Appendix 6.10

Simulation of Sedimentation

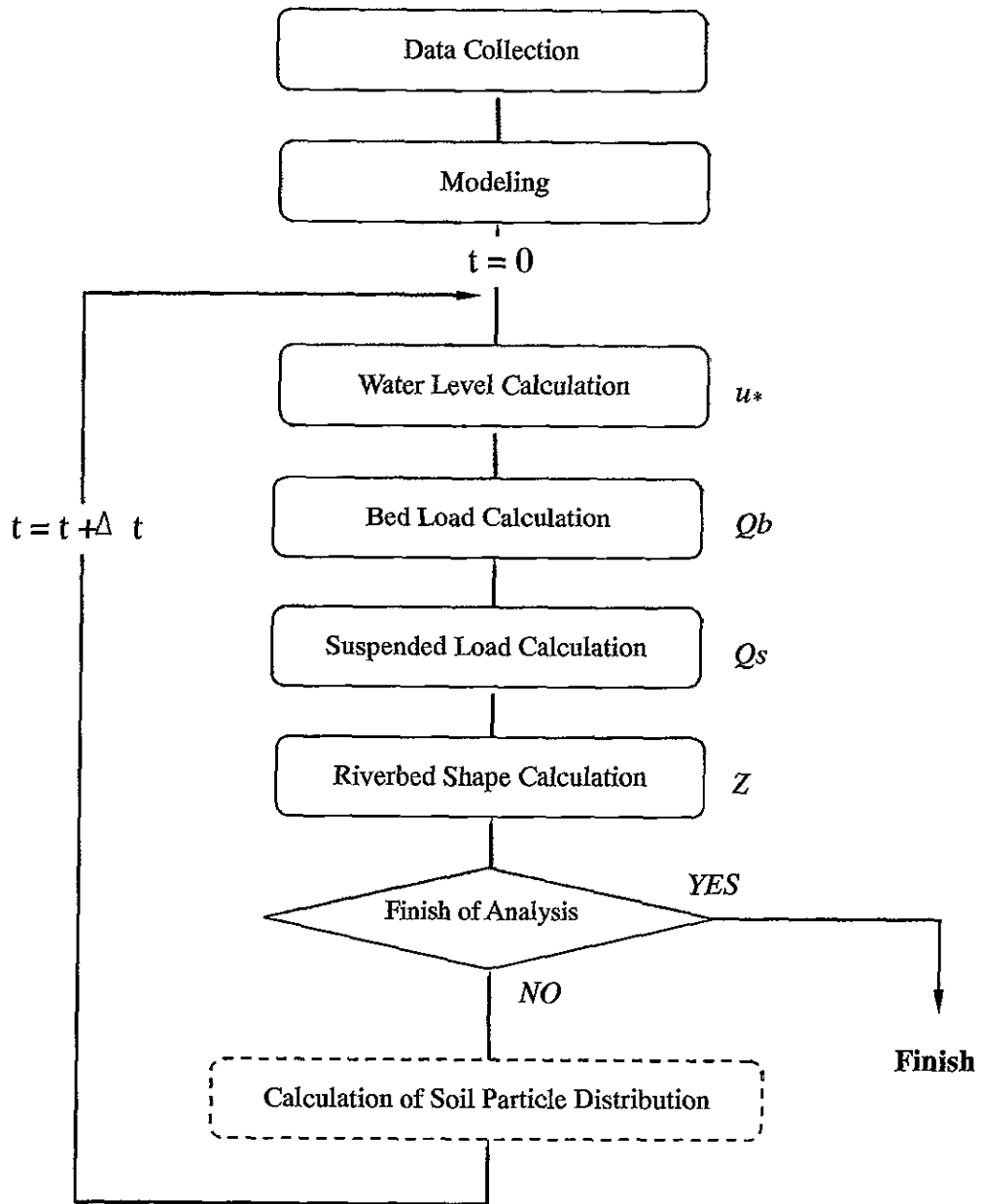# in El Chaparral Reservoir

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(118)

Fig. Flow for Simulation of Sedimentation

Simulation of Sedimentation

1. Water Level Calculation (FLOW 550)

(Basic equation)

$$\frac{d}{dx}\left[\frac{Q^2}{A}\right] + gA\left[\frac{dh}{dx} + Ie - i\right] = 0 \tag{1.1}$$

$$\frac{dQ}{dx} - q = 0 \tag{1.2}$$

Q: discharge (m³/s)

x: interval length (m)

h: water depth (m)

A: flow area (m²)

g: gravity acceleration (m/s²)

i: river bed gradient

q: lateral inflow per unit length of river (m³/s)

Ie: $energy\ gradient = \dfrac{n^2 Q^2}{R^{4/3} * A^2}$

n: Manning roughness coefficient

R: hydraulic radius (m)

from (1.1),

$$u\frac{dQ}{dx} + Q\frac{du}{dx} + gA\left[\frac{dh}{dx} + Ie - i\right] = 0 \tag{1.3}$$

from (1.1) and (1.2)

$$\frac{dh}{dx} + \frac{1}{2g}\frac{du^2}{dx} + \frac{q}{g}\frac{q}{A^2} + Ie - i = 0 \tag{1.4}$$

from (1.4)

$$h_i = h_{i+1} + \frac{1}{2g}\left\{\left[\frac{Q^2}{A^2}\right]_{i+1} - \left[\frac{Q^2}{A^2}\right]_i\right\}_i + \frac{\Delta x}{2}\left[\left\{\frac{q}{g}\left[\frac{Q}{A^2}\right]_{i+1} - \left[\frac{Q}{A^2}\right]_i\right\} + Ie_{i+1} + Ie_i\right] - \Delta x \cdot i \tag{1.5}$$

2. Bed Load Calculation (formula by Ashida/Michiue, FLOW550)

$$\frac{qb_j}{\sqrt{s \cdot g \cdot d_j^{~3}}} = 17.0 \cdot f_j \cdot \tau_{*ej}^{~3/2}\left[1 - \frac{\tau_{*cj}}{\tau_{*j}}\right]\left[1 - \frac{u_{*cj}}{u_{*j}}\right] \tag{2.1}$$

qb_j: load volume per unit time & unit width of river

s: $(\sigma/\rho\text{-}1)$: sand weight in water

d_j: soil particle size

f_j: soil particle distribution

u_*:   friction velocity

τ_{*m} $= u_*(s^*g^*d_m)$

d_m: average soil particle size

d_m: $= \dfrac{\sum fb_j \cdot d_j}{\sum fb_j}$

u_{*e} effective friction velocity for average soil particle size

u: average flow velocity

$$\frac{u}{u_{*e}} = 6.0 + 2.5\,ln\left[\frac{R}{(1 + 2\tau_{*m})d_m}\right]$$

τ_{*j}: $u_*^2(s^*g^*d_j)$

$Z_{*ej} = u_{*e}^{~2} = (s^*g^*d_j)$

u_{*cj}:   *critical friction velocity*

$$0.4d_m < d_j \quad \frac{u_{*cj}^{~2}}{u_{*cm}^{~2}} = \left[\frac{log_{10}\,19}{log_{10}\left[19\dfrac{dj}{d_m}\right]}\right]^2 \frac{di}{d_m}$$

$$0.4d_m \geq d_j \quad \frac{u_{*cj}^{~2}}{u_{*cm}^{~2}} = 0.85$$

here,

$$u_{*cm}^{~2} \doteq 0.05 \cdot s \cdot g \cdot d_m$$

$$\tau_{*cj} : j = u_{*cj}^{~2}(s \cdot g \cdot d_j)$$

/2/

3. Suspended Load Calculation (Lane-Kalinske formula)

(Basic equation)

$$q_s = q \cdot C_o \cdot P$$

$$C_o = 5.55 \cdot \Delta F(w_o) \cdot \left\{ 1/2 \cdot (u_* / w_o) \cdot \exp- (w_o / u_*)^2 \right\}^{1.61}$$

qs: suspended load per unit time and unit length of river

q flow discharge

C_o: concentration at river bed

w_o settlement velocity

u_*: friction velocity

4. Riverbed Shape Calculation (FLOW550)

In the river bed shape calculation, bed load and suspended load were considered (no wash load).

$$\Delta Z = Z_{t+1} - Z_t = \frac{(Q_b + Q_s)_{i+1} - (Q_b + Q_s)_i}{B_s \cdot \Delta x \cdot (1 - \lambda)} \Delta t \tag{4.1}$$

