1980	11	924.0	0.0	450.0	474.0	392.00	8.05	200.0	144.0
1980	12	343.0	0.0	346.0	0.0	391.00	0.00	157.3	113.3
1981	1	150.0	0.0	150.0	0.0	391.00	0.00	70.7	50.9
1981	2	98.0	0.0	98.0	0.0	391.00	0.00	46.0	33.2
1981	3	151.0	0.0	151.0	0.0	391.00	0.00	70.8	51.0
1981	4	447.0	0.0	447.0	0.0	391.00	0.00	197.6	142.3
1981	5	607.0	0.0	450.0	154.0	392.00	8.05	200.0	144.0
1981	6	486.0	0.0	450.0	36.0	392.00	8.05	200.0	144.0
1981	7	180.0	0.0	184.0	0.0	391.00	0.00	85.9	61.8
1981	8	93.0	0.0	93.0	0.0	391.00	0.00	44.0	31.7
1981	9	271.0	0.0	271.0	0.0	391.00	0.00	125.2	90.2
1981	10	719.0	0.0	450.0	266.0	392.00	8.05	200.0	144.0
1981	11	965.0	0.0	450.0	515.0	392.00	8.05	200.0	144.0
1981	12	342.0	0.0	345.0	0.0	391.00	0.00	157.0	113.1
1982	1	228.0	0.0	228.0	0.0	391.00	0.00	106.1	76.4
1982	2	157.0	0.0	157.0	0.0	391.00	0.00	73.7	53.1
1982	3	204.0	0.0	204.0	0.0	391.00	0.00	95.3	68.6
1982	4	293.0	0.0	293.0	0.0	391.00	0.00	134.7	97.0
1982	5	625.0	0.0	450.0	172.0	392.00	8.05	200.0	144.0
1982	6	390.0	0.0	393.0	0.0	391.00	0.00	176.5	127.0
1982	7	201.0	0.0	201.0	0.0	391.00	0.00	93.8	67.5
1982	8	122.0	0.0	122.0	0.0	391.00	0.00	57.5	41.4
1982	9	379.0	0.0	379.0	0.0	391.00	0.00	171.0	123.1
1982	10	828.0	0.0	450.0	375.0	392.00	8.05	200.0	144.0
1982	11	1,195.0	0.0	450.0	745.0	392.00	8.05	200.0	144.0
1982	12	376.0	0.0	379.0	0.0	391.00	0.00	170.8	123.0
1983	1	128.0	0.0	128.0	0.0	391.00	0.00	60.3	43.4
1983	2	67.0	0.0	67.0	0.0	391.00	0.00	31.4	22.6
1983	3	60.0	0.0	60.0	0.0	391.00	0.00	28.4	20.4
1983	4	165.0	0.0	165.0	0.0	391.00	0.00	77.5	55.8
1983	5	327.0	0.0	327.0	0.0	391.00	0.00	149.3	107.5
1983	6	242.0	0.0	242.0	0.0	391.00	0.00	112.1	80.7

Table 2 Energy Production Simulation

Small Scale Development Case (Runoff from only Ntem River)
Discharge modified by 1.0

