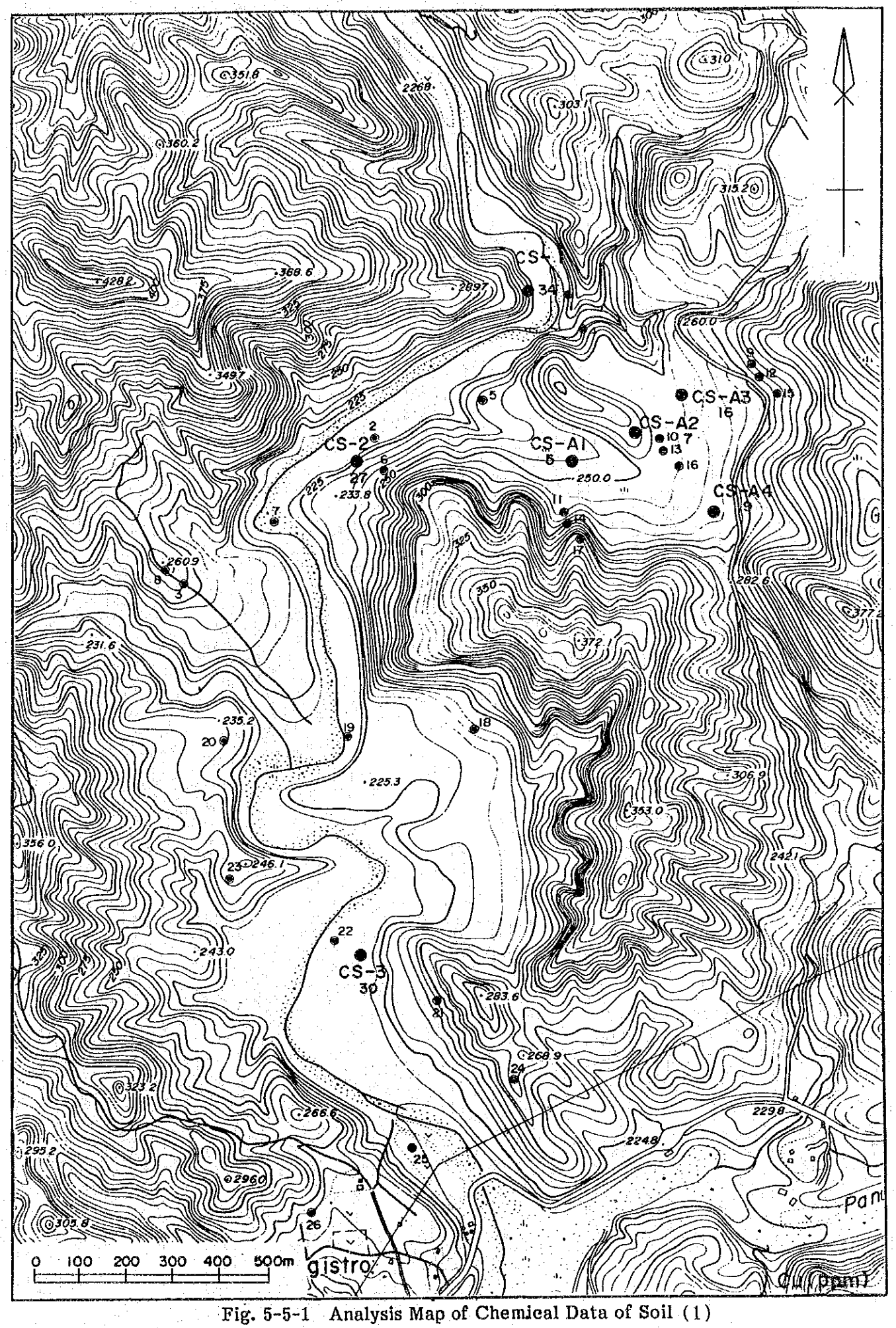

Fig. 5-5-1 Analysis Map of Chemical Data of Soil (1)

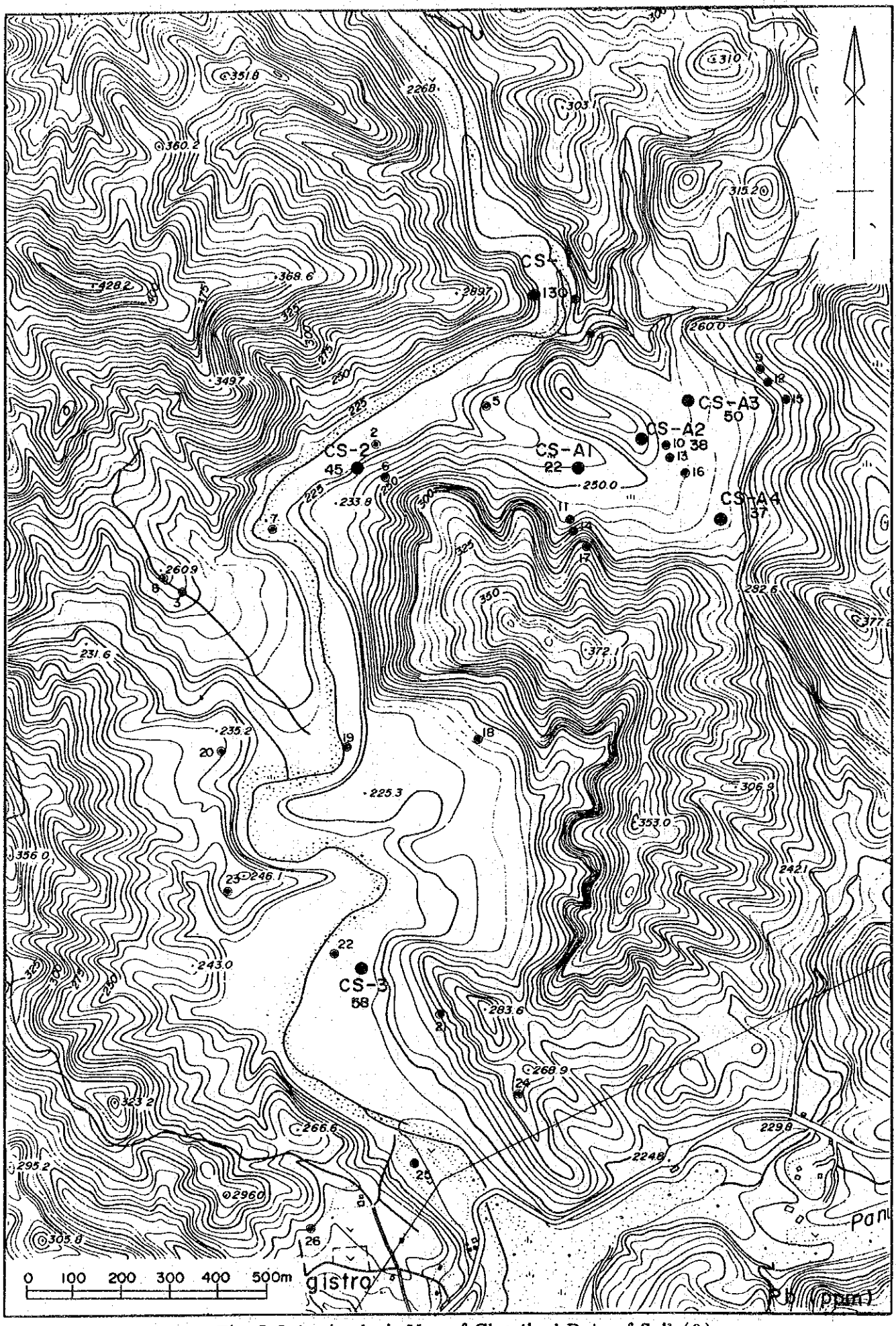

Fig. 5-5-1 Analysis Map of Chemical Data of Soil (2)

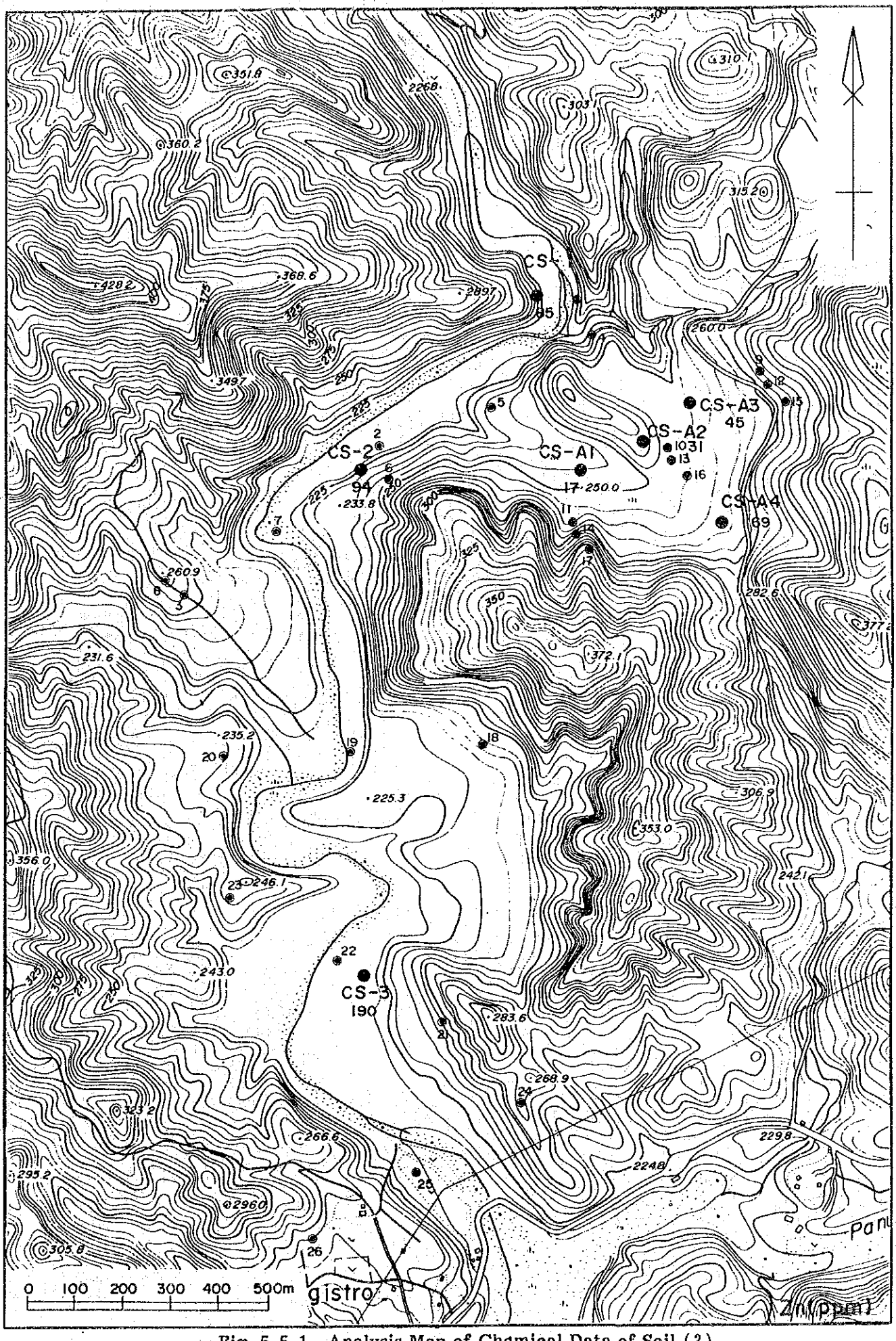

Fig. 5-5-1 Analysis Map of Chemical Data of Soil (3)

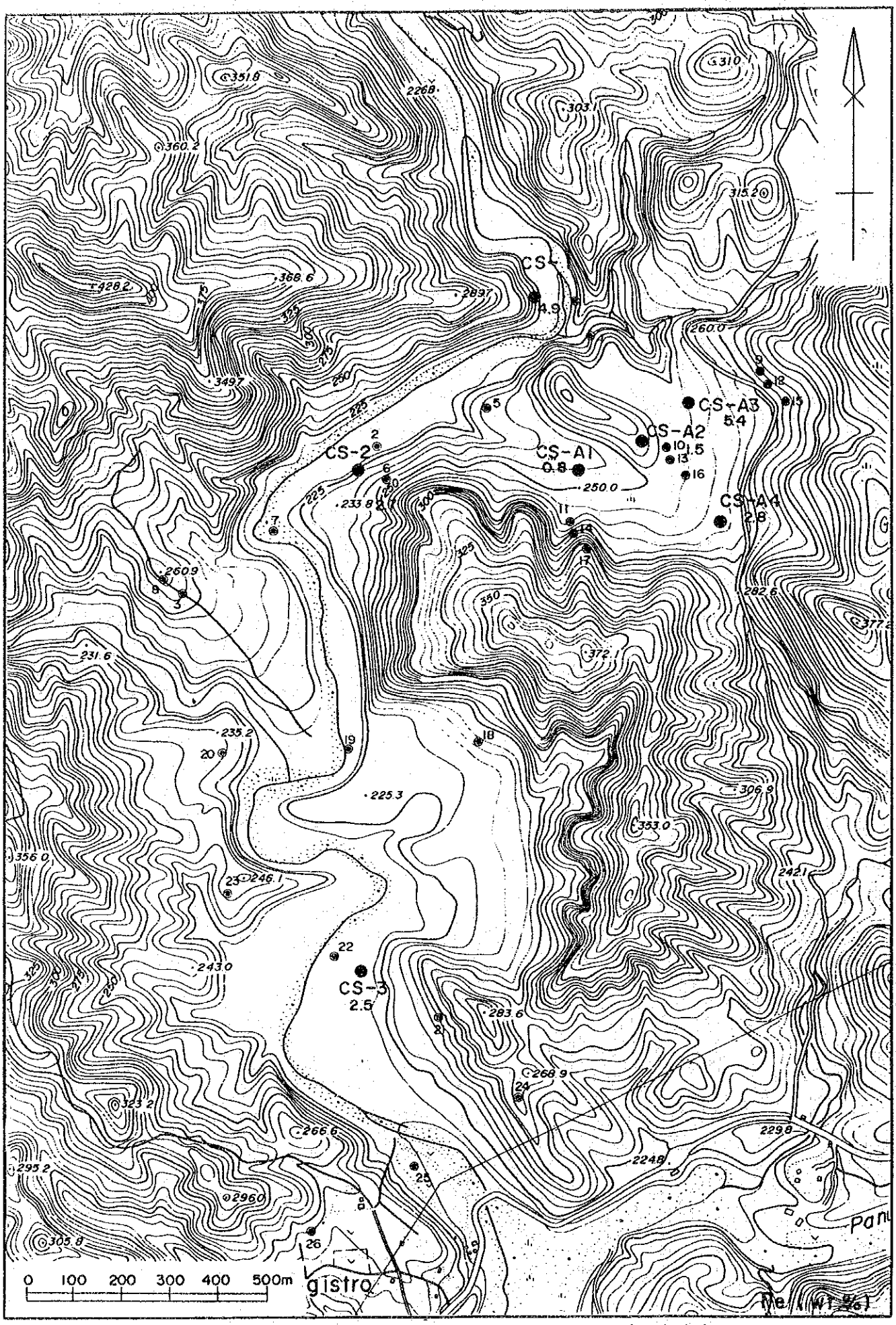

Fig. 5-5-1 Analysis Map of Chemical Data of Soil (4)