ΔZ: change of river bed height for Δt period

Z: river bed elevation at certain time

i: time

Δt: time interval

B_S: river width

Δx: river internal length

λ: rate of aperture

*

Q_b: $= q_b\, B_s$

*

Q_s: $= q_s\, B_s$
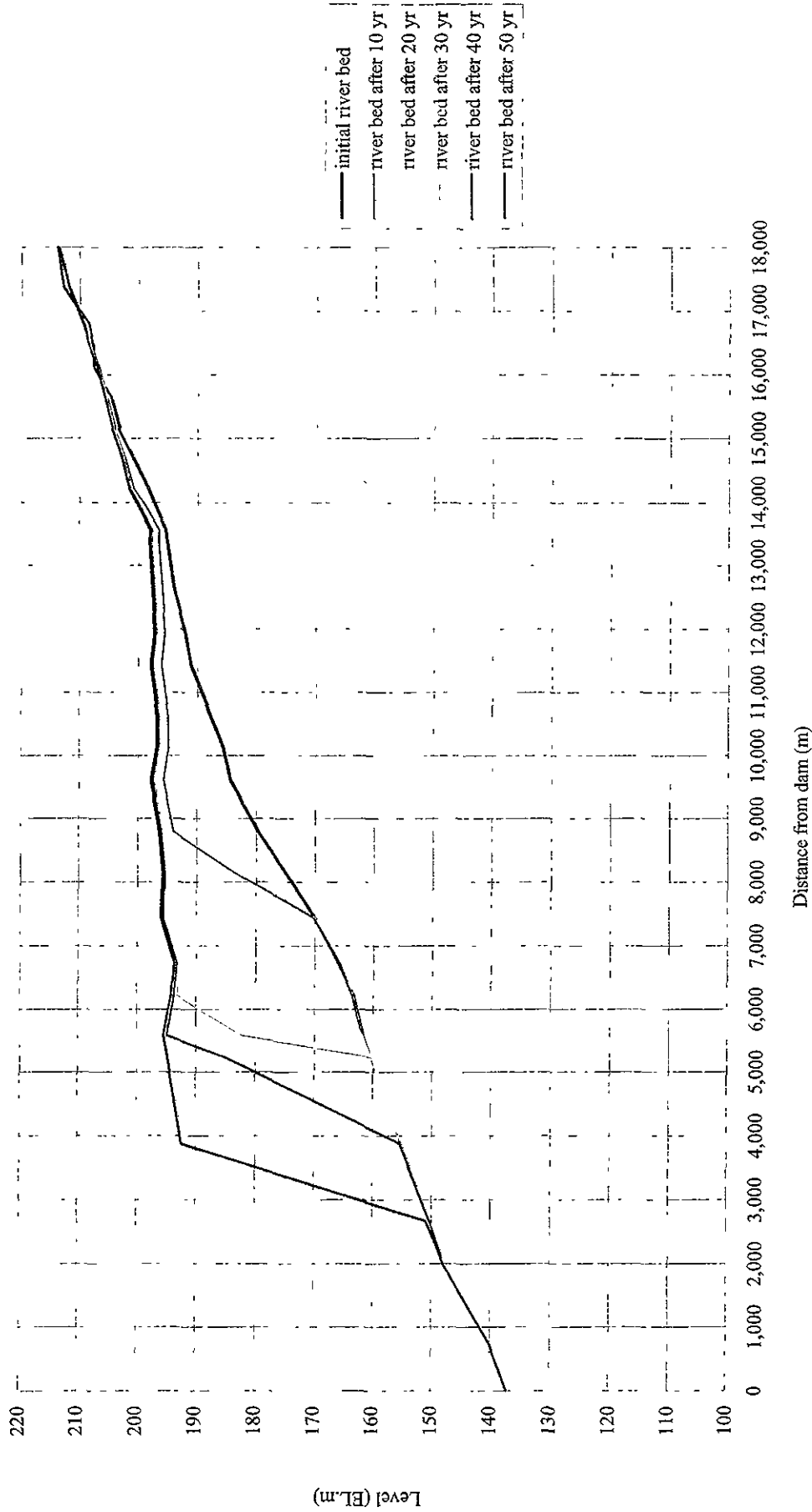
Fig. 6.25 Simulation of Sedimentation

Legend:
- initial river bed
- river bed after 10 yr
- river bed after 20 yr
- river bed after 30 yr
- river bed after 40 yr
- river bed after 50 yr

X-axis: Distance from dam (m) — 0, 1,000, 2,000, 3,000, 4,000, 5,000, 6,000, 7,000, 8,000, 9,000, 10,000, 11,000, 12,000, 13,000, 14,000, 15,000, 16,000, 17,000, 18,000

Y-axis: Level (EL.m) — 100, 110, 120, 130, 140, 150, 160, 170, 180, 190, 200, 210, 220
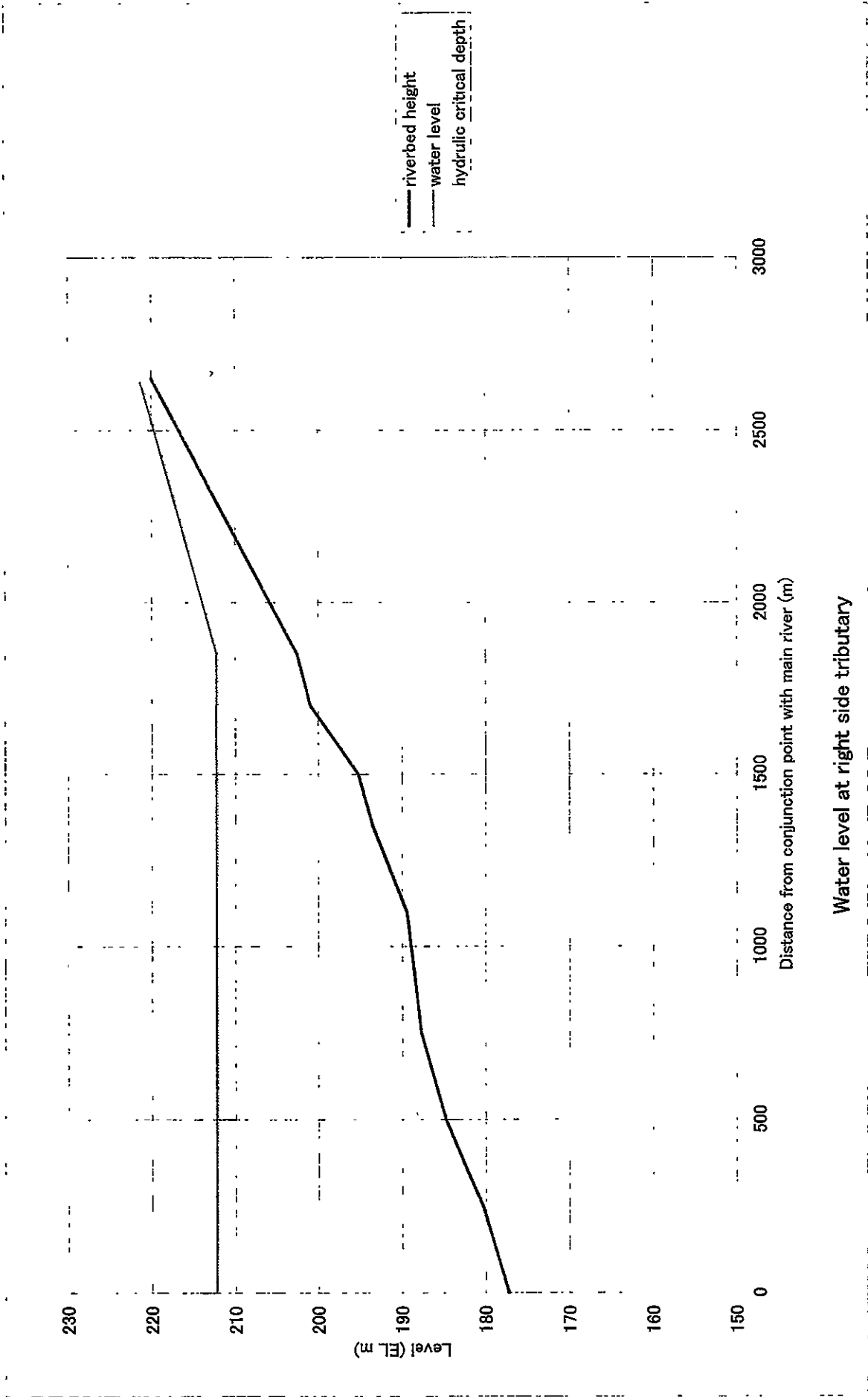
Water level at right side tributary