Year	Month	Q.in	Q.duty	Q.plant	Q.spill	WL	V	P.ave	E.ann
		(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m)	(mill.m3)	(MW)	(GWh)
1983	7	133.0	0.0	133.0	0.0	391.00	0.00	62.7	45.1
1983	8	58.0	0.0	58.0	0.0	391.00	0.00	27.3	19.7
1983	9	98.0	0.0	98.0	0.0	391.00	0.00	46.3	33.3
1983	10	530.0	0.0	450.0	77.0	392.00	8.05	200.0	144.0
1983	11	733.0	0.0	450.0	283.0	392.00	8.05	200.0	144.0
1983	12	450.0	0.0	450.0	0.0	391.98	7.43	199.9	143.9
1984	1	126.0	0.0	129.0	0.0	391.00	0.00	60.8	43.8
1984	2	73.0	0.0	73.0	0.0	391.00	0.00	34.6	24.9
1984	3	169.0	0.0	169.0	0.0	391.00	0.00	79.3	57.1
1984	4	302.0	0.0	302.0	0.0	391.00	0.00	138.6	99.8
1984	5	390.0	0.0	390.0	0.0	391.00	0.00	175.3	126.2
1984	6	490.0	0.0	450.0	36.0	392.00	8.05	200.0	144.0
1984	7	552.0	0.0	450.0	102.0	392.00	8.05	200.0	144.0
1984	8	402.0	0.0	405.0	0.0	391.00	0.00	181.5	130.6
1984	9	619.0	0.0	450.0	166.0	392.00	8.05	200.0	144.0
1984	10	936.0	0.0	450.0	486.0	392.00	8.05	200.0	144.0
1984	11	827.0	0.0	450.0	377.0	392.00	8.05	200.0	144.0
1984	12	394.0	0.0	397.0	0.0	391.00	0.00	178.3	128.4
1985	1	223.0	0.0	223.0	0.0	391.00	0.00	103.9	74.8
1985	2	116.0	0.0	116.0	0.0	391.00	0.00	54.8	39.5
1985	3	146.0	0.0	146.0	0.0	391.00	0.00	68.7	49.4
1985	4	569.0	0.0	450.0	115.0	392.00	8.05	200.0	144.0
1985	5	494.0	0.0	450.0	44.0	392.00	8.05	200.0	144.0
1985	6	425.0	0.0	428.0	0.0	391.00	0.00	190.5	137.2
1985	7	284.0	0.0	284.0	0.0	391.00	0.00	131.0	94.3
1985	8	254.0	0.0	254.0	0.0	391.00	0.00	117.7	84.8
1985	9	511.0	0.0	450.0	58.0	392.00	8.05	200.0	144.0
1985	10	1,101.0	0.0	450.0	651.0	392.00	8.05	200.0	144.0
1985	11	1,284.0	0.0	450.0	834.0	392.00	8.05	200.0	144.0
1985	12	466.0	0.0	450.0	16.0	392.00	8.05	200.0	144.0
1986	1	178.0	0.0	181.0	0.0	391.00	0.00	84.7	61.0
1986	2	163.0	0.0	163.0	0.0	391.00	0.00	76.5	55.1
1986	3	273.0	0.0	273.0	0.0	391.00	0.00	126.1	90.8
1986	4	274.0	0.0	274.0	0.0	391.00	0.00	126.5	91.1
1986	5	344.0	0.0	344.0	0.0	391.00	0.00	156.6	112.7
1986	6	421.0	0.0	421.0	0.0	391.00	0.00	187.8	135.2
1986	7	110.0	0.0	110.0	0.0	391.00	0.00	51.7	37.2
1986	8	71.0	0.0	71.0	0.0	391.00	0.00	33.7	24.2
1986	9	259.0	0.0	259.0	0.0	391.00	0.00	120.1	86.4
1986	10	865.0	0.0	450.0	412.0	392.00	8.05	200.0	144.0
1986	11	726.0	0.0	450.0	276.0	392.00	8.05	200.0	144.0
1986	12	256.0	0.0	259.0	0.0	391.00	0.00	119.9	86.3
1987	1	87.0	0.0	87.0	0.0	391.00	0.00	41.0	29.5
1987	2	61.0	0.0	61.0	0.0	391.00	0.00	28.7	20.7
1987	3	93.0	0.0	93.0	0.0	391.00	0.00	43.8	31.5
1987	4	226.0	0.0	226.0	0.0	391.00	0.00	105.1	75.7
1987	5	267.0	0.0	267.0	0.0	391.00	0.00	123.3	88.8
1987	6	204.0	0.0	204.0	0.0	391.00	0.00	95.1	68.5
1987	7	212.0	0.0	212.0	0.0	391.00	0.00	98.8	71.1
1987	8	131.0	0.0	131.0	0.0	391.00	0.00	61.8	44.5
1987	9	522.0	0.0	450.0	69.0	392.00	8.05	200.0	144.0
1987	10	1,000.0	0.0	450.0	550.0	392.00	8.05	200.0	144.0
1987	11	1,039.0	0.0	450.0	589.0	392.00	8.05	200.0	144.0

Table 2 Energy Production Simulation

Small Scale Development Case (Runoff from only Ntem River)
Discharge modified by 1.0