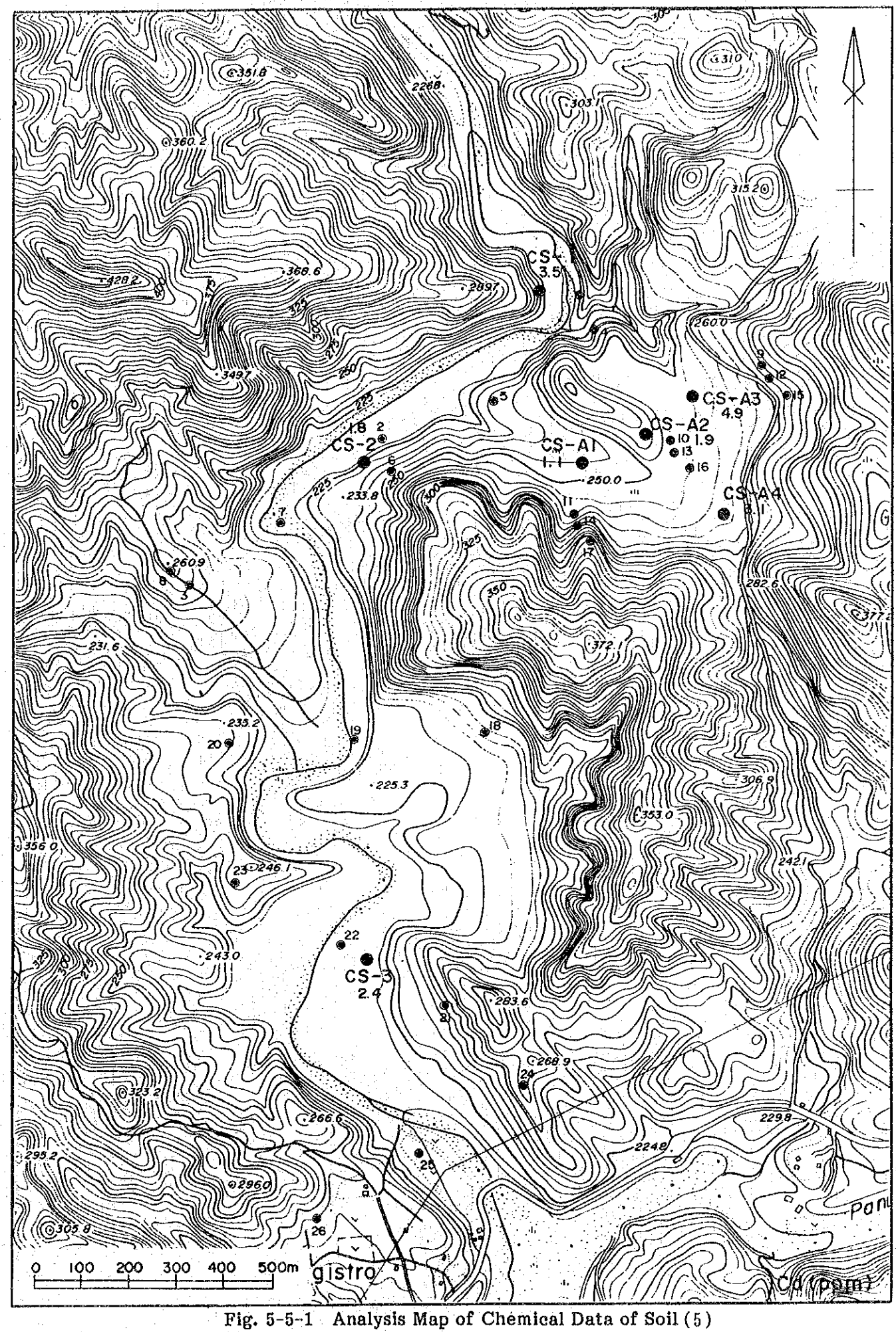

Fig. 5-5-1 Analysis Map of Chemical Data of Soil (5)

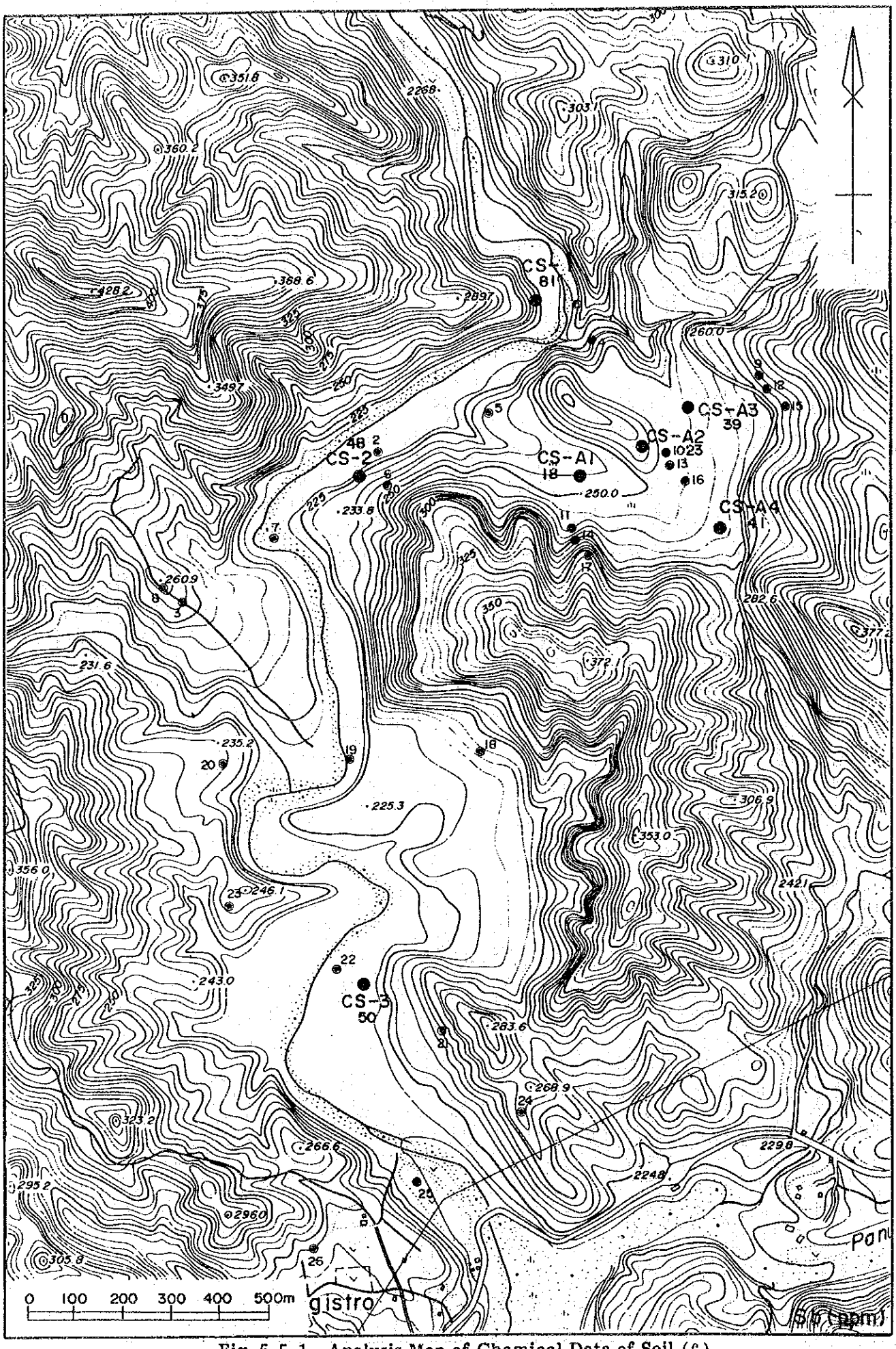

Fig. 5-5-1 Analysis Map of Chemical Data of Soil (6)

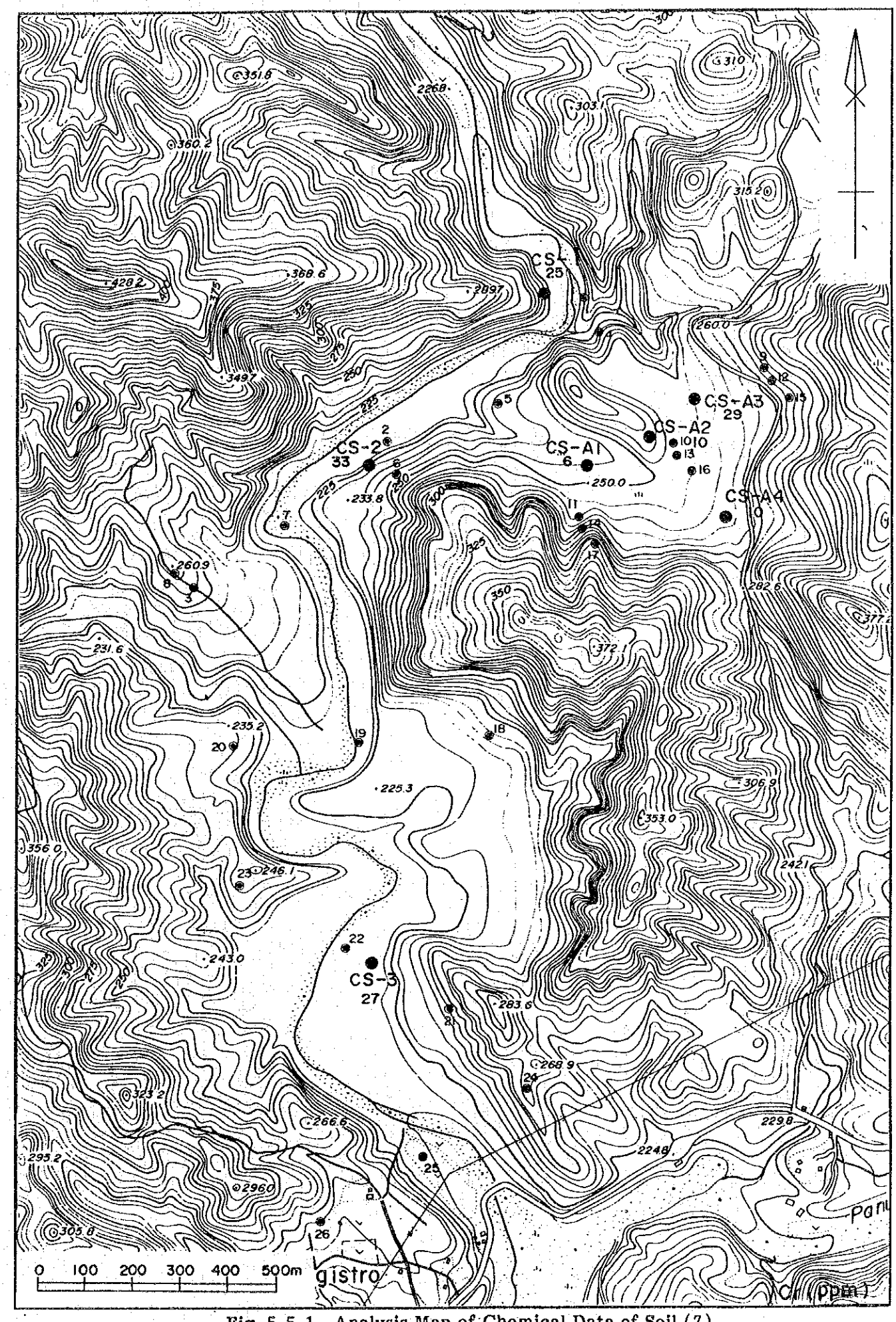

Fig. 5-5-1 Analysis Map of Chemical Data of Soil (7)

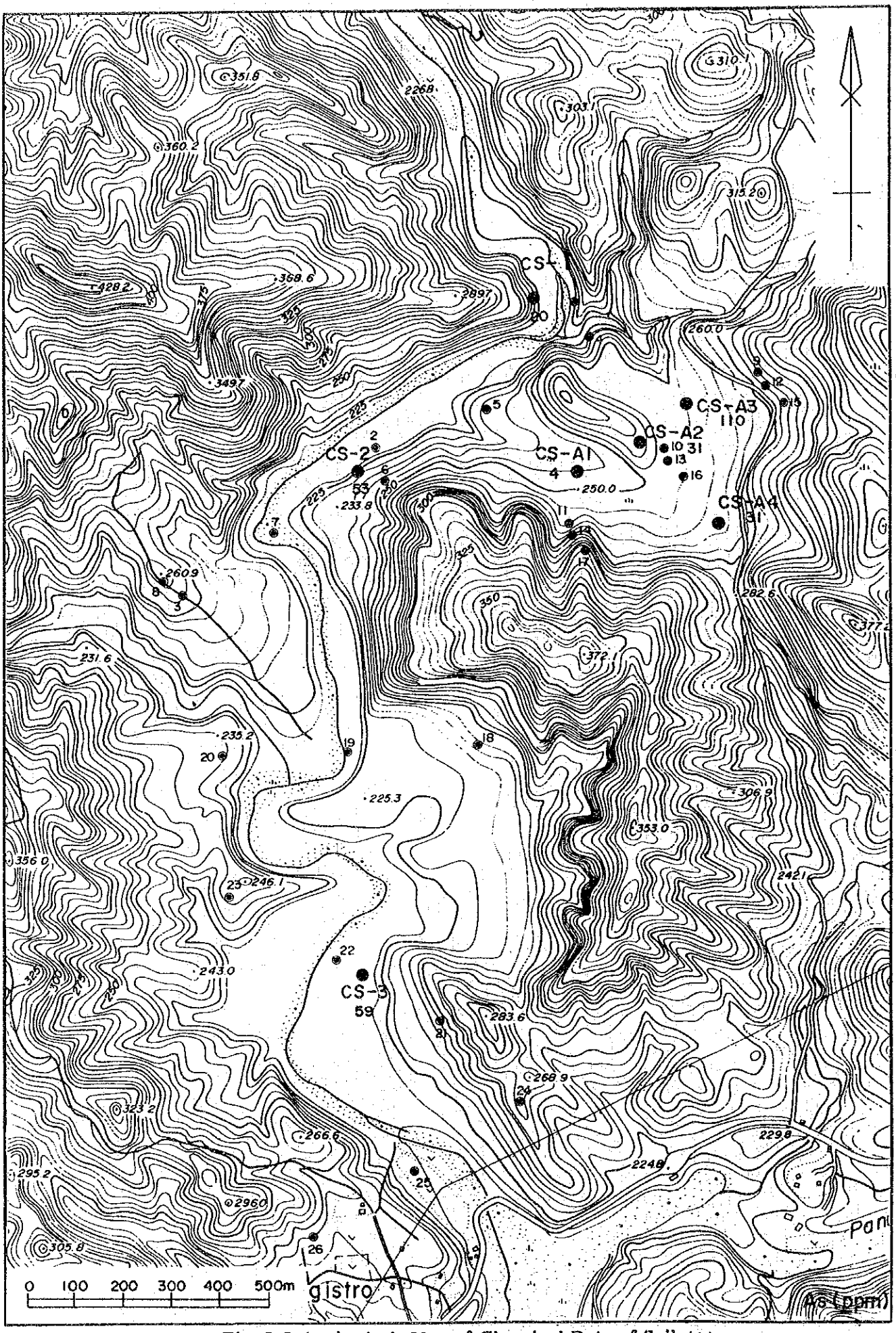

Fig. 5-5-1 Analysis Map of Chemical Data of Soil (8)

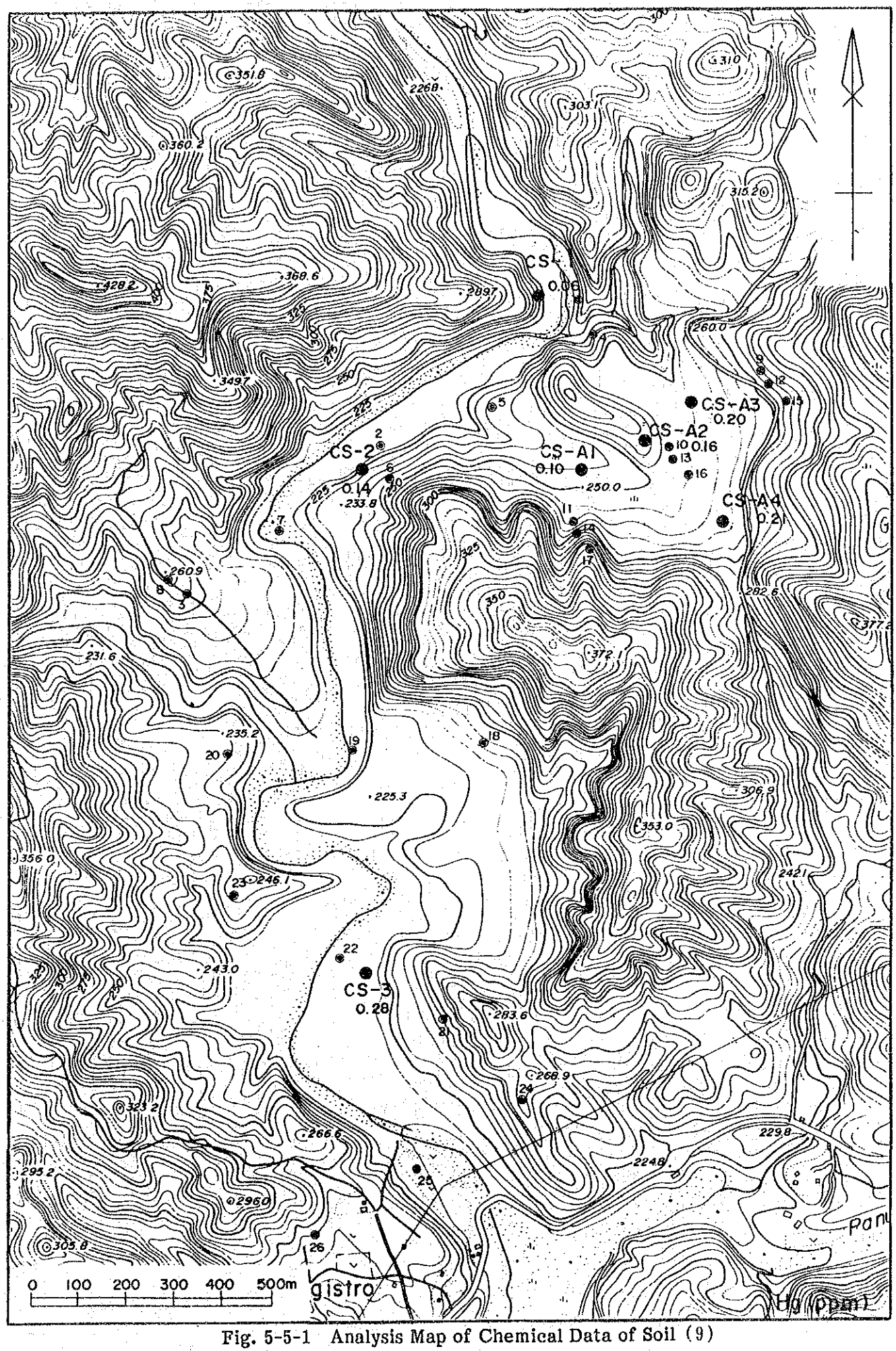

Fig. 5-5-1 Analysis Map of Chemical Data of Soil (9)