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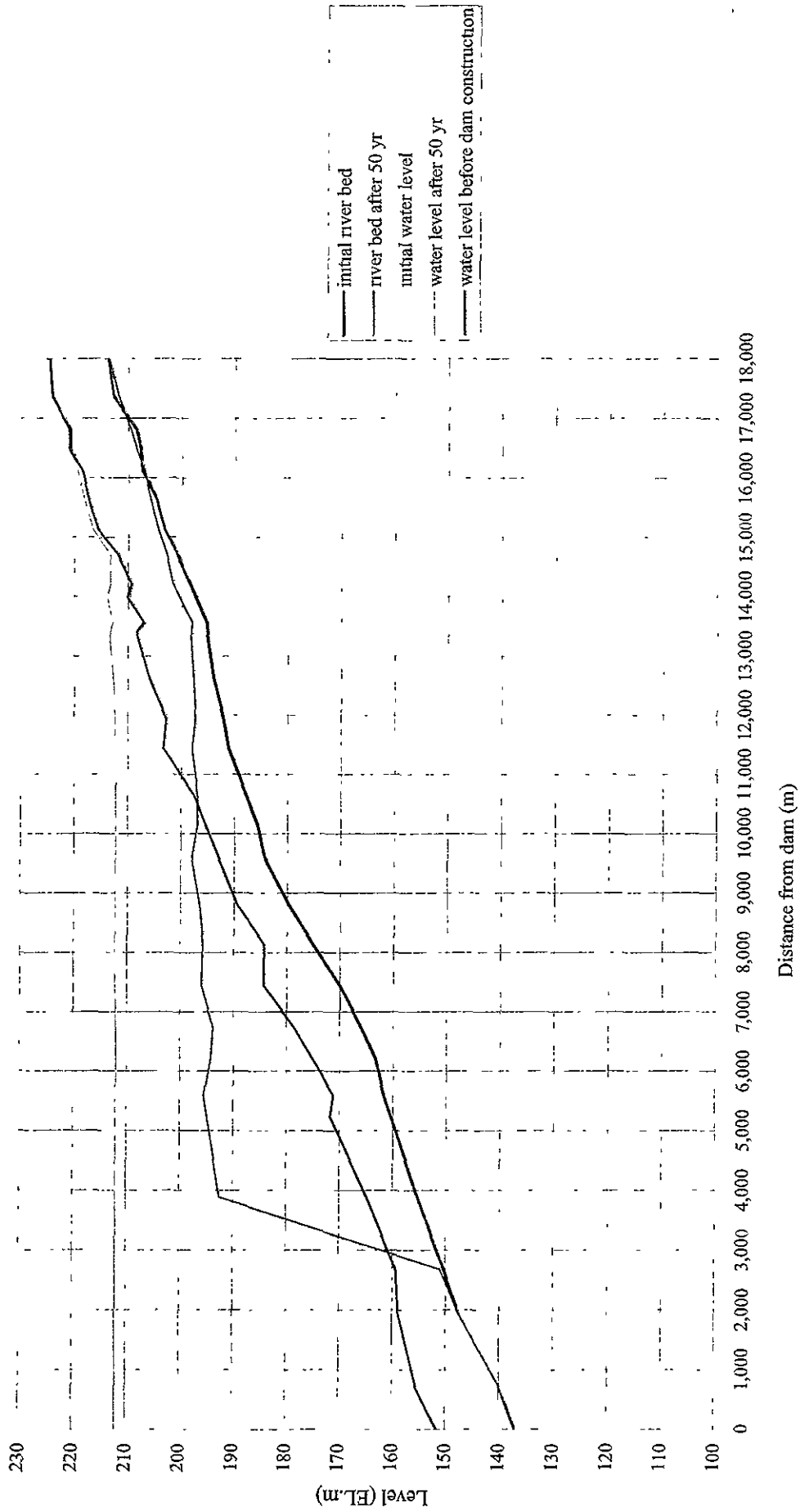
Fig. 6.26 Backwater Curve with a Flood Discharge (Q_F=6,484 m³/s)

daily discharge(m³/s : 1970-1980)

discharge(m³/s)

day
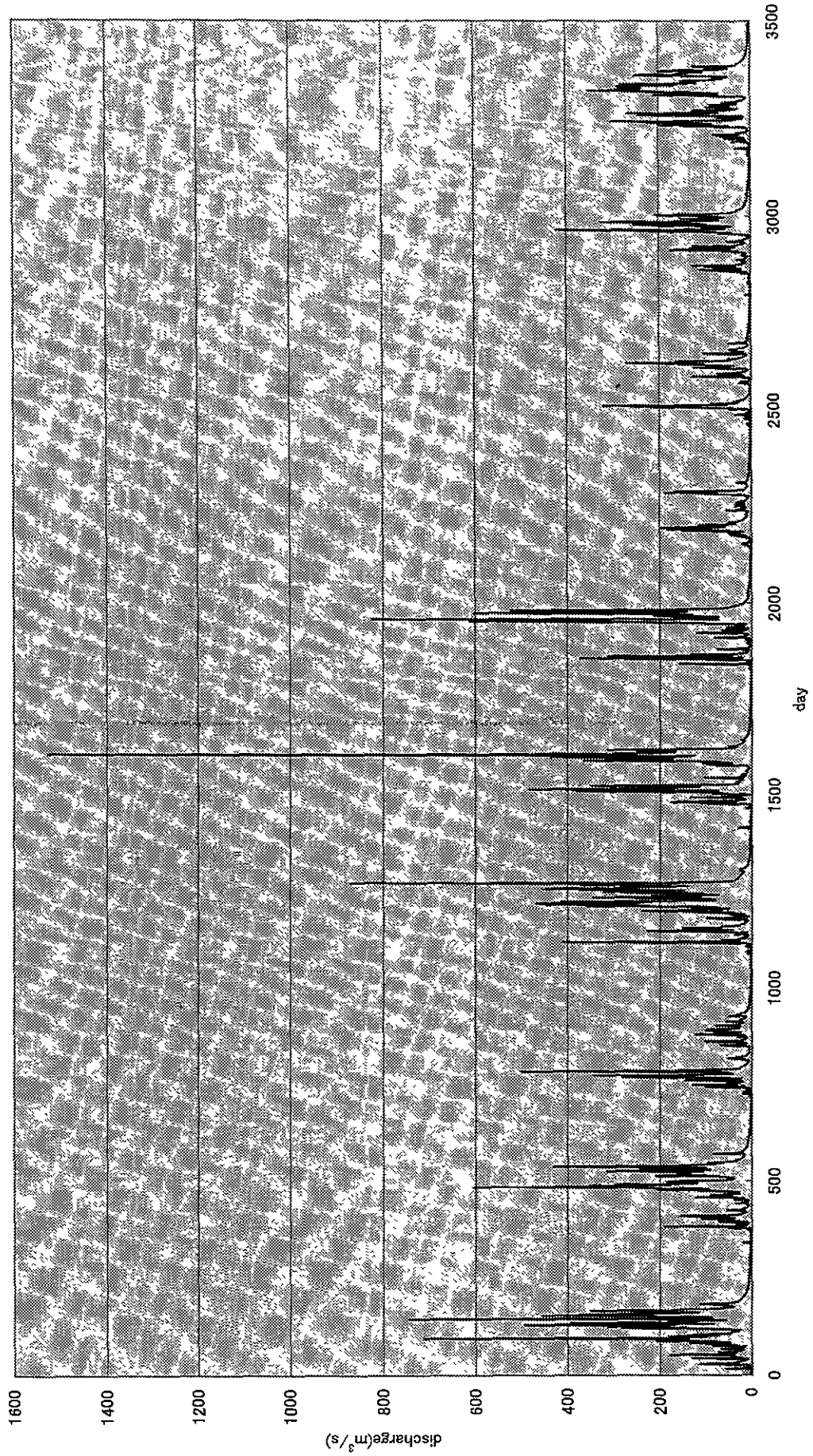
reservoir water level (EL m)

water level (EL m)