Year	Month	Q.in	Q.duty	Q.plant	Q.spill	WL	V	P.ave	E.ann
		(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m)	(mill.m3)	(MW)	(GWh)
1987	12	437.0	0.0	440.0	0.0	391.00	0.00	195.2	140.5
1988	1	174.0	0.0	174.0	0.0	391.00	0.00	81.5	58.7
1988	2	111.0	0.0	111.0	0.0	391.00	0.00	52.4	37.8
1988	3	151.0	0.0	151.0	0.0	391.00	0.00	71.1	51.2
1988	4	240.0	0.0	240.0	0.0	391.00	0.00	111.3	80.2
1988	5	581.0	0.0	450.0	128.0	392.00	8.05	200.0	144.0
1988	6	489.0	0.0	450.0	39.0	392.00	8.05	200.0	144.0
1988	7	277.0	0.0	280.0	0.0	391.00	0.00	129.0	92.9
1988	8	157.0	0.0	157.0	0.0	391.00	0.00	73.6	53.0
1988	9	410.0	0.0	410.0	0.0	391.00	0.00	183.5	132.1
1988	10	972.0	0.0	450.0	519.0	392.00	8.05	200.0	144.0
1988	11	1,415.0	0.0	450.0	965.0	392.00	8.05	200.0	144.0
1988	12	602.0	0.0	450.0	152.0	392.00	8.05	200.0	144.0
1989	1	211.0	0.0	214.0	0.0	391.00	0.00	99.8	71.8
1989	2	136.0	0.0	136.0	0.0	391.00	0.00	64.1	46.2
1989	3	102.0	0.0	102.0	0.0	391.00	0.00	48.1	34.6
1989	4	341.0	0.0	341.0	0.0	391.00	0.00	155.0	111.6
1989	5	592.0	0.0	450.0	139.0	392.00	8.05	200.0	144.0
1989	6	453.0	0.0	450.0	3.0	392.00	8.05	200.0	144.0
1989	7	276.0	0.0	279.0	0.0	391.00	0.00	128.9	92.8
1989	8	145.0	0.0	145.0	0.0	391.00	0.00	68.1	49.0
1989	9	336.0	0.0	336.0	0.0	391.00	0.00	152.9	110.1
1989	10	839.0	0.0	450.0	386.0	392.00	8.05	200.0	144.0
1989	11	973.0	0.0	450.0	523.0	392.00	8.05	200.0	144.0
1989	12	445.0	0.0	448.0	0.0	391.00	0.00	198.1	142.6
1990	1	183.0	0.0	183.0	0.0	391.00	0.00	85.4	61.5
1990	2	136.0	0.0	136.0	0.0	391.00	0.00	64.1	46.2
1990	3	193.0	0.0	193.0	0.0	391.00	0.00	90.0	64.8
1990	4	111.0	0.0	111.0	0.0	391.00	0.00	52.5	37.8
1990	5	374.0	0.0	374.0	0.0	391.00	0.00	169.0	121.7
1990	6	394.0	0.0	394.0	0.0	391.00	0.00	177.1	127.5
1990	7	75.0	0.0	75.0	0.0	391.00	0.00	35.7	25.7
1990	8	167.0	0.0	167.0	0.0	391.00	0.00	78.1	56.2
1990	9	529.0	0.0	450.0	76.0	392.00	8.05	200.0	144.0
1990	10	820.0	0.0	450.0	370.0	392.00	8.05	200.0	144.0
1990	11	1,109.0	0.0	450.0	659.0	392.00	8.05	200.0	144.0
1990	12	686.0	0.0	450.0	236.0	392.00	8.05	200.0	144.0
1991	1	322.0	0.0	325.0	0.0	391.00	0.00	148.4	106.9
1991	2	88.0	0.0	88.0	0.0	391.00	0.00	41.4	29.8
1991	3	295.0	0.0	295.0	0.0	391.00	0.00	135.5	97.5
1991	4	357.0	0.0	357.0	0.0	391.00	0.00	161.8	116.5
1991	5	483.0	0.0	450.0	30.0	392.00	8.05	200.0	144.0
1991	6	442.0	0.0	445.0	0.0	391.00	0.00	197.0	141.8
1991	7	233.0	0.0	233.0	0.0	391.00	0.00	108.3	78.0
1991	8	141.0	0.0	141.0	0.0	391.00	0.00	66.2	47.7
1991	9	336.0	0.0	336.0	0.0	391.00	0.00	152.9	110.1
1991	10	839.0	0.0	450.0	386.0	392.00	8.05	200.0	144.0
1991	11	973.0	0.0	450.0	523.0	392.00	8.05	200.0	144.0
1991	12	445.0	0.0	448.0	0.0	391.00	0.00	198.1	142.6
1992	1	183.0	0.0	183.0	0.0	391.00	0.00	85.4	61.5
1992	2	136.0	0.0	136.0	0.0	391.00	0.00	64.1	46.2
1992	3	81.0	0.0	81.0	0.0	391.00	0.00	38.2	27.5
1992	4	357.0	0.0	357.0	0.0	391.00	0.00	161.8	116.5

Table 2 Energy Production Simulation

Small Scale Development Case (Runoff from only Ntem River)
Discharge modified by 1.0

Year	Month	Q.in	Q.duty	Q.plant	Q.spill	WL	V	P.ave	E.ann
		(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m)	(mill.m3)	(MW)	(GWh)
1992	5	351.0	0.0	351.0	0.0	391.00	0.00	159.4	114.7
1992	6	487.0	0.0	450.0	34.0	392.00	8.05	200.0	144.0
1992	7	146.0	0.0	149.0	0.0	391.00	0.00	70.0	50.4
1992	8	51.0	0.0	51.0	0.0	391.00	0.00	24.2	17.4
1992	9	105.0	0.0	105.0	0.0	391.00	0.00	49.7	35.7
1992	10	585.0	0.0	450.0	132.0	392.00	8.05	200.0	144.0
1992	11	973.0	0.0	450.0	523.0	392.00	8.05	200.0	144.0
1992	12	445.0	0.0	448.0	0.0	391.00	0.00	198.1	142.6

Total Energy (GWh) 42,337.2
Iteration# 432
Annual Energy (GWh/year) 1,176.0

Max. plant discharge: 450 m3/s
Rated head: 52.3 m
Installed capacity: 4 x 50.3 MW