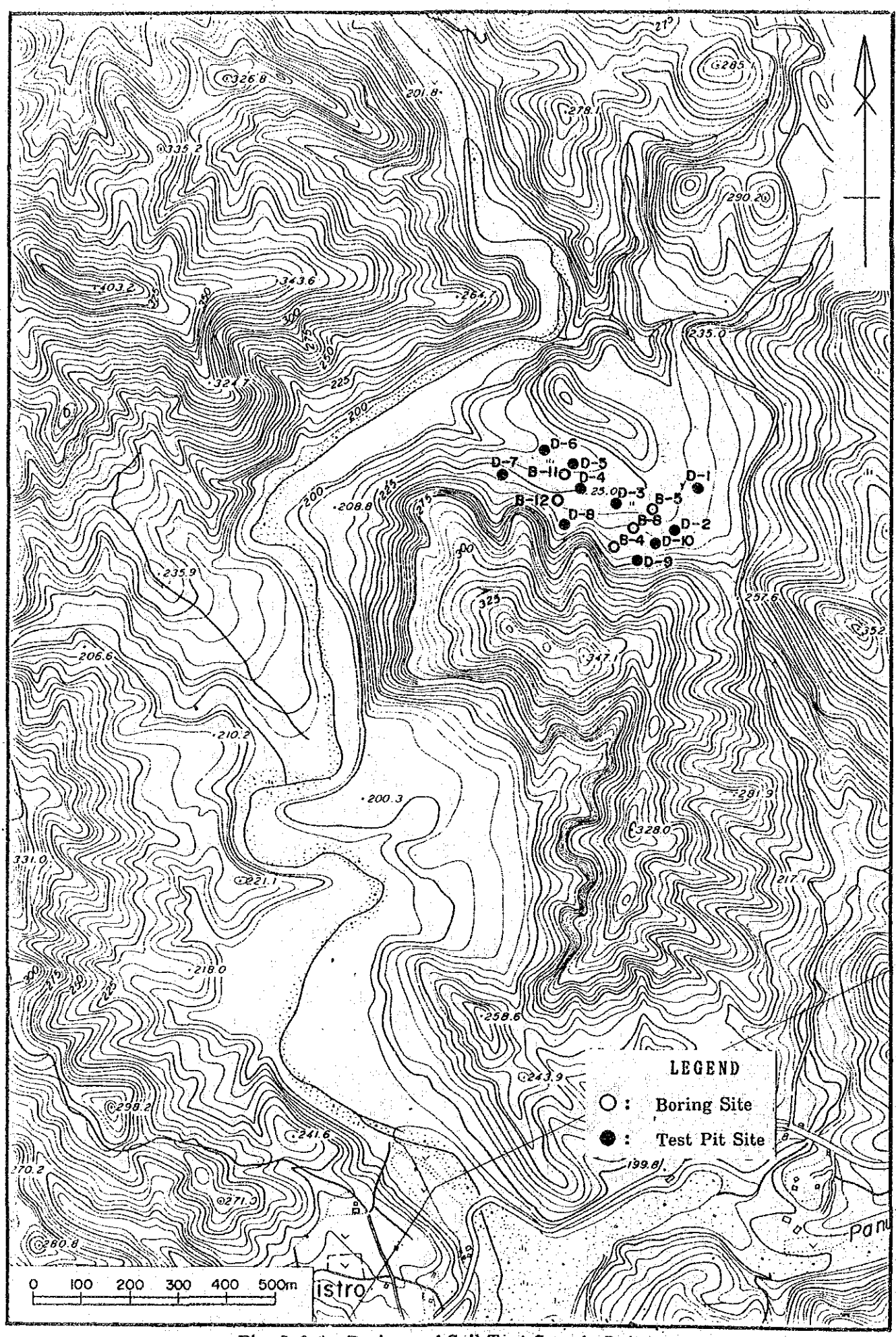

Fig. 5-6-1 Boring and Soil Test Sample Point

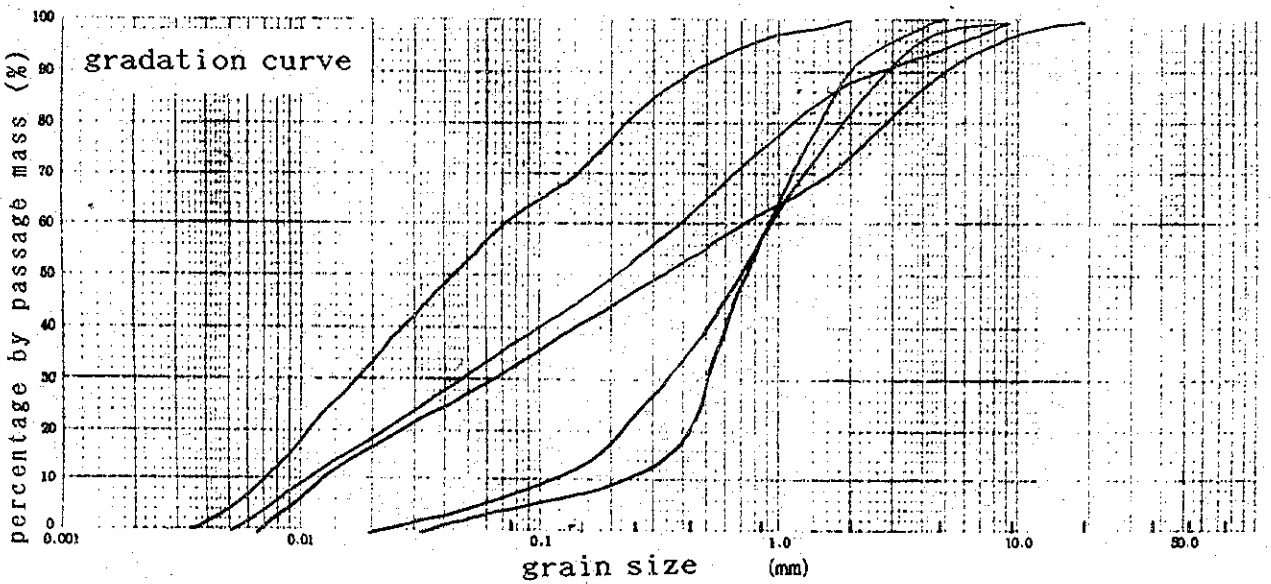

Fig. 5-6-2 Grain Size Accumulation Curve

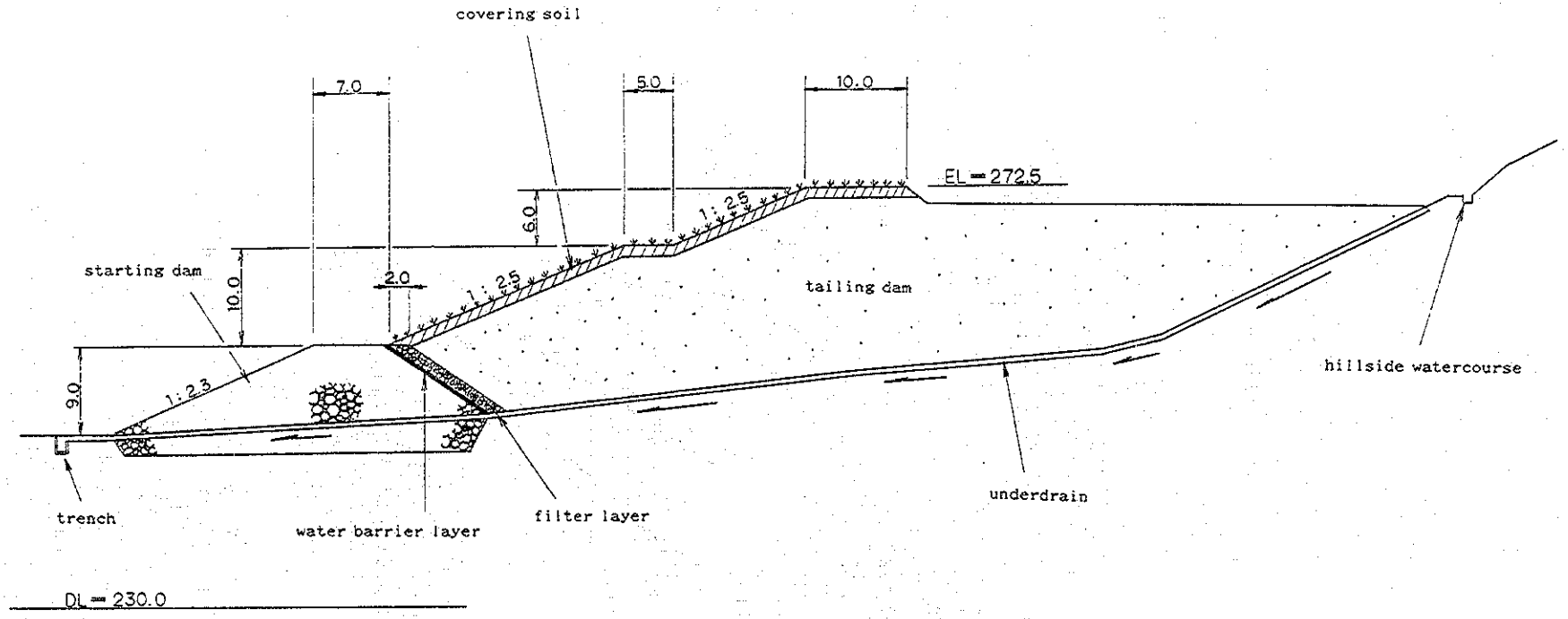

Fig. 5-6-3 Model of New El Coco Tailing Dam

CONDITION OF SOIL

Zone No.	SOIL	PARTIAL SATURATION DENSITY ρ_t (g/cm³)	SATURATION DENSITY ρ_{sat} (g/cm³)	COHESION C (kgf/cm²)	SHEARING RESISTANCE ANGLE ϕ (°)
①	SEDIMENT－1	1.689	1.816	0.10	23.0
②	SEDIMENT－2	1.910	2.094	0.00	30.0
③	SURFACE SOIL	1.443	1.801	0.50	33.0
④	GRAVEL	1.800	1.912	0.00	37.0
⑤	FOUNDATION GROUND	1.443	1.801	0.00	33.0

NEW EL COCO TAILING DAM

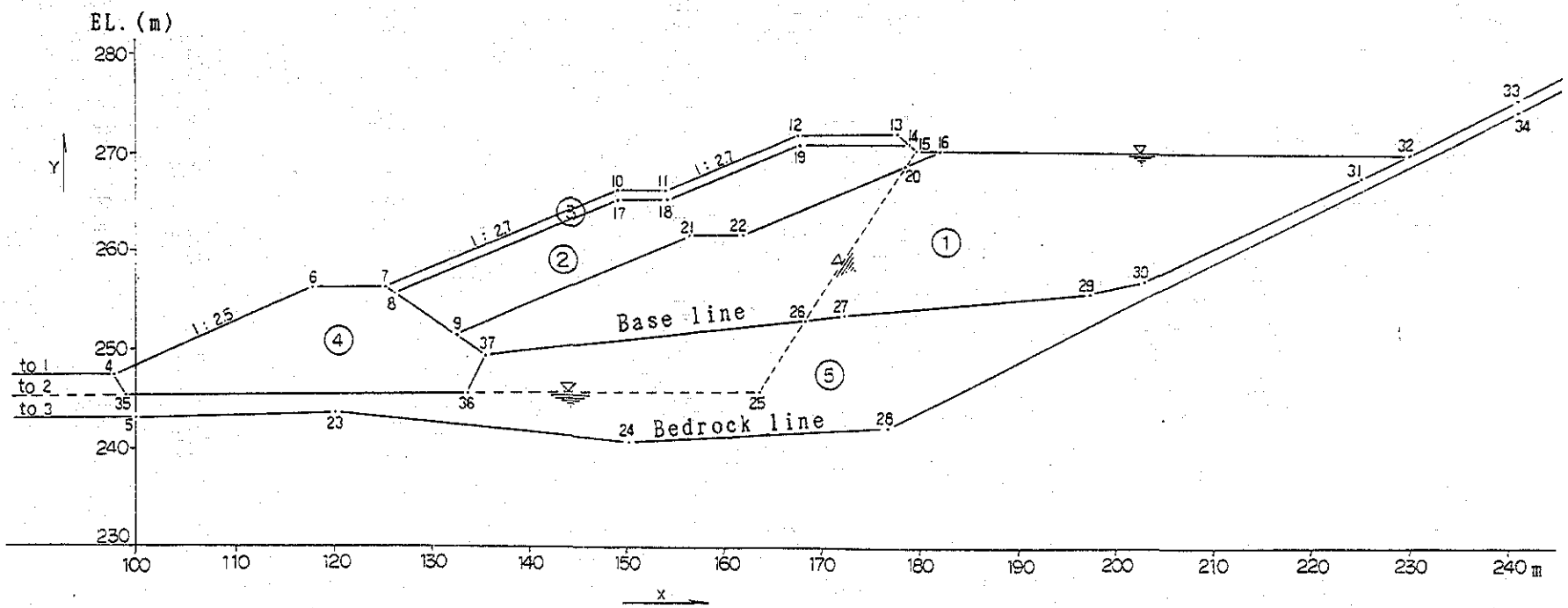

Fig. 5-8-1 The Model of Tailing Dam Stability Analysis

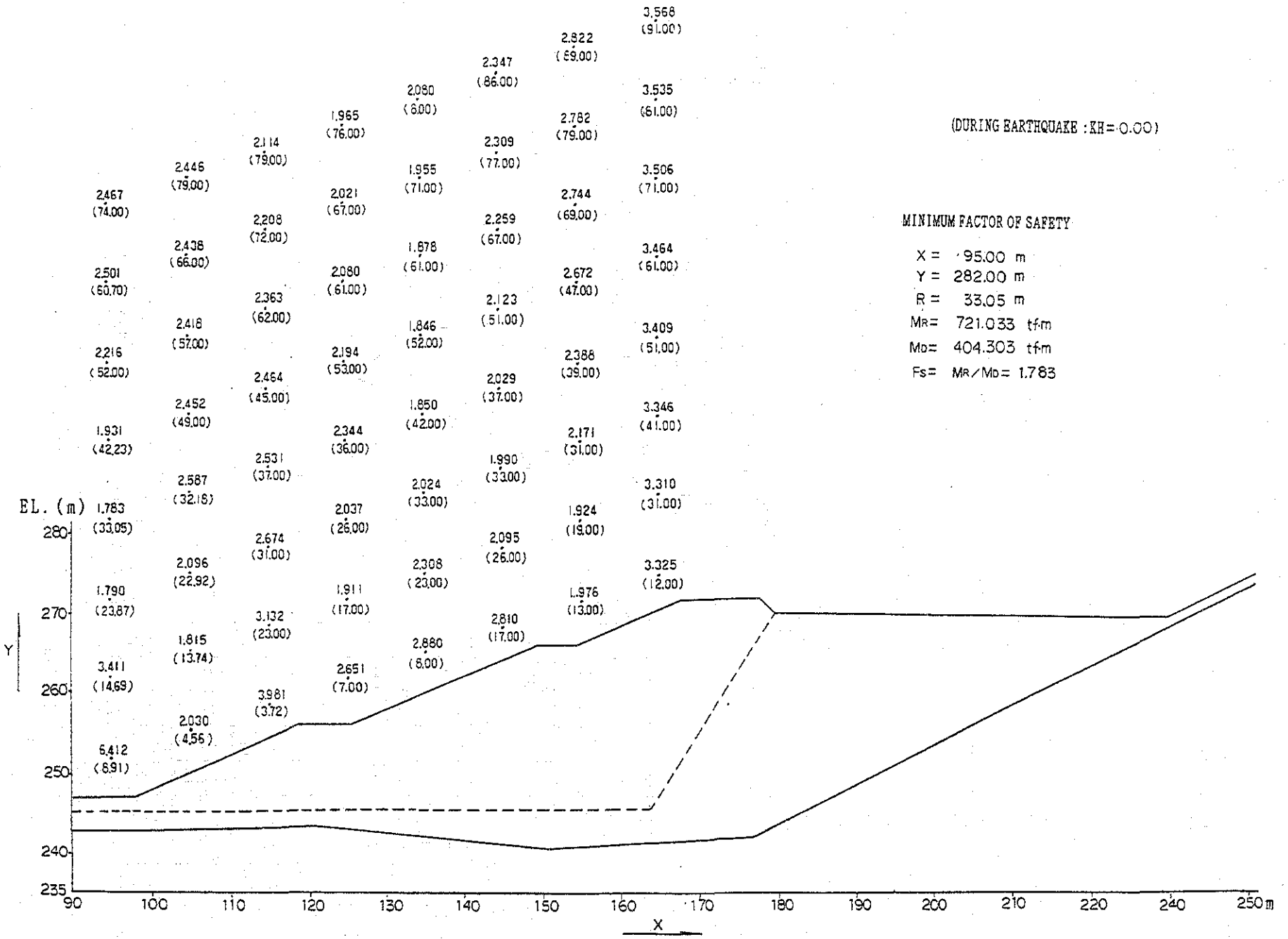

Fig. 5-8-2 A Result of Tailing Dam Stability Analysis (1)