day

6-10-9

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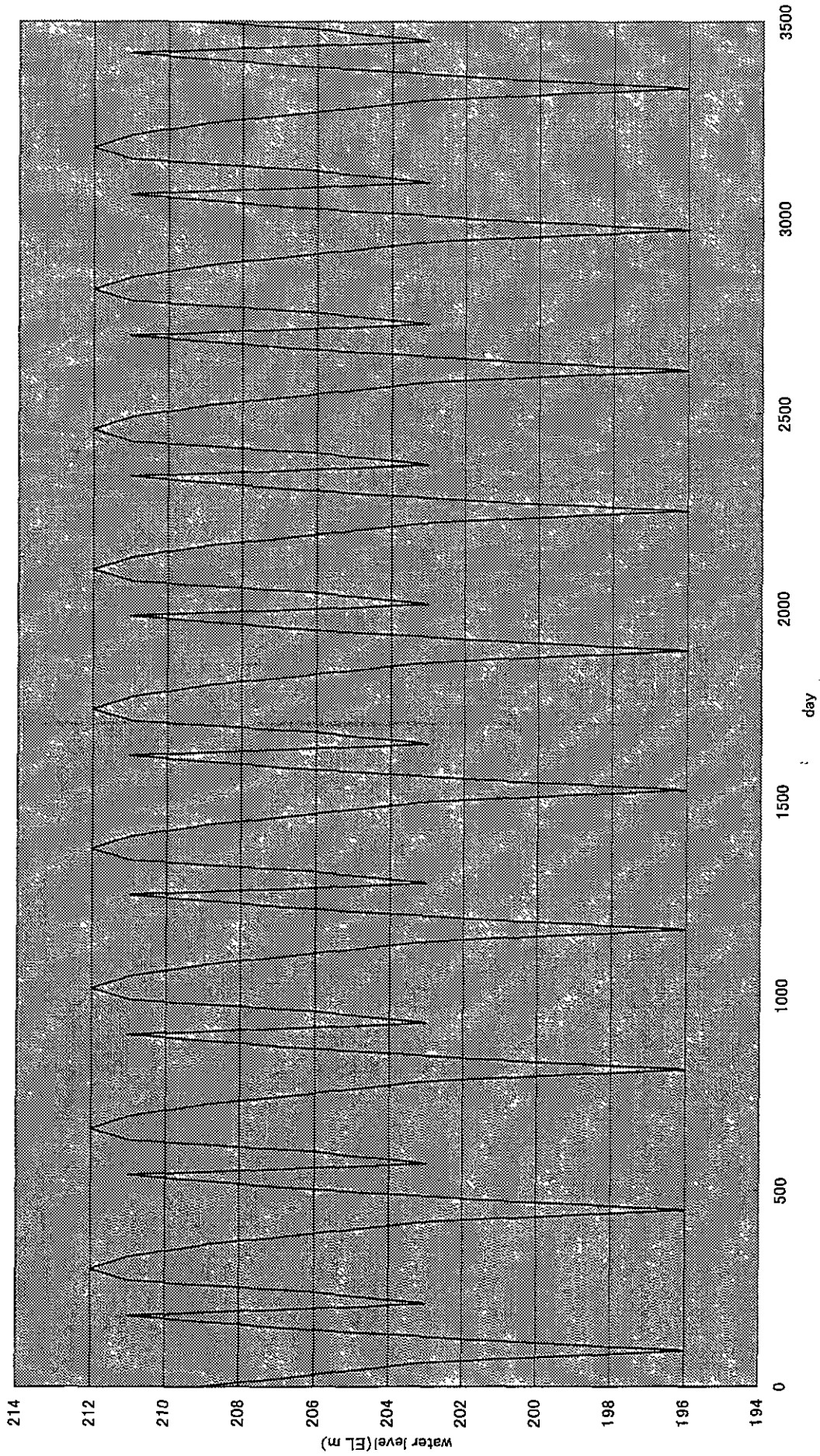
soil particle size distribution (suspended load : %)

size(cm) / section	0.0042	0.0074	0.015	0.03	0.119	0.238	0.476	1.27	2.54	5.08	total
1	0.004	0.003	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.735	1
2	0.003	0.003	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.736	1
3	0.013	0.060	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.669	1
4	0.023	0.060	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.659	1
5	0.033	0.060	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.649	1
6	0.043	0.060	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.639	1
7	0.043	0.060	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.639	1
8	0.043	0.060	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.639	1
9	0.043	0.060	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.639	1
10	0.043	0.060	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.639	1
11	0.043	0.060	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.639	1
12	0.043	0.055	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.644	1
13	0.041	0.050	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.651	1
14	0.040	0.045	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.657	1
15	0.037	0.045	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.660	1
16	0.035	0.045	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.662	1
17	0.033	0.041	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.668	1
18	0.031	0.039	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.672	1
19	0.029	0.036	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.677	1
20	0.025	0.033	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.684	1
21	0.012	0.013	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.717	1
22	0.010	0.013	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.719	1
23	0.004	0.008	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.730	1
24	0.004	0.008	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.730	1
25	0.004	0.008	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.730	1
26	0.004	0.003	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.735	1
27	0.004	0.003	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.735	1
28	0.004	0.003	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.735	1
29	0.004	0.003	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.735	1
30	0.004	0.003	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.735	1
31	0.004	0.003	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.735	1

6-10-10

soil particle size distribution (bed load : %)

size (cm) section	0.007	0.015	0.03	0.119	0.238	0.476	1.27	2.54	5.08	10	total
1	0.007	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.155	0.58	1
2	0.007	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.155	0.58	1
3	0.007	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.155	0.58	1
4	0.007	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.155	0.58	1
5	0.007	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.155	0.58	1
6	0.007	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.155	0.58	1
7	0.007	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.155	0.58	1
8	0.007	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.155	0.58	1
9	0.007	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.155	0.58	1
10	0.007	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.155	0.58	1
11	0.007	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.155	0.58	1
12	0.007	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.155	0.58	1
13	0.007	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.155	0.58	1
14	0.007	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.155	0.58	1
15	0.007	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.155	0.58	1
16	0.007	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.155	0.58	1
17	0.007	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.155	0.58	1
18	0.007	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.155	0.58	1
19	0.007	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.155	0.58	1
20	0.007	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.155	0.58	1
21	0.007	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.155	0.58	1
22	0.007	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.155	0.58	1
23	0.007	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.155	0.58	1
24	0.007	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.155	0.58	1
25	0.007	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.155	0.58	1
26	0.007	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.155	0.58	1
27	0.007	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.155	0.58	1
28	0.007	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.155	0.58	1
29	0.007	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.155	0.58	1
30	0.007	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.155	0.58	1
31	0.007	0.006	0.043	0.019	0.024	0.057	0.054	0.055	0.155	0.58	1