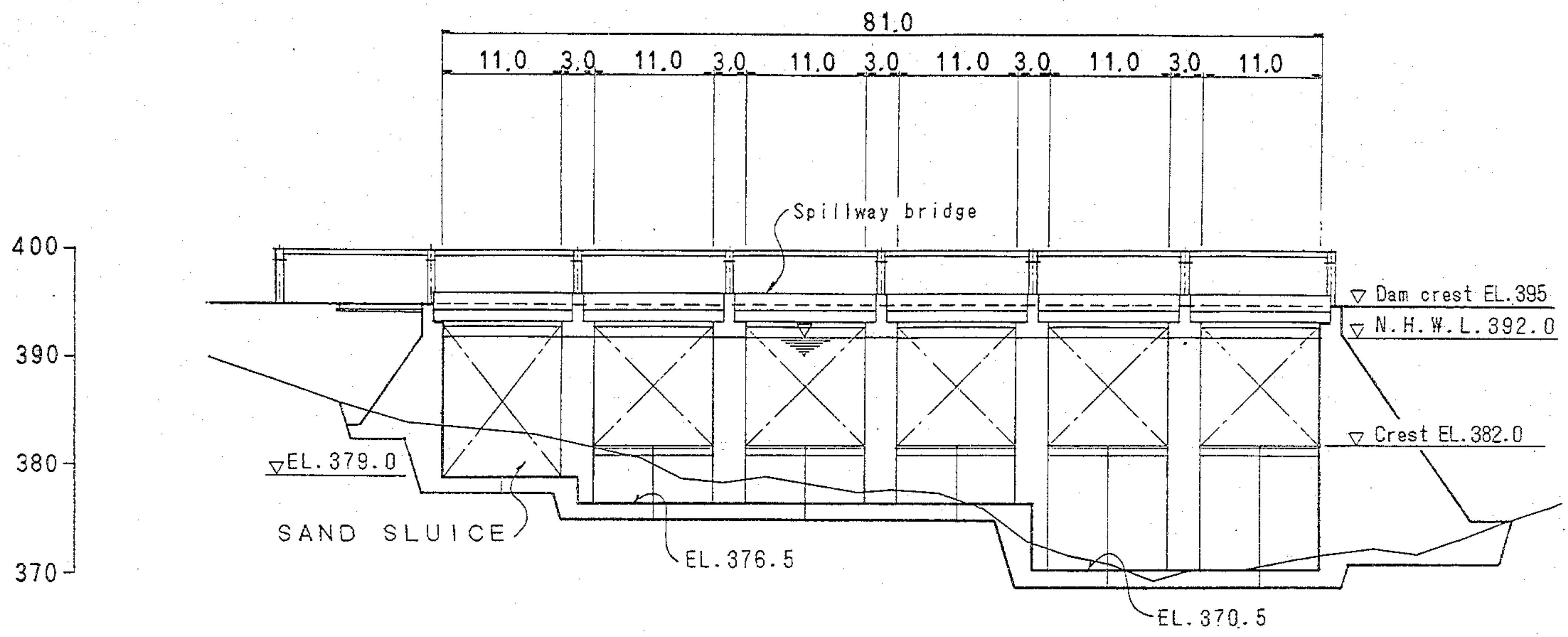


Fig. 1 Front Elevation of Spillway

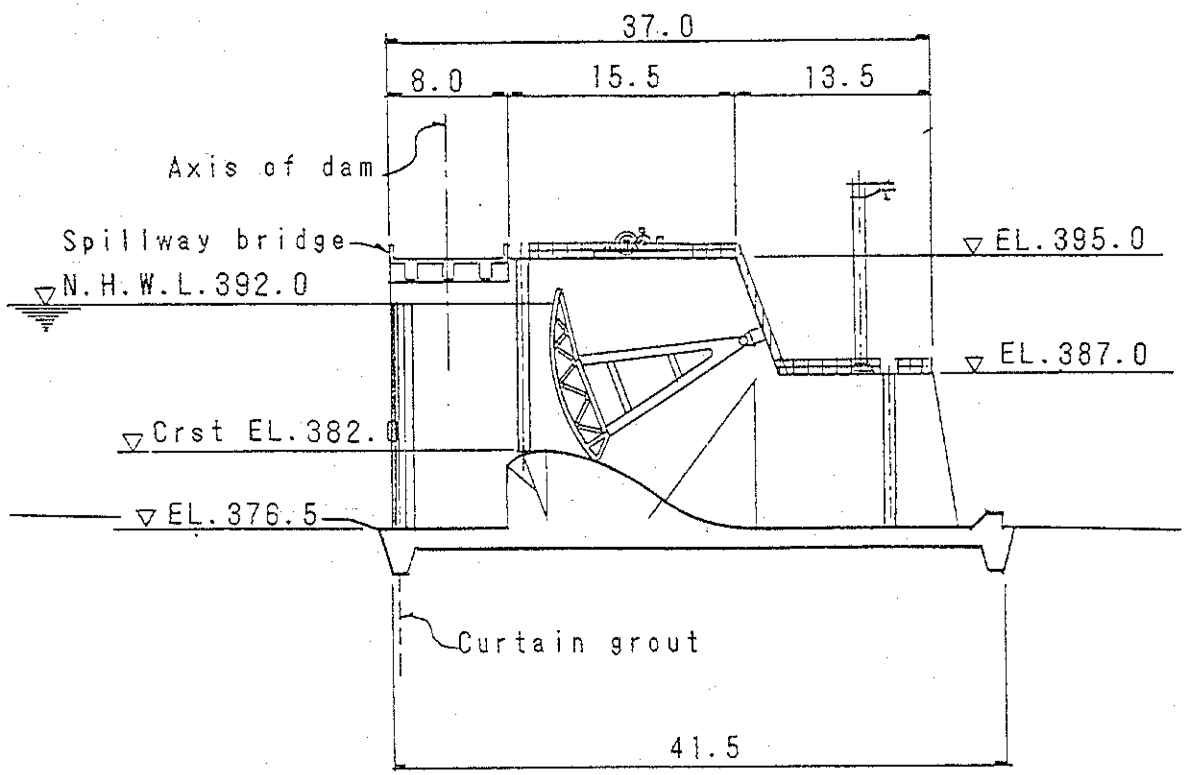