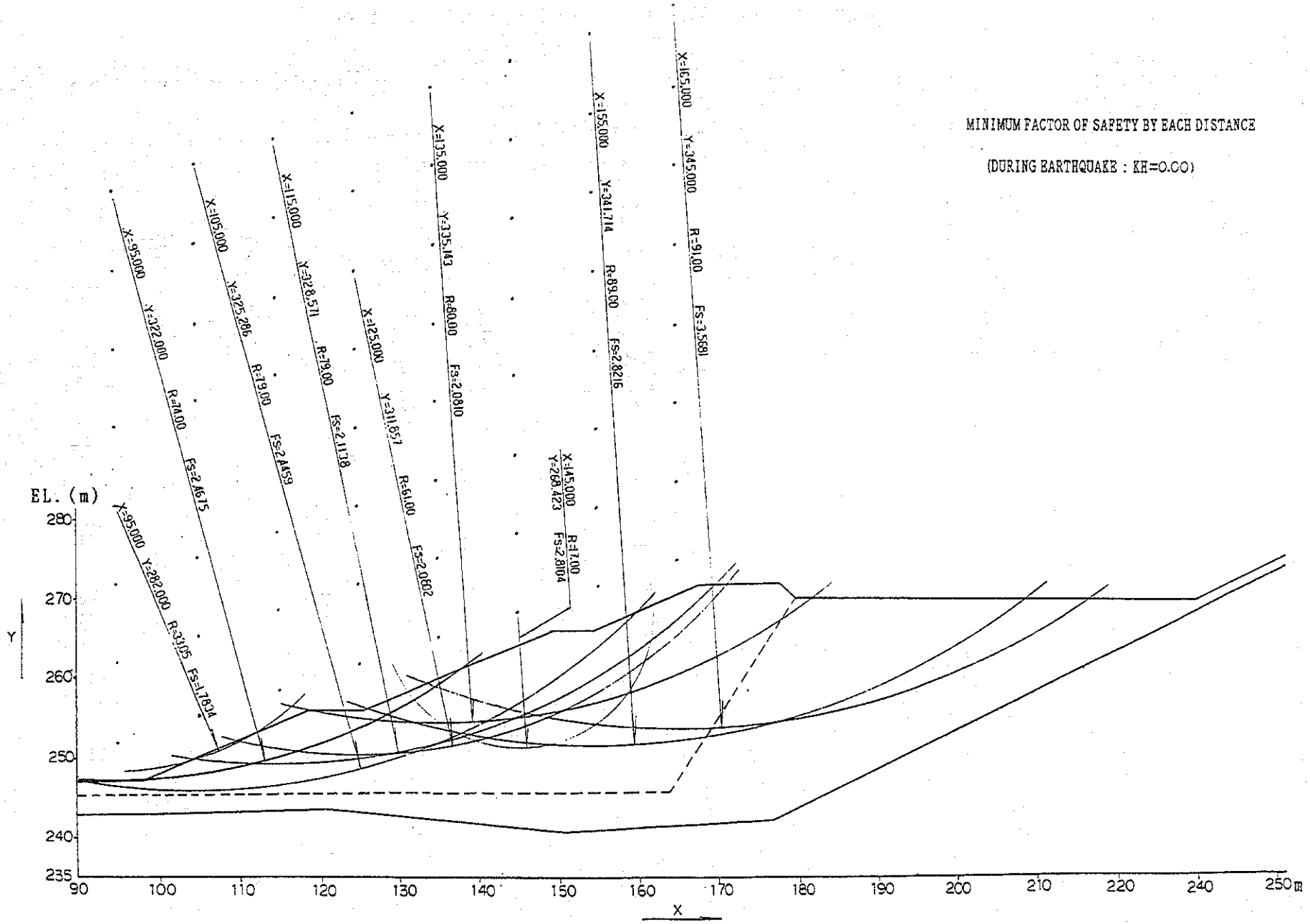

Fig. 5-8-3 A Result of Tailing Dam Stability Analysis (2)

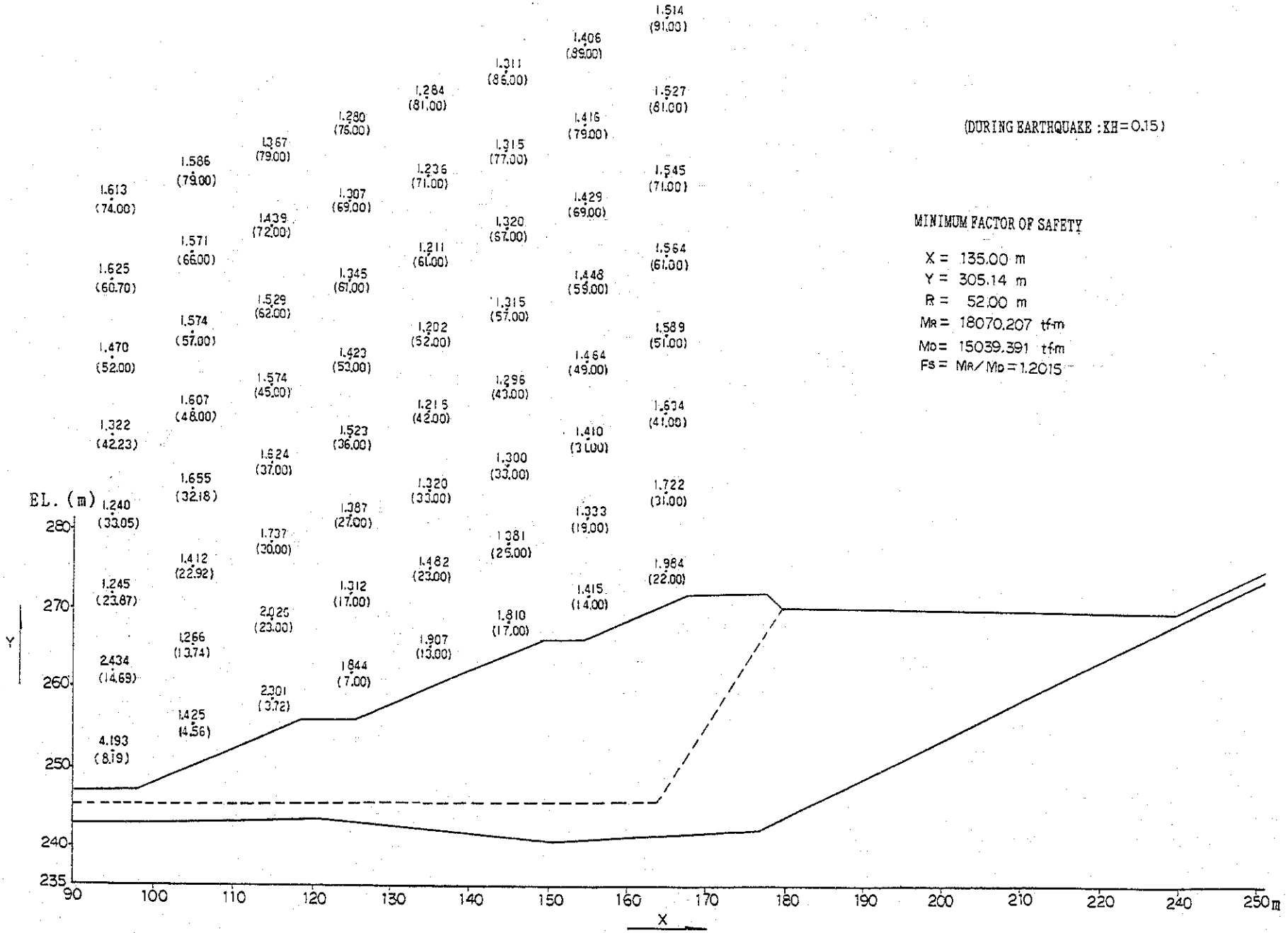

Fig. 5-8-4 A Result of Tailing Dam Stability Analysis (3)

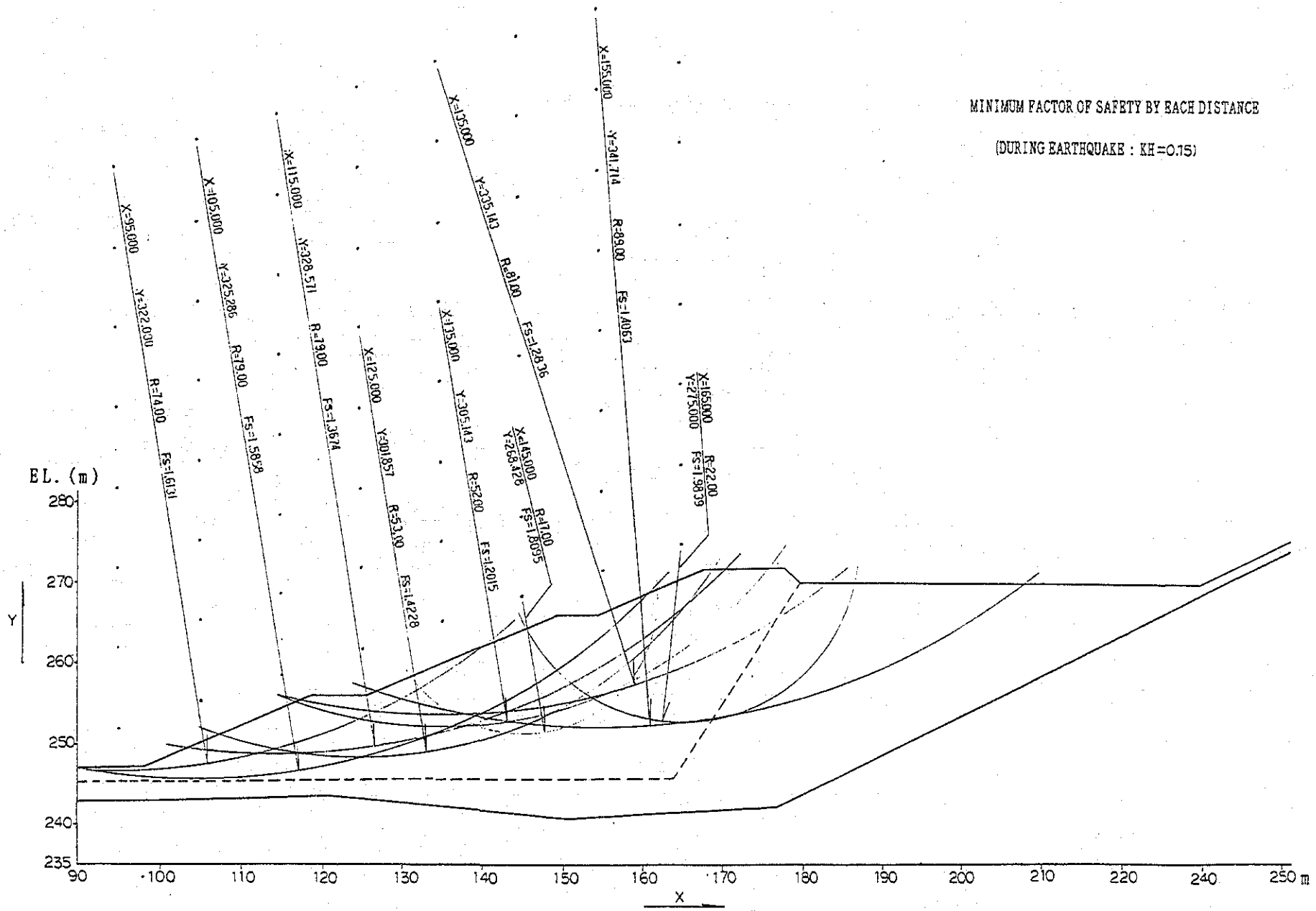

Fig. 5-8-5 A Result of Tailing Dam Stability Analysis (4)