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Chapter 7: Geology

Appendix 7.1

Dam Site Reconnaissance Map

GEOLOGICAL RECONNAISSANCE ROUTES,
OUTCROP SAMPLING AND MAPPING AND
PICTURE LOCATION
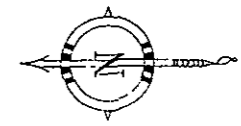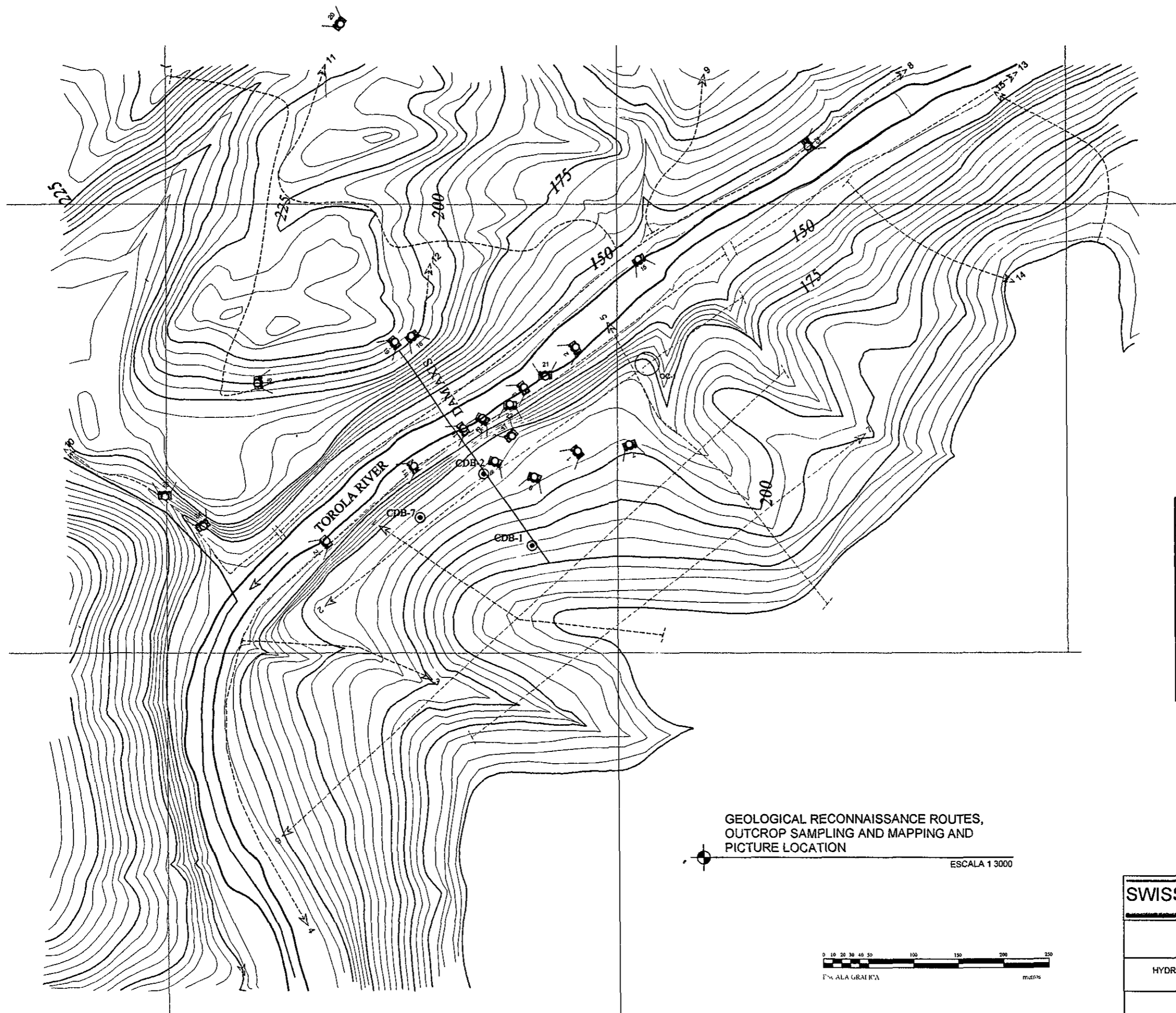
ESCALA 1 3000

LEGEND

◯ OC-1	SAMPLING SITE
↗	GEOLOGICAL INVESTIGATION ROUTE
→	
📷 1	SITE WHERE PICTURE WAS TAKEN
◉ CDB-1	BOREHOLE

TOROLA RIVER

CDB-2
CDB-7
CDB-1

0 10 20 30 40 50   100   150   200   250

ESCALA GRAFICA   metros
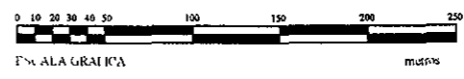
SWISSBORING

EPDC
ELECTRIC POWER DEVELOPMENT CO., LTD

CEL
COMISION EJECUTIVA HIDROELECTRICA DEL RIO LEMPA

HYDROELECTRIC COMPLEX OVER THE TOROLA RIVER

DAM SITE
RECONNAISSANCE MAP

SCALE 1 3000	DATE September 2002	FIGURE No 8

7-1-1

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(136)

Appendix 7.2

Photograph of El Chaparral Dam Site

and Geological Investigation

CHAPARRAL
DAM SITE
photo 1

RIGHT MARGIN

LEFT MARGIN

RIGHT MARGIN

LEFT MARGIN

CHAPARRAL
DAM SITE
photo 2

borehole CGB 1,2,3
Test Pit CBP-1

BORROW AREA

Photo No 3

ALLUVIAL TERRACE

Photography No. 4
BOREHOLE CONCRETE SLAB

Photography No. 5
PIEZOMETER SURFACE PROTECTION

Photography No. 6
BASALTIC LAVA OUTCROPS ALONG TOROLA VALLEY
(CHAPARRAL DAM SITE)

Photography No. 7
ANTECEDENT TERRACE IN THE LEFT ABUTMENT OF THE DAM SITE

Photography No. 8
ALLUVIAL DEPOSITS (Qal2) SAND AND GRAVEL
FRESH TO SLIGHTLY WEATHERED

Photrography No. 9
ALLUVIAL DEPOSITS IN THE
ANTECEDENT TERRACE
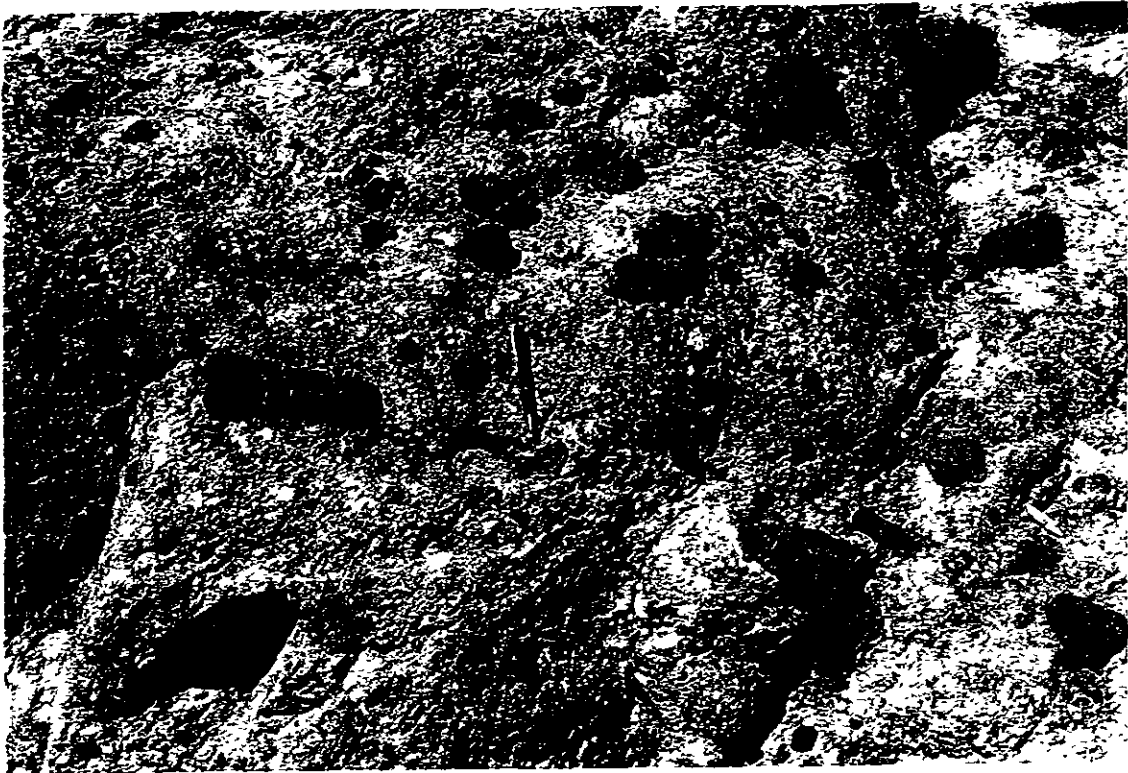
Photography No. 10
BRECCIACEOUS TUFF IN THE
LEFT SIDE OF THE DAM AXIS