Fig. 2 Profile of Spillway (1)

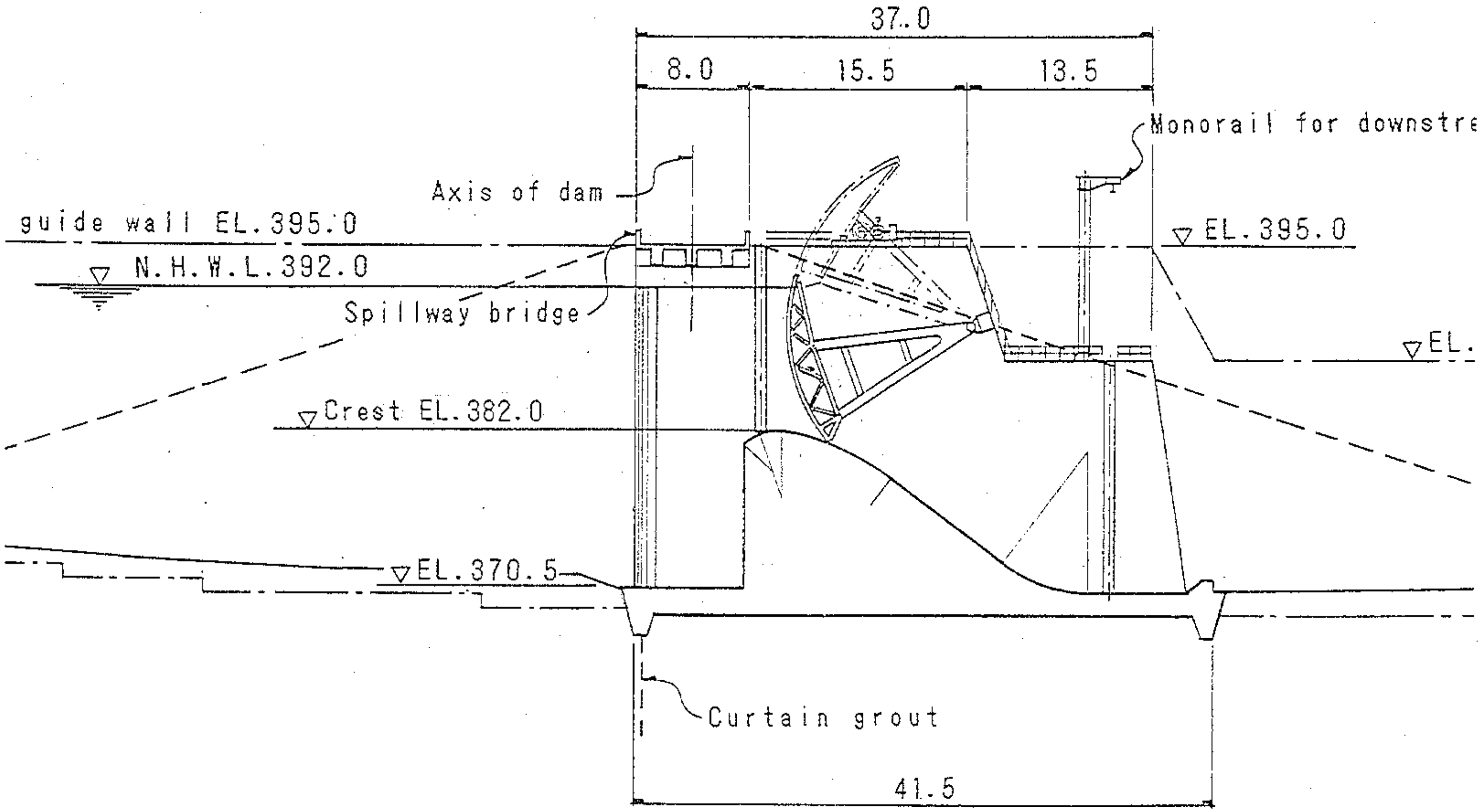


Fig. 3 Profile of Spillway (2)