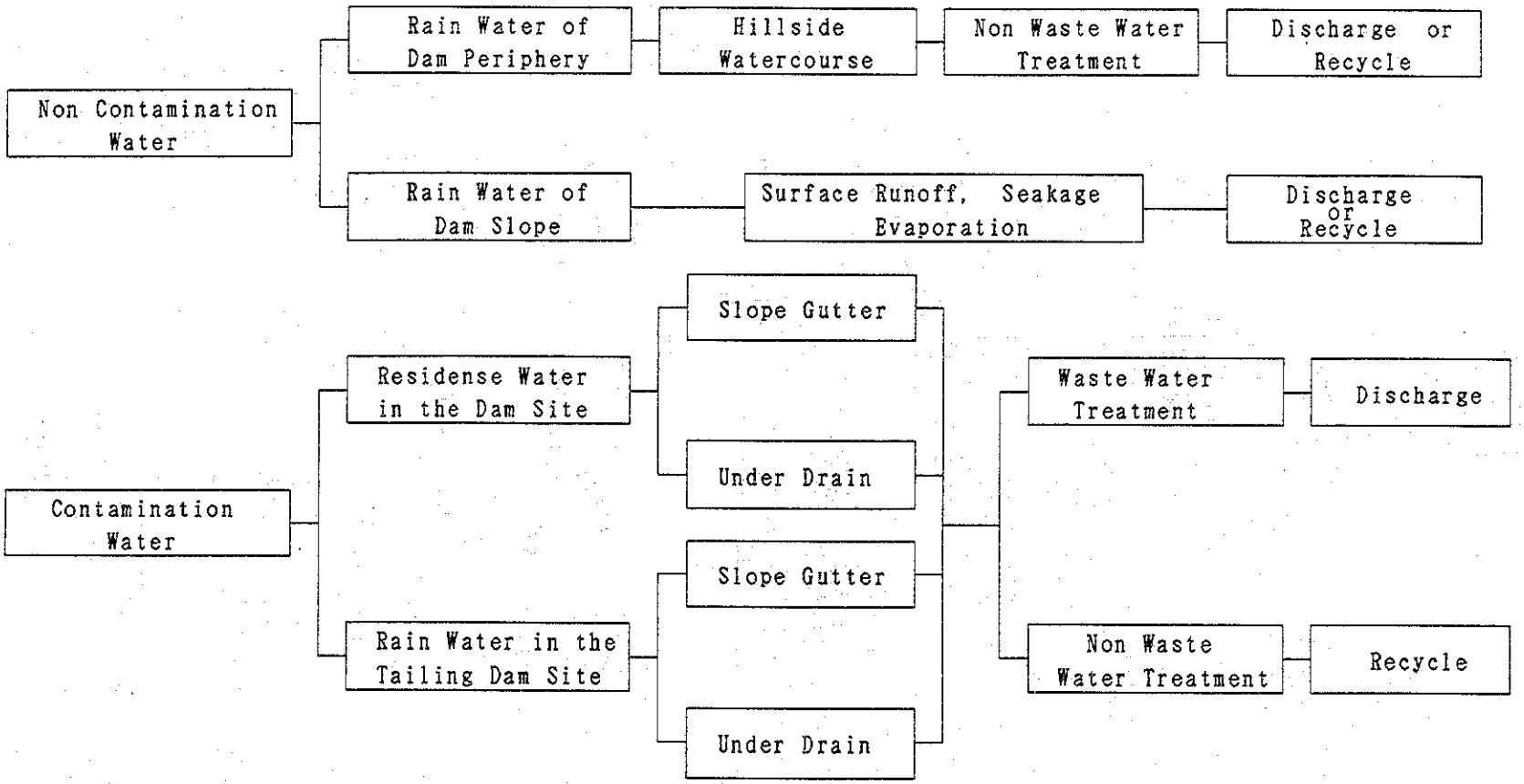

Fig. 5-8-6 Drainage Flow

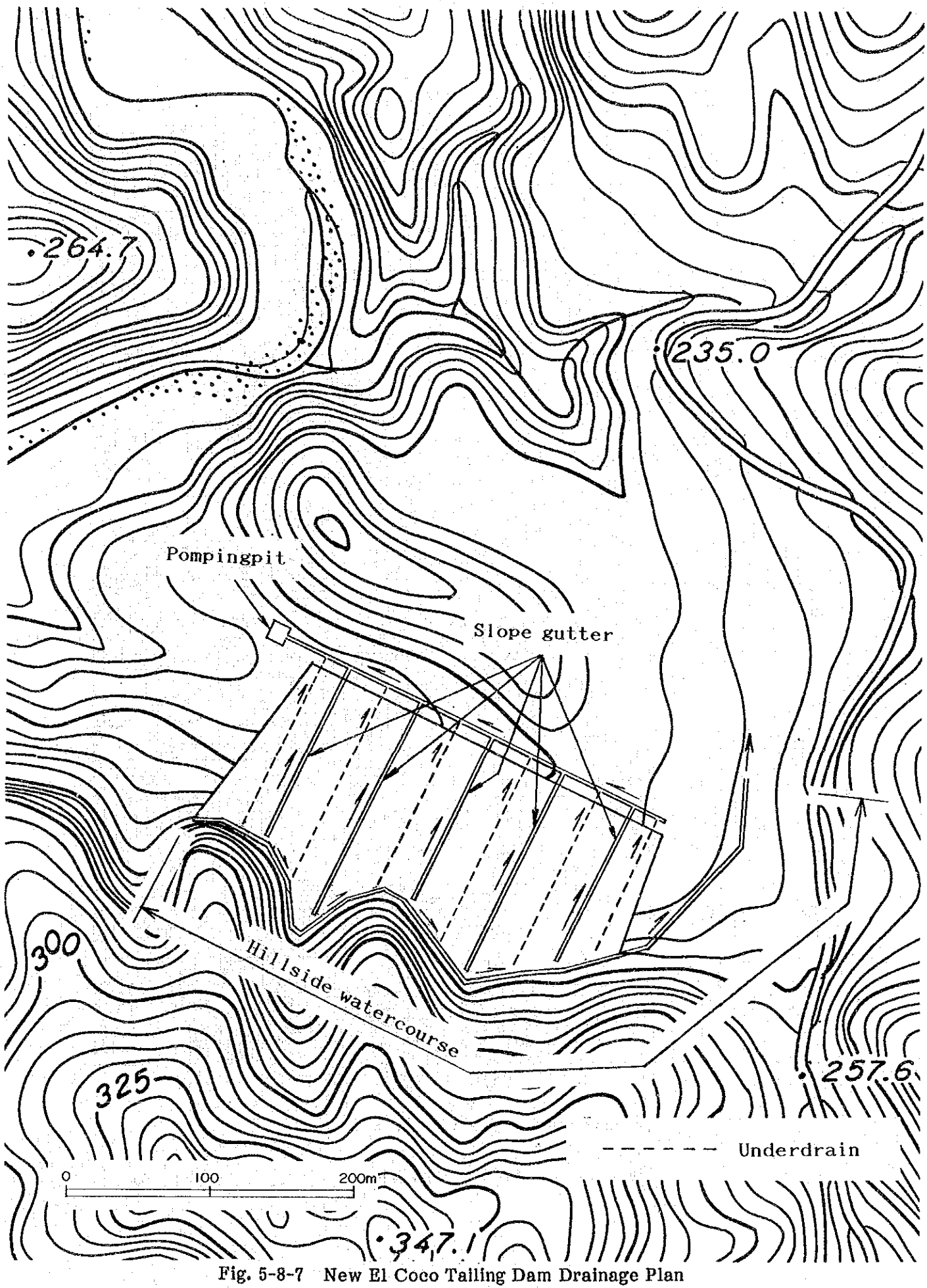

Fig. 5-8-7 New El Coco Tailing Dam Drainage Plan

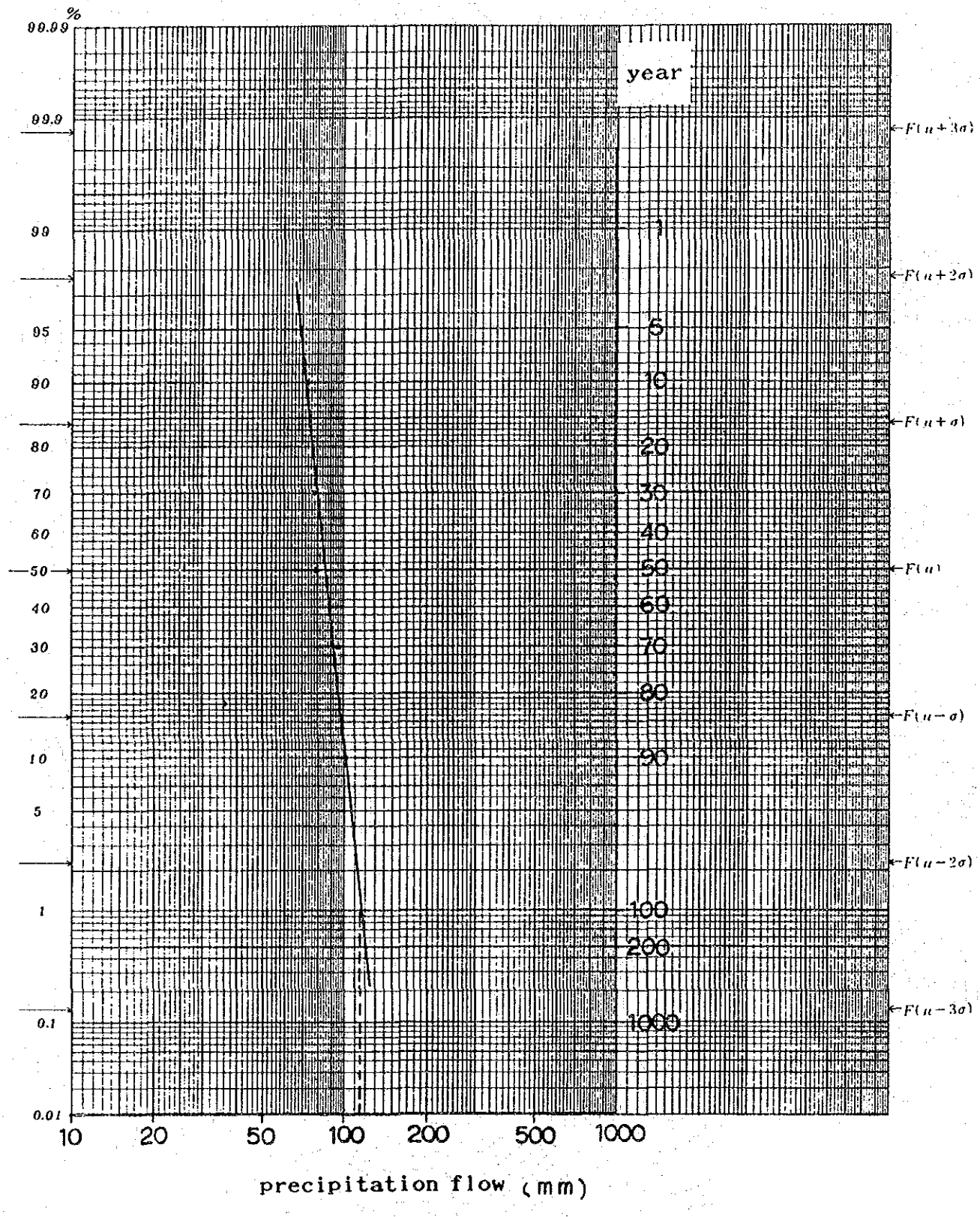

Fig. 5-8-8 Probability Precipitation

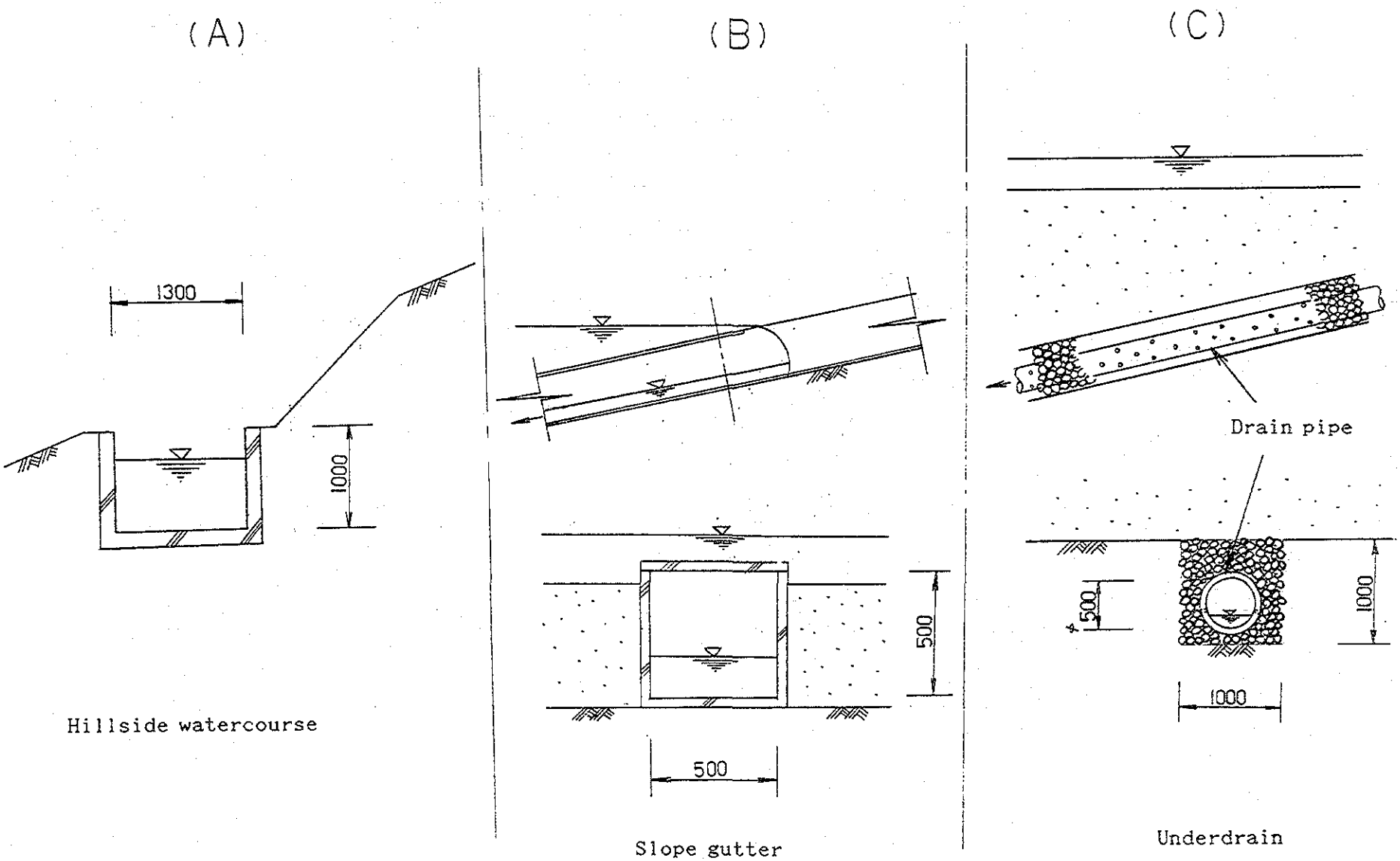

Fig. 5-8-9 Typical Cross Section of Drainage

Table 5-4-1 Hydrologic Measurement of Surface Water (New El Coco)

Site	Season	Date	Section of Flow (m^2)	Velocity (m/sec)	Flow Rate (m^3/sec)	Daily Flow (m^3/day)
No. 1	Dry	15, Mar.	0.4012	0.0120	0.481×10^{-2}	415.6
	Rainy	26, Jul.	0.1575	0.3040	4.788×10^{-2}	4,136.6
	Rainy	6, Aug.	1.6660	0.5980	0.963	86,077.3
No. 2	Dry	15, Mar.	1.1338	0	0	0
	Rainy	26, Jul.	1.2950	0.0639	8.278×10^{-2}	7,152.1
	Rainy	7, Aug.	2.0888	0.1587	0.3313	28,624.3
No. 3	Dry	15, Mar.	0.5225	0	0	0
	Rainy	27, Jul.	1.0183	0.0823	8.382×10^{-2}	7,241.8
	Rainy	6, Aug.	4.5850	0.1769	0.811	70,076.8
No. 4	Dry	15, Mar.	0	0	0	0
	Rainy	26, Jul.	0.0232	0.0706	0.164×10^{-2}	141.7
	Rainy	6, Aug.	0.0144	0.1537	0.175×10^{-2}	151.0
No. 5	Dry	15, Mar.	0	0	0	0
	Rainy	26, Jul.	0.0351	0.0650	0.228×10^{-2}	197.0
	Rainy	6, Aug.	0.0083	0.0833	0.069×10^{-2}	59.4
No. 6	Rainy	27, Jul.	0.0570	0	0	0
	Rainy	7, Aug.	0.0570	0	0	0

Table 5-4-2 Background and Water Supply Ceiling of Chemical Components in Water

(ppm)

Background Value	Cu	Pb	Zn	Fe	Cd	Total Cr	As	Hg	Cr^{6+}	CN
Fresh Water	0.003	0.003	0.020	0.1	0.032×10^{-3}	0.001	0.002	0.07×10^{-3}	0.001	0
Water Supply Ceiling	1	0.05	5	0.3	0.01	0.05	0.05	0.002	0.05	0

after Rose, W., Hawkes, H.E., and Webb, J.S. (1979): Geochemistry in Mineral Exploration
Water Supply Ceiling is by U.S. Enviromental Protection Agency (1977)

Table 5-4-3 Chemical Analysis of Surface Water (New El Coco)

Site	Season	Date	Cu (ppm)	Pb (ppm)	Zn (ppm)	Fe (ppm)	Cd (ppm)	Total Cr (ppm)	As (ppm)	Hg (ppm)	Cr^{6+} (ppm)	pH
C-R1	Dry	15, Mar.	n.d.	n.d.	0.005	0.28	n.d.	n.d.	n.d.	n.d.	n.d.	6.88
	Rainy	26, Jul.	0.012	n.d.	0.085	0.29	n.d.	0.001	0.003	n.d.	n.d.	7.28
C-R2	Dry	15, Mar.	n.d.	n.d.	0.01	0.06	n.d.	n.d.	0.027	n.d.	n.d.	7.28
	Rainy	26, Jul.	0.004	0.002	0.089	0.25	n.d.	0.002	0.004	n.d.	n.d.	7.68
C-R3	Dry	15, Mar.	0.001	n.d.	n.d.	0.03	n.d.	n.d.	n.d.	n.d.	n.d.	8.44
	Rainy	27, Jul.	0.003	0.009	0.090	0.31	n.d.	0.001	0.003	n.d.	n.d.	7.52
C-R4	Rainy	26, Jul.	0.005	n.d.	0.082	0.79	n.d.	0.003	0.026	n.d.	n.d.	7.40
C-R5	Rainy	26, Jul.	0.004	n.d.	0.079	0.24	n.d.	0.001	0.058	n.d.	n.d.	7.01
C-R6	Rainy	27, Jul.	n.d.	n.d.	0.028	0.95	n.d.	0.001	n.d.	n.d.	n.d.	6.58
	Rainy	21, Aug.	0.006	0.17	0.12	0.86	n.d.	0.048	0.003	n.d.	n.d.	6.88

Electric Conductivity (μs/cm) is:
C-R1(Dry)=43, C-R1(Rainy)=45, C-R2(Dry)=43, C-R2(Rainy)=46,
C-R3(Dry)=44, C-R3(Rainy)=47, C-R4(Rainy)=43, C-R5(Rainy)=43,
C-R6(Rainy)=42,43

R:River

Table 5-4-4 Micro Flow Measurement Data (New El Coco B-1) (1)

Depth (m)	Time (sec)	Impellor Count	Flow Direction	Velocity (cm/sec)
6.98	60	0	Up-flow	0.40
7.98	60	0	Up-flow	0.40
8.98	60	0	Up-flow	0.40
9.98	60	0	Up-flow	0.40
10.98	60	0	Up-flow	0.40
11.98	60	0	Up-flow	0.40
12.98	60	0	Up-flow	0.40
13.98	60	0	Up-flow	0.40
14.98	60	7	Up-flow	1.22
15.98	60	6	Up-flow	1.11
16.98	60	7	Up-flow	1.22
17.98	60	4	Up-flow	0.87
18.98	60	6	Up-flow	1.11
19.98	60	3	Up-flow	0.75
20.98	60	0	Up-flow	0.40
21.98	60	2	Up-flow	0.63
22.98	60	0	Up-flow	0.40
23.98	60	4	Up-flow	0.87
24.98	60	10	Up-flow	1.58
25.98	60	5	Up-flow	0.99
26.98	60	2	Up-flow	0.63
27.98	60	1	Up-flow	0.51
28.98	60	0	Up-flow	0.40
29.98	60	1	Up-flow	0.51
30.98	60	0	Up-flow	0.40
31.98	60	0	Up-flow	0.40
32.98	60	0	Up-flow	0.40
33.98	60	0	Up-flow	0.40
34.98	60	0	Up-flow	0.40
35.98	60	0	Up-flow	0.40
36.98	60	0	Up-flow	0.40
37.98	60	0	Up-flow	0.40
38.98	60	0	Up-flow	0.40
39.98	60	0	Up-flow	0.40
40.98	60	0	Up-flow	0.40
41.98	60	0	Up-flow	0.40
42.98	60	1	Up-flow	0.51
43.98	60	0	Up-flow	0.40
44.98	60	0	Up-flow	0.40
45.98	60	0	Up-flow	0.40
46.98	60	0	Up-flow	0.40
47.98	60	0	Up-flow	0.40

DATE 26 JUL 1991
TIME 03:43:43 PM
HOLE No.=B-1
WATER LEVEL=5.98m
DEPTH=50m

Table 5-4-4 Micro Flow Measurement Data (New El Coco B-1) (2)