Photography No. 11
CONTACT BETWEEN BASALTIC LAVA
AND TUFF (Thermal Metamorphism)
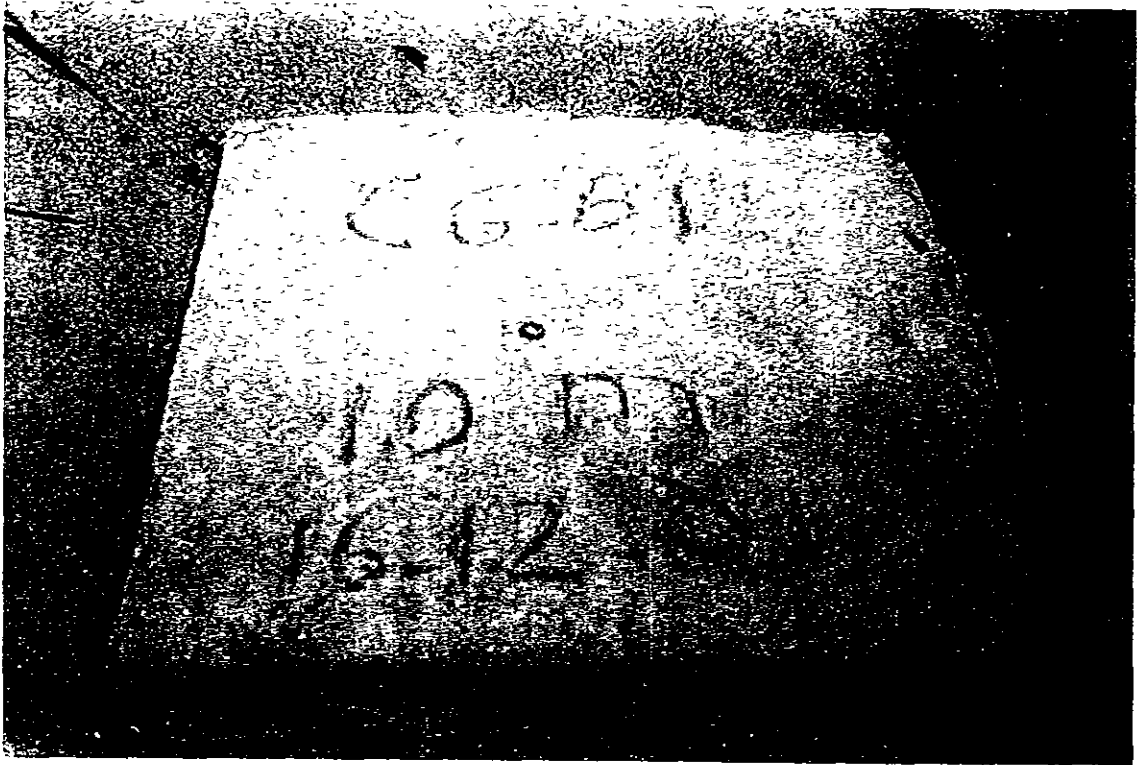
Photography No. 12

BOREHOLE CGB-1 CONCRETE SLAB
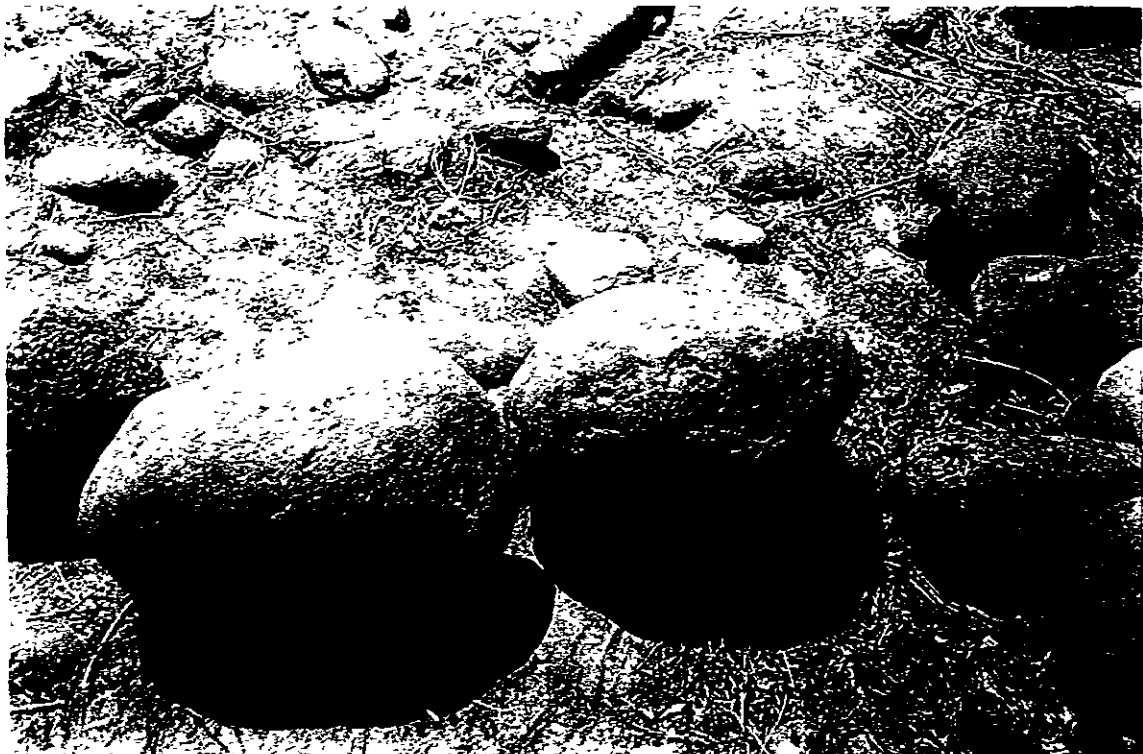
Photography No. 13

BOREHOLE CGB -3
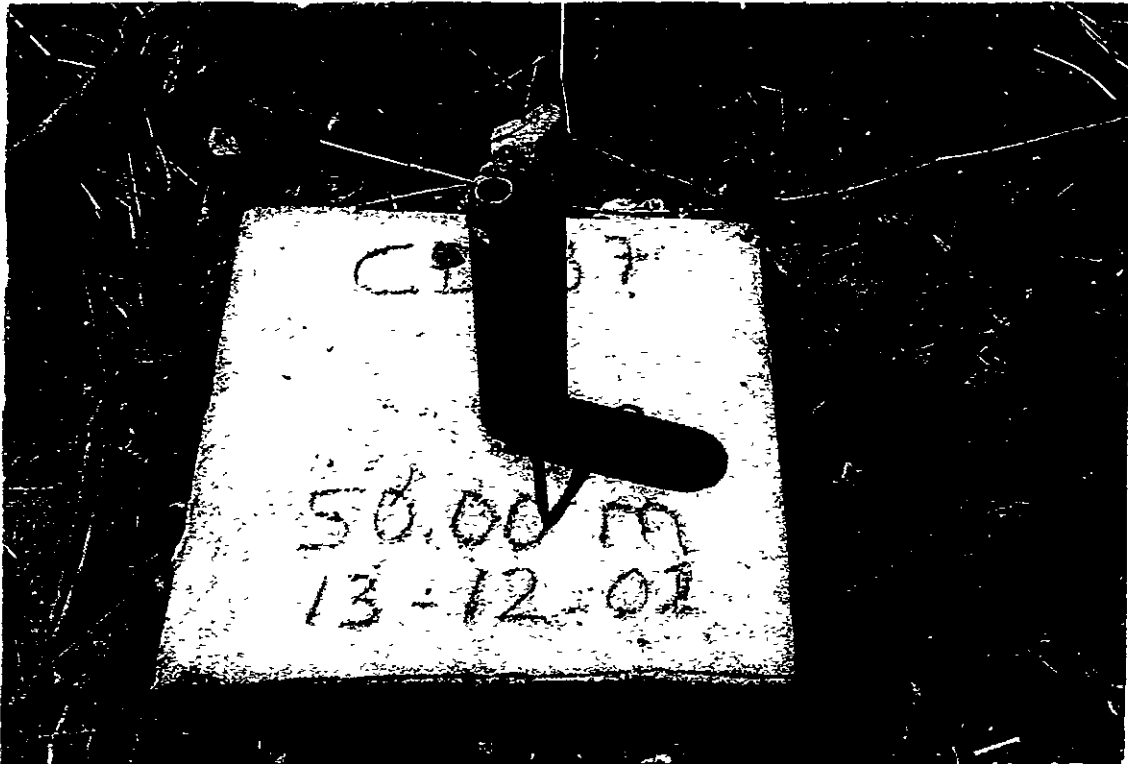
Photography No. 14
PIEZOMETER CDB-7 SURFACE PROTECTION