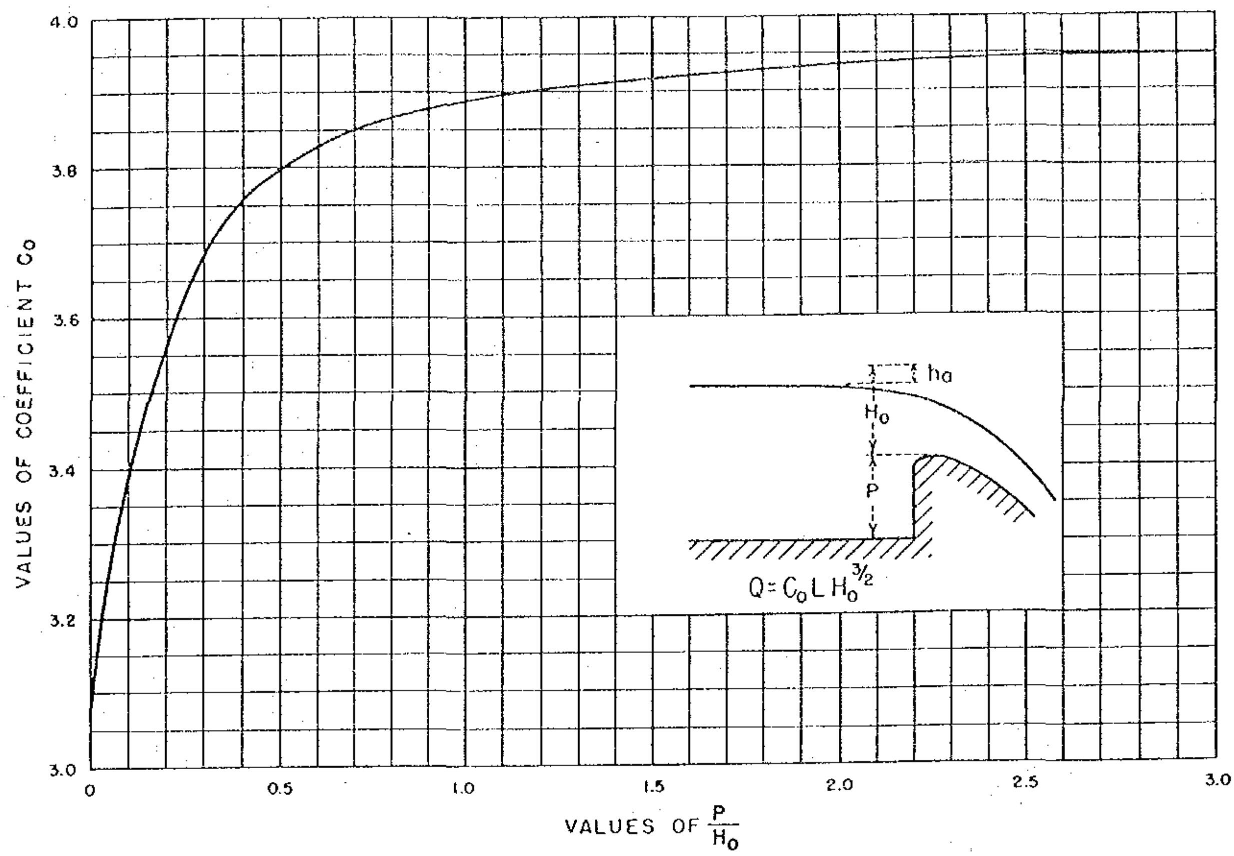


Fig. 4 Discharge Coefficients for Vertical-faced Ogee Crest

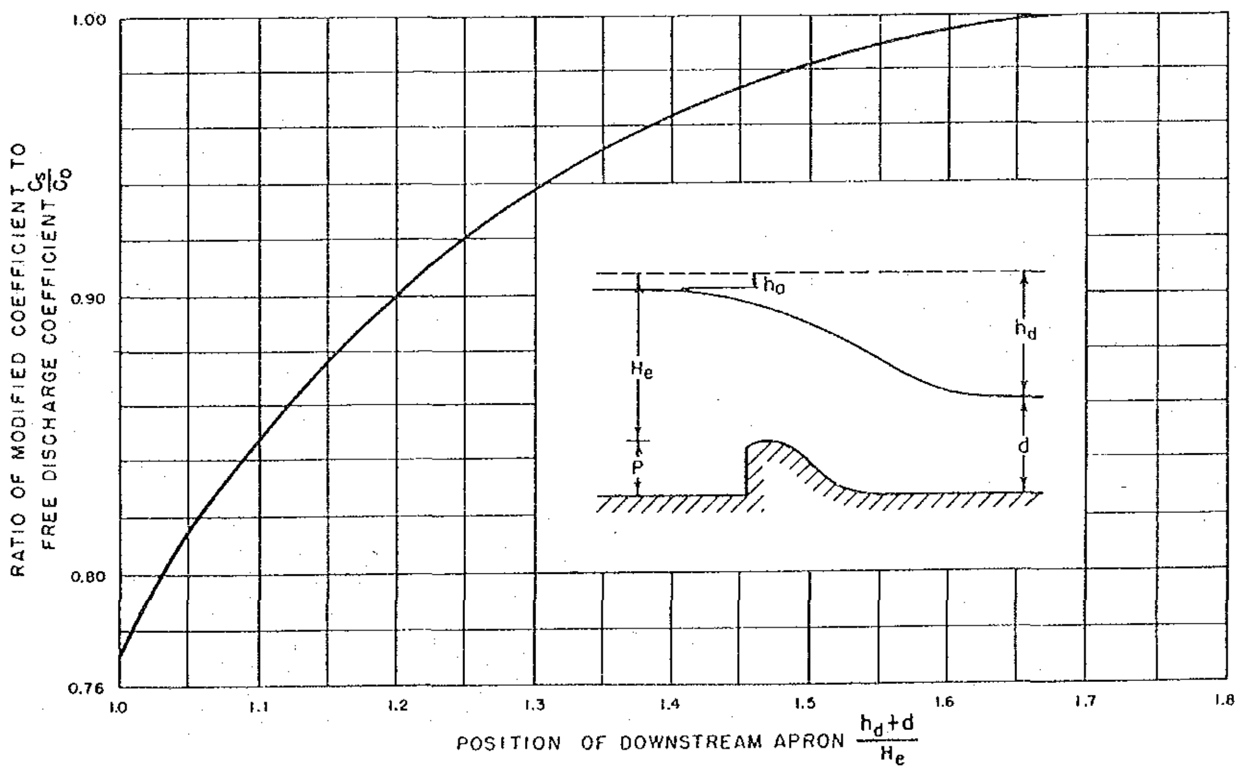