Depth (m)	Time (sec)	Impellor Count	Flow Direction	Velocity (cm/sec)
6.90	60	0	Up-flow	0.40
7.90	60	0	Up-flow	0.40
8.90	60	0	Up-flow	0.40
9.90	60	0	Up-flow	0.40
10.90	60	0	Up-flow	0.40
11.90	60	10	Up-flow	1.58
12.90	60	1	Up-flow	0.51
13.90	60	14	Up-flow	2.05
14.90	60	20	Up-flow	2.76
15.90	60	22	Up-flow	3.00
16.90	60	21	Up-flow	2.88
17.90	60	21	Up-flow	2.88
18.90	60	22	Up-flow	3.00
19.90	60	14	Up-flow	2.05
20.90	60	10	Up-flow	1.58
21.90	60	0	Up-flow	0.40
22.90	60	0	Up-flow	0.40
23.90	60	12	Up-flow	1.82
24.90	60	12	Up-flow	1.82
25.90	60	10	Up-flow	1.58
26.90	60	7	Up-flow	1.22
27.90	60	6	Up-flow	1.11
28.90	60	4	Up-flow	0.87
29.90	60	2	Up-flow	0.63
30.90	60	2	Up-flow	0.63
31.90	60	0	Up-flow	0.40
32.90	60	0	Up-flow	0.40
33.90	60	0	Up-flow	0.40
34.90	60	0	Up-flow	0.40
35.90	60	0	Up-flow	0.40
36.90	60	0	Up-flow	0.40
37.90	60	0	Up-flow	0.40
38.90	60	0	Up-flow	0.40
39.90	60	0	Up-flow	0.40
40.90	60	6	Up-flow	1.11
41.90	60	6	Up-flow	1.11
42.90	60	0	Up-flow	0.40
43.90	60	5	Up-flow	0.99
44.90	60	0	Up-flow	0.40
45.90	60	0	Up-flow	0.40
46.90	60	1	Up-flow	0.51
47.90	60	0	Up-flow	0.40
48.90	60	0	Up-flow	0.40

DATE 06 AUG 1991
TIME 10:20:43 AM
HOLE No.=B-1
WATER LEVEL=5.90m
DEPTH=50m

Table 5-4-4 Micro Flow Measurement Data (New El Coco B-1) (3)

Depth (m)	Time (sec)	Impellor Count	Flow Direction	Velocity (cm/sec)
6.85	60	0	Up-flow	0.40
7.85	60	0	Up-flow	0.40
8.85	60	0	Up-flow	0.40
9.85	60	0	Up-flow	0.40
10.85	60	1	Up-flow	0.51
11.85	60	0	Up-flow	0.40
12.85	60	0	Up-flow	0.40
13.85	60	0	Up-flow	0.40
14.85	60	0	Up-flow	0.40
15.85	60	0	Up-flow	0.40
16.85	60	0	Up-flow	0.40
17.85	60	0	Up-flow	0.40
18.85	60	0	Up-flow	0.40
19.85	60	0	Up-flow	0.40
20.85	60	0	Up-flow	0.40
21.85	60	0	Up-flow	0.40
22.85	60	0	Up-flow	0.40
23.85	60	0	Up-flow	0.40
24.85	60	0	Up-flow	0.40
25.85	60	0	Up-flow	0.40
26.85	60	0	Up-flow	0.40
27.85	60	0	Up-flow	0.40
28.85	60	0	Up-flow	0.40
29.85	60	0	Up-flow	0.40
30.85	60	0	Up-flow	0.40
31.85	60	0	Up-flow	0.40
32.85	60	0	Up-flow	0.40
33.85	60	0	Up-flow	0.40
34.85	60	0	Up-flow	0.40
35.85	60	0	Up-flow	0.40
36.85	60	0	Up-flow	0.40
37.85	60	0	Up-flow	0.40
38.85	60	0	Up-flow	0.40
39.85	60	0	Up-flow	0.40
40.85	60	2	Up-flow	0.63
41.85	60	7	Up-flow	1.22
42.85	60	2	Up-flow	0.63
43.85	60	4	Up-flow	0.87
44.85	60	0	Up-flow	0.40
45.85	60	0	Up-flow	0.40
46.85	60	0	Up-flow	0.40
47.85	60	0	Up-flow	0.40

DATE 20 AUG 1991
TIME 03:07:38 PM
HOLE No.=B-1
WATER LEVEL=5.85m
DEPTH=50m

Table 5-4-4 Micro Flow Measurement Data (New El Coco B-2) (1)

Depth (m)	Time (sec)	Impellor Count	Flow Direction	Velocity (cm/sec)
0.00	120	6	Up-flow	0.75
1.00	120	0	Up-flow	0.40
2.00	120	0	Up-flow	0.40
4.00	120	0	Up-flow	0.40
6.00	120	0	Up-flow	0.40
8.00	120	0	Up-flow	0.40
10.00	120	0	Up-flow	0.40
12.00	120	0	Up-flow	0.40
14.00	120	0	Up-flow	0.40
16.00	120	0	Up-flow	0.40
18.00	120	0	Up-flow	0.40
20.00	120	0	Up-flow	0.40
22.00	120	0	Up-flow	0.40
24.00	120	0	Up-flow	0.40
26.00	120	0	Up-flow	0.40
28.00	120	0	Up-flow	0.40
30.00	120	0	Up-flow	0.40
32.00	120	0	Up-flow	0.40
34.00	120	0	Up-flow	0.40
36.00	120	0	Up-flow	0.40
37.00	120	0	Up-flow	0.40
38.00	120	0	Up-flow	0.40
39.00	120	0	Up-flow	0.40
40.00	120	0	Up-flow	0.40
41.00	120	69	Up-flow	4.48
42.00	120	0	Up-flow	0.40
43.00	120	68	Up-flow	4.42
44.00	120	72	Up-flow	4.66
45.00	120	69	Up-flow	4.48
46.00	120	72	Up-flow	4.66
47.00	120	1	Up-flow	0.45
48.00	120	11	Up-flow	1.05
49.00	120	76	Up-flow	4.89
50.00	120	61	Up-flow	4.00
51.00	120	70	Up-flow	4.54
52.00	120	0	Up-flow	0.40
53.00	120	0	Up-flow	0.40
54.00	120	0	Up-flow	0.40
55.00	120	0	Up-flow	0.40
56.00	120	5	Up-flow	0.69
57.00	120	1	Up-flow	0.45
58.00	120	2	Up-flow	0.51
59.00	120	0	Up-flow	0.40

DETA 25 JUL 1991
TIME 11:59:57 AM
HOLE No.=B-2
WATER LEVEL=0.00m
DEPTH=105m

Table 5-4-4 Micro Flow Measurement Data (New El Coco B-2) (2)

Depth (m)	Time (sec)	Impellor Count	Flow Direction	Velocity (cm/sec)
0.00	60	0	Up-flow	0.40
2.00	60	0	Up-flow	0.40
4.00	60	0	Up-flow	0.40
6.00	60	0	Up-flow	0.40
8.00	60	0	Up-flow	0.40
10.00	60	0	Up-flow	0.40
12.00	60	0	Up-flow	0.40
14.00	60	0	Up-flow	0.40
16.00	60	0	Up-flow	0.40
18.00	60	0	Up-flow	0.40
20.00	60	0	Up-flow	0.40
22.00	60	0	Up-flow	0.40
24.00	60	0	Up-flow	0.40
26.00	60	0	Up-flow	0.40
28.00	60	0	Up-flow	0.40
30.00	60	1	Up-flow	0.51
32.00	60	0	Up-flow	0.40
34.00	60	0	Up-flow	0.40
36.00	60	0	Up-flow	0.40
37.00	60	0	Up-flow	0.40
38.00	60	0	Up-flow	0.40
39.00	60	0	Up-flow	0.40
40.00	60	0	Up-flow	0.40
41.00	60	35	Up-flow	4.54
42.00	60	34	Up-flow	4.42
43.00	60	0	Up-flow	0.40
44.00	60	37	Up-flow	4.77
45.00	60	0	Up-flow	0.40
46.00	60	38	Up-flow	4.89
47.00	60	1	Up-flow	0.51
48.00	60	0	Up-flow	0.40
49.00	60	0	Up-flow	0.40
50.00	60	0	Up-flow	0.40
51.00	60	38	Up-flow	4.89
52.00	60	38	Up-flow	4.89
53.00	60	36	Up-flow	4.66
54.00	60	37	Up-flow	4.77
55.00	60	32	Up-flow	4.18
56.00	60	39	Up-flow	5.01
57.00	60	33	Up-flow	4.30
58.00	60	34	Up-flow	4.42
59.00	60	0	Up-flow	0.40

DATE 05 AUG 1991
TIME 09:54:40 AM
HOLE No.=B-2
WATER LEVEL=0.00m
DEPTH=105m

Table 5-4-4 Micro Flow Measurement Data (New El Coco B-2) (3)

Depth (m)	Time (sec)	Impellor Count	Flow Direction	Velocity (cm/sec)
0.00	60	0	Up-flow	0.40
2.00	60	1	Up-flow	0.51
4.00	60	0	Up-flow	0.40
6.00	60	0	Up-flow	0.40
8.00	60	0	Up-flow	0.40
10.00	60	0	Up-flow	0.40
12.00	60	0	Up-flow	0.40
14.00	60	0	Up-flow	0.40
16.00	60	0	Up-flow	0.40
18.00	60	0	Up-flow	0.40
20.00	60	0	Up-flow	0.40
22.00	60	0	Up-flow	0.40
24.00	60	0	Up-flow	0.40
26.00	60	0	Up-flow	0.40
28.00	60	0	Up-flow	0.40
30.00	60	0	Up-flow	0.40
32.00	60	0	Up-flow	0.40
34.00	60	0	Up-flow	0.40
36.00	60	0	Up-flow	0.40
37.00	60	0	Up-flow	0.40
38.00	60	0	Up-flow	0.40
39.00	60	0	Up-flow	0.40
40.00	60	0	Up-flow	0.40
41.00	60	35	Up-flow	4.54
42.00	60	32	Up-flow	4.18
43.00	60	0	Up-flow	0.40
44.00	60	0	Up-flow	0.40
45.00	60	0	Up-flow	0.40
46.00	60	45	Up-flow	5.72
47.00	60	0	Up-flow	0.40
48.00	60	44	Up-flow	5.60
49.00	60	45	Up-flow	5.72
50.00	60	39	Up-flow	5.01
51.00	60	35	Up-flow	4.54
52.00	60	37	Up-flow	4.77
53.00	60	35	Up-flow	4.54
54.00	60	0	Up-flow	0.40
55.00	60	0	Up-flow	0.40
56.00	60	1	Up-flow	0.51
57.00	60	0	Up-flow	0.40
58.00	60	0	Up-flow	0.40
59.00	60	0	Up-flow	0.40

DATE 07 AUG 1991
TIME 10:02:28 AM
HOLE No.=B-2
WATER LEVEL=0.00m
DEPTH=105m

Table 5-4-4 Micro Flow Measurement Data (New El Coco B-2) (4)

Depth (m)	Time (sec)	Impellor Count	Flow Direction	Velocity (cm/sec)
0.00	60	0	Up-flow	0.40
2.00	60	0	Up-flow	0.40
4.00	60	0	Up-flow	0.40
6.00	60	1	Up-flow	0.51
8.00	60	0	Up-flow	0.40
10.00	60	0	Up-flow	0.40
12.00	60	0	Up-flow	0.40
14.00	60	0	Up-flow	0.40
16.00	60	0	Up-flow	0.40
18.00	60	0	Up-flow	0.40
20.00	60	0	Up-flow	0.40
22.00	60	0	Up-flow	0.40
24.00	60	0	Up-flow	0.40
26.00	60	0	Up-flow	0.40
28.00	60	0	Up-flow	0.40
30.00	60	0	Up-flow	0.40
32.00	60	0	Up-flow	0.40
34.00	60	0	Up-flow	0.40
36.00	60	0	Up-flow	0.40
38.00	60	0	Up-flow	0.40
40.00	60	1	Up-flow	0.51
41.00	60	51	Up-flow	6.43
42.00	60	59	Up-flow	7.38
43.00	60	46	Up-flow	5.84
44.00	60	54	Up-flow	6.79
45.00	60	0	Up-flow	0.40
46.00	60	46	Up-flow	5.84
47.00	60	0	Up-flow	0.40
48.00	60	45	Up-flow	5.72
49.00	60	63	Up-flow	7.85
50.00	60	42	Up-flow	5.37
51.00	60	57	Up-flow	7.14
52.00	60	60	Up-flow	7.50
53.00	60	43	Up-flow	5.48
54.00	60	37	Up-flow	4.77
55.00	60	9	Up-flow	1.46
56.00	60	41	Up-flow	5.25
57.00	60	7	Up-flow	1.22
58.00	60	42	Up-flow	5.37
59.00	60	40	Up-flow	5.13

DATE 20 AUG 1991
TIME 09:35:07 AM
HOLE No.=B-2
WATER LEVEL=0.00m
DEPTH=105m

Table 5-4-4 Micro Flow Measurement Data (New El Coco B-3)

Depth (m)	Time (sec)	Impellor Count	Flow Direction	Velocity (cm/sec)
7.37	120	0	Up-flow	0.40
8.37	120	0	Up-flow	0.40
9.37	120	0	Up-flow	0.40
10.37	120	0	Up-flow	0.40
11.37	120	0	Up-flow	0.40
12.37	120	0	Up-flow	0.40
13.37	120	0	Up-flow	0.40
14.37	120	0	Up-flow	0.40
15.37	120	0	Up-flow	0.40
16.37	120	0	Up-flow	0.40

DATE 25 JUL 91
TIME 04:35:49 PM
HOLE No.=3
WATER LEVEL=6.37m
DEPTH=20m

Depth (m)	Timer (sec)	Impellor Count	Flow Direction	Velocity (cm/sec)
5.86	60	0	Up-flow	0.40
6.86	60	0	Up-flow	0.40
7.86	60	0	Up-flow	0.40
8.86	60	0	Up-flow	0.40
9.86	60	0	Up-flow	0.40
10.86	60	0	Up-flow	0.40
11.86	60	0	Up-flow	0.40
12.86	60	0	Up-flow	0.40
13.86	60	0	Up-flow	0.40
14.86	60	0	Up-flow	0.40
15.86	60	0	Up-flow	0.40
16.86	60	0	Up-flow	0.40

DATE 06 AUG 1991
TIME 04:35:44 PM
HOLE No.=B-3
WATER LEVEL=4.86m
DEPTH=20m

Depth (m)	Time (sec)	Impellor Count	Flow Direction	Velocity (cm/sec)
5.00	60	0	Up-flow	0.40
6.00	60	4	Up-flow	0.87
7.00	60	4	Up-flow	0.87
8.00	60	0	Up-flow	0.40
9.00	60	0	Up-flow	0.40
10.00	60	1	Up-flow	0.51
11.00	60	0	Up-flow	0.40
12.00	60	0	Up-flow	0.40
13.00	60	0	Up-flow	0.40
14.00	60	0	Up-flow	0.40
15.00	60	0	Up-flow	0.40
16.00	60	0	Up-flow	0.40
17.00	60	1	Up-flow	0.51

DATE 20 AUG 1991
TIME 12:32:12 PM
HOLE No.=B-3
WATER LEVEL=5.00m
DEPTH=20m

Table 5-4-4 Micro Flow Measurement Data (New El Coco B-4)

Depth (m)	Time (sec)	Impellor Count	Flow Direction	Velocity (cm/sec)
11.74	60	0	Up-flow	0.40
12.74	60	1	Up-flow	0.51
13.74	60	0	Up-flow	0.40
14.74	60	0	Up-flow	0.40
15.74	60	2	Up-flow	0.63
16.74	60	0	Up-flow	0.40
17.74	60	2	Up-flow	0.63
18.74	60	0	Up-flow	0.40
19.74	60	0	Up-flow	0.40
20.74	60	1	Up-flow	0.51
21.74	60	0	Up-flow	0.40
22.74	60	0	Up-flow	0.40
23.74	60	0	Up-flow	0.40
24.74	60	0	Up-flow	0.40
25.74	60	0	Up-flow	0.40
26.74	60	0	Up-flow	0.40
27.74	60	0	Up-flow	0.40
28.74	60	0	Up-flow	0.40

DATE 24 JUL 1991
TIME 02:06:56 PM
HOLE No.=B-4
WATER LEVEL=10.74m
DEPTH=30m

Depth (m)	Time (sec)	Impellor Count	Flow Direction	Velocity (cm/sec)
12.19	60	0	Up-flow	0.40
13.19	60	2	Up-flow	0.63
14.19	60	0	Up-flow	0.40
15.19	60	0	Up-flow	0.40
16.19	60	0	Up-flow	0.40
17.19	60	0	Up-flow	0.40
18.19	60	0	Up-flow	0.40
19.19	60	0	Up-flow	0.40
20.19	60	0	Up-flow	0.40
21.19	60	0	Up-flow	0.40
22.19	60	0	Up-flow	0.40
23.19	60	0	Up-flow	0.40
24.19	60	0	Up-flow	0.40
25.19	60	0	Up-flow	0.40
26.19	60	0	Up-flow	0.40
27.19	60	0	Up-flow	0.40
28.19	60	0	Up-flow	0.40