Photography No. 15
ROAD ACCESS ACROSS THE TOROLA RIVER

Photography No. 16
LEFT MARGIN OF THE DAM SITE

Photography No. 17
RIGHT MARGIN OF THE DAMSITE

7-2-10
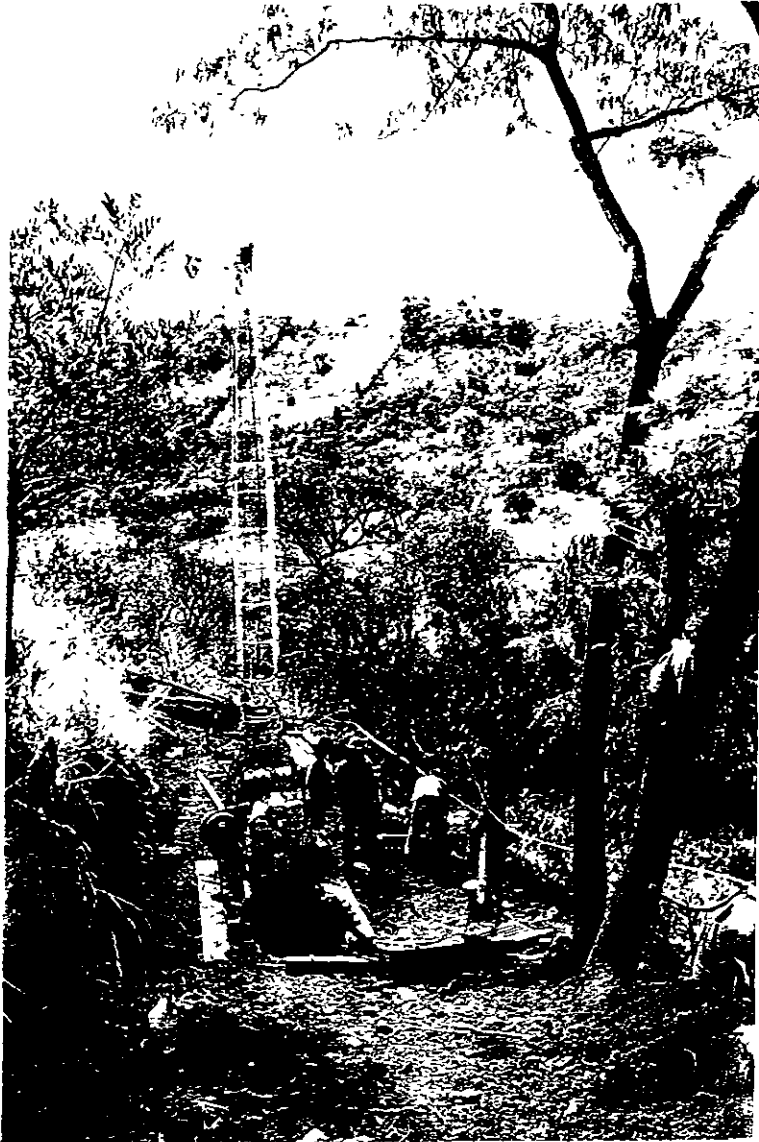
Photography No. 19
BOREHOLE CDB-4
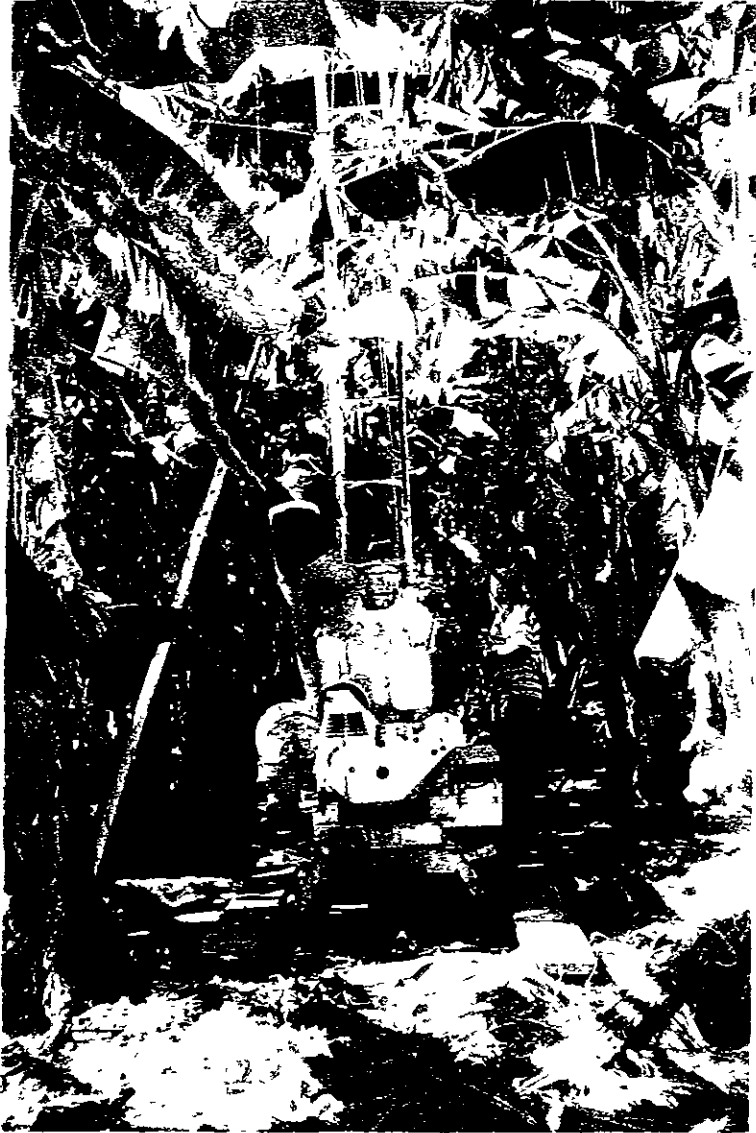
Photography No. 21
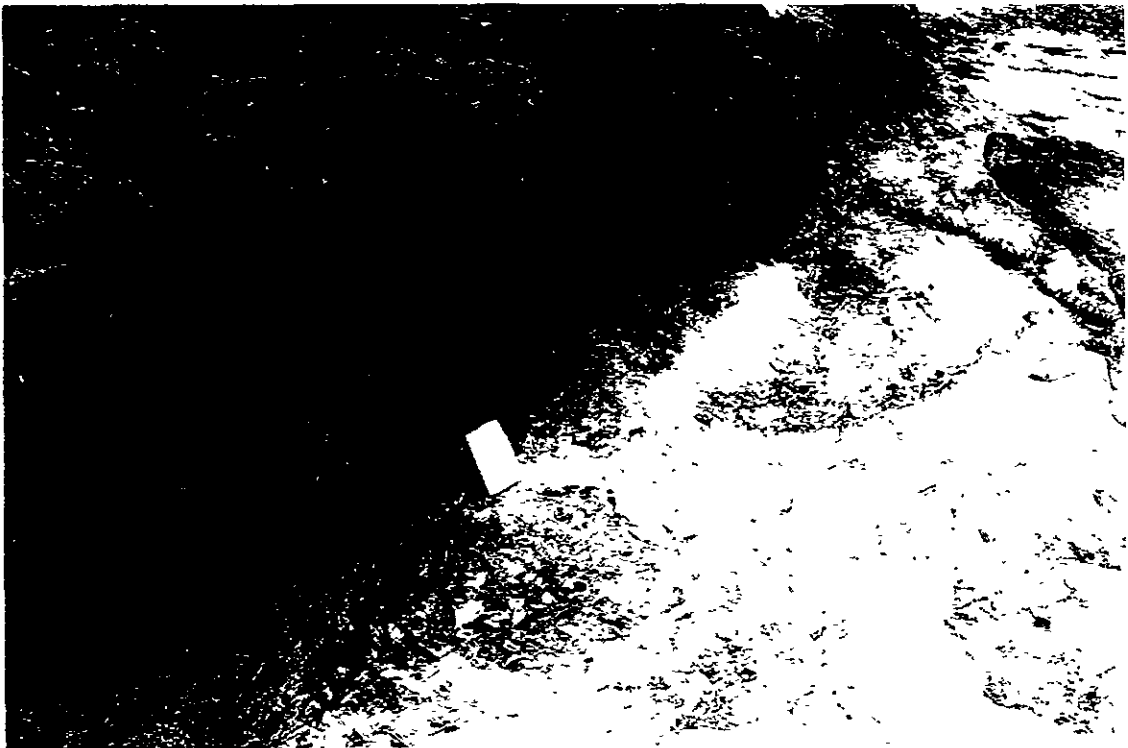**RIGHT SIDE THE TOROLA RIVER, DOWNSTREAM OF THE DAM SITE**
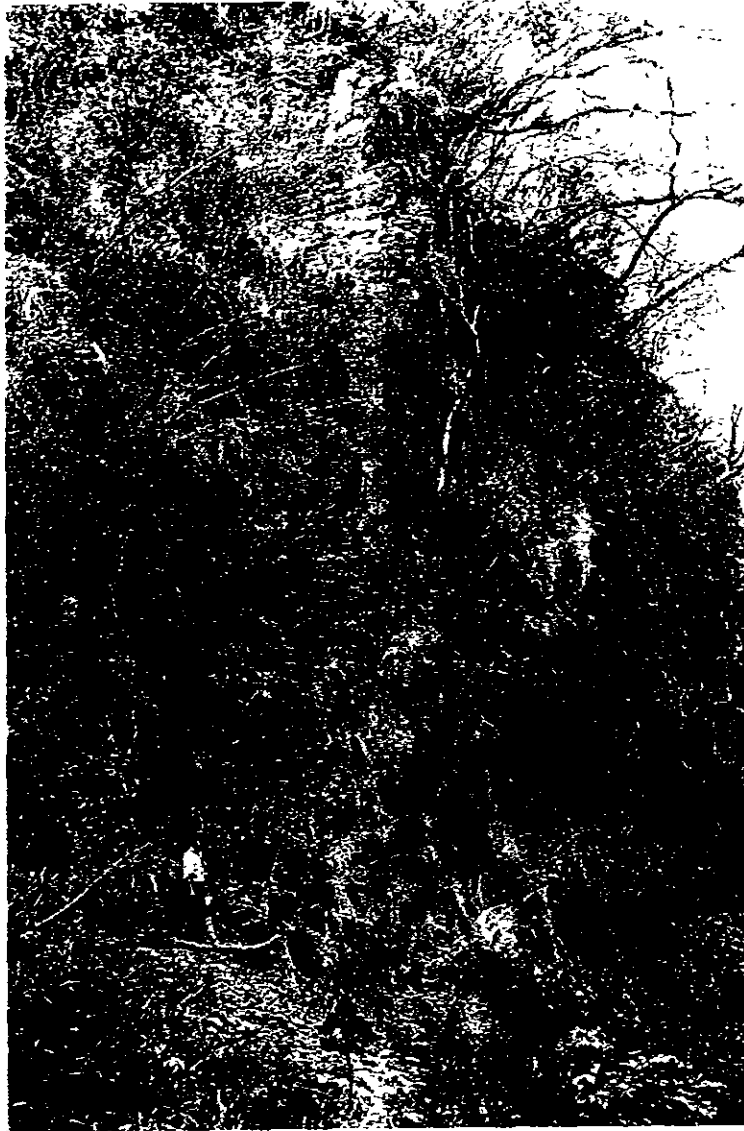
Photography No. 22
BASALTIC OUTCROP
RIGHT SIDE OF THE DAM
SITE