Fig. 5 Ratio of Discharge Coefficients Resulting from Apron Effects

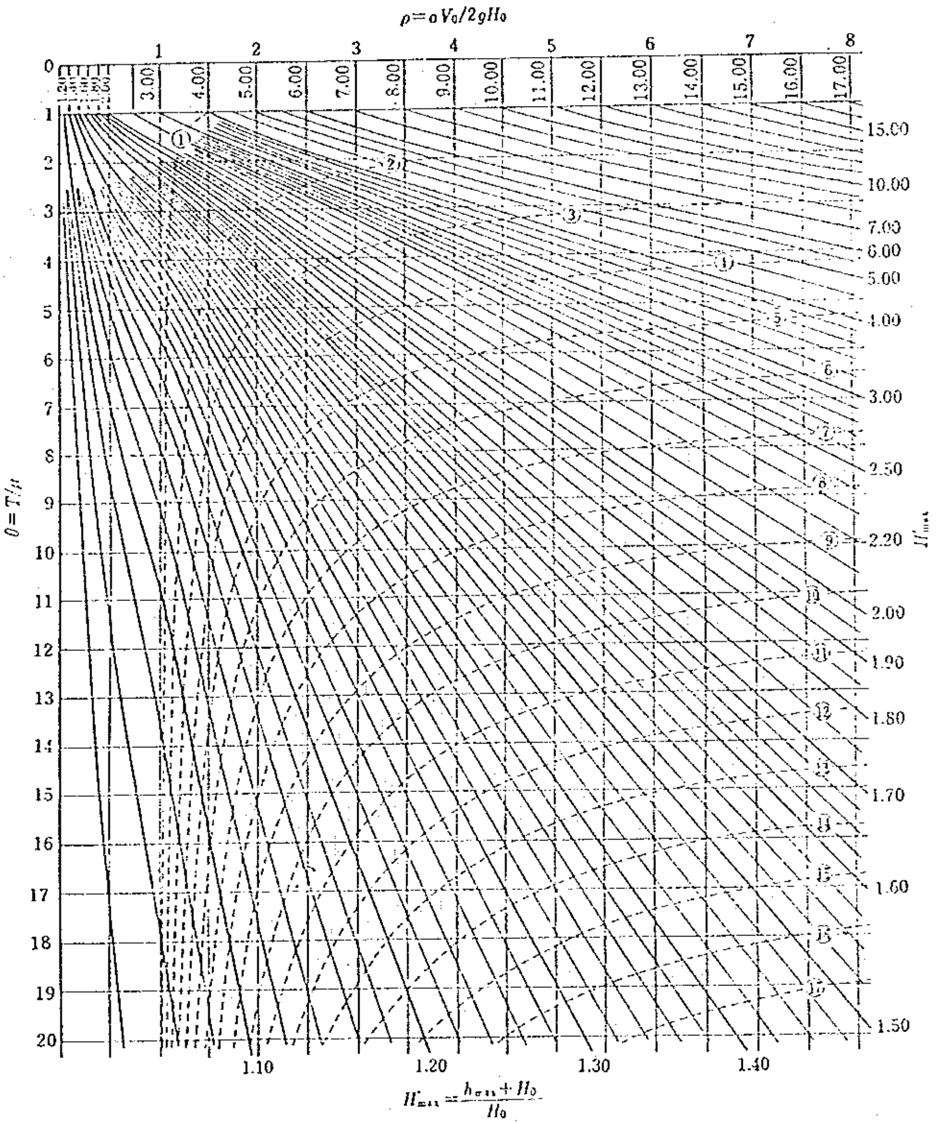