DATE 05 AUG 1991
TIME 11:45:32 AM
HOLE No.=B-4
WATER LEVEL=11.19m
DEPTH=30m

Depth (m)	Time (sec)	Impellor Count	Flow Direction	Velocity (cm/sec)
12.22	60	0	Up-flow	0.40
13.22	60	0	Up-flow	0.40
14.22	60	6	Up-flow	1.11
15.22	60	1	Up-flow	0.51
16.22	60	0	Up-flow	0.40
17.22	60	21	Up-flow	2.88
18.22	60	20	Up-flow	2.76
19.22	60	31	Up-flow	4.06
20.22	60	23	Up-flow	3.12
21.22	60	0	Up-flow	0.40
22.22	60	0	Up-flow	0.40
23.22	60	0	Up-flow	0.40
24.22	60	0	Up-flow	0.40
25.22	60	0	Up-flow	0.40
26.22	60	0	Up-flow	0.40
27.22	60	0	Up-flow	0.40
28.22	60	0	Up-flow	0.40
29.22	60	0	Up-flow	0.40

DATE 19 AUG 1991
TIME 10:58:42 AM
HOLE No.=B-4
WATER LEVEL=11.22m
DEPTH=30m

Table 5-4-4 Micro Flow Measurement Data (New El Coco B-5)

Depth (m)	Time (sec)	Impellor Count	Flow Direction	Velocity (cm/sec)
5.35	60	0	Up-flow	0.40
6.35	60	1	Up-flow	0.51
7.35	60	2	Up-flow	0.63
8.35	60	7	Up-flow	1.22
9.35	60	6	Up-flow	1.11
10.35	60	6	Up-flow	1.11
11.35	60	3	Up-flow	0.75
12.35	60	0	Up-flow	0.40
13.35	60	3	Up-flow	0.75
14.35	60	4	Up-flow	0.87
15.35	60	0	Up-flow	0.40

DATE 24 JUL 1991
TIME 12:09:09 PM
HOLE No.=B-5
WATER LEVEL=4.35m
DEPTH=14.30m

Depth (m)	Time (sec)	Impellor Count	Flow Direction	Velocity (cm/sec)
5.57	60	0	Up-flow	0.40
6.57	60	1	Up-flow	0.51
7.57	60	6	Up-flow	1.11
8.57	60	4	Up-flow	0.87
9.57	60	4	Up-flow	0.87
10.57	60	0	Up-flow	0.40
11.57	60	0	Up-flow	0.40
12.57	60	0	Up-flow	0.40

DATE 30 JUL 1991
TIME 11:06:35 AM
HOLE No.=B-5
WATER LEVEL=4.57m
DEPTH=14.50m

Depth (m)	Time (sec)	Impellor Count	Flow Direction	Velocity (cm/sec)
5.57	60	0	Up-flow	0.40
6.57	60	0	Up-flow	0.40
7.57	60	0	Up-flow	0.40
8.57	60	0	Up-flow	0.40
9.57	60	0	Up-flow	0.40
10.57	60	0	Up-flow	0.40
11.57	60	0	Up-flow	0.40
12.57	60	0	Up-flow	0.40
13.57	60	0	Up-flow	0.40

DATE 05 AUG 1991
TIME 03:09:46 PM
HOLE No.=B-5
WATER LEVEL=4.57m
DEPTH=14.30m

Depth (m)	Time (sec)	Impellor Count	Flow Direction	Velocity (cm/sec)
5.63	60	0	Up-flow	0.40
6.63	60	0	Up-flow	0.40
7.63	60	1	Up-flow	0.51
8.63	60	1	Up-flow	0.51
9.63	60	0	Up-flow	0.40
10.63	60	0	Up-flow	0.40
11.63	60	0	Up-flow	0.40
12.63	60	0	Up-flow	0.40
13.63	60	0	Up-flow	0.40

DATE 19 AUG 1991
TIME 00:20:33 PM
HOLE No.=B-5
WATER LEVEL=4.63m
DEPTH=14.50m

Table 5-4-4 Micro Flow Measurement Data (New El Coco B-6)

Depth (m)	Time (sec)	Impellor Count	Flow Direction	Velocity (cm/sec)
6.50	60	0	Up-flow	0.40
7.00	60	0	Up-flow	0.40
7.50	60	0	Up-flow	0.40
8.00	60	0	Up-flow	0.40
8.50	60	0	Up-flow	0.40
9.00	60	0	Up-flow	0.40
9.50	60	0	Up-flow	0.40

DATE 25 JUL 1991
TIME 09:48:55 AM
HOLE No.=B-6
WATER LEVEL=6.00m
DEPTH=10m

Depth (m)	Time (sec)	Impellor Count	Flow Direction	Velocity (cm/sec)
7.36	60	0	Up-flow	0.40
8.36	60	0	Up-flow	0.40
9.36	60	0	Up-flow	0.40

DATE 06 AUG 1991
TIME 02:35:31 PM
HOLE No.=B-6
WATER LEVEL=6.36m
DEPTH=10m

Depth (m)	Time (sec)	Impellor Count	Flow Direction	Velocity (cm/sec)
7.40	60	0	Up-flow	0.40
8.40	60	3	Up-flow	0.75
9.40	60	2	Up-flow	0.63

DATE 19 AUG 1991
TIME 02:11:19 PM
HOLE No.=B-6
WATER LEVEL=6.40m
DEPTH=10m

Table 5-4-4 Micro Flow Measurement Data (New El Coco B-7)

Depth (m)	Time (sec)	Impellor Count	Flow Direction	Velocity (cm/sec)
7.74	60	0	Up-flow	0.40
8.24	60	0	Up-flow	0.40
8.74	60	0	Up-flow	0.40
9.24	60	0	Up-flow	0.40
9.74	60	0	Up-flow	0.40
10.24	60	0	Up-flow	0.40
10.74	60	0	Up-flow	0.40
11.24	60	0	Up-flow	0.40

DATE 25 JUL 1991
TIME 10:26:13 AM
HOLE No.=B-7
WATER LEVEL=7.24m
DEPTH=14m

Depth (m)	Time (sec)	Impellor Count	Flow Direction	Velocity (cm/sec)
8.22	60	0	Up-flow	0.40
9.22	60	0	Up-flow	0.40
10.22	60	0	Up-flow	0.40
11.22	60	0	Up-flow	0.40

DATE 06 AUG 1991
TIME 02:55:59 PM
HOLE No.=B-7
WATER LEVEL=7.22m
DEPTH=14m

Depth (m)	Time (sec)	Impellor Count	Flow Direction	Velocity (cm/sec)
8.25	60	0	Up-flow	0.40
9.25	60	0	Up-flow	0.40
10.25	60	0	Up-flow	0.40
11.25	60	0	Up-flow	0.40

DATE 19 AUG 1991
TIME 02:39:44 PM
HOLE No.=B-7
WATER LEVEL=7.25m
DEPTH=14m

Table 5-4-4 Micro Flow Measurement Data (New El Coco B-8)

Depth (m)	Time (sec)	Impellor Count	Flow Direction	Velocity (cm/sec)
7.00	60	0	Up-flow	0.40
8.00	60	0	Up-flow	0.40
9.00	60	3	Up-flow	0.75
10.00	60	2	Up-flow	0.63
11.00	60	5	Up-flow	0.99
12.00	60	7	Up-flow	1.22
13.00	60	4	Up-flow	0.87

DATE 24 JUL 1991
TIME 11:27:01 AM
HOLE No.=B-8
WATER LEVEL=6.00m
DEPTH=14.5m

Depth (m)	Time (sec)	Impellor Count	Flow Direction	Velocity (cm/sec)
7.07	60	0	Up-flow	0.40
8.07	60	0	Up-flow	0.40
9.07	60	0	Up-flow	0.40
10.07	60	0	Up-flow	0.40
11.07	60	0	Up-flow	0.40
12.07	60	0	Up-flow	0.40
13.07	60	0	Up-flow	0.40

DATE 05 AUG 91
TIME 01:06:48 PM
HOLE No.=B-8
WATER LEVEL=6.07m
DEPTH=14.5m

Depth (m)	Time (sec)	Impellor Count	Flow Direction	Velocity (cm/sec)
7.12	60	0	Up-flow	0.4
8.12	60	0	Up-flow	0.4
9.12	60	0	Up-flow	0.4
10.12	60	0	Up-flow	0.4
11.12	60	0	Up-flow	0.4
12.12	60	0	Up-flow	0.4
13.12	60	0	Up-flow	0.4

DATE 19 AUG 1991
TIME 11:51:39 PM
HOLE No.=B-8
WATER LEVEL=6.12m
DEPTH=14.3m

Table 5-4-4 Micro Flow Measurement Data (New El Coco B-9)

Depth (m)	Time (sec)	Impellor Count	Flow Direction	Velocity (cm/sec)
6.05	60	0	Up-flow	0.40
7.05	60	0	Up-flow	0.40
8.05	60	0	Up-flow	0.40
9.05	60	0	Up-flow	0.40
10.05	60	0	Up-flow	0.40
11.05	60	0	Up-flow	0.40
12.05	60	0	Up-flow	0.40
13.05	60	0	Up-flow	0.40
14.05	60	0	Up-flow	0.40

DATE 05 AUG 1991
TIME 03:51:23: PM
HOLE No.=B-9
WATER LEVEL=5.05m
DEPTH=20.20m

Depth (m)	Time (sec)	Impellor Count	Flow Direction	Velocity (cm/sec)
5.57	60	0	Up-flow	0.4
6.57	60	0	Up-flow	0.4
7.57	60	0	Up-flow	0.4
8.57	60	0	Up-flow	0.4
9.57	60	0	Up-flow	0.4
10.57	60	0	Up-flow	0.4
11.57	60	0	Up-flow	0.4
12.57	60	0	Up-flow	0.4
13.57	60	0	Up-flow	0.4

DATE 06 AUG 1991
TIME 03:26:57 PM
HOLE No.=B-9
WATER LEVEL=4.57m
DEPTH=20.20m

Depth (m)	Time (sec)	Impellor Count	Flow Direction	Velocity (cm/sec)
8.70	60	0	Up-flow	0.40
9.70	60	0	Up-flow	0.40
10.70	60	0	Up-flow	0.40
11.70	60	0	Up-flow	0.40
12.70	60	0	Up-flow	0.40
13.70	60	0	Up-flow	0.40

DATE 19 AUG 1991
TIME 03:16:52 PM
HOLE No.=B-9
WATER LEVEL=7.70m
DEPTH=20m

Table 5-4-4 Micro Flow Measurement Data (New El Coco B-10)

Depth (m)	Time (sec)	Impellor Count	Flow Direction	Velocity (cm/sec)
8.25	60	0	Up-flow	0.40
9.25	60	0	Up-flow	0.40

DATE 05 AUG 91
TIME 04:26:37 PM
HOLE No.=B-10
WATER LEVEL=7.25m
DEPTH=15m

Depth (m)	Time (sec)	Impellor Count	Flow Direction	Velocity (cm/sec)
8.25	60	0	Up-flow	0.40
9.25	60	0	Up-flow	0.40
10.25	60	0	Up-flow	0.40

DATE 06 AUG 91
TIME 03:12:02 PM
HOLE No.=B-10
WATER LEVEL=7.25m
DEPTH=15m

Depth (m)	Time (sec)	Impellor Count	Flow Direction	Velocity (cm/sec)
7.80	60	0	Up-flow	0.40
8.30	60	0	Up-flow	0.40
8.80	60	0	Up-flow	0.40
9.30	60	0	Up-flow	0.40
9.80	60	0	Up-flow	0.40
10.30	60	0	Up-flow	0.40
10.80	60	0	Up-flow	0.40
11.30	60	0	Up-flow	0.40
11.80	60	0	Up-flow	0.40
12.30	60	0	Up-flow	0.40
12.80	60	0	Up-flow	0.40
13.30	60	0	Up-flow	0.40

DATE 21 AUG 1991
TIME 09:27:09 AM
HOLE No.=B-10
WATER LEVEL=7.30m
DEPTH=15m

Table 5-4-4 Micro Flow Measurement Data (New El Coco B-13)

Depth (m)	Time (sec)	Impellor Count	Flow Direction	Velocity (cm/sec)
3.86	60	0	Up-flow	0.40
4.86	60	0	Up-flow	0.40
5.86	60	0	Up-flow	0.40
6.86	60	0	Up-flow	0.40
7.86	60	0	Up-flow	0.40

DATE 19 AUG 1991
TIME 03:50:38 PM
HOLE No.=B-13
WATER LEVEL=2.86m
DEPTH=10m

Table 5-4-5 Characteristic of Aquifer (New El Coco)

Site	Season	Date	Elevation (m)	Thickness of Aquifer	Flow Rate (m^3/sec)	Flow in Bore Hole (m^3/day)	Width of Aquifer	Total Flow (m^3/day)
B-1	Dry	25, Apr.	187 to 192	5m	0.0054	116.6	100m	233, 280
	Rainy	26, Jul.			0.0042	90.7		181, 440
		6, Aug.			0.0074	159.8		319, 680
		20, Aug.			0.0069	149.0		298, 080
	Dry	25, Apr.	200 to 208	8m	0.0069	238.5		476, 930
	Rainy	26, Jul.			0.0070	241.9		483, 840
		6, Aug.			0.0112	387.1		774, 140
		20, Aug.			0.0040	138.2		276, 480
	Dry	25, Apr.	210 to 221	11m	0.0074	351.6		703, 300
	Rainy	26, Jul.			0.0074	351.6		703, 300
		6, Aug.			0.0192	912.4		1, 824, 770
		20, Aug.			0.0041	194.8		389, 660
B-2	Dry	25, Apr.	141 to 144	3m	0.0097	125.7	90m	226, 280
	Dry	25, Apr.	165 to 184	19m	0.0310	2, 544.5	80m	4, 071, 170
	Rainy	25, Jul.			0.0210	1, 723.7		2, 757, 890
		5, Aug.			0.0295	2, 421.4		3, 874, 180
		7, Aug.			0.0246	2, 019.2		3, 230, 670
		20, Aug.			0.0479	3, 931.6		6, 290, 610
	Dry	25, Apr.	216 to 220	4m	0.0063	108.9	100m	217, 730
	Rainy	25, Jul.			0.0040	69.1		138, 240
		5, Aug.			0.0040	69.1		138, 240
		7, Aug.			0.0040	69.1		138, 240
		20, Aug.			0.0044	76.0		152, 060
B-3	Rainy	20, Aug.	201 to 202	1m	0.0087	376.	250m	187, 920
B-4	Dry	25, Apr.	236 to 240	4m	0.0040	69.1	—	—
	Rainy	24, Jul.			0.0047	81.2		
		5, Aug.			0.0040	69.1		
		19, Aug.			0.0264	456.2		
B-5	Dry	25, Apr.	238 to 244	6m	0.0091	235.9	100m	471, 740
	Rainy	24, Jul.			0.0089	230.7		461, 380
		30, Jul.			0.0065	168.5		336, 960
		5, Aug.			0.0040	103.7		207, 360
		19, Aug.			0.0043	111.5		222, 910
B-6	Rainy	19, Aug.	244 to 246	2m	0.0069	59.6	—	—
B-8	Rainy	24, Jul.	239 to 244	5m	0.0081	175.0	—	—

Table 5-4-6 Chemical Analysis of Groundwater (New El Coco)

site	Season	Date	Cu (ppm)	Pb (ppm)	Zn (ppm)	Fe (ppm)	Cd (ppm)	Total Cr (ppm)	As (ppm)	Hg (ppm)	Cr^{6+} (ppm)	pH
C-B1	Dry	15, Mar.	0.03	0.13	0.16	30	n.d.	0.007	0.25	n.d.	n.d.	7.60
	Rainy	26, Jul.	n.d.	0.020	0.11	1.5	n.d.	0.001	0.14	n.d.	n.d.	7.61
C-B2	Dry	15, Mar.	0.01	0.91	0.044	1.9	0.001	n.d.	n.d.	n.d.	n.d.	8.87
	Rainy	26, Jul.	0.003	0.029	0.12	1.3	n.d.	0.006	0.001	n.d.	n.d.	8.46
C-B3	Dry	16, Mar.	0.03	n.d.	0.05	3.8	n.d.	0.003	0.015	n.d.	n.d.	8.71
	Rainy	27, Jul.	0.039	5.3	0.22	12	0.002	0.036	0.018	n.d.	n.d.	7.26
C-B4	Dry	15, Mar.	0.02	0.011	0.04	9.3	n.d.	0.009	0.024	n.d.	n.d.	7.45
	Rainy	27, Jul.	0.011	0.042	0.06	8.0	n.d.	0.020	0.010	n.d.	n.d.	7.40
	Rainy	19, Aug.	0.009	0.037	0.11	0.93	n.d.	0.005	0.032	n.d.	n.d.	7.38
C-B5	Dry	15, Mar.	0.03	0.05	0.075	22	0.003	0.006	0.045	n.d.	n.d.	8.64
	Rainy	27, Jul.	0.014	0.12	0.044	6.3	n.d.	0.008	0.030	n.d.	n.d.	7.60
	Rainy	19, Aug.	0.10	0.033	0.14	0.58	0.0006	0.006	0.014	n.d.	n.d.	7.77
C-B6	Rainy	27, Jul.	0.093	0.11	0.085	20	0.0008	0.037	0.041	n.d.	n.d.	7.53
	Rainy	19, Aug.	0.022	0.045	0.043	1.7	n.d.	0.012	0.031	n.d.	n.d.	7.69
C-B7	Dry	15, Mar.	0.03	0.1	0.06	5.2	0.002	n.d.	0.12	n.d.	n.d.	7.94
	Rainy	27, Jul.	0.048	0.15	0.20	30	0.0004	0.058	0.10	n.d.	n.d.	7.45
	Rainy	22, Aug.	0.008	0.001	0.009	2.0	0.001	0.017	0.075	n.d.	n.d.	6.71
C-B8	Rainy	27, Jul.	0.022	0.20	0.10	16	0.003	0.029	0.026	n.d.	n.d.	7.41
	Rainy	19, Aug.	0.010	0.001	0.055	1.7	n.d.	0.024	0.019	0.004	n.d.	7.71
C-B9	Rainy	19, Aug.	0.007	0.059	0.080	1.9	n.d.	0.033	0.011	0.001	n.d.	7.86
C-B10	Rainy	9, Sep.	0.015	0.032	0.25	0.77	n.d.	0.003	0.019	n.d.	n.d.	-
C-B11	Rainy	9, Sep.	0.033	0.093	0.17	2.2	0.001	0.010	0.011	0.001	n.d.	7.95
C-B12	Rainy	9, Sep.	0.045	0.12	0.15	2.4	0.001	0.006	0.005	n.d.	n.d.	7.71
C-B13	Rainy	19, Aug.	0.011	0.026	0.091	1.8	n.d.	0.045	0.005	n.d.	n.d.	7.55