Photography No. 23
AGGLOMERATE OUTCROP   OF THE DAM SITE
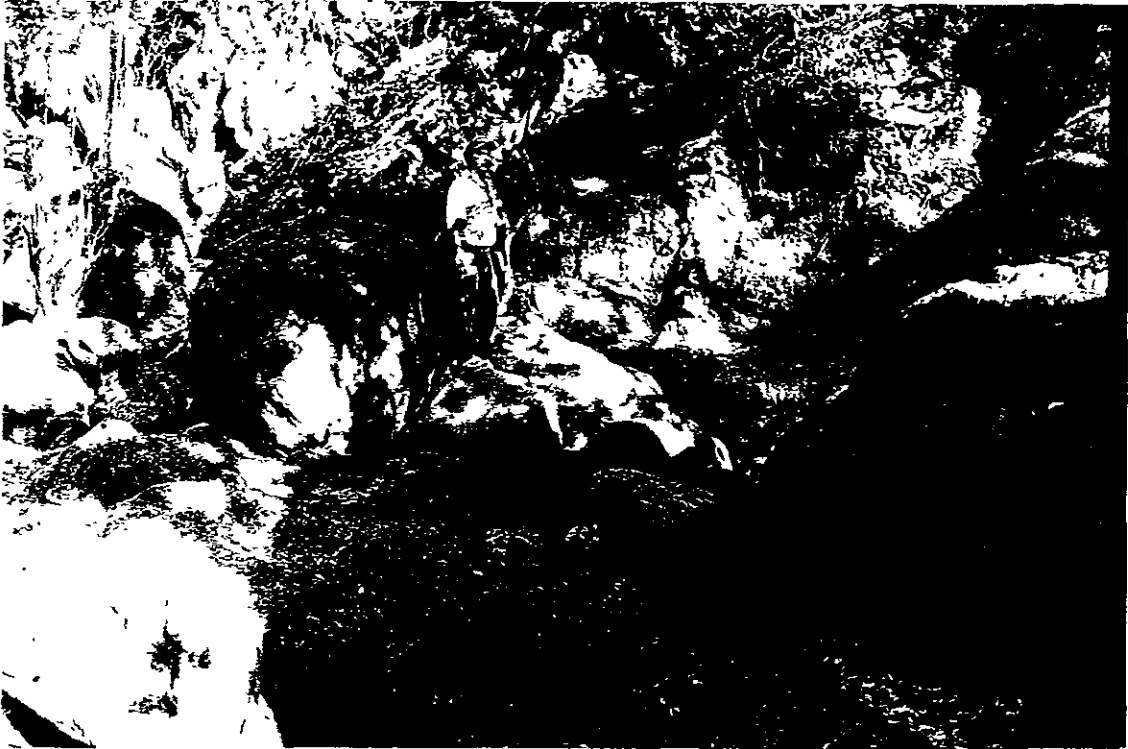
Photography No. 24
AGGLOMERATE OUTCROP   UPSTREAM OF DAM SITE

Photography No. 25
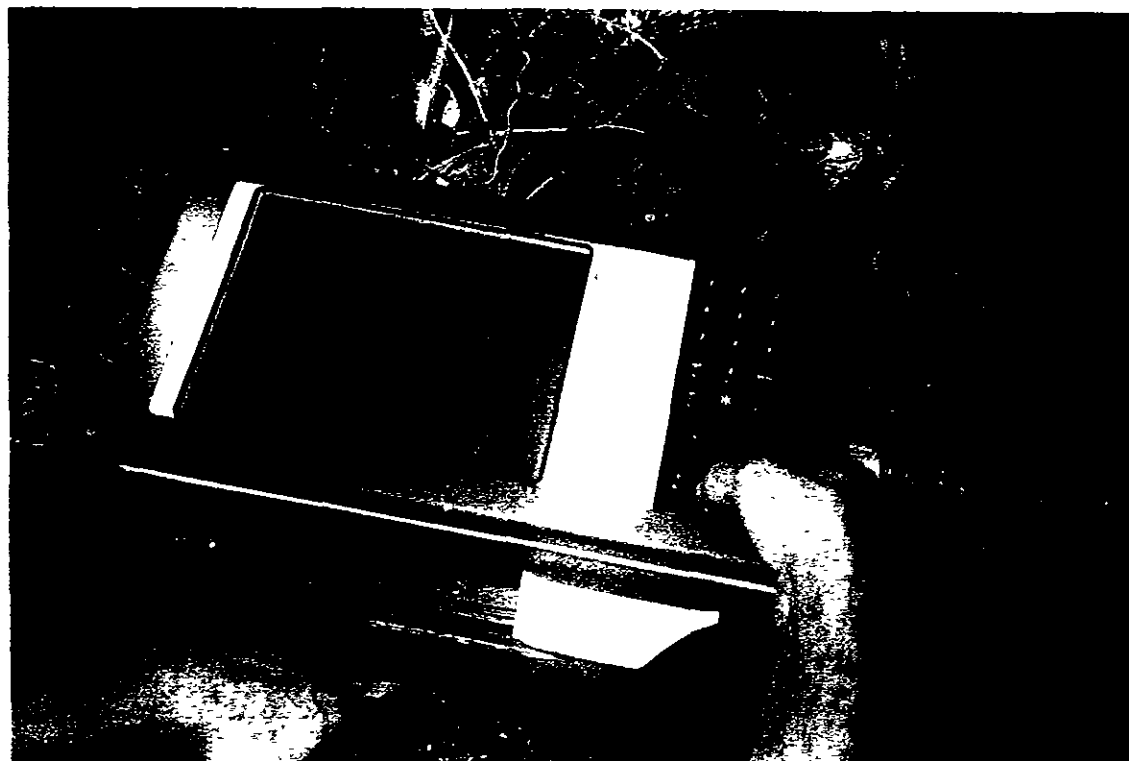**BASALTIC OUTCROP   ON THE DAM SITE**

**Photography No. 26
SOUND AGGLOMERATIC
ROCKS, DOWNSTREAM OF
THE DAM SITE**

**Photography No. 27
BASALTIC ROCKS, ON THE DAM SITE**

Photography No. 28
GEOPHYSICAL LINE ON THE BORROW AREA

Photography No. 29
GEOPHYSICAL EQUIPMENT