Fig. 6 Maximum Pressure Rise in Pnstock

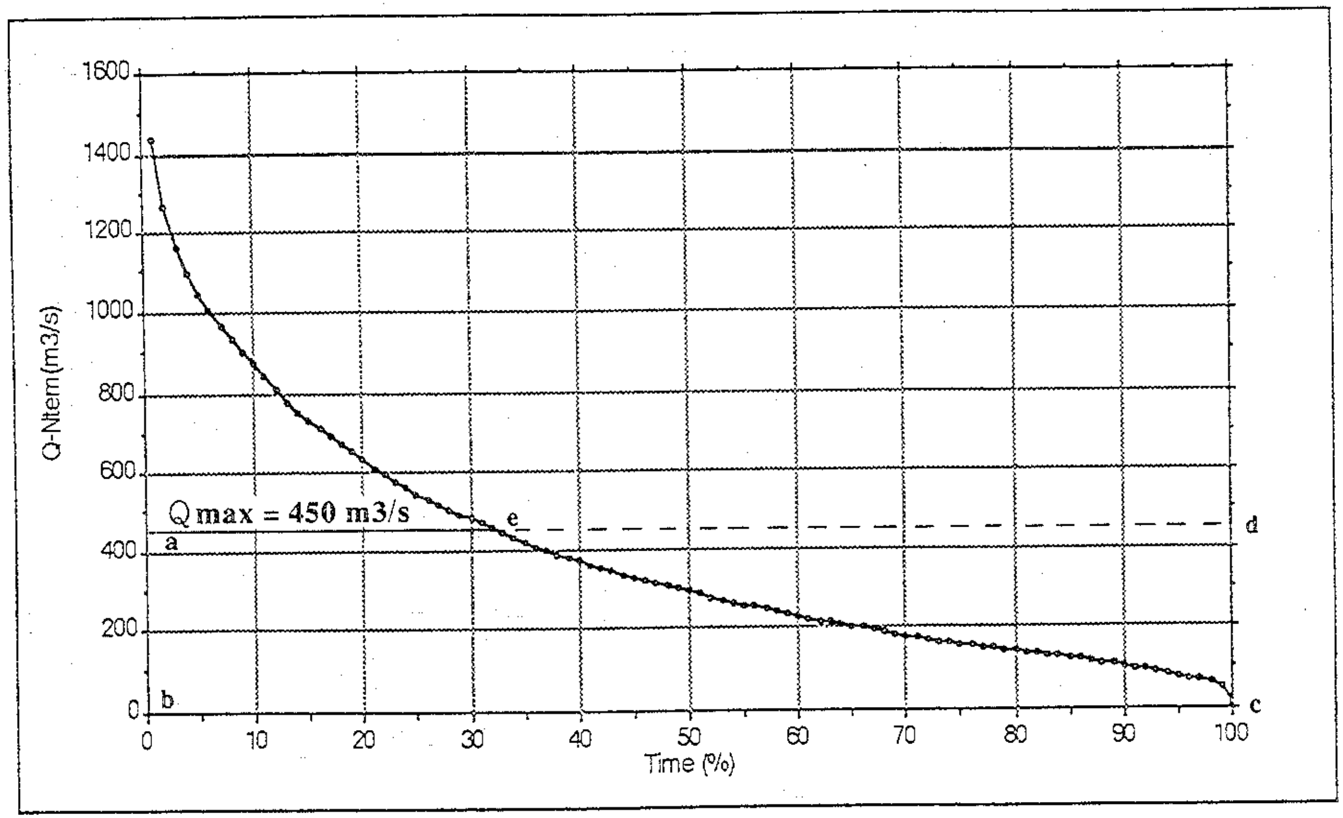


Fig. 7 Flow Duration Cueve of the Ntem at Damsite