Electric Conductivity (μ s/cm) is;
C-B1(Dry)=50, C-B1(Rainy)=48, C-B2(Dry)=53, C-B2(Rainy)=50,
C-B3(Dry)=47, C-B3(Rainy)=49, C-B4(Dry)=45, C-B4(Rainy)=41, 44,
C-B5(Dry)=46, C-B5(Rainy)=44, 44, C-B6(Rainy)=49, 47, C-B7(Dry)=46,
C-B7(Rainy)=47, 45 C-B8(Rainy)=45, 43, C-B9(Rainy)=45, C-B11(Rainy)=42,
C-B12(Rainy)=43, C-B13(Rainy)=45

Table 5-4-7 Permeability Coefficient Data

(New El Coco)

Sample Number	CR-1	CR-2	CR-3	CR-4	CR-5	CR-6
D 10(mm)	0.0005	0.0020	0.0004	0.0008	0.0023	0.0060
D 60(mm)	0.5000	0.2800	0.0200	0.2300	0.3700	0.3800
Uniformity Coeffcient	1000.0	140.0	50.0	287.5	160.9	63.3
K (cm/sec) by Hazen's Formula	3.34E-07	5.34E-06	2.13E-07	8.54E-07	7.06E-06	4.80E-05

K:Permeability Coefficient(cm/sec)

D10(mm):Particle-size(mm) on 10% Cumulative Curve = Effecitve Size(de)

Table 5-4-8 Permeability and Porosity Model

Legend No.	Matrix Permeabilty pkm(cm/sec)	Fracture Permeability pkf(cm/sec)	Fracture Zone Width hef(m)	Matrix Porosity porm(%)	Fracture Porosity porf(%)
1 (Aquiclude)	5×10^{-5}	10^{-3}	0	15	30
2 (Aquifer)	10^{-6}	10^{-3}	20	10	30
3 (Aquitard)	10^{-4}	10^{-3}	0	20	30
4 (Aquifuge)	10^{-7}	10^{-3}	0	5	30

Model's Block Permeability(K) = $(hef/\triangle x)\times pkf+(1-hef/\triangle x)\times pkm$

$\triangle x$ = block width(m)

Table 5-5-1 Chemical Analysis of Soil

(New El Coco) (ppm)

No.	Cu	Pb	Zn	Fe(wt%)	Cd	Sb	Cr	As	Hg
CS-1	34	130	85	4.9	3.5	81	25	20	0.06
CS-2	27	45	94	2.7	1.8	48	33	53	0.14
CS-3	30	58	190	2.5	2.4	50	27	59	0.28
CS-A1	5	22	17	0.8	1.1	18	6	4	0.10
CS-A2	7	38	31	1.5	1.9	23	10	31	0.16
CS-A3	16	50	45	5.4	4.9	39	29	110	0.20
CS-A4	9	37	69	2.8	3.1	41	10	31	0.21

(Background in Soil) (ppm)

Elemnts	Cu	Pb	Zn	Fe(wt%)	Cd	Sb	Cr	As	Hg
Background	15	17	36	2.1	0.5	2	43	7.5	0.056

by Rose, A.T. et al. (1979):Geochemistry in Mineral Exploration, Academic Press, 657P.

Table 5-6-1 Soil Test Quantity

Dry Season		Rainy Season	
No.	Depth(m)	No.	Depth(m)
D-1	0.5- 0.7	B-11	2.0- 2.6
D-2	0.5- 0.7		4.0- 4.6
	1.2- 1.4	B-12	2.0- 2.6
D-3	0.5- 0.7		4.0- 4.6
	1.2- 1.4		6.0- 6.6
D-4	0.5- 0.7		
	1.2- 1.4		
D-5	0.5- 0.7		
	1.2- 1.4		
D-6	1.0- 1.2		
D-7	0.5- 0.7		
D-8	0.5- 0.7		
D-9	0.5- 0.7		
D-10	0.5- 0.7		
Total	14 samples	Total	5 samples

Table 5-6-2 Soil Test Data

(dry season)

Sample No.	D-1	D-2		D-3		D-4		D-5		D-6
Depth (m)	0.5~0.7	0.5~0.7	1.2~1.4	0.5~0.7	1.2~1.4	0.5~0.7	1.2~1.4	0.5~0.7	1.2~1.4	1.0~1.2
Water Content (%)	10.5	14.6	8.9	18.0	16.0	8.0	7.5	13.5	8.7	8.5
Specific Gravity	2.63	2.70	2.69	2.67	2.63	2.58	2.61	2.64	2.62	2.57
Wet Density (g/cm³)	1.859	1.694	1.593	1.609	1.553	1.281	1.290	1.170	1.426	1.370
Liquid Limit (%)	40.2	72.2	63.2	64.0	53.2	26.3	27.3	32.0	26.2	22.9
Plastic Limit (%)	20.7	20.0	21.5	22.0	21.6	19.0	18.0	19.0	20.2	19.8
Angle of Internal Fliction (°)	26.5	28.0	32.2	25.0	30.5	32.6	31.6	35.2	33.5	32.0
Cohesion (tf/m²)	7.2	6.0	4.5	5.0	5.3	3.6	3.8	4.5	5.5	4.0
Coefficient of Permeability (cm/sec)	1.87 $\times10^{-5}$	1.19 $\times10^{-5}$	1.18 $\times10^{-5}$	1.18 $\times10^{-5}$	2.99 $\times10^{-4}$	2.74 $\times10^{-4}$	3.15 $\times10^{-4}$	2.70 $\times10^{-4}$	4.21 $\times10^{-4}$	1.65 $\times10^{-4}$

(dry season)

Sample No.	D-7	D-8	D-9	D-10
Depth (m)	0.5~0.7	0.5~0.7	0.5~0.7	0.5~0.7
Water Content (%)	15.3	7.4	8.1	10.3
Specific Gravity	2.61	2.59	2.56	2.55
Wet Density (g/cm³)	1.409	1.180	1.474	1.485
Liquid Limit (%)	44.0	24.7	27.0	30.5
Plastic Limit (%)	22.0	19.9	21.0	22.3
Angle of Internal Fliction (°)	35.6	33.5	33.0	32.0
Cohesion (tf/m²)	5.5	5.0	5.3	4.8
Coefficient of Permeability (cm/sec)	2.83 $\times10^{-4}$	1.90 $\times10^{-4}$	2.15 $\times10^{-4}$	5.38 $\times10^{-4}$

(rainy season)

Sample No.	B-11		B-12		
Depth (m)	2.0~2.6	4.0~4.6	2.0~2.6	4.0~4.6	6.0~6.6
Water Content (%)	16.4	25.3	10.2	8.3	19.5
Specific Gravity	2.59	2.63	2.65	2.66	2.58
Wet Density (g/cm³)	1.78	1.95	1.81	1.81	2.01
Liquid Limit (%)	32.4	42.5	19.2	21.5	25.0
Plastic Limit (%)	21.1	22.4	N.P.	N.P.	14.0
Angle of Internal Fliction (°)	33.5	34.6	34.2	35.3	30.1
Cohesion (tf/m²)	5.0	6.3	5.8	4.0	3.0
Coefficient of Permeability (cm/sec)	5.59 $\times10^{-3}$	2.75 $\times10^{-3}$	7.38 $\times10^{-3}$	2.75 $\times10^{-3}$	1.20 $\times10^{-3}$

Table 5-6-3 Natural Moisture Content and Wet Density

Site	Natural Water Content (W)	Wet Density (ρ_t)
B-11	20.9 (%)	1.87
B-12	12.7 (%)	1.88
Average	16.8 (%)	1.875

Table 5-8-1 A Result of Tailing Dam Stability Analysis

Element		Ordinary Condition (Kh=0.00)	Earthquake Condition (Kh=0.15)
Center of Circular Arc	X(m)	95.00	135.00
	Y(m)	282.00	305.143
Radius R(m)		33.048	52.00
Resisting Moment MR(tf・m)		721.033	18070.207
Sliding Moment MD(tf・m)		404.303	15039.391
Safety Factor Fs=MR/MD		1.7834	1.2015

Table 5-8-2 Day Probability Precipitation

Order i	Date	Precipitation (mm)	$\frac{2i-1}{2N} \times 100$
1	1986.9	101.2	10.0
2	1985.9	96.2	30.0
3	1989.9	79.6	50.0
4	1987.9	77.6	70.0
5	1988.8	73.6	90.0

6. Summary

6. SUMMARY

This survey works were composed of the following three steps as described in the indication made in Dec., 1990.

First Step : Collection and review of all existing data and information related to the Survey

Second Step : Field reconnaissance and measurement to obtain necessary data in the dry and rainy seasons

Third Step : Design of counterplans for appropriate environmental protection measures

As the first step, existing data on topography, geology, mining, metallurgy and tailing dam were collected at the headquarters of CFM as well as the mine offices in each survey area. Furthermore, meteorological data were obtained at a local station of each area.

Field reconnaissance and measurement were carried out in the three designated areas, El Bote, Parral, and New El Coco, on geology, hydrology, soil property, dust concentration etc.,in and around the tailing dams or its proposed site (New El Coco).

The collected data and the survey results were collectively analysed in Japan for understanding the present environmental situation at the mining sites and making any counterplans against the pollution problems.

Throughout the survey period, technology transfer was made to the Mexican Counterparts on the key elements of environmental study, measurement method, apparatus and others.

The results obtained in each area are summarized as below.

El Bote Area In this area, first of all, a part of the dam embankment has already collapsed by landslide and any counterplan is urgently required on entire embankment. Study from the soil property tests also led to a conclusion that the dam was in a dangerous condition. As a counterplan "Counter Weight Fill Work" method was proposed in Sec.3-9.

Dust problem brought by the wind from the dam is another serious problem. It is concluded at present that dust particles never reach the urban area,

however, they should have a great influence on living conditions at and around the mine site Against this problem "Soil Covering" and Planting on the dam surface are recommended.

Copper and other heavy metal ions were detected in the samples of surface and ground water as well as soils in this area. All possible sources of these metals are listed below.

(1) Effluent from CFM El Bote plant and tailing dam
(2) Effluent from other mines than CFM
(3) Natural phenomena derived from local mineralization

Environmental pollution in this area is possibly related to all three sources above-mentioned. It is so difficult or practically impossible to know how much effect were brought by each pollution source. However,it can be concluded that CFM mining operation is not the only one source because a highly contaminated point (B-R2) is found at upper stream from CFM plant and tailing dam. This point is always short of water flow, almost stagnant during the dry season. This suggests that metals were dissolved and concentrated there from natural mineralization zone in the area.

The samples taken directly from the El Bote flotation plant tailing (B-W1) and tailing dam (B-D1) contain less metal ions than those of Parral operation. No cyanide was detected in either sample. Consequently, it is not absolutely necessary to install water treatment facility. The following measures are recommended tentatively.

(1) To reuse as much waste water as possible by recycling to the mineral processing plant
(2) To install a drainage system inside the dam to prevent rain water from contacting with the dam deposits
(3) to widen the waste water evaporation area by flattening the deposition plane

Details of the drainage system was described in Sec. 3-9.

Parral Area The stability of the tailing dam is a serious problem as in El Bote. In case of the Parral dam "Earth Removal Work" method, which reduces overload of soil mass, is recommended together with "Counter Weight Fill Work" proposed in El Bote.

On the dust problem the "Soil covering" and Planting are recommended as in the El Bote dam.

On the water contamination, it is obvious that the effluents from the Parral plant and dam have an influence on the nearby rivers because high levels of metals are detected in these effluents. Especially, detection of cyanide ions in the river water is noticeable and any countermeasures are required. As one example "Alkali-Chlorine Method" is described in the Sec. 4-9.

The drainage system inside the tailing dam is also recommended as in the El Bote dam.

It is suggested to make a deposition pond between the tailing dam and Parral river and connect it to the drainages from the dam to expand the evaporating area in the dry season, and to prevailing the discharge of tailings with an unexpected big storm rainfall in the rainy season.

Groundwater from the tunnel of the Parral mine indicates strongly acid. This water is no adequate to drink. It is thought that this groundwater is deep-seated origin.

The Parral river runs in the upside of this area. It is considered that there exists no deep polluted groundwater in the shallow aquifer, because the unconfined groundwater consists by water that originate in rainwater, from the view points of topography and river morphology.

To improve this water quality , new shallow aquifer along the Parral river should be utilized by boring work, because more clean groundwater can be got.

New El Coco Area Contamination by heavy metals is also detected in the near by water system and soil of this area. However, concentration levels are not as high as those of other survey areas, El Bote and Parral. Since there exists no mining activity at present, these contamination should have been derived from natural and local mineralization. It is recommended that another investigations shall be performed to compare the environmental situation after some mining activities get started.

As the results of soil property tests, the ground foundation of the proposed dam site was found suitable for construction. Based on these results a model tailing dam of pollution-free was designed technically and economically for final recommendation.

The tailing dam construction guide line of Japan is referred to design this new El Coco tailing dam in section 5-8-1 and 5-8-2, in which a engineering method for drainage system is described to prevent tailing-rainwater contamination and waste water infiltration. On the other hand, a hydraulic method, described in section 5-4-3 in which groundwater flow systems are simulated, is recommended as a counterplan to reduce construction cost. The hydraulic method is the second countermeasure to prevent groundwater pollution. This method utilizes flow system between waste water and groundwater, in which system waste water infiltrates underground and mixed with groundwater. The groundwater is pumped up from the bore hole near the new tailing dam to use for slime transport. This waste water recycle system is adequate to prevent groundwater pollution and to use groundwater efficiently below the planned new tailing dam.

Since the above-mentioned countermeasures against the regional pollution are all practicable without difficulty, it is desirable to realize them urgently. Furthermore, this type of investigation shall be continued in a long term plan for recognition and protection of environment. Pollution problem is often involved in mining activities. Consequently, expenditure for preventing pollution should have been included originally in initial development costs. However, in case when some countermeasures are to be planned after the mine started, it is inevitable to finance and budget the necessary funds apart from the daily operation costs urgently.

Global attention and concern have been focussed increasingly on pollution of life-environment. Mining activities are indispensable to the growth of modern life, however, they sometimes bring serious environmental contamination on the surrounding area. Therefore, special attention should be paid to the protection against the pollution and destruction of the nature, which may be accompanied with mine development.

Japan International Cooperation Agency (JICA) hereby proposes to enact official Guidelines that ensure the compatibility of mine development and the

environment throughout the United Mexican States. If any laws or regulations are already existing, they should be observed strictly.

The principal concerns are as follows.

Air pollution by dust
Water pollution by mine effluent
Soil contamination by waste materials, dust and mine effluent
Regulation on construction of tailing dam
Subsidence of mining site
Noise and vibration
Destruction of forests

For reference the principal Guidelines established in Japan are listed below.

The Basic Law on Countermeasures against Pollution
(Kogai-Kihon-Ho), Aug., 1967
The Act for Prevention of Air Contamination
(Taiki-Osen-Boshi-Ho), Jun., 1968
The Act for Prevention of Water Contamination
(Suishitsu-Odaku- Boshi-Ho), Dec., 1968
The Construction Standard of Rubble/Slime Deposition Mound and its Explanation
(Suteishi-Kosai-Taisekijo-Kensetsu-Kijun-Oyobi-Kaisetsu),
Nov., 1954 by the Ministry of International Trade and Industry
OECF Environmental Guidelines, Oct., 1989 by The Overseas Economic Cooperation Fund
Environmental Control Regulation in Japan July, 1990, Industrial Pollution Control Association of Japan , Tokyo, Japan